REMOVAL ACTION
ENGINEERING EVALUATION & COST ANALYSIS

Blue Ledge Mine Site
Rogue River-Siskiyou National Forest

Final April 26, 2010

Prepared for:
United States Department of Agriculture
Rogue River-Siskiyou National Forest
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April 26, 2010

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Re: Engineering Evaluation/Cost Analysis
Blue Ledge Mine Site
Rogue River-Siskiyou National Forest

Dear Mr. Jones:

The attached Engineering Evaluation/Cost Analysis (EE/CA) describes the basis for a removal action and considers a range of alternatives to mitigate the source of ongoing environmental damage and potential human health risk at the abandoned Blue Ledge Mine Site. This final EE/CA incorporates comments received from the Forest Service and supersedes the April 14, 2009 document.

If you have any questions regarding this report, please call one of us.

Sincerely,
URS CORPORATION

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Attachment: Report

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TABLE OF CONTENTS

SUMMARY v

Section 1.0 INTRODUCTION 1-1
1.1 Site Location and Description 1-1
1.2 EE/CA Approach 1-2

Section 2.0 SITE CHARACTERIZATION 2-1
2.1 Previous Investigations 2-1
2.2 Previous Actions 2-1
2.3 2008 Data Gap Investigations 2-2
2.4 Summary of Site Investigations, Risk Evaluation, and Geotechnical Assessment 2-3
2.4.1 Quantities, Areas, and Volumes 2-3
2.4.2 Ecological Risk Evaluation 2-4
2.4.3 Macroinvertebrate Survey 2-5
2.4.4 Human Health Risk Evaluation 2-6
2.4.5 Residential Water Supply Sampling 2-7
2.5 Sources of Acid Mine Drainage and Conceptual Hydrogeologic Model 2-8

Section 3.0 RATIONALE FOR REMOVAL ACTION, CLEANUP CRITERIA, AND REMOVAL ACTION OBJECTIVES 3-1
3.1 Natural Resource Damage Assessment 3-1
3.2 Site Investigation Rationale for Removal Action 3-2
3.3 Applicable or Relevant and Appropriate Requirements 3-3
3.4 Removal Action Objectives 3-4
3.5 Removal Action Schedule 3-4

Section 4.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION TECHNOLOGIES 4-1
4.1 Waste Rock Removal 4-1
4.1.1 Waste Rock Removal Methods 4-2
4.1.2 Waste Rock Classification and Repository Elements 4-3
4.1.3 In Situ Stabilization and Treatment of Waste Rock 4-5
4.2 AMD and Run-off Control and Treatment 4-6
4.3 Reclamation Cover 4-6
4.4 Adit Closure 4-8
4.5 Remediation Not Included 4-8
4.5.1 Adit Discharge Collection and Treatment 4-8
4.5.2 Waste Rock Sediments in Joe and Elliott Creeks 4-9
4.5.3 Groundwater 4-10

Section 5.0 SITE CHARACTERISTICS AND DATA GAPS 5-1
5.1 Geotechnical Characteristics 5-1
5.1.1 Geotechnical Characteristics of Waste Rock Piles 5-1
5.1.2 Geotechnical Assessment of Repository Sites 5-2
5.1.3 Characteristics of the Blue Ledge Mine Camp Site 5-5
5.2 Data Gaps and Additional Assessment 5-5
5.2.1 Additional Survey 5-5

5.2.2 Supplemental Geotechnical Investigation and Stability Analysis of Repository Sites 5-6
5.2.3 Additional Waste Rock Areas 5-6
5.2.4 Test Pits 5-7
5.2.5 Test Removals 5-7

Section 6.0 REMOVAL ACTION ALTERNATIVES 6-1
6.1 General Response Actions 6-1
6.2 No Action 6-1
6.3 Alternative 1 Description 6-1
6.4 Alternative 2 Description 6-2
6.5 Alternative 3 Description 6-2
6.6 Cost Estimates 6-3
6.6.1 Capital Costs 6-3
6.6.2 Recurring and Future Costs 6-4
6.6.3 Uncertainty and Contingencies 6-4

Section 7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES 7-1

Section 8.0 REMOVAL ACTION RECOMMENDATION 8-1
8.1 Removal Action Implementation 8-1

Section 9.0 SIGNATURES OF PREPARERS 9-1

Section 10.0 REFERENCES 10-1

TABLE OF CONTENTS

TABLES ..... FOLLOWING REPORT

Table 3-1a Chemical-Specific Applicable or Relevant and Appropriate Requirements
Table 3-1b Location-Specific Applicable or Relevant and Appropriate Requirements
Table 3-1c Action-Specific Applicable or Relevant and Appropriate Requirements
Table 4-1 Removal Action Technology Screening
Table 6-1 Summary of Removal Action Alternatives
Table 6-2 Summary of Alternatives Costs
Table 6-3 Summary of NCP Removal Action Factors

FIGURES ..... FOLLOWING REPORT

Figure 1-1 Vicinity Map
Figure 1-2 Site Surroundings
Figure 1-3 Waste Rock Areas
Figure 2-1 Sources of AMD and Conceptual Hydrogeologic Model
Figure 4-1 Alternative Waste Rock Repository Locations
Figure 4-2 Repository Site Schematic
Figure 4-3 Concept Reclamation Areas
Figure 4-4 Concept Reclamation Section

APPENDICES

Appendix A Photo Log
Appendix B Macroinvertebrate Survey
Appendix C Preliminary Geotechnical Investigation
Appendix D Supplementary Geotechnical Investigation and Stability Analysis
Appendix E Cost Details

ABBREVIATIONS

AMD	acid mine drainage
ARARs	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic foot per second
CY	cubic yards
DTSC	Department of Toxic Substances Control
EE/CA	Engineering Evaluation and Cost Analysis
EPA	US Environmental Protection Agency
ET cover	evapotranspiration cover
FOS	factor of safety
GCL	geosynthetic clay liner
gpm	gallons per minute
LiDAR	Light Detection and Ranging
MCL	Maximum Contaminant Level
msl	mean sea level
µg/L	micrograms per liter
NCP	National Contingency Plan
NFS	National Forest System
NRDA	natural resource damage assessment
PA/SI	Preliminary Assessment/Site Inspection
PRB	Permeable Reactive Barrier
RAOs	removal action objectives
RFP	request for proposal
RSL	Regional Screening Level
SI	Site Inspection for the Blue Ledge Mine site
Site	Blue Ledge Mine site
SOU	Southern Oregon University
T	tons
URS	URS Corporation
USDA	United States Department of Agriculture
USFS	United States Forest Service
RWQCB	California North Coast Regional Water Quality Control Board
WRP	waste rock pile

SUMMARY

This Engineering Evaluation and Cost Analysis (EE/CA) describes technologies and alternatives to mitigate the primary source of environmental damage and potential human health risk at the abandoned Blue Ledge Mine site (the Site) and recommends a removal action. URS Corporation (URS) prepared this document for the US Forest Service, Department of Agriculture (USFS) under the terms of the USFS request for proposal (RFP) RFP-27-06-113 (USFS, 2006).

BACKGROUND

The Site is located on patented and National Forest System (NFS) land in northern California, within the Rogue River-Siskiyou National Forest, approximately 3 miles south of the Oregon border. The mine site lies at the upper headwaters of the Joe Creek watershed on a steep hillslope. Joe Creek flows north to Elliott Creek, which in turn is a tributary to the Middle Fork of the Applegate River. The Applegate River feeds the Applegate Reservoir. The small community of Joe Bar is located downstream of the Site just downstream of the confluence of Joe Creek with Elliott Creek.

Mines that exploit mineralized sulfide deposits are common sources of acid mine drainage (AMD). Acid mine drainage refers to acidic water that discharge from mine adits or leaches from waste rock or tailings. An estimated 70,000 tons of sulfide-rich waste rock was discarded on the hillsides below the adits. The waste rock is located in four primary areas downslope of historically productive adits. Over time, the waste rock has eroded and leached acidity and metals to Joe Creek and Elliott Creek. Both the acidity and the dissolved metals in AMD are harmful to aquatic and terrestrial natural resources and potentially harmful to humans.

Discharges from one or more mine adits, contaminated sediments in Joe Creek, and contaminated groundwater are also significant adverse impacts at the Site. Subsequent remedial action will be required to control these sources and mitigate the impacts. The specific remedial actions that may be needed are beyond the scope of this EE/CA.

PREVIOUS INVESTIGATIONS

Various investigations since 1992 have documented the conditions at the Blue Ledge Mine and show that AMD from the Site has impacted surface water, stream sediments, and groundwater near the Site. The 2009 Site Investigation (SI) report documents previous investigations and the current site conditions (URS). The site investigations indicate that the mine site is a source of arsenic, cadmium, copper, iron, lead, and zinc to soil, groundwater, surface water, and sediments.

RISK EVALUATION

The 2008 quantitative ecological risk evaluation and biological stream surveys reflect the obvious visual impacts:

- Joe Creek is severely impacted, with virtually no visual signs of aquatic life.
- The ecological damage to Joe Creek is confirmed by past macroinvertebrate surveys and a 2008 macroinvertebrate survey by URS.
- The macroinvertebrate surveys show poor ecological health of Joe Creek, as compared to Elliott Creek.

- The lack of native fish and amphibians in a creek that should support aquatic life is notable and in stark contrast to the abundant aquatic life observed just upstream of the mine site.

The quantitative risk evaluation performed by URS in 2008 concluded that metals sourced at the mine pose significant ecological risk in surface water at the Site and in Joe Creek and in riparian soil and sediments of Joe Creek. Metals concentrations in water, sediment, and riparian soil of Elliott Creek were lower than in Joe Creek but still exceeded the minimum threshold for unacceptable ecological risk.

Potentially complete exposure pathways for humans include consumption of fish, direct contact with sediments and riparian soils, and ingestion of groundwater. Arsenic in surface water exceeded human health screening criteria. The Blue Ledge mine is a source of arsenic, but regional sources may also exist. Residents of Joe Bar use groundwater from four wells and one groundwater seep for drinking water. Groundwater samples collected in 2008 were used to support the human health risk assessment. Human health risks in the Applegate Reservoir appear to be low, but that system may not be in equilibrium with contaminants being transported from the mine, and the risk to humans may increase in the future.

RATIONALE FOR REMOVAL ACTION

Site data clearly demonstrate that a removal action is justified. The Site is a historic and ongoing source of AMD from adits and waste rock. Site contamination has eliminated fish and significantly reduced macroinvertebrate populations in Joe Creek and poses an unacceptable ecological risk. Site contamination results in an unacceptable human health risk within the immediate site area and may also impact drinking water.

The Site meets the criteria for a natural resource damage assessment claim. The National Contingency Plan (NCP) grants authority to lead agencies to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of release of hazardous substances. Absent a removal action, fish are unlikely to return to Joe Creek for the foreseeable future.

The removal action objectives (RAOs) considered in the EE/CA reflect the NCP objectives to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of releases from the waste rock that pose environmental risk (NCP 40CFR 300.415). This EE/CA assesses treatment technologies and alternatives to mitigate the contamination sourced at the mine. The most significant source of contamination is the waste rock. Removal or stabilization of the waste rock would eliminate the primary source of acid mine drainage. AMD discharge from mine adits and sediments that are already present in Joe Creek may also be significant sources of environmental impacts, but treating AMD discharging from adits and sediments in Joe Creek is not within the scope of this EE/CA.

SCREENING OF TECHNOLOGIES AND ALTERNATIVES

The EE/CA considered the effectiveness, implementability, and costs of technologies and alternatives. Technologies considered included removal and off-site disposal and in situ stabilization of the waste rock. In situ stabilization was considered to be impractical and was not retained in removal alternatives. Removal by dozers, excavators, and draglines was considered to be feasible. Once removed, the waste rock would be deposited in an engineered repository

located near the mine site. Two potential repository sites, referred to as the north and south repository sites, are located within one mile of the mine site, and appear to be feasible, but the EE/CA also considered more distant repositories and landfilling. It is likely that one or the other of the repository sites would have adequate capacity to accommodate the entire volume of waste rock. Based primarily on its size, ease of construction, and absence of critical habitat, the south repository site is the preferred site to construct the repository. The north site is retained as a storage and lay-down area.

Alternatives considered in the EE/CA also include technologies for the following:

- AMD and run-off control and treatment;
- Reclamation cover after removal of waste rock; and
- Adit closure.

This EE/CA focuses on removal of the waste rock, which is believed to be a significant source of the contamination in Joe Creek. This EE/CA does not consider other potentially significant environmental concerns at the site because they are outside the scope of a removal action. Additional study and possible remediation may include the following:

- AMD discharge from adits;
- Waste rock sediments in Joe Creek; and
- Groundwater.

The major elements and costs of the alternatives that were considered include the following:

No Action Performance monitoring and reporting and road maintenance for access. $0.14M.

Alternative 1 Waste rock removal, unlined repository with impervious cover at local site. $15.99M.

Alternative 2 Waste rock removal, lined repository with impervious cover and AMD treatment at local site. $17.65M.

Alternative 3 Waste rock removal. More distant repository or landfill disposal. $19.65M.

RECOMMENDED REMOVAL ACTON

Alternative 2 is the recommended removal action. It consists of the following primary elements:

- Construct access roads as needed to complete the removal action. Generally, an access road will be needed to some portion of each of the four waste rock areas. Some improvements to existing roads to the mine may be required.
- Excavate waste rock with dozers, excavators, and draglines. The selected contractor will select the methods depending on the slopes and characteristics of the waste rock area.
- Construct the upland repository at the south repository site and prepare it for waste rock placement. The repository will be lined with a geosynthetic clay liner (GCL) and have AMD collection and treatment.

- Place the excavated waste rock in the repository.
- Install a composite GCL and soil cover over the waste rock, including native revegetation, run-on diversion, grading and drainage to isolate the waste rock from the environment and inhibit leaching of acidity and metals.
- Place and stabilize reclamation fill, where practical, and plant selected native vegetation on portions of the former waste rock areas. The reclamation fill and plantings will stabilize waste rock that remains after the removal is complete and minimize erosion and AMD from the residual waste rock.
- Install sedimentation basins and bioswales to control transport of contaminants from run-off, seeps, and erosion. Generally each waste pile will have one or more sedimentation basin to collect eroded sediments. These basins may require annual maintenance until the reclaimed site stabilizes.
- Close adits with bat gates to allow access by wildlife, prevent human access, and minimize physical hazards from the mine shafts.
- Conduct performance monitoring and reporting to assess water quality and long-term restoration of the Joe Creek and Elliott Creek watersheds.

Treatment of mine adit water, sediments in Joe Creek, and groundwater are not components of this alternative. Additional investigation and feasibility study are necessary to assess remedial alternatives for these issues.

It will take an estimated two construction seasons (June through October) to construct the remedy. A removal action should be implemented as soon as possible to mitigate continued degradation of the environment and potential risks to human health.

1.0 INTRODUCTION

This Engineering Evaluation and Cost Analysis (EE/CA) describes alternatives to mitigate the primary source of ongoing environmental damage and potential human health risk at the abandoned Blue Ledge Mine site (the Site). This EE/CA summarizes the basis for a removal action, considers a range of potential removal alternatives, and recommends a preferred removal action. URS Corporation (URS) prepared this document for the US Forest Service, Department of Agriculture (USFS) under the terms of the USFS request for proposal (RFP) RFP-27-06-113 (USFS, 2006).

1.1 Site Location and Description

The Site is an abandoned mine located within the Rogue River-Siskiyou National Forest in northern California, approximately three miles south of the Oregon border. Figure 1-1 shows the Site location. For purposes of implementing a removal action the Site is identified, as in the National Contingency Plan (NCP), to be the areal extent of contamination and all suitable areas in close proximity to the contamination necessary for implementation of the response action. The Site is identified generally as the work areas as necessary and required to complete the proposed action, including, but is not limited to, the following:

- private patented land parcel,
- the waste piles themselves, the identified repository site, identified and possible nearby storage areas and laydown areas,
- private and Forest Service roads near the mine site, as necessary to access working areas including the waste rock piles, the repository, storage areas,
- and Joe Creek and the downstream reaches.

The mine was discovered in 1898 and was active from 1904 until approximately 1930 (Environment International Ltd., 2002). The mine operation included at least five productive mine adits and several prospect adits. Copper, zinc, silver and gold ores were extracted from sulfide deposits and shipped from the Site, reportedly to the nearby historic town of Copper (now submerged beneath the Applegate Reservoir), and then to a former smelter in Tacoma, Washington.

The mine site lies at the upper headwaters of the Joe Creek watershed on a steep generally north-facing hillslope above the confluence of Joe Creek and an unnamed tributary to Joe Creek. Joe Creek flows north to Elliott Creek, which in turn is a tributary to the Middle Fork of the Applegate River.

The small community of Joe Bar is located downstream of the Site just downstream of the confluence of Joe Creek with Elliott Creek (Figure 1-2; Appendix A, photo 1). The Joe Bar community consists of approximately four dwellings and approximately six year-round or part-time residents.

The Applegate River flows north across the California-Oregon border to the Applegate Reservoir. The Applegate Reservoir was first filled in 1980. From the reservoir, the Applegate

River flows to the Rogue River near Grants Pass, Oregon. Figure 1-2 shows the Site surroundings.

Sulfide-rich waste rock was discarded on the hillsides below the adits. Over time, the waste rock has eroded and leached acidity and metals to Joe Creek and to Elliott Creek farther downstream. Section 2.4.1 provides the updated estimate of waste rock remaining at the Site to be 70,000 tons. Photos 2 through 11 (Appendix A) show examples of the waste rock piles.

There are four distinct waste rock areas, referred to as waste rock piles (WRP). WRP-1 through WRP-4 (Figure 1-3). Waste rock piles WRP-1 and WRP-2 comprise most of the waste rock. Two smaller piles, WRP-3 and WRP-4, are located within 1,000 feet of the main piles. An eroded access road traverses the middle part of WRP-1 (Appendix A, Photo 9).

Stormwater and snow melt from the mine area drain through ephemeral drainageways to Joe Creek. The drainageway through the main waste rock area passes through a log dam constructed when the mine was active (Figure 1-3). Photo 12 (Appendix A) shows the log dam. Upstream of the log dam is a stormwater detention basin that the US Environmental Protection Agency (EPA) built during their previous removal action at the Site in 2006. The detention basin was full of sediment at the time of URS' observations in 2008.

Mines that exploit mineralized sulfide deposits are common sources of sulfuric acid and dissolved metals. Water that discharges from adits, percolates through the waste rock, or becomes entrained in groundwater can be high in acidity and dissolved metals. Such impacted surface water and groundwater is referred to as acid mine drainage (AMD). Both the acidity and the dissolved metals in AMD are harmful to aquatic and terrestrial natural resources and potentially harmful to humans. AMD from the Site has impacted surface water, stream sediments, and groundwater near the Site. Photos 13 through 16 in Appendix A show examples of the impacts. The Site Inspection report (SI) documents the Site conditions and the extent of contamination, and the risks to human health and the environment posed by the Site (URS, 2009a). A removal action is warranted to mitigate the environmental damage being caused by the AMD associated with the waste rock piles.

1.2 EE/CA Approach

This report summarizes the Site conditions, risk evaluations, rationale for a removal action, alternatives analysis, and cost estimates to conduct a non-time-critical removal action (also referred to as a response action) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The EE/CA identifies the objectives of the removal action and provides a framework for evaluating and selecting alternative technologies. This EE/CA follows EPA guidance (EPA, 1993) and the outline specified by the USFS (2006). The EE/CA also follows guidance provided by the EPA in its Abandoned Mine Site Characterization and Cleanup Handbook (EPA, 2000a). The EPA developed the Handbook as a resource for project managers working on addressing the environmental concerns posed by inactive mines and mineral processing sites.

The EE/CA does the following:

- Summarizes the nature and extent of contamination as described in the SI report (URS, 2009a).
- Summarizes the results of the human health and environmental risk evaluations.
- Identifies removal action objectives (RAOs).
- Identifies general response actions.
- Screens treatment technologies against the criteria of effectiveness, implementability, and applicability.
- Assembles, develops, and compares removal action alternatives on the basis of effectiveness, implementability, and estimated cost.
- Recommends an alternative that meets the RAOs.

2.0 SITE CHARACTERIZATION

2.1 Previous Investigations

Results of various investigations starting in 1992 and continuing through the present characterize the Site. The SI (URS, 2009a) documents the current conditions and fills data gaps in the previous investigations. Investigations and results of previous work include the following:

- Water quality sampling conducted by the USFS in 2000 and 2001 demonstrated that concentrations of cadmium, copper, iron, lead, and zinc in Joe Creek increased significantly downstream of the Blue Ledge Mine.

- A macroinvertebrate survey conducted by Southern Oregon University (SOU) during the Fall of 2000 and Spring of 2001 showed substantial reductions in the stream biota of Joe Creek adjacent to and downstream of the mine site. Impacts were attributed to drainage and contaminants transport from the Blue Ledge Mine. The survey indicated that the impacts of the mine drainage increased during periods of high run-off.

- A 2002 Level II macroinvertebrate study and fish survey indicated an absence of macroinvertebrates in Joe Creek near the mine site (Siskiyou Research Group, 2002). No fish were found in the lowest 2-mile portion of Joe Creek where fish would be expected. The aquatic habitat in Joe Creek improved substantially upstream of the mine. The habitat improved with distance down Elliott Creek. Fish were observed in Elliott Creek.

- A 2002 Preliminary Assessment Screen demonstrated that the mine site is the source of natural resource damages to Joe Creek and Elliott Creek and that the Site meets the criteria for a natural resource damage assessment (Environment International Ltd, 2002).

- A 2004 Preliminary Assessment/Site Inspections (PA/SI) prepared by Weston (2004) identified the presence of ferricrete and the release of metals from the site. The PA/SI estimated the extent of the waste rock piles and the potential for environmental impacts. The PA/SI was the basis of the EPA's 2006 time-critical removal action act the site (see Section 2.2).

- Water samples collected in Joe Creek, Elliott Creek, and at Seattle Bar from May 2005 through November 2007 by SOU further documented the impacts from the mine and demonstrated seasonal trends in metal concentrations in water leaving the Site (Elliott, et al, 2007).

- Golder visited the Site in 2007 to observe site conditions and assess removal action alternatives. Golder (2007) estimated removal alternatives and costs on the basis of their preliminary review of the Site conditions.

2.2 Previous Actions

In September 2006, the US EPA terraced and regraded approximately the lower 25 percent of the main waste rock pile (WRP-1) to redirect AMD to a channel lined with large marble (limestone) boulders. Figure 1-3 shows the approximate location of the EPA's work. A settling basin was

constructed behind the log dam to trap sediment eroded from the waste rock piles. The goal was to stabilize the slope, reduce erosion, and provide passive treatment of acidic run-off. Photos 17 through 20 (Appendix A) show the conditions following the EPA work on the lower slopes. Limited erosion from the regraded slopes indicates successful regrading.

Elliott (2007) observed that the marble boulders became coated with iron precipitates in approximately three weeks after construction and the sedimentation basin quickly filled with sediment (see Appendix A, photos 19 and 20). Elliott also observed that run-off and AMD from higher on the slope flow in an undeveloped and unlined channel until directed into the settling pond by a marble berm. During periods of heavy precipitation, run-off overtops the log dam. On the basis on monitoring data, Elliott concluded that the remediation had minimal impact on water quality in Joe Creek.

The USFS and URS visited the Site in summer of 2008 to collect environmental samples and assess removal action alternatives. URS made similar observations of coatings on the marble boulders and sediment accumulation in the sedimentation basin. Nonetheless, it appears that the regraded waste rock is generally stable and there are few obvious signs of substantial erosion from the regraded piles. The success of the regrading reflects the relatively easy working conditions on the lower slopes, as compared to the much steeper and more difficult working conditions higher on the slope.

2.3 2008 Data Gap Investigations

URS (2009a) conducted additional site assessment to complete the SI in 2008. The purpose of the 2008 investigation was to fill data gaps from the previous investigations, assess risk associated with mine-affected media, and evaluate three potential disposal sites (referred to as "repositories") for potential disposal of excavated waste rock. The 2008 investigations included the following five major elements:

1. Collected groundwater, surface water, soil, waste rock, sediment, and fish tissue samples to assess mine-related impacts to upland and freshwater aquatic habitats.

2. Conducted a macroinvertebrate survey of Joe Creek and Elliott Creek to confirm previous macroinvertebrate results. Appendix B provides details of the macroinvertebrate survey.

3. Conducted screening-level human health and ecological risk evaluations to assess potential risk to human and ecological receptors posed by exposure to contaminated media.

4. Assessed geotechnical properties of waste rock samples.

5. Conducted preliminary and supplementary geotechnical analyses of potential repository sites.

Fieldwork conducted by URS to fill data gaps to complete the SI included the following:

- June 23 to June 28, 2008: Collected samples of waste rock, river sediment, and riparian soil from 32 locations. Water samples were collected from seeps, adits, the log dam, Joe Creek, tributaries to Joe Creek, Elliott Creek, Applegate River, and Applegate Reservoir.

- June 24 and 27, 2008: Conducted visual reconnaissance and geotechnical evaluation of waste rock areas and potential waste rock repositories.
- June 26 to July 1, 2008: Surveyed waste rock piles and measured piles to assess waste rock volumes.
- August 22, 2008: Visited site with contractor experienced in site reclamation to assess site conditions, removal action alternatives, and access.
- September 9, 2008: Conducted macroinvertebrate survey.
- November 3 to November 8, 2008: Conducted supplementary geotechnical field investigation and characterization of potential repository sites.
- November 8, 2008: Collected water samples from Joe Bar water supplies.

2.4 Summary of Site Investigations, Risk Evaluation, and Geotechnical Assessment

The SI report (URS, 2009a) tabulates sampling data and presents quantitative ecological and human health risk evaluations. This section summarizes the findings and conclusions of the SI report. The findings of the SI and risk evaluation provide the basis for the removal action.

The potential remedies for the Site include removal of waste rock and placement of the removed rock in a constructed repository at a local site. Other alternatives include stabilizing the waste rock in place or placing the excavated waste rock in an off-site landfill. The data gaps evaluation included preliminary geotechnical assessment of the waste rock and potential waste rock repository sites. Section 5 discusses removal action technologies and the geotechnical characteristics of the waste rock and evaluations of the potential repositories.

2.4.1 Quantities, Areas, and Volumes

The following site characteristics reflect observations and analysis by URS in 2008 and previous evaluations and sampling by others:

- There are four primary waste rock areas (Figure 1-3). The estimated area, volume (cubic yards [CY]), and mass (tons [T]) of the waste rock are:

Summary of Waste Rock Areas

Waste Rock Pile ID	Location	Area (acres) (1)	Volume (CY)	Weight (T) (2)
WRP-1	Slope north of main mine site	5.4	35,000	52,500
WRP-2	Slope east of main mine site	1.3	5,000	7,500
WRP-3	1,000 feet south of main mine site	0.8	4,600	6,900
WRP-4	Across drainage north of main mine site	0.6	2,100	3,150
	Totals	8.1	46,700	70,050

Areas in the above table are calculated from site survey. Weight assumes 1.5 tons per cubic yard.

- At least eight adits above the respective waste rock piles were observed and include the following:
  - WRP-1: two formerly productive adits (1A [upper] and 1B [lower])
  - WRP-2: two formerly productive adits (one high on the slope, now caved in and minimally visible [2A], and one lower on the slope [2B]) and two exploratory adits (2C, 2D)
  - WRP-3: at least one productive adit (3A)
  - WRP-4: one productive adit (4A) and one exploratory adit (4B)

Photos 21 through 26 in Appendix A show adits.

- Waste rock is deposited on steep slopes that typically range from approximately 30 to 45 degrees from horizontal, although waste rock is also present on some shallower and some steeper slopes.

- URS and Golder observed a groundwater discharge of approximately 0.5 gallons per minute (gpm) from the lower adit in Area 1 (Adit 1B). The discharge is reportedly higher in the wet season. Photo 21 (Appendix A) shows discharge from Adit 1B. A discharge of approximately 0.4 gpm was observed by URS in June 2008 from Adit 5 (referred to as AD-02 in the SI). Other adits were wet during URS' August 2008 site visit, and seasonal discharge is possible.

- Golder observed a discharge seep below the log dam in the main drainage gully. The seep was not flowing during URS visits in June or August 2008.

- There are four primary drainage gullies in the waste rock areas (see Figure 1-3):

  1. An erosional depression running through the center of WRP-1.
  2. A seasonal drainage to the west of WRP-1.
  3. A seasonal drainage in the lower portion of WRP-2.
  4. A seasonal drainage in the lower portion of WRP-3.

The gullies drain to Joe Creek. There is no obvious drainageway within WRP-4.

- Environment International (2002) reported surface water flows as high as 1 cubic foot per second (cfs) in the main drainage gully in Area 1.

- Waste rock materials have been eroded and transported through the drainage gullies to the streambed of Joe Creek. Erosion and transport of waste rock materials, along with AMD, are the primary source of the adverse impacts to Joe Creek.

2.4.2 Ecological Risk Evaluation

The ecological risk evaluations presented in the SI Report (URS, 2009a) included sampling of environmental media (soil, sediment, surface water, and groundwater) and fish tissue. The ecological risk evaluations concluded that mine-related metals pose unacceptable ecological risk in surface water, sediments, and riparian soils near the mine. A reader of this EE/CA should refer

to the SI report for detailed discussion of sampling methods, detected concentrations, and risk calculations.

Potential risks to ecological receptors are higher near the mine and generally decrease with distance. An ecological risk was indicated if detected concentrations were higher than typical background levels and exceeded applicable ecological screening level values. Results of the risk evaluation are summarized as follows:

- Metals concentrations in the discharge from adits 1B and 5 (samples AD-01 and AD-02, respectively) were high for arsenic, cadmium, and zinc. Adit 1B also contained very high concentrations of copper, iron and lead. A sample collected from the log dam seep also exhibited high concentrations of cadmium, copper, iron, lead and zinc. Copper and cadmium concentrations in Joe Creek surface water below the Site indicate an unacceptable ecological risk.

- Copper, zinc, and cadmium in sediments of Joe Creek pose significant ecological risk. Copper in riparian soil along Joe Creek poses significant ecological risk. Cadmium, zinc, and lead pose low ecological risk in riparian soil along Joe Creek.

- Copper concentrations in Elliott Creek are lower than in Joe Creek, but quantitative evaluation indicates that copper concentrations in the surface water of Elliott Creek exceed the minimum threshold for unacceptable ecological risk. Copper concentrations in Elliott Creek sediment and riparian soil exceed the lowest screening values and background concentrations.

- Ecological risks in the Applegate River and Applegate Reservoir media (i.e., water, sediment, and riparian soil) are relatively low. Metals concentrations were low in fish tissue and do not appear to indicate an unacceptable ecological risk.

The risk assessment (URS, 2009a) provides details of chemical concentrations and risk-based standards. Data used in the risk evaluation represent low flow conditions. Dissolved metals concentrations and mass flux may be substantially different during spring run-off conditions.

In summary, the quantitative ecological risk evaluation and stream surveys reflect obvious visual impacts: Joe Creek is severely impacted, with virtually no visual signs of aquatic life observed during site visits by URS and others.

Elliott Creek is impacted, but less so than Joe Creek. Applegate River and Applegate Reservoir are not visibly impacted and the calculated ecological risk was low. Residents of Joe Bar pointed out to our sampling team that mineral staining indicative of adverse impacts from the mine has been common in Joe Creek for years. They have observed in the last couple of years that the staining has been manifesting farther down Elliott Creek. These observations may indicate potential accumulations of impacts farther downstream over time.

2.4.3 Macroinvertebrate Survey

Macroinvertebrate surveys conducted in streams near the mine site are an important part of the biological sampling and ecological risk evaluation. The number, distribution, and species of aquatic macroinvertebrates are important indicators of stream health. Previous surveys were

completed in the Fall of 2000 and Spring of 2001. URS completed a macroinvertebrate survey in September 2008.

Fieldwork for the 2008 survey was conducted in early September. The survey results were not available to include in the SI report (URS, 2009a). The macroinvertebrate survey is summarized below. Appendix B provides details of the survey sampling methods and results.

The survey consisted of collecting macroinvertebrates from four locations in the following areas:

- Elliott Creek downstream from the confluence with Joe Creek.
- Elliott Creek upstream from the confluence with Joe Creek.
- Joe Creek downstream of mine run-off contribution.
- Joe Creek upstream of mine run-off contribution.

The sampling locations were designed to allow assessment of benthic community composition in response to water quality parameters, including the presence of metals in run-off from waste rock piles associated with the Site.

The results of the survey indicate that macroinvertebrate communities in Joe Creek downstream of the waste rock piles are significantly degraded, as compared to the upstream control sample. Differences in community are largely between species that are susceptible to metals toxicity and water temperature. Because water temperature was similar between sites, the results indicate that metals contamination from the mine site is adversely impacting the macroinvertebrate community in Joe Creek.

Macroinvertebrate communities in Elliott Creek varied slightly between samples collected downstream of the confluence with Joe Creek and the control located upstream. The aquatic macroinvertebrate survey gave no clear indication that assemblages were responding to the presence of metals. While this does not rule out an influence from metals, metrics were not sensitive enough to make such a correlation.

The aquatic macroinvertebrate survey clearly indicates that discharges from the mine (i.e., sediment erosion, surface water discharge, and/or groundwater discharge) are impacting aquatic biota assemblages in Joe Creek. Species composition, total numbers of a species, trophic distribution, and diversity of species all show an adverse response to water quality impairment. Impacts to Elliott Creek are uncertain. Variations within Elliott Creek aquatic macroinvertebrate assemblages were not statistically significant; as such, analytical models were unable to discern whether aquatic macroinvertebrate assemblages were responding to water quality contributed by Joe Creek. The SI provides additional discussion of the health of nearby surface water bodies.

2.4.4 Human Health Risk Evaluation

Potentially complete exposure pathways for humans include consumption of fish, direct contact with sediments and riparian soils, and ingestion of groundwater. Direct contact with surface water was assumed to be an insignificant pathway for humans.

Only arsenic exceeded human health screening criteria for the complete exposure pathways. Human health criteria protective of recreational fishers from the carcinogenic effects of arsenic

was exceeded in all fish tissue samples. Concentrations in the samples ranged from 21to 39 times the criteria.

The data and observations indicate that arsenic in surface water could be naturally occurring, or the arsenic in Elliott Creek could originate from mining activity other than at the Blue Ledge Mine. The sampling completed for the SI is not adequate to identify the sources of arsenic in the surface water in the area.

Residents of Joe Bar use groundwater from four wells and one groundwater seep for drinking water. URS collected groundwater samples from two wells and seep on November 8, 2008. Section 2.4.5 of this document summarizes the groundwater sampling. The data were used to update the human health risk assessment (URS, 2009a).

2.4.5 Residential Water Supply Sampling

The community of Joe Bar is located just downstream of the confluence of Joe Creek and Elliott Creek. Joe Bar consists of four houses and associated outbuildings. Interviews with one resident indicate that there are six full- or part-time residents.

High metals concentrations detected in seeps and surface water may be indicative of metals in groundwater. Groundwater was not a specific target of the SI. The risk assessment assumed that groundwater was not a complete human health exposure pathway because the initial understanding was that groundwater was not used. Recent communications indicate that residents of Joe Bar use groundwater, but not surface water (i.e., Elliott Creek), for drinking water. Elliott Creek water is used for watering gardens and as drinking water for domestic animals. The USFS requested sampling of groundwater from domestic water supply sources. The SI describes the sampling and results.

Residents of Joe Bar obtain drinking water from four wells and a spring. One well is reportedly inoperable. One operable well (Ziem residence) is located approximately 200 feet north of Elliott Creek, and the other operable well (Nielson residence) is approximately 100 feet south of Elliott Creek. The Ziem well is approximately 60 feet deep. The depth of the Nielson well is not known. The construction of the wells is not known. The Ruetiger and Lara residences obtain groundwater for drinking from a spring located north of Forest Service Road 1050. Accordingly, the spring source is on the opposite site of Elliott Creek from the Site.

URS collected domestic water samples from two wells and a spring on November 8, 2008. Groundwater samples were analyzed in the field or sent to the laboratory for analysis of the following parameters:

Field Analysis
- pH
- Conductivity
- Turbidity
- Salinity
- Dissolved Oxygen
- TDS
- ORP

Laboratory Analysis
- Alkalinity
- Acidity
- Hardness
- Metals
- TSS
- Sulfate

The resident reports that water from the Ziem well is clear and odorless, but has "milky taste" and has "a lot of calcium." Users of the other sources were not available to provide descriptions. Field monitoring parameters indicate water of suitable drinking water quality.

No parameters exceeded either the Federal or California regulatory Maximum Contaminant Levels (MCLs). Dissolved arsenic concentrations ranged from 0.22 micrograms per liter (µg/L) to 6.24 µg/L. These detections exceed the conservative EPA Regional Screening Level (RSL) for arsenic in tapwater of 0.045 µg/L. The available data do not indicate the source of the arsenic. The arsenic may not be related to arsenic detected in surface water in Elliott Creek, but rather may be the result of naturally high levels of arsenic in local soils.

2.5 Sources of Acid Mine Drainage and Conceptual Hydrogeologic Model

Metal-sulfide ore deposits contained the target metals, primarily copper, zinc, gold and silver that were mined at the Site. High-grade ore was shipped from the Site. Low-grade ore and waste rock were discarded on the hillsides below the adits.

There are several potential sources of AMD and mechanisms of transport. The predominant sources of AMD at the Site include the following:

- **Mine workings.** Hundhausen (1947) estimated approximately 8,240 linear feet of workings and reported good natural ventilation. Formation of acidity and leaching of dissolved metals are likely in the abandoned workings. AMD could discharge through adits or directly to groundwater.

- **Percolation of water through the waste rock**. Waste rock and massive pyrite were discarded on the slopes below the adits. Weathering of the pyrite and waste rock produces sulfuric acid and dissolved metals. The relatively fine-grained waste rock promotes the production of AMD, as compared to waste rock consisting of larger rocks.

- **Erosion and transport of waste rock.** Erosion and mass wasting transport waste rock materials lower on the slopes or in drainageways (e.g., Joe Creek). Subsequent weathering produces sulfuric acid and dissolved metals.

Figure 2-1 depicts AMD sources and process. The relative contribution of these sources to the degraded conditions in Joe Creek is uncertain. Elements of the hydrogeologic model consist of the following:

- The reported average annual precipitation in the vicinity of the mine is 138 inches of snow and 33 inches of rain (Hundhausen, 1947). The USFS (1995), however, estimates that rainfall at the Site is likely to be over 40 inches per year due to its location and elevation. Over 86 percent of the annual run-off at the mine occurs from December through June (USFS, 1995).

- Overland flow of run-off transport acidity and dissolved metals. Rain-on-snow events and heavy summer rains can result in intense erosion and mass wasting. Mass wasting and erosion mobilize and expose eroded waste rock and underlying waste rock which then oxidizes to release acid and metals.

- Some of the incident precipitation and run-off infiltrates into the porous waste rock to become groundwater. Dissolution of waste rock creates acid and dissolved metals. Flow of groundwater through the waste rock transports acid and metals.

- Groundwater discharges from seasonal seeps (Appendix A, Photo 15). One observed seep discharges directly into the channel that diverts flow from the lower adit to the settling pond and over the log dam ultimately discharging into Joe Creek. Wet areas on lower slopes indicate seeps that discharge directly into Joe Creek.

- Groundwater above the mine may infiltrate into the mine workings and then discharge from adits as AMD or permeate deeper into the groundwater system. The fate of deep groundwater through fracture flow is complex.

Consideration of the hydrogeologic conceptual model and mechanisms of contaminant fate and transport influence the approach to removal actions. The relative contribution of the transport mechanisms is uncertain. Following are general observations regarding the conceptual model and transport processes:

- High intensity rainfall, rain-on-snow events, and spring run-off cause significant erosion and transport of the waste rock. Waste rock sediments deposited in Joe Creek subsequently release acidity and metals directly into surface water.

- High mass loading and transport of sediments impact Joe Creek and probably Elliott Creek, as well as potentially the Applegate River and Applegate Reservoir.

- Overland flow on the waste rock transports dissolved metals and acidity. Elliott (2007) noted that metals concentrations are high in “first flush” run-off when fall rains transport dissolved metals that accumulate over the summer.

- Rainwater and snow melt that infiltrate the waste rock seep slowly through the waste rock, causing release of acidity and dissolution of metals.[1] This mechanism probably causes high concentrations in shallow groundwater but probably relatively low flux of acidity and contamination to deeper groundwater and eventually to surface water.

- AMD that discharges from some adits has a low pH and high metals concentrations. The observed flows are relatively low, but higher flows are likely in the winter. Additional

[1] Note high copper and zinc concentrations in seeps and adits reported in the SI report (URS, 2009a)

investigation is warranted to assess the environmental impact of AMD discharged from the adits.

3.0 RATIONALE FOR REMOVAL ACTION, CLEANUP CRITERIA, AND REMOVAL ACTION OBJECTIVES

This section summarizes the regulatory basis of the removal action. The rationale for the removal includes a 2002 natural resource damage assessment (NRDA) and the SI (URS, 2009a), which compiles previous environmental data and data collected by URS in 2008. Applicable or relevant and appropriate requirements (ARARs) further support a removal action and provide the regulatory framework for implementation.

3.1 Natural Resource Damage Assessment

Environment International (2002) conducted a preassessment screen to assess whether conditions at the Site meet the criteria for a NRDA claim. Environment International's observations demonstrate that the Site meets the criteria for a NRDA claim. Their report provided data and analysis supporting the conclusion that the conditions for a NRDA claim are met. Environment International drew the following four conclusions regarding conditions at the Site:

1) A release of hazardous substances has occurred.

2) Natural resources under the trusteeship of the USFS and other natural resource trustees have been affected.

3) The quantity and concentration of released hazardous substance is sufficient to cause injury to natural resources.

4) An assessment can be conducted at a reasonable cost and response actions would not sufficiently remedy the injury without further action.

Environment International's assessment focused on impacts to aquatic life in Joe Creek. Environment International also stated "groundwater resources are likely to be impacted," but the report does not discuss groundwater impacts in detail.

Stratus Consulting, Inc (Stratus) conducted a preliminary evaluation of the potential range of natural resource damages resulting from injury to Trust resources at the Blue Ledge Mine (Stratus, 2007). Stratus followed procedures developed by the U.S. Department of the Interior for conducting NRDAs under CERCLA (43 CFR Part 11).

Natural resource damages are separate from, and in addition to, removal action or response costs incurred to control ongoing risks to human health or the environment. Damages under a NRDA claim compensate the public for past, present, or expected future harms to natural resources, considering the effect of any cleanup actions. Although NRDA damages are separate from removal action costs, the NRDA assessment demonstrates that the mine has degraded the environment.

Stratus observed the following potential injury to natural resources:

- Copper and zinc concentrations in Joe Creek and Elliott Creek in locations downstream of the Site exceed the Ambient Water Quality Criteria (AWQC), with the highest metals levels noted during spring high flows.
- Precipitation and erosion of the waste rock cause significant transport of contaminated sediments into Joe Creek, with likely transport into Elliott Creek, the Applegate River, and eventually into Applegate Reservoir.
- Fish surveys conducted by the USFS in September 2000 identified no fish in Joe Creek, except at the confluence with Elliott Creek. The few fish observed were all young-of-year rainbow trout, which likely migrated from Elliott Creek. In the absence of degradation caused by the mine, fish should be present in Joe Creek for an estimated two miles up from Elliott Creek.
- Stratus concludes that discharges from the mine have impacted resident fish populations in Joe Creek and the segment of Elliott Creek downstream of Joe Creek. Stratus inferred impacts to fish in the Applegate River between the Elliott Creek and the Applegate Reservoir.

Stratus calculated restoration-based damages as exceeding $12 million.

3.2 Site Investigation Rationale for Removal Action

Waste rock from mines that exploit mineralized sulfide deposits are common sources of AMD and associated dissolved metals. Both the acidity and the metals in AMD are potentially harmful to aquatic and terrestrial natural resources and humans.

The PA/SI (Weston, 2004), investigations by Southern Oregon University (Elliott, 2007), a site review by Golder Associates (Golder, 2007), and the April 2009 SI report (URS, 2009a) document release of AMD from the Site and demonstrate environmental damage.

Percolation and run-off of water and erosion of waste rock are primary sources of AMD at the Site (see Section 2.5). Sampling at the Site demonstrates that water percolating through the waste rock at the Site carries dissolved cadmium, copper, zinc, and other metals into Joe Creek creating an environment toxic to aquatic life and potentially causing human health risks to residents of Joe Bar and others. Direct erosion of the waste rock into run-off from the Site contributes to spreading of the chemicals of concern into the watershed.

Removal or other mitigation of the waste rock risk is necessary to protect human health and the environment. The SI in combination with prior investigations clearly demonstrates that a removal action is justified for the following reasons:

- The site is a historic and ongoing source of AMD from adits and waste rock.
- Historic and ongoing releases of AMD and metals from the Site have adversely impacted groundwater, surface water, and sediment.

- Site contamination results in an unacceptable human health risk within the immediate site area.
- Site contamination results in an unacceptable ecological risk from the Site downstream to Applegate Reservoir.
- Site contamination has eliminated fish and reduced macroinvertebrate populations in Joe Creek, demonstrating the watershed-scale impacts.
- Adverse impacts and ecological and human health risks will continue if the sources are not eliminated or controlled.
- Continued discharge from the mine area and downstream transport of contaminants could cause adverse impacts and risk to human and ecological receptors as far downstream as Applegate Reservoir. The dam was built in 1980, sediments continue to accumulate in the reservoir and the system is not likely at equilibrium with contaminants being transported from the mine. Although the risk assessment identified no unacceptable human health risk in Applegate Reservoir, the risk to humans may increase in the future.
- Absent a removal action, fish, amphibians, macroinvertebrates and other aquatic life are unlikely to return to Joe Creek for the foreseeable future.

3.3 Applicable or Relevant and Appropriate Requirements

The EE/CA reflects requirements of the National Contingency Plan (NCP).[2] The NCP grants authority to lead agencies to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of release. The removal action must consider site conditions that result in actual or potential threat to humans or ecological populations.

Selection and implementation of a removal action must comply with ARARs to the extent practicable. ARARs are federal and state standards that are directly applicable or may be considered relevant and appropriate to the circumstances of the Site. The NCP (40 CFR 300.5) defines ARARs.

Applicable requirements are federal and state cleanup standards and other requirements promulgated under Federal or State law that specifically address a hazardous waste cleanup site. Only requirements that directly address circumstances at the Site are considered to be applicable.

Relevant and appropriate requirements are federal, state, and local standards cleanup standards and other requirements that are not specifically "applicable" to a hazardous waste cleanup site but address problems or situations that are sufficiently similar to those at the site that their use is well suited to the particular site. A requirement must be both relevant and appropriate to an ARAR. According to the NCP, only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements are relevant and appropriate [40 CFR 300.525(d)].

Federal requirements are considered ARARs if they directly address circumstances at the Site. State requirements are ARARs only if promulgated laws, substantive, consistently applied, and

[2] NCP 40CFR 300.415 Removal Action and particularly to (b)(1), (b)(2)(i-viii), and (b)(4)

more stringent than a Federal requirement. Criteria, guidance, or advisories that fail to meet all of the criteria to be defined as a Federal or State ARAR but are determined to be useful in the selection of protective cleanup levels or methods (or in the absence of regulatory standards) are classified as 'to be considered' in the ARARs summary.

Tables 3-1a, b, and c list ARARs identified by the USFS as potential ARARs for the Blue Ledge Site. The USFS previously notified several agencies/Native American tribes to solicit their interest in the Site and the cleanup process. Agencies that responded and were contacted for further comment on the proposed removal action included the following:

- The Confederated Tribes of Siletz Indians
- California Department of Fish and Game, Office of Spill Prevention and Response
- United States Department of the Interior, Fish and Wildlife Service, Oregon Fish and Wildlife Office
- United States Environmental Protection Agency, Region IX

In addition, the RWQCB, and the California Department of Toxic Substances Control (DTSC) were specifically asked to comment on the proposed ARARs. The RWQCB provided comments on March 29, 2010 (RQWCB, 2010) and the DTSC provided comments on April 13, 2010 (DTSC, 2010). All comments were considered in the ARARs analysis.

3.4 Removal Action Objectives

Removal action objectives (RAOs) reflect the objective to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of releases that pose environmental risk. 40 CFR 300.415(b)(2)(i)-(viii) lists factors to consider in determining site-specific RAOs. At the Blue Ledge Mine, "released" AMD has caused and continues to cause environmental risk and damage.

Proposed RAOs for the Site are as follows:

- Mitigate unacceptable human and ecological risks posed by exposures to waste rock constituents in soil, surface water, and groundwater.
- Minimize future erosion and transport of waste rock that contribute to unacceptable human or ecological risk in Joe Creek, Elliott Creek, and the Applegate Reservoir.
- Implement a removal action in a manner that satisfies ARARs to the extent practicable and minimizes unacceptable human health and ecological exposures during the removal action.

3.5 Removal Action Schedule

The removal action is scheduled to begin in the spring of 2010. The removal construction is estimated to take approximately two construction seasons. Three years of post-removal operations, maintenance and monitoring are planned.

4.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION TECHNOLOGIES

This section discusses removal action approaches and technologies to mitigate the contamination. Section 6 combines technologies into a range of removal action alternatives.

This EE/CA considers a removal action for the approximately 70,000 tons of waste rock and underlying impacted native materials on the hillsides above Joe Creek. The waste rock is considered to be the primary source of contamination.

This EE/CA does not consider actions to address AMD discharges from mine adits, contaminated sediments in Joe Creek, or contaminated groundwater. These sources and impacts are also significant environmental concerns at the Site, but are beyond the scope of this EE/CA.

The EE/CA also includes the following actions as components of removal action alternatives:

- Reclamation of waste rock areas (if waste rock removed).
- Adit closures to prevent future access by the public.

The following sections discuss potential removal approaches. Table 4-1 summarizes the technologies considered.

4.1 Waste Rock Removal

The EE/CA considered two general actions for the waste rock piles:

(1) Removal and off-site disposal of the waste rock and,

(2) In situ stabilization and eventual remediation of the waste rock by a combination of surface cover and phytoremediation.

For purposes of this EE/CA and the associated cost estimates, URS determined that stabilization of the waste rock in place was not viable because of the steep slopes and the characteristics of the material (See Section 5.1). In situ stabilization as the only action is impractical for the following reasons:

- Observations and geotechnical analysis indicate that waste rock on upper slopes is unstable in situ and could not be practically stabilized due to the steep slopes and high water flows that occur during certain times of the year.
- Waste rock left in place would be a continuing source of erosion if not stabilized adequately, and even if stabilized, the material could continue to be a source of AMD as water flows through the residual waste rock.

Partial stabilization of waste rock on lower slopes is considered a viable element of alternatives and is discussed further in Section 4.1.3.

4.1.1 Waste Rock Removal Methods

Removal of the waste rock would eliminate the predominant source of acid mine drainage. Once removed, the waste rock would be deposited in an engineered repository located near the mine site or taken to an off-site disposal facility.

Technology options considered for removing the waste rock include:

- Excavator and dozers
- Draglines
- Hydraulicking

Table 4-1 describes the technologies and analyzes the effectiveness, implementability, and overall applicability of the waste removal methods.

All of the technologies that included removal of the waste rock from the mountainside would require consolidation, loading, and transport of the waste rock to a repository location (see Section 4.1.2).

Dozers and excavators are the presumed equipment used to excavate waste rock and regrade the slopes. Production rates are high, and the previous EPA removal action demonstrated success in using this technology at the Site. However, use of excavators and dozers may not be practical on the steep and rocky upper slopes of the waste piles or where access is difficult. Specialized techniques may be required in some areas. Dozers and excavators are retained as waste rock removal technologies.

Draglines are a proven technology to remove soil and rock and to regrade steep and rocky slopes. Production rates, however, are lower than dozers and excavators and additional construction is needed to set up the equipment. Draglines are retained as a waste rock removal technology.

Hydraulicking is not considered to be implementable. The significant volume of water that would be required is not readily available at the Site. In addition, containing and treating that water to meet surface water criteria would be prohibitively difficult and expensive.

The very steep and rocky slopes where the waste rock is deposited will require specialized methods to remove the waste rock. The approaches considered in this report reflect site visits and discussions with contractors experienced in earth-moving and logging operations on steep slopes at remote sites. Removal methods would likely combine draglines, excavators, and dozers. Examples of specialized methods include the following:

- Winching techniques to move dozers up and down steep slopes safely.
- Excavating and blasting benches for access, working platforms, and slope stability.
- Dragline and cable excavators to reach difficult access areas.

URS does not currently believe that is safe or practical to winch dozers on the very steep upper slopes (i.e., approximately upper third of waste rock Area 1). In such areas, the removal might include methods such as:

- Benching, excavation, and using machines to push material downslope from working benches.
- Use of draglines to excavate and move waste rock down the slope.

After the waste rock is removed, the hillsides could be left bare to naturally recover, or the hillsides could be reclaimed by placing cover soil and planting. Section 4.3 discusses the reclamation alternatives.

The effectiveness of the removal action to mitigate environmental impacts depends on adequate removal of the waste rock or adequate isolation of the waste rock from continued erosion and weathering. Use of heavy machinery could remove most of the waste rock. Greater than 99 percent removal may be possible, but the exact quantity is difficult to estimate. Even small mounts of residual waste rock, however, could be a continuing source of low pH and metals in run-off. The design will consider several methods to remove small amounts of residual waste rock from the steep rocky hillsides and provide performance criteria for the removal. Reclamation cover soil and plantings on the lower slope may provide adequate isolation and buffering capacity to mitigate the residual source of metals and low pH.

Removal of the waste rock is expected to substantially reduce the toxicity of the run-off and AMD from the Site, but such removal can not guarantee that all water quality standards (like Clean Water Act) will be met, in the short and long-term.

4.1.2 Waste Rock Classification and Repository Elements

The California North Coast Regional Water Quality Control Board (RWQCB) provided guidance concerning the classification and management requirements relating to the waste rock that will be placed in the site repository. Title 22 of California Code of Regulations (CCR) §66261.4(b)(5)(B) excludes “waste from the extraction, beneficiation, and processing of ores and minerals” as a hazardous waste. Although the waste rock is not a hazardous waste, Title 27 CCR §22480 requires classification of mining wastes to determine disposal requirements. RWQCB Group A, Group B, and Group C classifications indicate the potential risk of water quality degradation posed by the waste.

The waste rock at the Blue Ledge site is classified as a Group B waste on the basis of chemical testing, although “mitigating factors” may apply. Group B (‘designated’) mining wastes consist of or contain hazardous wastes that qualify for a variance under Title 22 CCR, contain nonhazardous soluble pollutants at concentrations that exceed water quality objectives, or could cause degradation of waters of the State.

Waste rock removed from the slope should be placed in a repository to isolate the material from the environment and minimize the potential for future erosion and generation of AMD. Title 27 CCR §22490 specifies construction standards for mining waste disposal sites, including liners and leachate collection.

Title 27 CCR §22470 allows disposal facilities for Group B mine wastes to be constructed without a bottom liner at sites where there are only minor amounts of underlying groundwater or there is no hydraulic interconnection with high quality groundwater resources. Liner exemptions can also be granted if it can be demonstrated that leachate will not form in or escape from the

disposal facility. Analysis by URS (2009b) indicated that the waste rock and site conditions may qualify for a Group B variance under 27 CCR §22470(c). A low permeability cover will minimize potential for infiltration, and drilling did not encounter perched groundwater or permanent water table.

The RWQCB (2010), however, concluded that the proposed repository must comply with the requirements of 27 CCR §22490, including all liner and AMD ("leachate") collection requirements. Consequently, the design features of the repository reflect the design RAOs, ARARs, the preferences of the USFS, and requirements of the RWQCB. The repository will have the following design features to minimize water contact with the waste rock:

- Geotechnically stable site.
- Constructed in a location entirely above the seasonal water table.
- Engineered evapotranspiration (ET) cover or engineered low permeability liner and cap.
- Limestone to chemically neutralize AMD from the fill, if any.

The initial design analysis considered an ET cover consisting of native trees and shrubs to take up moisture from the cover and prevent percolation into the waste rock. Water balance analysis, however, indicated that an ET cover would not take up sufficient water to prevent infiltration, and an ET cover is, therefore, not viable. The design must include a low permeability cover.

Golder (2007) identified two possible repository locations. URS reviewed both locations and identified a third location. The three locations are as follows:

- Former site of the Blue Ledge Mine camp.
- Ridgeline area of approximately located approximately 0.9 road miles north of the Blue Ledge Mine camp ("north site").
- Hillside area located approximately 0.8 road miles north of the Blue Ledge Mine camp ("south area").

In addition to local repository locations, other locations were considered, including the following:

- Open and level areas near the Applegate Reservoir.
- Commercial landfill.

Table 4-1 describes the repository locations. The former Blue Ledge Mine camp site is not considered suitable due to its location in an active landslide area. Suitable disposal areas have not been identified near Applegate Reservoir, and accessibility is uncertain. The nearest commercial landfill (Dry Creek Landfill, White City, Oregon) is approximately 46 road miles from the Site. Transport to this distant location would add significant cost. The north and south repository sites are the most likely and the preferred alternatives (see Figure 4-1).

Geotechnical assessment conducted in November 2008 indicates that both the north and south areas are viable locations (see Section 5.1.3). On the basis of the estimated waste rock volumes, the usable acreage of the potential repository areas, and the design concepts, a repository in the

north area would be approximately 2 acres, and the south area would be approximately 4 acres. URS prefers the south area due to access and space advantages.

Construction of the repository on the private land of the mining area is considered to be an “on-site action” for the purpose of implementing the removal action. The NCP section 300.400(e) (1) and EPA (1992) define "on site" as “the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.”

The final design will develop design elements and monitoring program and performance criteria. Figure 4-2 is a conceptual section of a repository at the south repository site.

This report assumes that either the north or south repository areas are suitable as repository locations. Additional assessment was conducted in November 2008 to further assess suitability of repository sites and obtain data to design the repository. Preliminary assessments indicate that both sites are likely to be suitable repository locations, Section 5.1.3 discusses the assessments.

4.1.3 In Situ Stabilization and Treatment of Waste Rock

If feasible, there may be advantages to stabilizing and treating a portion the waste rock in place at the Site. In situ stabilization would involve a combination of moving waste rock from upper slopes, terracing and stabilization of the waste rock piles on the lower slopes, amendment additions, engineered phytoremediation plantings, and passive treatment of AMD and run-off.

The combination of surface water controls, a vegetated ET cover, and graded benches in the waste rock piles might minimize the contact between waste rock and surface water and might minimize erosion and transport of waste rock and contaminants to the sediments of Joe Creek. Phytoremediation may provide opportunity to cost effectively treat acidic waste rock in place or in consolidated piles on lower slopes (Bini, 2005).

Several potential conditions might adversely impact the effectiveness and implementability of in situ stabilization and treatment approaches. Considerations include the following:

- The waste rock in its current condition supports very little plant growth. A combination of excessive drainage (low water availability), high acidity, and metals toxicity affect plant growth.

- Additional research and testing would be necessary to assess tolerant plant species for the conditions at the Site.

- Site observations indicate that the waste rock is inherently unstable and significant slope failures appear possible. It may be difficult to sufficiently stabilize waste rock in place.

- Infiltration of surface water through the remaining waste rock and leaching of acidity and metals are still possible or likely. AMD production may continue to impact groundwater and surface water quality. Golder (2007) reasonably assumed that the chemistry of surface water and seeps would continue to have a low pH and high dissolved metals.

- Passive treatment of surface water and groundwater would likely be necessary. Such systems would add to cost and increase maintenance requirements.

- In situ stabilization could be used in combination with removal. The effectiveness of in situ stabilization depends on an ability to stabilize the waste rock piles, which is uncertain.

4.2 AMD and Run-off Control and Treatment

AMD and run-off treatment are possible elements of all potential alternatives, although the design might vary depending on the particular alternative. Examples of circumstances that may require some form of treatment include the following:

- If waste rock remains, precipitation and snow melt could infiltrate into the waste rock and produce AMD. If a reclamation cover is placed, reclamation plantings would be expected to reduce infiltration and AMD production, although some infiltration and associated leaching would likely still occur.

- If waste rock is removed and the slopes are not covered, incident precipitation would likely produce high-velocity run-off. Residual waste rock and associated acidity and metals would be transported down slope. The downstream extent and duration of adverse impacts would depend on the effectiveness of the waste rock removal method and how much residual rock remained in place.

- Substantial removal of waste rock and placement of a reclamation cover would likely result in substantial reductions in AMD production and contaminated run-off.

Examples of AMD and run-off collection and treatment alternatives include the following:

- Sedimentation basins
- Interceptor drains
- Open limestone trenches and ponds
- Limestone drains or upflow limestone ponds
- Bioswales and constructed wetlands
- Soil cover and revegetation
- Periodic chemical addition

The above methods are generally passive in that they do not include mechanical systems, aeration, or continuous chemical additions. Active treatment methods were not considered due to the high maintenance requirements and high operation costs that are anticipated at this remote site. Table 4-1 reviews the AMD treatment and run-off control technologies.

4.3 Reclamation Cover

In the context of this EE/CA, reclamation cover refers to placement of clean fill and establishing vegetation over areas where waste rock has been removed. Certain elements of this action would be similar to those for in situ stabilization and treatment (Section 4.1.3). The objectives of the reclamation cover include the following:

- Cover residual waste rock that was impractical to remove.
- Minimize erosion of residual waste rock.
- Minimize infiltration of water through residual waste rock.
- Improve aesthetics of removal areas.
- Improve habitat value of removal areas.

Elements of the reclamation cover alternatives could include a combination of the following:

- Placement, terracing, and compaction of cover materials.
- Installation of run-off controls.
- Addition of soil amendment, fertilizers, neutralizing additives, and native plants to stabilize metals and promote vegetation growth.
- Passive treatment of AMD and run-off.

Figure 4-3 is a conceptual sketch of reclamation and stabilization elements of waste rock reclamation areas. Figure 4-4 is a typical section showing concepts of reclamation fill, terracing, and reclamation plantings. The amount of imported reclamation fill would depend on the quantity and quality of underlying native soil. Substantial rock outcrops and the very steep upper portions of WRP-1, WRP-2, and WRP-4 would not be amenable to reclamation planting. Different techniques including placement of large rock and logs and/or construction of engineered retention structures may be used to stabilize reclamation areas.

The USFS and URS had previously identified soils in the landslide feature near the former Blue Ledge Mine camp as a possible source of reclamation cover. Additional testing would be needed to assess the suitability of the source. Uncertain geotechnical characteristics of the silty clay soils and the uncertain quantity of large boulders in the area would need to be determined. Also, the antecedent moisture content of the soil is not known and may impact usability of the material. Another possible reclamation fill is native schist soils, such as excavated from the repository locations or obtained from another as-yet unidentified borrow site. After additional consultation with the USFS, use of the Blue Ledge Mine camp site for borrow material was eliminated from consideration.

A “technology” that may be considered by the USFS is no revegetation of the former waste rock areas; that is there would be no placement of cover fill and no replanting of the waste rock areas. The USFS’ primary goal is to eliminate the source of impacts to Joe Creek and public lands. Reclamation of the mine site itself is not a specific objective of the USFS, except as needed to remove the source of impacts on public lands. Nonetheless, a removal action will not remove 100 percent of the waste rock. Residual waste rock will be a continuing source of erosion and leaching of metals, but the magnitude of the impact is difficult to estimate. Installation of a reclamation cover is a presumed element of the alternatives in this report. One optional approach could be to conduct the waste rock removal and then monitor for a period of time to collect data to determine definitively whether reclamation is a necessary component of the final removal action. However, this stepwise approach is not assumed in this report.

Even though a reclamation cover is assumed in combination with removal, residual waste rock is likely to remain and could be a continuing source of acidity and metals in AMD. Technologies to collect and treat AMD and run-off may still be necessary (see Section 4.2). URS assumes that reclamation cover would be placed and planted if the waste rock removal is the selected technology.

4.4 Adit Closure

The USFS concludes that closure of adits is necessary. Closure of Site adits would accomplish the following:

- Reduce hazards to humans and/or animals and minimize exposure to chemical and physical hazards.
- Maintain or improve access and/or habitat for wildlife.
- Protect cultural resources.
- Reduce or prevent contamination of surface water and groundwater

Many different types of wildlife, including bats, snakes and owls, use abandoned mines for either permanent or temporary habitat. The USFS has expressed preference for a closure that accommodates wildlife.

There are approximately eight adits that would require closure. Table 4-1 summarizes alternatives for closure of mine adits.

4.5 Remediation Not Included

This EE/CA focuses on removal of the waste rock, which is believed to be a significant source of the contamination in Joe Creek. This EE/CA does not consider other significant environmental concerns at the site. Additional study and possible remediation may include the following:

- Adit discharge collection and treatment;
- Waste rock sediments in Joe Creek and downstream reaches; and
- Groundwater.

4.5.1 Adit Discharge Collection and Treatment

URS and others have observed water discharge from the lower adit in Area 1 (Adit 1B) and Adit 5 (AD-02). The observed discharge rates have been approximately 0.5 gpm, but seasonal discharge rates are probably higher. Golder assumed a seasonal high discharge rate of 10 gpm. The adit discharge from Adit 1B has both a low pH and high metals concentrations while the discharge from Adit 5 has a near neutral pH and contains significant metals concentrations (URS, 2009a). Discharge from the mine adits may be a continuing source of environmental contamination even after the waste rock is removed.

Additional study is warranted to assess the environmental impacts and options to treat adit discharges at the Blue Ledge Site. Additional study should include the following:

- Conceptual hydrogeologic model of AMD and metals-laden groundwater production and measured seasonal adit discharge flow rates.
- Environmental impact of the discharges.
- Treatment goals of adit discharge remediation.
- Design objective and remedial alternatives for adit discharge treatment.

There are several potential methods to control and treat discharge of acidic and metals-laden groundwater from the mine adits, including the following:

- Groundwater source control.
- Water detention and active treatment.
- Water detention and passive treatment.

This EE/CA does not consider the scope or account for costs of additional testing or treatment of AMD and metals-laden discharge from the mine adits.

4.5.2 Waste Rock Sediments in Joe and Elliott Creeks

Waste rock has been transported from the Site to the sediments of Joe and Elliott Creeks. URS conducted additional sediment sampling as part of the SI. Sediment samples exceeded ecological screening criteria for arsenic and copper in Joe Creek, Elliott Creek, Applegate River and Applegate Reservoir. Joe Creek sediment samples downstream of the Site to the confluence of with Elliott Creek additionally exceeded ecological criteria for cadmium and zinc. The SI report and risk evaluation provide details of the impacts to sediments (URS, 2009a). The risk evaluation conducted by URS indicates that the sediments in Joe Creek pose elevated ecological risk due to elevated concentrations of metals (Section 2.4.2).

Additional study is warranted to assess the environmental impacts and options to treat sediments in Joe Creek. Additional study should include the following:

- Nature and distribution of waste rock sediments.
- Potential impact of removal action on sediment distribution.
- Acid generating potential and metals leaching potential of sediments.
- Impact of waste rock sediments on stream health.

URS and others have considered several different technologies to address the sediments in Joe Creek. Technologies that were considered include the following:

- Dredging the creek bed.
- Installing a cap over impacted sediments.
- Applying periodic doses of crushed limestone to the creek bed.
- Monitoring only to determine improvement following waste rock removal.

This EE/CA does not consider the scope or account for costs of additional testing or treatment of impacted sediments in Joe Creek.

4.5.3 Groundwater

Groundwater may be impacted by seepage from flooded mine workings or by infiltration of surface water through the waste rock and into groundwater. Sampling by USFS and reported by Environment International (2002) detected elevated concentrations of metals in seeps, indicating that groundwater has been affected. Sampling by Environment International at seep location JCS2 showed metal concentrations substantially higher than both drinking water standards and acute and chronic aquatic life criteria. URS sampled groundwater from two domestic wells in November 2008. Seep samples collected by URS exceeded one or more water quality criteria for cadmium, copper, and zinc. Although a formal spring and seep survey has not been conducted, URS and others have sampled several seeps. The results indicate variable impacts to water quality.

Additional study is warranted to assess the nature and extent of groundwater impacts by AMD at the Blue Ledge Site. Additional study should include the following:

- Conceptual hydrogeologic model of AMD production and measured seasonal AMD flow rates.
- Environmental impact of AMD.
- Treatment goals of groundwater remediation.
- Design objective and remedial alternatives for groundwater treatment.

There are several potential methods to control and treat discharge of acidic and metals-laden groundwater from the mine adits, including the following:

- Interceptor Drains;
- Pumping wells; and
- Permeable reactive barrier (PRB).

This EE/CA does not consider the scope or account for costs of additional testing or treatment of groundwater.

5.0 SITE CHARACTERISTICS AND DATA GAPS

Before and during the feasibility study, URS conducted several assessments to develop information to assess the feasibility of removal alternatives and design the removal action. This section discusses the assessments. The removal action alternatives discussed in Section 6 are considered in light of the feasibility assessments.

5.1 Geotechnical Characteristics

5.1.1 Geotechnical Characteristics of Waste Rock Piles

Waste rock areas were characterized by the following methods:

- Visual observations of site characteristics.
- Measured waste rock thickness at discrete locations throughout the slopes.
- Identified approximate location of rock outcrops.
- Estimated areal extent of waste rock from survey data, field measurements and visual observations.
- Visually classified the waste rock materials in general accordance with ASTM D2487.

Waste rock piles extend down slope from the productive adits. Following are general characteristics of the waste rock piles and surrounding areas:

- Elevations at the Site range from about 4,000 to 5,200 feet mean sea level (msl). Mine adits are located at approximately 4,800 feet msl.

- Ungraded slopes at the mine site range from about 1.5 horizontal(H):1 vertical(V) to 1H:1V. Slopes tend to be steepest above elevation 4,450 feet msl. Local rock outcrops within the slopes at the Site are near vertical.

- Waste rock thickness is highly variable. In general, 3 to 6 feet of waste rock overlies intact bedrock. WRP-1 is estimated to be up to 8 feet thick near its base. Locally, drainage gullies and channels have eroded through the waste rock piles to bedrock (Appendix A, photos 27 and 28).

- In general, the waste rock is silty gravel with sand. Grain size ranges from silty sand to sandy gravel with silt (Appendix A, Photo 29). Field observations and laboratory testing indicate the following properties:
  - Friction angle ranging from 36 to 42 degrees (based on the orientation of natural slopes present at the mine site).
  - In situ moisture content of 5 to 8 percent.
  - Silt content of up to 20 percent.
  - A maximum dry density of about 115 pounds per cubic foot at an optimum moisture content of 12.5 percent, as measured by the standard proctor test (ASTM D698).

- Tension cracks at the top of WRP-1, evidence and reports of washouts, and channels within waste rock eroded to underlying bedrock rock are evidence of erosion, instability, and potential massive slope failure under current site conditions.

- Seepage from the waste rock piles was not observed during summer work periods, but seasonal infiltration and seepage is likely.

- Access to WRP-1 is provided by construction roads that reach the base of the pile and the center of the pile at approximate elevation 4,450 feet MSL. These roads are accessed by Forest Service Road 1060. There is no developed access above 4,450 feet MSL at the Site, nor is there any access to WRP-2, WRP-3, or WRP-4.

- The EPA regraded lower portion of WRP-1 in 2006. These modifications included the following:
  - Regrading slopes to approximately 2H:1V between elevation 4,280 and 4,150 feet msl.
  - Construction of a riprap-lined channel through the regraded area to control surface water flow.
  - Construction of a settling pond at the base of the regraded area with a series of step-pool basins constructed below the settling pond to treat surface and groundwater flowing through this drainage. Both the pond and the channel were lined with marble.

URS visited the Site in August 2008 with a contractor experienced with earthwork on steep slopes at remote sites. Site observations and work complete by EPA in 2006 demonstrate the feasibility of excavating and reworking the waste rock on the lower slopes. URS and the contractor do not believe that is safe or practical to winch dozers on the very steep upper slopes (i.e., approximately upper third of WPR-1). Other techniques, such as blasting and benching, would be needed to create work platforms to access the steepest areas. Dragline excavation may also be considered as a removal technology.

5.1.2 Geotechnical Assessment of Repository Sites

The SI data gaps evaluation included several tasks to assess the geotechnical properties of the waste rock and potential waste rock repository sites. The Preliminary Geotechnical Report (Appendix C) documents the geotechnical investigations. Geotechnical assessments completed in June 2008 included the following:

- Visual reconnaissance and characterization of the mine site and repository areas.
- Characterization and development a thickness profile of the existing waste rock material at the mine site.
- Excavation of nine test pits.
- Collection of soil samples from test pits and waste rock piles for laboratory characterization.

Additional geotechnical investigation was performed between November 3 and November 8, 2008. The additional investigation included drilling five borings, more detailed visual

reconnaissance, additional laboratory testing, and analysis of slope stability. Details of the supplemental investigation will be incorporated into the design.

5.1.2.1 North Repository Site

The north repository site is a former USFS logging landing. The site is approximately 2 acres on a relatively flat ridge crest (Appendix A, Photos 30 and 31). The ridge crest is clear of brush and trees and is covered in aggregate surfacing with some grass. Down the southwest slope of the landing, the slopes are covered with open second-growth forest and light brush (Appendix A, Photo 32). The ridge slopes moderately to the south (3H:1V to 5H:1V). Slopes below the Site to the north and west are steep.

The ridge is leveled and covered with approximately 6 inches of gravel and 1 to 4 feet of compacted fill characteristic of weathered schist. Below the fill, weathered schist (dense to very dense silty sand with gravel) extends to a depth of at least 14 feet below ground surface (bgs), the maximum depth investigated during the preliminary geotechnical investigation. Groundwater was not encountered and is not expected in this area at these depths.

Slope stability was inferred from site observations and reconnaissance test pits and drilling and from preliminary slope-stability analyses. Reconnaissance inspection and reviews of aerial photos and topographic maps showed no signs of instability. Subsurface soils are predominantly weathered schist soils that still maintain remnant rock fabric, indicating the soil has weathered in place from bedrock.

The results of the stability analyses indicate static factor of safety of 1.8 for a constructed repository at the north site, which is greater than a typical minimum static factor of safety of 1.3 for new fills. Site reconnaissance and pre-design explorations and analysis indicate that the Site is sufficiently stable for the proposed repository.

The supplemental geotechnical investigation conducted in November 2008 (Appendix D; also see Section 5.2.2) confirmed residual schist soil from the ground surface to 41.5 feet bgs, the limits of the depths explored. The schist consists of dense to very dense, light brown silty sand with gravel. The schist maintained remnant foliation at depths of 5 feet and greater. Standard Penetration Test refusal (greater than 50 blows for 6 inches) was encountered at depths between 10 and 30 feet bgs. Topographic maps provided by the USFS were field confirmed; slopes varied from about 3.5H:1V to 5H:1V south of the ridge line. The moderate slopes and very dense subsurface profile at this site confirm its suitability as a potential repository site.

5.1.2.2 South Repository Site

The south repository is a former private logging landing. The site is approximately 4 acres on a relatively flat bench (Appendix A, photo 33). Slopes below the Site generally range from 2H:1V to 2.5H:1V. Immediately west of the Site (below the access road), slopes are locally as steep as 1.4H:1V. Slopes steepen upwards to the east. The former landing is partially covered in brush and young trees. The area is suspected to be a part of a large, but very old landslide.

Soils at the south site consist of 6 inches to 2 feet of regraded organic-rich sand and gravel underlain by at least 13 feet of colluvium (medium dense silty sand with gravel) with weathered schist rock fragments as large as 3 feet. Supplemental investigation in November 2008 indicated these soils extended to depths of 20 to 60 feet bgs. The soil matrix did not have remnant rock

fabric. Soils are interpreted to be landslide debris or colluvium deposited on a displaced rock mass. Groundwater was not encountered, but site observations suggest that shallow soils could become seasonally saturated.

Slope stability was inferred from site observations and reconnaissance test pits and drilling and from preliminary slope-stability analyses. Site investigation and review of aerial photos and topographic maps indicates that the bench feature may be a part of a large landslide complex that extends upslope and potentially as far down slope as Joe Creek, approximately 700 vertical feet below. However, reconnaissance inspection of the area around the proposed site showed no signs of recent instability such as cracks, scarps, displaced or hummocky ground, settlement, or rotated/pistol-butted trees. Trees in close proximity to the Site are estimated to be more than 300 years old and show no signs of historical earth movement.

The results of the stability analyses indicate static factor of safety of 1.3 for a constructed repository at the north site, which is at the low end of acceptable factors of safety for fills of this type. Preliminary analysis indicated that the proposed repository would not have a significant affect on the stability of the larger ancient slide feature. Accordingly, the Site is interpreted to be sufficiently stable for the proposed repository.

Additional reconnaissance and field investigation conducted in November 2008 (also see Section 5.2.2) included review of topographic maps and aerial photos and drilling three geotechnical borings. Borings encountered 20 to 60 feet colluvial soils consisting of medium dense silty sand with gravel, underlain by extremely to completely weathered dark gray schist. The colluvium probably formed by mass wasting from the steep slopes above depositing on large schist blocks that were displaced from their original locations.

The November 2008 investigations generally confirmed the observations and conclusions of the preliminary investigations (Appendix D). The south site may be a part of a large, but very old, landslide complex that extends both up and down slope. Reconnaissance traverses identified no fresh signs of displacement in the form of ground cracks, depressions or wet areas. Further, mature trees (estimated to be up to 300 years old) showed no signs of displacement over time (“pistol-butting”). Initial slope stability analyses indicate that the proposed fill will not significantly affect the stability of this historic landslide. Accordingly, the November 2008 investigation confirms that the Site is sufficiently stable for a proposed waste rock repository.

5.1.2.3 Summary of Repository Suitability

Both the north and south sites appear to be feasible as repository sites for the waste rock. There are advantages and disadvantages to either site. These considerations are summarized below.

North Repository Site

- The north site is smaller than the south site.
- The north site may require more foundation preparation than the south site before waste fill placement.
- Soils beneath the Site are more consistent and potentially less permeable than the south site.
- Native material excavated from the Site may readily be used as cover fill.

- The site is geotechnically stable.

South Repository Site

- The south site is larger than the north site.
- The site will require little preparation before construction other than clearing and grubbing.
- Soils beneath the Site are anticipated to be heterogeneous.
- Native material excavated from the Site will require processing before use as cover fill.
- The south site appears to less geotechnically stable that the north site. However, analyses to date indicate the proposed repository will not significantly affect the site stability, and the Site is expected to be an acceptable disposal location.

5.1.3 Characteristics of the Blue Ledge Mine Camp Site

The USFS has identified the area of the former mine camp site as a potential borrow area for site restoration and repository area cap materials. The site is characterized as follows:

- The site is covered in young trees and dense brush.
- Slopes range from 3H:1V to 4H:1V. Local topography is irregular.
- The area is approximately 3.5 acres.
- Elevations range from about 4,020 to 4,160 feet msl, sloping downward to the southwest to Joe Creek.
- The USFS reports that the area is a landslide deposit (Jones, 2009). URS agrees with that observation on the basis of reviews of aerial photographs and topographic maps that indicate potential landslide geomorphology upslope and west of the Site.

After additional consultation with the USFS, use of the Blue Ledge Mine camp site for borrow material was eliminated from consideration.

5.2 Data Gaps and Additional Assessment

URS conducted additional assessments and reconnaissance in 2009 and 2010 to fill data gaps and provided information to design the removal action. The primary purpose of the additional assessment was to refine the waste rock volume estimates and provide additional geotechnical data on the north and south repository sites.

5.2.1 Additional Survey

OBEC Consulting Engineers of Medford, Oregon completed a detailed survey (5-foot elevation resolution) on the two largest waste rock piles (WRP-1 and WRP-2) at the mine site in June 2008. The survey is shown on Figure 3-1 of the Preliminary Geotechnical Report (Appendix C). URS used the survey to estimate areas and volumes of the primary waste rock piles and to estimate repository capacity requirements. URS estimated volumes of WRP-3 and WRP-4 by walking the piles and taking physical measurements to calculate volumes.

URS contracted Terrapoint USA, Inc. in 2009 to conduct an aircraft-deployed Light Detection and Ranging (LiDAR) survey of the Site. LiDAR improved the topographic survey resolution to delineate the waste rock piles, road alignments, and other site features. LiDAR data and maps were incorporated into the design.

Ground-based survey was used to delineate the limits of the waste rock piles, potential north and south repository areas, and potential new road alignments for work area access.

5.2.2 Supplemental Geotechnical Investigation and Stability Analysis of Repository Sites

Preliminary analysis indicated that the proposed repository sites were geotechnically stable (Section 5.1.3, Appendix C). Additional geotechnical information was needed to affirm stability and design repositories.

URS performed additional geotechnical investigation between November 3 and November 8, 2008. The additional investigation included drilling five borings at the two repository sites, a more detailed visual reconnaissance of the potential repository sites, and laboratory testing of soil samples collected during the investigation. Field and laboratory data were used to develop and execute a stability model of the repository sites. Appendix D provides details of the supplemental investigation and the slope stability analysis.

The local geomorphology strongly suggests previous (ancient) landslide activity in the area of the south repository site and on both sides of the north repository site ridgeline. However, there are no obvious indications of recent, large-scale landslide activity (see Section 5.1.3.2).

Stability analyses were performed for both repository sites considering the most critical slope section. Two geometries were considered at each location: the existing slope geometry (as measured by topographic maps) and that of an assumed repository fill geometry. Fifteen feet of waste rock/cover fill was considered for the final fill conditions for each repository. Stability analyses were performed for each geometry for static and seismic loading conditions.

Stability analyses were performed using the limit equilibrium method based on the Morgenstern-Price method of slices using the commercial software SLOPE/W (2006). Using this methodology, the factor of safety (FOS) for a given geometry is calculated as the ratio of resisting forces to driving forces on a particular trial failure surface.

Typical minimum static factors of safety for new fills range from 1.3 to 1.5, depending on the nature of the fill material and potential failure hazard it poses. These factors of safety indicate that the failure hazard of the proposed repository structures is relatively low. In our judgment, acceptable factors of safety for this type of earth structure are 1.1 and 1.3 for seismic and static loading conditions, respectively. Accordingly, the results of slope-stability assessment performed on the repository sites indicate that both the north and south sites are adequately stable for a proposed waste fill repository. If final design criteria are established that differ from those assumed, slope stability should be reevaluated.

5.2.3 Additional Waste Rock Areas

During a June 2009 Site visit, URS and the USFS identified areas of possible waste rock that required additional investigation. One area was a densely forested area below the log dam south

of Joe Creek and east of the ephemeral drainage that extends from the bottom of WRP-1. Another area was a rocky and sparsely forested ridge on the western edge of WRP-1. Due to well established trees, these areas were not previously identified as areas of waste rock. Investigations consisted of excavating test pits using a backhoe and hand tools.

Excavations in September 2010 identified relatively thin deposits of waste rock in the forested area below the log dam. Waste rock was apparently distributed beyond the ephemeral drainage by high run-off flows. The delineated limits of waste rock in WRP-1 were expanded to reflect the investigation and the final volume estimate includes the area.

Excavations indicated a relatively thin (less than 2 feet thick) layer of waste rock on top of the rocky ridge on the western edge of WRP-1. Native colluvial soils underlay the waste rock. Minimal waste rock was intermixed (estimated less than 50 percent by volume) with the colluvium in the upper 1-foot (perpendicular) of the very steep slopes west of the ephemeral drainage. Updated waste rock volumes reflect the investigation.

5.2.4 Test Pits

Previous volume estimates assumed waste rock depths based on estimated topography and depth distribution. The true depth of the waste rock had not been investigated. Excavations with hand tools and an excavator confirmed that waste rock overlies one of three broad categories of materials: hard bedrock, scree/talus, or soil. Several excavations in each of the four waste rock areas identified the depths to rock or underlying native materials. Updated waste rock volumes reflect the investigation.

Where waste rock overlay soil, scree, or colluvium, analytical testing indicated that metals concentrations and acid generation potential approach background concentrations at a typical depth of approximately 1-foot into the underlying native material. On that basis, the design assumes that overexcavation of the waste rock by approximately 1-foot, would attain adequate removal.

5.2.5 Test Removals

Given the difficult and rough terrain, some minor amounts of waste rock will remain after a practicable and acceptable removal. The degree to which removal is possible is uncertain. URS conducted test removals to identify feasibility of removals and to differentiate between waste rock and underlying or surrounding soils. The observations provided information to develop performance criteria for the removal design and specifications.

6.0 REMOVAL ACTION ALTERNATIVES

The primary purpose of the EE/CA is to estimate the feasibility and cost-effectiveness of removal action alternatives. This section of the report assembles technologies into a range of actions that we believe represent a reasonable range of removal actions and costs.

Technologies that are screened forward in Section 4 (Table 4-1) are assembled into several removal action alternatives. Alternatives are evaluated against the criteria of protectiveness, effectiveness, reliability, implementability, and cost. The most cost effective removal action that meets the RAOs is recommended in Section 8. Table 6-1 summarizes the alternatives.

6.1 General Response Actions

General response actions are broad categories of actions that may satisfy the RAOs. Likely general response actions for the Site include the following:

Response Action	Example at Blue Ledge
• No action	Monitoring only
• Institutional controls	Land-use restrictions at repositories
• Engineering controls	Passive treatment of run-off
• Excavation and treatment	Excavate waste rock and place in repository
• In situ treatment	Phytoremediation of residual waste rock

6.2 No Action

The only actions under the “no action” alternative are long-term performance monitoring and reporting. The roads would be maintained to allow access for sampling and monitoring. This would result in no improvement to the ongoing and potential future risks previously identified for this site.

6.3 Alternative 1 Description

Alternative 1 consists of the following:

- Construct access roads as needed to complete the removal action. Generally, an access road will be needed to some portion of each of the four waste rock areas. Some improvements to existing roads to the mine may also be required.
- Excavate waste rock with dozers, excavators, and draglines. The specific method may vary depending on the slopes and characteristics of the waste rock area.
- Construct the unlined upland repository and prepare it for waste rock placement.
- Place the excavated waste rock in an upland repository at either the north or south repository site.
- Install a composite GCL and soil cover over the waste rock, including native revegetation, run-on diversion, grading and drainage on the repository to isolate the waste rock from the environment and inhibit leaching of acidity and metals.

- Install sedimentation basins and bioswales to control transport of contaminants from run-off, seeps, and erosion. Generally, each waste pile will have one or more sedimentation basin to collect eroded sediments. These basins may require annual maintenance until the site stabilizes.
- Place and stabilize reclamation fill and plant selected native vegetation on portions of the former waste rock areas. The reclamation fill and plantings will stabilize residual waste rock that remains after the removal is complete and minimize erosion and AMD from the residual waste rock.[3]
- Close adits with bat gates to allow access by wildlife, prevent human access, and minimize physical hazards from the mine.
- Conduct performance monitoring and reporting to assess water quality and long-term restoration of the Joe Creek and Elliott Creek watersheds.

6.4 Alternative 2 Description

Alternative 2 consists of the following primary components, many of which were described more fully under the Alternative 1 Description:

- Construct access roads as needed to complete the removal action.
- Excavate waste rock with dozers, excavators, and draglines. The specific method may vary depending on the slopes and characteristics of the waste rock area.
- Construct lined and capped repository with collection and treatment at local site. This differs from Alternative 1 in that a GCL bottom and sideslope liner is added. This creates the need to treat AMD that might leach from the waste, although AMD volumes would likely be small.
- Install sedimentation basins and bioswales to control transport of contaminants from run-off, seeps, and erosion. Generally, each waste pile will have one or more sedimentation basin to collect eroded sediments. These basins may require annual maintenance until the site stabilizes.
- Place and stabilize reclamation fill and plant selected native vegetation on portions of the former waste rock areas.
- Close adits with bat gates.
- Conduct performance monitoring and reporting.

The primary differences between Alternatives 1 and 2 include a lined and capped repository, and constructed wetlands to treat AMD and run-off from the waste rock areas.

6.5 Alternative 3 Description

Alternative 3 consists of the following, many of the components of which are described in the previous two alternatives:

[3] The amount of residual waste rock is difficult to quantify with certainty. We expect that up to 99 percent of the waste rock will be removed by conventional excavation and grading. The design will develop criteria.

- Construct access roads as needed to complete the removal action.
- Excavate waste rock with dozers, excavators, and draglines. The specific method may vary depending on the slopes and characteristics of the waste rock area.
- Haul waste rock to a landfill disposal. If neither the north nor south repository sites are suitable or otherwise permissible, then offsite disposal will be required. There appear to be suitable open areas near the Applegate Reservoir, although no particular area has been identified and investigated. If no local repository sites are suitable, commercial landfilling would be considered. The nearest commercial landfill is Dry Creek Landfill located northeast of Medford.
- Install sedimentation basins and bioswales to control transport of contaminants from run-off, seeps, and erosion. Generally, each waste pile will have one or more sedimentation basin to collect eroded sediments. These basins may require annual maintenance until the site stabilizes.
- Place and stabilize reclamation fill and plant selected native vegetation on portions of the former waste rock areas.
- Close adits with bat gates.
- Conduct performance monitoring and reporting.

The primary difference between Alternatives 2 and 3 is that a local repository is not viable and a landfill disposal would be required..

6.6 Cost Estimates

Cost estimates were developed using standard methods for conducting EE/CAs and feasibility studies. Methods were in general accordance with EPA guidance (EPA, 2000b). Costs include capital costs, recurring and future costs, and contingencies. Future costs are presented as net present value.

Table 6-2 summarizes the costs. Appendix E includes costing assumptions and cost details. Costs estimate accuracies are considered representative of typical feasibility studies. Additional details of costs estimates are provided below.

6.6.1 Capital Costs

Following are examples of capital costs:

- Design-level testing and technology development (e.g., pilot treatment tests test removals)
- Removal action implementation
- Construction management
- Contingencies
- Project Management

Capital costs are 2010 dollars and are not discounted. Costs implement the removal action were assumed to be in 2010 dollars, even if the removal may occur over a two year period.

6.6.2 Recurring and Future Costs

Following are examples of recurring and future costs:

- Road maintenance.
- Erosion repair and regrading.
- Supplemental planting of phytoremediation remedy, repository cover, or reclamation cover.
- Maintenance of repository AMD collection and treatment, if used.
- Sediment removal from sedimentation basins.
- Maintenance of passive treatment systems.
- Restoring limestone channels and ponds.

This EE/CA includes an estimate for only three years operation and maintenance costs (although operation and maintenance will likely occur over a longer period). Accordingly, future costs assume 2010 dollars and are not discounted.

6.6.3 Uncertainty and Contingencies

This report estimates costs on the basis of a feasibility-level review of technologies and alternatives. Feasibility study screening-level costs are generally assumed to vary by -50 percent to +100 percent from the estimated costs (i.e., 50 percent high to 100 percent low) (EPA, 2000b). The range in costs reflects the uncertainties in technologies and alternatives that are inherent in the conceptual stage of the EE/CA.

For the Blue Ledge Mine and this report, the following are examples of the significant uncertainties and the implications for cost estimates:

- **Methods and feasibility of waste rock removal**. This report assumes that removing waste rock from the very steep and rocky slopes can be successful using the removal methods described in this report. If assumed removal alternatives prove to be infeasible or effort is greater than expected, then removal costs could be higher.

- **Hydrogeologic conceptual model**. The processes that control fate and transport of metals from the Site are complex. Accordingly, the need for and response to actions to control surface run-off and AMD are uncertain. More or less control and treatment than assumed may be necessary.

- **Repository design.** Geotechnical review indicates that nearby repository locations are suitable and of adequate size. The RWQCB only recently provided formal comments on the repository design. The RWQCB comments are incorporated into the design concepts and the cost estimates. The feasibility and costs assume minimal additional regulatory restriction. This assumption reflects that the waste is not a listed or characteristic waste and the lack of RCRA regulation.

- **Needed level of AMD and run-off treatment**. This report assumes minimal levels of passive treatment of AMD and run-off. For example, bioswales and perhaps addition of

passive treatment media are presumed to be adequate to treat run-off and AMD. If more aggressive treatment were necessary, then costs would be higher.

- **Regulatory requirements.** This report assumes that the removal actions can be implemented on private land with few regulatory restrictions. If substantial regulatory intervention occurs, or certain actions are not allowed (e.g., if California law or stakeholder interests prevent the repository in the preferred location), then costs could be higher.

In this report, contingencies applied to the capital and operations costs are intended to offset uncertainties. Contingencies include scope contingencies, which reflect technical uncertainties in the removal action approach, and bid contingencies, which reflect unforeseen conditions that impact implementation of the selected removal action. An assumed contingency of 20 percent was used (see Table 6-2).

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section screens removal-action alternatives against the criteria of protectiveness, effectiveness, reliability, implementability, and cost.

The NCP identifies factors to be considered to determine an appropriate removal action. 40 CFR 300.415(b)(2)(i-viii). Table 6-1 summarizes removal action alternatives and the comparative analysis. Table 6-2 and Appendix E summarize details of the alternatives costs. Table 6-3 summarizes the NCP removal action factors for the Site.

The technology screening and comparison of alternatives generally considered the following criteria, as described in EPA guidance (1988, 1993, 2000b):

- Effectiveness: Preliminary effectiveness ratings of high, medium, and low reflect estimated relative effectiveness of the technology to treat the Site contaminants and meet RAOs.

- Implementability: Implementability rating of easy, moderately difficult, and difficult reflects estimated relative complexity and cost of implementing the technology.

- Applicability: Applicability reflects the relative overall relevance of the technology to the Site. Low applicability indicates low effectiveness or severe constraints to implementation. Technologies with low applicability were not retained from the removal action technology screening (Table 4-1) for comparative analysis.

- Cost: Total costs were calculated for each removal alternative. Total costs included capital (construction) and three years of operation and maintenance costs. Costs incurred after construction were calculated as net-present value. Table 6-2 summarizes the costs for each alternative as net-present value.

The comparative analysis of the alternatives assimilates the criteria and results of the technology screening. The comparative analysis is summarized as follows:

No Action – Performance monitoring and reporting
- Resource not protected.
- Ongoing ecological and human health risk not mitigated.
- Cost is low and includes only monitoring and access maintenance.
- $0.14M.

Alternative 1 - Waste rock removal. Unlined repository with low permeability cover at local site.
- Removing the waste rock would eliminate most of the primary sources of contamination.
- Residual waste rock could continue to erode and leach metals, but probably at much lower loading and concentrations.
- Reliability of unlined repository is medium.
- Alternative includes minimal treatment of run-off and seeps from former waste rock areas.
- $15.99M.

Alternative 2 - Waste rock removal. Lined and capped repository with AMD collection and treatment at local site. Includes additional passive treatment elements for the treatment of AMD in run-off.

- Removing the waste rock would eliminate most of the primary sources of contamination.
- Additional passive treatment of AMD and run-off, as compared to Alternative 1 increase protectiveness and reliability.
- Reliability of lined and capped repository is high, but costs are higher.
- Implementability of constructed wetlands for treatment of residual AMD in run-off increases treatment effectiveness.
- $17.65 M.

Alternative 3 - Waste rock removal. More distant repository or landfill disposal.

- Removing the waste rock would eliminate most of the primary sources of contamination.
- Need for off-site repository or landfill depends on availability and suitability of local repository site.
- Implementability of constructed wetlands for treatment of residual AMD in run-off increases treatment effectiveness of run-off.
- $19.65M.

Table 6-1 summarizes the comparative analysis of the alternatives. The comparative analysis should lead to the identification and recommendation of the most cost effective alternative.

Alternative 1 is the lowest cost. Removing the waste rock would eliminate the primary source of contamination but the effectiveness of Alternative 1 is limited by the absence of the passive treatment elements that treat residual AMD in run-off. Although an unlined repository may be adequate under the circumstances, lining the repository, as in Alternative 2 would increase effectiveness.

The cost of Alternative 2 is higher than Alternative 1 due to the addition of passive treatment elements and a lined and capped repository. Treating residual AMD that might leach from residual waste rock is an important treatment objective of the removal action. Adding a liner to the repository will increase its effectiveness in treating possible AMD.

Alternative 3 has the highest cost which results from the off-site hauling and disposal of the waste rock. Although this alternative eliminates the need to construct an on-site repository, the costs of off-site disposal are high. Off-site disposal would eliminate the possibility of residual AMD from an on-site repository, but the marginal benefits are lower because an on-site repository would also be effective.

8.0 REMOVAL ACTION RECOMMENDATION

This report summarizes and evaluates a range of removal action alternatives. The alternatives reflect a range of approaches and technologies. The four alternatives included no action and three removal action alternatives.

The recommended removal action is Alternative 2. Alternative 2 includes the actions that address the primary source of the contamination, address RAOs, and comply with the known ARARs. The costs of Alternative 2 are in the middle of the range of the alternatives considered and we consider Alternative 2 to be the most cost effective.

The recommended removal action includes the following primary elements:

- Access roads as needed to complete the removal action.
- Waste rock removal with dozers, excavators, and draglines.
- Placement of excavated waste rock in a lined upland repository at local site.
- Impervious cover, run-on diversion, grading and drainage on repository to isolate the waste rock from the environment and inhibit leaching of acidity and metals.
- Reclamation fill and planting on former waste rock areas, where practical.
- Sedimentation basins and bioswales to control transport of contaminants from run-off, seeps, and erosion.
- Adit closure with bat gates.
- Performance monitoring and reporting to assess water quality and long-term restoration of the Joe Creek and Elliott Creek watersheds.

8.1 Removal Action Implementation

The USFS has not established a final schedule to implement the removal action. We estimate that it will take approximately two construction season (June through November) to construct the recommended alternative.

9.0 SIGNATURES OF PREPARERS

This document was prepared under the supervision of the undersigned professionals. Prepared By:

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TABLES

TABLE 3-1a

Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
FEDERAL			
Clean Water Act	33 USC §§ 1251 - 1387		
National Ambient Water Quality Criteria	40 CFR Part 131	Establishes non-enforceable ambient water quality criteria (AWQC) based on toxicity to aquatic organisms and human health. Criteria developed by the EPA and used by the state to establish water quality standards.	To the extent that the AWQC are more stringent than the State of California surface water quality standards they will be considered ARARs.
California Toxics Rule	40 CFR Part 131.38 (a)	Establishes California water quality standards for priority toxic pollutants under the authority of the CWA.	ARAR. Requirement is applicable to the surface water bodies in California.
Effluent Limitations	40 CFR Part 440.100-440.105	Effluent limitations for active copper mines.	Not an ARAR. No point sources are anticipated to result from this removal action.
Safe Drinking Water Act	40 USC § *300*		
National Primary Drinking Water Regulations and Maximum Contamination Goals	40 CFR Part 141	Establishes health-based standards, maximum contaminant levels (MCLs), for public water systems and sets goals for contaminants.	ARAR. To the extent that the National Primary Drinking Water Regulations have been adopted by the State of California they will be considered ARARs for surface water. Addressing groundwater is outside the scope of this removal action, but the removal action cannot adversely impact groundwater quality.
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes non-enforceable aesthetic standards (secondary MCLs) for public water systems.	ARAR. To the extent that the State of California has adopted the Secondary Drinking Water Regulations they will be considered ARARs for surface water. Addressing groundwater is outside the scope of this removal action, but the removal action cannot adversely impact groundwater quality.
Clean Air Act	40 USC § 7409		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes air quality levels that protect public health, sets standards for air emissions.	Not an ARAR. Only “major” sources are subject to requirements related to NAAQS, will defer to state regulation of fugitive dust emissions.

TABLE 3-1a

Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
Resource Conservation and Recovery Act	40 USC § 7601		
Lists of Hazardous Wastes	40 CFR Part 261, Subpart D and C	Defines those solids wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Not an ARAR. Mine waste is not a listed hazardous waste, and waste-rock TCLP results less than limits for characteristic waste. Mine waste exempt under RCRA Subpart C, (40 CFR 261.4(b)(7). Parts of RCRA may be relevant and appropriate, however, and are discussed under location and action-specific requirements.
Preliminary Remediation Goals (PRGs) for soil and water	US Environmental Protection Agency (EPA) Region 9	Preliminary Remediation Goals (PRGs) are a risk-based screening concentrations used to assess cleanup goals. PRGs are generic and do not reflect site-specific information. PRGs are guidelines and not legally enforceable standards.	TBC. The PRGs will be considered in the development of project cleanup goals.
STATE OF CALIFORNIA			
California Hazardous Waste Control Law	Title 22 CCR Division 4.5	Establishes regulation of hazardous waste control including management and control of hazardous waste facilities, transportation and classification.	Not an ARAR. Mining waste is exempt from California's Hazardous Waste Control statutes and regulations under Bevill exclusion.
	Title 22 CCR Section 66261 et seq	Identifies waste subject to regulation as hazardous wastes and which are subject to the notification requirements of HSC 25153.6. Defines criteria for hazardous waste determination using Soluble Threshold Limit Concentrations (STLCs) and Total Threshold Limit Concentrations (TTLCs).	Applicable requirement for off-site disposal.
	Title 22 CCR Section 66268 et seq	Identifies hazardous wastes restricted from land disposal and defines circumstances under which an otherwise prohibited waste may continue to be land disposed.	Applicable requirement for off-site disposal.
Carpenter-Presley-Tanner Hazardous Substances Account Act	HSC Section 25300 et seq.	Establishes program for state response to cleanup releases of hazardous substances including compensation to persons for injuries caused by exposure to hazardous substances and establish adequate funds to assure payment.	Not an ARAR. State administrative requirements not applicable to CERCLA response actions.

TABLE 3-1a

Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
California Safe Drinking Water Act	Title 22 CCR Sections 64431 and 64449 (a)	Primary and secondary MCLs for public drinking water.	ARAR. To the extent that the primary and secondary MCLs that are more stringent than the Federal MCLs they will be considered ARARs for surface water. Addressing groundwater is outside the scope of this removal action, but the removal action cannot adversely impact groundwater quality.
Porter-Cologne Water Quality Control Act	California Water Code, Division 7: Water Quality Water Code Section 13000 et seq.	Establishes the policy to protect the quality of all waters of the state for the enjoyment of the people.	Applicable requirement
	Sections 13397 through 13398	Establishes the policy to reduce the threat to water quality caused by abandoned mine lands.	Applicable requirement
Basin Plan	Water Quality Control Plan for the North Coast Region		
State Anti-degradation Policy	SWRCB Resolution 68-16	Establishes the requirements for continued maintenance of high-quality water of the state.	ARAR. Requirements set forth in this resolution are applicable to maintain water quality during the action.
Sources of Drinking Water Policy	SWRCB Resolution 88-63	Establishes the policy for sources of drinking water in the state. Groundwater is considered as potential drinking water if total dissolved solids levels are below 3,000 mg/L and the yield is greater than 200 gallons per day.	ARAR. Requirement is applicable; the removal action cannot adversely impact groundwater quality.
Cleanup and Containment Zone Policy	SWRCB Resolution 92-49 Section IIIG	Establishes the policy and procedures for regional boards related to investigation and cleanup activities for all discharges subject to California Water Code Section 13304. Requires the attainment of background water quality or the best water quality that is reasonable if background cannot be achieved.	ARAR. Applicable requirement

TABLE 3-1b

Location-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
FEDERAL			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800 40 CFR 6.30l(b)	Requires Federal Agencies to take into account the effect of any Federally assisted undertaking or licensing on any property with historic, architectural, archeological, or cultural value that is included in or eligible for inclusion in the National Register of Historic Places.	ARAR. This is an applicable requirement. Cultural Resources Survey has been conducted and historic features identified. These features will be preserved.
Archeological and Historic Preservation Act	16 USC § 469 40 CFR 6.30l(c)	Establishes procedures to provide for preservation of significant scientific, prehistoric, historic, and archeological data that might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	ARAR. This is an applicable requirement. Cultural Resources Survey has been conducted and historic features identified. These features and any additional archeological findings encountered during the course of the removal action will be preserved.
Native American Graves Protection and Repatriation Act (NAGPRA)	25 USC 3001-3013 43 CFR Part 10	Establishes regulations that pertain to the identification, protection, and appropriate disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony.	ARAR
American Indian Religious Freedoms Act (AIRFA)	42 USC § 1996 et seq.	Protects and preserves the traditional religious rights and cultural practices of the American Indians, Eskimos, Aleuts, and Native Hawaiians. The act requires all governmental agencies to eliminate interference with the free exercise of Native religion, based on the First Amendment, and to accommodate access to and use of religious sites to the extent that the use is practicable and is not inconsistent with an agency's essential functions.	ARAR.
Protection of Wetlands Executive Order No. 11990	40 CFR Part 6; Appendix A, 40 CFR 6.302(a)	Avoid adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	ARAR. This is an applicable requirement; however, no wetlands will be affected by the removal action.
Dredge and Fill Regulations	33 USC § 1344, 33 CFR 323.1 et seq.	Prohibits discharge of dredged or fill material into waters of the United States without a permit.	ARAR. This is an applicable requirement for stream crossings required to complete the removal action.

TABLE 3-1b

Location-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
Floodplain Management Executive Order No. 11988	40 CFR Part 6, Appendix A 40 CFR 6.302(b)	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain to the extent possible.	ARAR. This is an applicable requirement; however, the removal action will not affect any mapped floodplain.
Fish and Wildlife Coordination Act	16 USC 661 et seq.	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body to assure adequate protection of fish and wildlife resources.	ARAR. This is an applicable requirement for stream crossings required to complete the removal action. Plans have been provided to the USFWS.
Endangered Species Act	16 USC Chapter 35	Act to protect habitat of endangered and threatened species. Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.	ARAR. This is an applicable requirement; the USFWS (2003) states that service "trust resources" are known to occur in the Elliott Creek watershed.
Bald Eagle Protection Act	16 USC §§ 668 et seq.	Requires consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald or golden eagle.	ARAR. This is an applicable requirement; the USFWS (2003) states that bald eagles are known to occur in the Elliott Creek watershed.
Migratory Bird Treaty Act	16 USC §§ 703 et seq.	Establishes federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	ARAR. This is an applicable requirement for the removal action.
Resource Conservation and Recovery Act	42 USC § 6901 40 CFR Part 264	Location standards for hazardous and solid waste facilities and municipal waste landfills.	Not applicable. Could be relevant and appropriate for the siting of the mine waste repository. For this site, however, will defer to State of California requirements for the proper siting of disposal facilities.
STATE OF CALIFORNIA			
California Preservation Laws	Administrative Code, Title 14, Section 4307	No person shall remove, injure, deface or destroy any object of paleontological, archaeological or historical interest or value.	ARAR. Applicable requirement for CERCLA actions on private lands.

TABLE 3-1b

Location-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
California Endangered Species Act (CESA)	Fish and Game Code Section 2080 Title 14 CCR Section 783 et seq	The CESA Act generally parallels the main provisions of the Federal ESA to protect habitat of rare, endangered, and threatened species. The 'take' of any species that the commission has determined to be an endangered or threatened species is prohibited. However, CESA allows incidental take for lawful development projects and emphasizes early consultation to avoid impacts on projects that have a potential for a 'take'.	ARAR. This is an applicable requirement for the removal action.

TABLE 3-1c

Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
FEDERAL			
Clean Water Act	33 USC § 1342		
National Pollutant Discharge Elimination System	40 CFR Part 122	In general, Part 122 provides permit requirements for the discharge of pollutants from any point source into waters of the United States. Part 122.26 requires permits for stormwater discharges.	No point sources are anticipated to result from this removal action so, with the exception of stormwater requirements, this is not an ARAR.
Surface Mining Control and Reclamation Act	30 USC § 1201	A program for addressing environmental and human health effects from surface coal mine operations. The EPA has expressed that it may also be relevant and appropriate to other types of mining sites. Parts 816 and 817 provide post-mining guidelines for rehabilitation and reclamation.	Not an ARAR. Pacific Northwest Regional Forest Service Best Management Practices will be used.
Hazardous Materials Transportation Act	49 USC §§ 1801-1813 49 CFR Parts 107, 171-177	Regulates transportation of hazardous materials.	ARAR. Requirements are applicable for transport of materials off-site.
Resource Conservation and Recovery Act	46 USC § 7601		
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities	40 CFR Part 263	Regulations applicable off-site transportation and disposal of hazardous wastes.	ARAR. Requirements are applicable for the off-site disposal of wastes if the wastes exhibit toxicity characteristics.
Land Disposal Restrictions (LDRs)	40 CFR Part 268	LDRs prohibit the placement of hazardous wastes in a land disposal unit if the wastes fail to meet treatment standards promulgated for them.	Not an ARAR. Data indicate that sediments do no fail any of the relevant LDR treatment standards. Operations monitoring will confirm disposition of sediments that collect in sedimentation basins.
Closure Requirements	40 CFR Part 264 Subpart N	Provides closure criteria for such activities as capping and run-on and run-ff controls for hazardous waste facilities and municipal waste landfills.	Not applicable. Could be relevant and appropriate to the design of the mine waste repository. For this site, however, will rely on State of California requirements for the proper closure of disposal facilities.

TABLE 3-1c

Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
Landfill Design and Construction	40 CFR 264.301	Hazardous waste landfills must meet minimum design standards.	Not applicable. Could be relevant and appropriate to the design of the mine waste repository. For this site, however, will rely on State of California requirements for the design and construction of landfills.
Groundwater Monitoring	40 CFR & 264, Subpart F 40 CFR & 264, Subpart X	Establishes standards for detection and compliance monitoring. Site wide monitoring will accommodate specific groundwater monitoring requirements.	Not applicable to this removal action. Groundwater monitoring requirements will be determined as part of the overall site remedy
Federal Noxious Weed Act	7 USC §2801 et seq	Designates certain plants as noxious weeds and establishes the requirements to control the spread of them.	ARAR. Requirements are applicable to control the spread of noxious weeds during the removal action.
Fire Protection and Suppression	USDA Pacific Northwest Region Forest Service Standard	Establishes fire protection and suppression standards	ARAR. Requirements are applicable; the removal action is taking place under the USDA Pacific Northwest Region Forest Services' jurisdiction.
STATE OF CALIFORNIA			
California Surface Mining and Reclamation Act of 1975 (SMARA)	Title 14 CCR Section 3700 et seq	Reclamation standards adopted by the California Department of Conservation Office of Mine Reclamation including protection standards for wildlife habitat and performance standards for earthwork, revegetation, drainage, erosion control, stream protection, and closure of surface openings.	Not an ARAR. Pacific Northwest Regional Forest Service Best Management Practices will be used.
Permit Requirements for Storm Water Discharges	Order 2009-0009-DWQ	Requires that storm water runoff associated with construction meet substantive requirements of the General NPDES Permit for Storm Water Discharges Associated with Construction Activity. All discharges are required to obtain coverage effective July 1, 2010.	ARAR. The substantive requirements are applicable to the construction activities associated with the removal action.
Dust Emissions	HSC Section 41700 Siskiyou County APCD Regulation 4.2	Establishes nuisance dust prohibitions.	ARAR. The requirements are applicable during the construction of the removal action.
Diesel Emissions	Title 13 CCR, Article 4.5, Chapter 1	Establishes standards for the reduction of emissions of diesel particulate matter, oxides of nitrogen and other pollutants from in-use heavy-duty diesel-fueled vehicles.	ARAR. The requirements are applicable during the removal action.

TABLE 3-1c

Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
California Hazardous Waste Control Law and Hazardous Disposal Regulations	Title 22 CCR, 66262.1 et seq	Establishes hazardous waste management requirements including handling, storage and documentation of hazardous waste.	Not an ARAR. Mining waste is exempt from California's Hazardous Waste Control statutes and regulations under Bevill exclusion.
	HSC Division 20, Chapter 6.5, Section 25100 HSC Division 20, Chapter 6.5, Section 25143.1	Mining waste is exempt from California's Hazardous Waste Control statutes and regulations under Bevill exclusion. However, the wastes are subject to the requirements of Article 9.5 and Chapter 6.8 if the waste would be classified as hazardous pursuant to Section 25117 and 25141.	Applicable to off-site disposal.
	HSC Division 20, Chapter 6.5, Section 251117.13, 25222.1, 25230; Chapter 6.8, Section 25355.5 Title 22 CCR, Section 67391.1	Regulations deed restriction requirements to restrict certain uses.	May be an ARAR.
Solid Waste Rules	Title 27 CCR, Division 2		
Mining Waste Management	Title 27 CCR Section 22470-22510, 20080 et seq., 21710 et seq.	Establishes SWRCB regulations for mining waste management.	ARAR. The regulations are applicable to the repository design.
	Title 27 CCR Section 22480	Establishes the groups of mining waste based on an assessment of the potential risk of the water quality degradation posed by the waste.	ARAR. The mining waste has been classified accordingly as a 'Group B' waste. The repository design will comply with requirements for Group B wastes.
	Title 27 CCR Section 22490 (a) & (b)	Establishes the requirements for siting of the waste repository.	ARAR. The repository design will meet the siting requirements by being located away from Holocene faults, areas of rapid geologic change, and areas. and areas within a floodplain (i.e. 100-year peak streamflow).
	Title 27 CCR Section 22490 (c)	Establishes the construction and discharge standards for mining waste units.	ARAR. The design will meet the prescriptive liner requirements for natural and artificial containment.
	Title 27 CCR Section 22490 (d)	Establishes the requirement for design and construction oversight by registered professionals.	ARAR. The design will be completed by a registered civil engineer and the construction will be supervised by a registered civil engineer a certified engineering geologist.

TABLE 3-1c

Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements

Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate Requirement (ARAR) or To Be Considered (TBC)?
Mining Waste Management	Title 27 CCR Section 22490 (e) and 20320	Establishes the general criteria for containment structures.	ARAR. The design will meet the appropriate general containment criteria defined in Section 20320.
	Title 27 CCR Section 22490 (f), 21410, and 20330 (a) & (d)	Establishes liner requirements.	ARAR. The liner design and construction will meet requirements for Group B mining waste management units.
	Title 27 CCR Section 22490 (g) and 20340 (b-e)	Establishes requirements for Leachate Collection and Removal Systems (LCRS) for Group A and B wastes.	ARAR. The blanket-type LCRS design will meet the requirements for strength, placement, head buildup, clogging.
	Title 27 CCR Section 22490 (h), 20365 (d) & (e), 20375	Establishes precipitation and drainage control requirements.	ARAR. The diversion and drainage facilities will be designed and constructed to accommodate the anticipated volume of precipitation and peak flows from surface runoff for one 10 year, 24 hour storm event. Precipitation and runoff not diverted by containment structures will be collected and managed through the LCRS.
	Title 27 CCR Section 22500 and 20385-20430	Establishes water quality monitoring requirements for new and existing Group A and B mining units, subject to agreements among agencies.	ARAR.
	Title 27 CCR Section 22510 and 20950 (b) & (d)	Establishes closure and post closure maintenance requirements for mining units including performance standards, plans, funding, financial assurance, vegetation, closure standards, erosion & sediment protection, subject to agreements among agencies.	ARAR.
Porter-Cologne Water Quality Act	Order 97-03	Establishes stormwater requirements for construction activities.	ARAR. Requirements are applicable to construction activities.
California Environmental Quality Act (CEQA)	Public Resource Code Div. 13 Section 2100 et seq.	Binding guidelines for the Environmental Impact Review (EIR) of development of projects. Defines responsibility of state agencies in the EIR process.	Not an ARAR. State or local governments may have to comply with CEQA if it is triggered by their own actions.
	Title 14 CCR, Div. 1, part 3 Chapter 4, Section 750 et seq.	Specifies the objectives, criteria and procedures followed by the Fish and Game Commission in implementing CEQA.	Not an ARAR. State or local governments may have to comply with CEQA if it is triggered by their own actions.
	Title 14 CCR, Div. 6, Chapter 3 Title 22 CCR, Div 4, Chapter 2 Title 23 CCR Chapter 4	Guidelines for the implementation of CEQA, including the responsibilities, authority of public agencies, lead agency, initial studies, negative declaration process and EIR process. Defines limits, contents, types, considerations, review, litigation, monitoring, exemptions, funding, public hearings and approval.	Not an ARAR. State or local governments may have to comply with CEQA if it is triggered by their own actions.

Table 4-1
Removal Action Technology Screening
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Technology	Description	Effectiveness[1] **Low, Medium, High**	Implementability[2] **Easy to Difficult**	Applicability[3] **Low, Med, High**	Retained **Yes, No**
Waste Rock Removal					
Hydraulicking	Waste rock removed by spraying high-pressure stream of water at the material to create slurry and transport the material downhill to a location for loading and transport.	**High** Hydraulicking could remove most waste rock with little residual.	**Difficult** Estimated that 800 million gallons of water would be required (Golder, 2007). Containing runoff and dewatering for transport would be difficult	**Low** Hydraulicking could be effective but is not practicable.	**No**
Dragline Excavation	Operate drag bucket with aerial cables. Commonly used in mining and dredging. Dragline operation would used aerial cables to drag a bucket down and waste rock down hill to a location for loading and transport	**Medium** Could be effective to remove large quantities of waste rock down slope. May leave significant residual material on slope. Draglines could be used to place cover fill, but would require other methods to distribute, grade, and compact. Residual waste rock on slope could be a continuing source.	**Moderately Difficult** Dragline would be moderately difficult to install and operate on the steep, rocky, and irregular slopes.	**Medium** Draglines could be effective but are moderately difficult to install and would leave residual waste rock on slopes.	**Yes**
Excavators	Excavate and move waste rock down hill to a location for loading and transport. Work on benches built across the waste rock. Excavation would start at the top and the work downward on successive benches while placing soil cover behind.	**Medium** Could be effective to move large quantities of waste rock down slope. May leave significant residual material on slope. Excavator could remove more material than dragline. Residual waste rock on slope could be a continuing source.	**Moderately Difficult** Steep slopes would make benching difficult. Delivery access for reclamation cover would be difficult.	**Medium** Excavators could be effective but are moderately difficult to operate on steep slopes. Delivery and compaction of restoration fill would be problematic.	**Yes**
Dozers	Push waste rock down slope to a location for loading and transport using dozers.	**Medium to High** Dozers could effectively push waste rock to loading locations. Dozers and loaders could be effective in placing reclamation cover. Residual waste rock on slope could be a continuing source.	**Moderately Difficult** Portions of the steep slopes would require use of winching techniques.	**High** Use of dozers could be effective and implementable.	**Yes**
Waste Rock Repositories					
Blue Ledge Mine Camp Site	Moderately sloped and heavily vegetated. Near former Blue Ledge Mine Camp Site. Estimated area of approximately 2 acres.	**Low** Area is an active landslide area and would not be stable for a repository.	**Easy** Area is close to waste rock areas and would be easy to construct.	**Low** Instability makes area unsuitable. Implications of historic structures uncertain.	**No**
South Site	Formerly cleared and minimally vegetated hillside and apparent former logging operations area of approximately 1.7 acres. Estimated haul of 0.8 miles. Possible former landslide area.	**Medium to High** Properly constructed repository above the water table on a stable slope would adequately isolate waste rock and minimize potential leaching and erosion.	**Easy** Area is close to waste rock areas and would be easy to construct.	**High** Area is nearby and south area alone may be of sufficient size to accommodate all rock.	**Yes**
North Site	Cleared ridge location and former logging operations area of approximately 0.5 acres. Estimated haul of 0.9 miles.	**Medium to High** Properly constructed repository above the water table on a stable slope would adequately isolate waste rock and minimize potential leaching and erosion.	**Easy to Moderately Difficult** Area is close to waste rock areas and would be easy to construct. North area would require significant expansion to accommodate all waste rock.	**Medium** North area alone may not be adequate without significant expansion.	**Yes**
Area near Applegate Reservoir	No specific areas are identified, although several reported logging operations areas may be suitable.	**Medium to High** Properly constructed repository above the water table on a stable slope would adequately isolate waste rock and minimize potential leaching and erosion.	**Moderately Difficult** No specific area identified. Minimum estimated haul distance is 10 miles. Additional road maintenance would be required.	**Low to Medium** Longer haul distance would result in high cost. Applicability depends on viability of other options.	**No** Unless other locations are deemed unviable.

Table 4-1
Removal Action Technology Screening
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Technology	Description	Effectiveness[1] **Low, Medium, High**	Implementability[2] **Easy to Difficult**	Applicability[3] **Low, Med, High**	Retained **Yes, No**
Repository Design Elements	Potential repository design elements typical of landfills include impermeable cap, bottom liner, AMD collection and treatment.	**High** Landfill design elements are well understood and reliable. However, these conservative design elements may not be necessary.	**Easy to Moderately Difficult** Landfill design elements are well understood and easy to construct. AMD collection and treatment would be moderately difficult due to additional operation requirements.	**Medium** Landfill design elements should be installed to isolate waste rock and minimize AMD generation in the repository.	**Yes**
Chemical Stabilization of Waste Rock in Repository	Various commercial products, lime, and industrial process byproducts have been used to neutralize pH and stabilize metals in acid forming mine wastes. Such amendments may be used to stabilize waste rock placed in repository.	**High** Placement of treated waste rock in a properly designed repository would effectively stabilize waste rock.	**Moderately Difficult** Waste rock would have to be processed and mixed with additives.	**Low to Medium** A properly designed repository would effectively isolate waste rock. Chemical treatment in addition does not appear necessary.	**No**
Nearest Landfill	Nearest commercial landfill appears to be Dry Creek Landfill located northeast of Medford.	**High** Lined landfill would effectively contain deleterious materials.	**Easy** No construction necessary. Estimated haul distance is 40 miles.	**Low** Long haul distance would result in high cost. Applicability depends on viability of other options.	**No** Unless north and south repositories become unviable.
In Situ Stabilization and Treatment of Waste Rock					
In Situ Stabilization	Waste rock stabilized in situ without additional treatment. Waste rock piles regraded in a series of benches. Runoff diversions installed to direct surface water. Cover material placed and replanted.	**Low to Medium** Physical stabilization would minimize runoff and erosion. Redirecting runoff would reduce infiltration and AMD formation, but source waste rock would remain.	**Difficult** Construction on steep hillsides difficult. Ability to achieve effective stabilization in situ uncertain.	**Low** Existing waste rock piles are eroding and unstable. Ability to stabilize waste rock long term and minimize AMD is uncertain.	**No**
In Situ Chemical Treatment	Various commercial products, lime, and industrial process byproducts have been used to neutralize pH and stabilize metals in acid forming mine wastes. Waste rock would be blended in situ to neutralize pH and sequester metals. Treatment would minimize AMD.	**Medium** The principals of stabilization and sequestration are well understood. Metals can be effectively immobilized and pH neutralized.	**Difficult** Treatment depends on adequate mixing of treatment materials and waste rock. Volume of waste rock and steep slopes make in situ treatment impractical. Slope stability is substantial concern.	**Low** Treatment techniques are well understood, but implementation is not feasible.	**No**
In Situ Stabilization and Phytoremediation	Use of plants to reduce, remove, degrade, or immobilize metals. Waste rock would be redistributed, regraded, and planted with metals and pH tolerant species. Plant community would transform to native species over time. Could be used in combination with partial removal.	**Medium** Physical stabilization would minimize runoff and erosion. Redirecting runoff would reduce infiltration and AMD formation. Designed phytoremediation would enhance effectiveness. Underflow of groundwater beneath root zone might generate AMD.	**Difficult** Construction on steep hillsides difficult. Effective stabilization in situ uncertain but unlikely. Effective development of successional vegetation is uncertain.	**Low** Ability to stabilize waste rock long term is uncertain. Reconsolidation on lower slopes and design phytoremediation may be effective. Uncertainty minimizes applicability.	**No**
Runoff Collection and Treatment					
Sedimentation Basins	Runoff would be direct through sedimentation basins to collect sediments eroded from the slopes above.	**Low to High** Principles of sedimentation are well understood. Effectiveness depends on design capacity and maintenance. Capacity and maintenance provisions should be added to improve performance over existing sedimentation basin in Area 1.	**Easy to Moderately Difficult** Construction in low-lying areas of site has been demonstrated. Construction on higher slopes would be more difficult.	**High** Sedimentation basins should be installed to minimize sediment transport in runoff.	**Yes**
Interceptor Drains	Interceptor drains consisting of porous rock would be installed at intervals along lower slopes to intercept AMD runoff. Collected AMD would be directed to passive treatment.	**Medium** Interceptor drains may effective in directing subsurface flow within waste rock to passive treatment. If so, AMD might not discharge through seeps to Joe Creek.	**Moderately Difficult to Difficult** Construction on steep hillsides moderately difficult. Configuring drains to effectively AMD may be difficult.	**Medium** AMD discharge to Joe Creek could be a continuing source of metals and acidity. Metals content of AMD under removal alternatives probably low.	**Yes**

Table 4-1
Removal Action Technology Screening
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Technology	Description	Effectiveness[1] **Low, Medium, High**	Implementability[2] **Easy to Difficult**	Applicability[3] **Low, Med, High**	Retained **Yes, No**
Open Limestone Trenches and Ponds	Limestone boulders or fragments would be added directly to channels, basins, or ponds. Limestone dissolved to produce alkalinity to buffer pH and precipitate metals.	**Low to Medium** Slow dissolution rates, burial by sediments, and transport of limestone from the channel during high flow are problems. Coating with iron precipitates may reduce contact and effectiveness. Rapid coating of limestone in existing channels at the site demonstrates the problems.	**Easy** Open ponds and trenches are easy to construct in low-lying areas, such as the location of the current log dam and limestone basin.	**Medium** Data indicate that the existing limestone ponds are not effective in reducing metals and acidity. Monitoring indicates minimal impact of the existing open limestone trenches and ponds on water quality (Elliot, 2007)	**Yes**
Anoxic Limestone Drains or Upflow Limestone Ponds	Burial of limestone in trenches or placement in submerged ponds could limit drawbacks of open channels and ponds. Buried or submerged limestone contacts AMD. Higher carbon dioxide and lower oxygen enhances limestone dissolution and minimizes iron oxidation and fouling. Ponds would be constructed to direct collected AMD upward through the bottom of the pond and through the limestone.	**Low to Medium** Design capacity and maintenance are significant issues. It may be difficult to maintain anoxic conditions in ponds during low water times of the year.	**Moderately difficult** Maintenance and sufficient summertime water to maintain submerged conditions are potential problems. Visual observation and access are advantages over buried systems.	**Medium** Ponds or drains could be targeted at specific sources such as underflow AMD or a particular seep.	**Yes**
Bioswales and Constructed Wetlands	Biological treatment consists of a series of shallow ponds planted with emergent wetland plants. Microbe-plant associations remove dissolved metals. Treatment is passive, requiring minimal continuing maintenance.	**Medium** Constructed wetlands are demonstrated effective at buffering pH and removing metals. Greatest utility appears for small flows. Very high flows common during rain-on-snow events or summer storms and cold winter temperatures may limit treatment efficiency. Treatment processes are complex and variable. Maintenance may be required.	**Easy to Moderately Difficult** Initial design and construction costs may be significant. May not be sufficient area to construct wetland of adequate capacity.	**Medium to High** May be the most effective AMD and runoff treatment technology for runoff and AMD.	**Yes**
Soil cover and Revegetation	Soil cover would isolate and minimize erosion of residual waste rock. Vegetation would control soil erosion, encourage soil development, and create aesthetically pleasing landscape.	**Medium** Effectiveness depends on proper placement of suitable cover and selection and placement vegetation species that are compatible with the conditions. Ability to place and maintain effective cover and vegetation uncertain.	**Easy to Moderately Difficult** Placement of soil on steep hillsides moderately difficult.	**High** Soil cover and revegetation provides utility and aesthetics.	**Yes**
Active AMD and runoff treatment	AMD and runoff would be collected and treated using conventional technologies to the extent practical. Conventional technologies include pH adjustment, metals precipitation, and solids management.	**Low to High** Effectiveness depends on design capacity. A system could not be reasonably designed with capacity for high flows resulting from rain-on-snow or summer storms.	**Difficult** Siting, design, construction, and operation would be difficult and extremely expensive in this remote location.	**Low** Active conventional treatment is not a viable alternative.	**No**
Reclamation Cover					
Reclamation Fill and Planting	Clean fill from a local source would be placed on slopes were waste rock was removed. Reclamation fill would be placed and graded into a series of benches. Runoff diversions would be installed to direct surface water. Cover material would be planted with native species.	**High** A well-established and stable reclamation cover would minimize erosion and leaching and would be aesthetic.	**Moderately Difficult to Difficult** Moderately difficult construction on steep hillsides at the site.	**High** URS assumes that reclamation cover is likely if the waste rock removal is the selected technology.	**Yes**

Table 4-1
Removal Action Technology Screening
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Technology	Description	Effectiveness[1] **Low, Medium, High**	Implementability[2] **Easy to Difficult**	Applicability[3] **Low, Med, High**	Retained **Yes, No**
No Action	No reclamation cover.	**Low** Absence of cover would allow continued erosion and transport of residual waste rock down slope to Joe Creek. Effectiveness depends on completeness of waste rock removal and susceptibility of underlying rock and surrounding areas to erode.	**Easy** No action necessary.	**Medium** Effectiveness assumes that residual waste rock would be a continuing source.	**No** Unless employed in as part of a stepwise evaluation.
Adit Closure					
Sealing	Adits can be sealed with plugs, walls, or dams or backfilled with native or imported materials.	**Medium** Sealing prevents access by people but also prevents access by wildlife. Sealing may result in accumulation of AMD in mine workings that could cause AMD formation and discharge elsewhere.	**Easy** A variety of methods are routinely implemented at abandoned mines.	**Low** The long term benefits of sealing have not been investigated.	**No**
Gates	Gates can be fixed or movable.	**High** Gates prevent access by people but allow access by wildlife.	**Easy** A variety of gates are routinely implemented at abandoned mines.	**High** Gates are a good option to allow wildlife use, limit access by people, and minimize physical hazards to people.	**Yes**
Fences	Fences installed to block access to mines by people.	**Low to Medium** Fences are minimally effective in preventing access by people and tend to be damaged over time.	**Easy** Fences are easy to construct.	**Low** Fences require ongoing maintenance, have low likelihood of preventing access by humans, and restrict wildlife mobility.	**No**

NOTES:

1 Preliminary effectiveness ratings of high, medium, and low reflect estimated relative effectiveness of the technology to treat the site contaminants and meet RAOs.

2 Implementability rating of easy, moderately difficult, and difficult reflects estimated relative complexity and cost of implementing the technology.

3 Applicability reflects the relative overall relevance of the technology to the site. Low applicability indicates low effectiveness or severe constraints to implementation. Uncertainty rating reflects additional data needs or technology development needed to demonstrate applicability.

Table 6-1
Summary of Removal Action Alternatives
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Alternative	Actions	Comparison Summary (elements in addition to alternative above)	Cost	Comments on advantages and limitations regarding protectiveness, effectiveness, implementability and reliability
No Action	• Monitoring, reporting and road maintenance	• Performance monitoring and reporting • Road maintenance for access	$0.14 M	Resource not protected. Ongoing ecological and human health risk not mitigated.
Alternative 1 Waste rock removal. Unlined repository with GCL and soil cover at local site.	• Design, specifications, contracting • Waste rock removal with dozers, excavators, and drag lines • Unlined repository with GCL and soil cover at local site • Sedimentation basins, bioswales • Reclamation fill and planting • Adit closure with bat gates • No groundwater treatment • Performance monitoring and reporting	• Includes elements of No Action alternative. • Primary design elements are waste rock removal, repository, reclamation fill and planting, and passive leachate and runoff treatment.	$15.99 M	Removing the waste rock would eliminate most of the primary sources of contamination, presumably resulting in a protective and effective remedy. Reliability of unlined and uncapped repository is medium to high. Residual waste rock could continue to erode and leach metals. Alternative provides minimal leachate treatment.
Alternative 2 Waste rock removal. Lined and capped repository with leachate treatment at local site.	• Design, specifications, contracting • Waste rock removal with dozers, excavators, and drag lines • Lined and capped repository with leachate treatment at local site • Sedimentation basins, bioswales and constructed wetlands • Reclamation fill and planting • Adit closure with bat gates • Performance monitoring and reporting	• Includes elements of No Action alternative. • Lined and capped repository is more complex. • Constructed wetland added to leachate and runoff treatment. • More intensive O&M due to added passive treatment.	$17.65 M	Removing the waste rock would eliminate most of the primary sources of contamination, presumably resulting in a protective and effective remedy. Reliability of lined and capped repository is high. Additional passive treatment of leachate and runoff, as compared to Alternative 2 increases protectiveness and reliability. Implementability of constructed wetlands for leachate treatment is uncertain due to space constraints and possible capacity constraints during high flows.
Alternative 3 Waste rock removal. More distant repository or landfill disposal.	• Design, specifications, contracting • Waste rock removal with dozers, excavators, and drag lines • More distant repository or landfill disposal • Sedimentation basins, passive treatment, bioswales and constructed wetlands. • Reclamation fill and planting • Adit closure with bat gates • Performance monitoring and reporting	• Includes elements of No Action alternative. • More distant repository or landfill disposal increases disposal costs.	$19.65 M	Removing the waste rock would eliminate most of the primary sources of contamination, presumably resulting in a protective and effective remedy. Reliability of lined and capped off-site repository or landfill is high. Need for off-site repository of landfill depends on availability and suitability of local repository site.

Table 6-2
Summary of Alternative Costs
Preliminary Removal Action Costs
Blue Ledge Mine

	Item	No Action	Alt 1	Alt 2	Alt 3
line	**Capital Costs**				
1	Waste Rock Removal (incl. roads, mobe, demobe)	$0	$5,672,000	$5,765,000	$5,765,000
2	Repository and Disposal	$0	$1,377,000	$1,555,000	$3,825,000
3	Leachate and Runoff Collection and Treatment (passive)	$0	$300,000	$350,000	$350,000
4	Reclamation Cover	$0	$1,551,000	$1,551,000	$1,551,000
5	Adit Closure	$0	$160,000	$160,000	$160,000
6	Construction Mgmt, Engineering, Consulting, Construction Completion report	$0	$1,669,000	$1,963,000	$1,669,000
7	Construction Management	$0	$365,000	$487,000	$365,000
8	IQAT	$0	$428,000	$571,000	$428,000
9	Operation and Maintenance	$18,000	$360,000	$585,000	$423,000
10	Monitoring and Reporting	$105,000	$150,000	$300,000	$255,000
11	Subtotal	$123,000	$12,032,000	$13,287,000	$14,791,000
12	Contingency (%)	0%	20%	20%	20%
13	Contingency ($)	$0	$2,406,400	$2,657,400	$2,958,200
14	Prime Fee on Subs (5.45%)	$6,704	$786,893	$868,970	$967,331
15	Forest Service Oversight (5% on capital costs)	$6,000	$761,000	$841,000	$936,000
16	Subtotal	$13,000	$3,954,000	$4,367,000	$4,862,000
17	**Total Alternative Cost**	$0.14 M	$15.99 M	$17.65 M	$19.65 M

Notes:
Alternatives assembled to demonstrate a range in costs.
No Action: Long term monitoring and performance evaluation.
Alternative 1: Waste rock removed with dozers and excavators. Unlined repository. Partial revegetation and leachate treatment by sedimentation basins.

Alternative 2: Waste rock removed with dozers and excavators. Lined and capped repository. Revegetation and leachate treatment by sedimentation basins and constructed wetland.

Alternative 3: Waste rock removed with dozers and excavators. Landfill disposal. Revegetation and leachate treatment by sedimentation basins and constructed wetlands.

TABLE 6-3

Summary of NCP Removal Action Factors
40 CFR 300.415(b) (2)
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Factor	Site Condition	Justification[1]
1) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants	• Groundwater is used for drinking water but impacts are uncertain. • Surface water is used for gardening and as a water supply for domestic animals. • Metals concentrations in soil, surface water, and groundwater exceed risk-based concentrations protective of ecological receptors. • Groundwater discharges from seeps and adits are present at high concentrations that result in an unacceptable risk to human and ecological receptors. • Survey results indicate that metals from the Site are impacting the macroinvertebrate community of Joe Creek.	Yes
2) Actual or potential contamination of drinking water supplies or sensitive ecosystems	• Groundwater is used for drinking water, but impacts are uncertain. • Groundwater discharges from seeps and adits are present at high concentrations that result in an unacceptable risk to human and ecological receptors. • Humans routinely contact surface water in Joe Creek and Elliott Creek. • Ecological receptors within Joe Creek exposed to contamination. • Within a sensitive ecosystem (Northern Goshawk, Northern Spotted Owl, Siskiyou Mountain Salamander)	Yes
3) Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers, that may pose a threat of release.	• No drums or barrels located at site.	No
4) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate	• Waste rock is rich in arsenic, copper, cadmium, lead and zinc. • Erosion and leaching transport metals from waste rock piles resulting in unacceptable metals concentrations in surface water, groundwater, soil, and sediment.	Yes

TABLE 6-3

Summary of NCP Removal Action Factors
40 CFR 300.415(b) (2)
Engineering Evaluation and Cost Analysis
Blue Ledge Mine

Factor	Site Condition	Justification[1]
5) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released	• Heavy rains and spring runoff cause erosion and leaching of pollutants resulting in unacceptable metals concentrations in surface water, groundwater, soil, and sediment.	Yes
6) Threat of fire or other explosion	• The site contaminants do not cause threat of fire or explosion.	No
7) The availability of other appropriate federal or state response mechanisms to respond to the release	• N/A	No
8) Other situations or factors that may pose threats to public health or welfare of the United States or the environment	• Steep waste rock piles cause physical hazard. • Mine adits cause physical hazard.	No

Notes:

[1] Yes justification means factor provides compelling rationale for the removal action.

FIGURES

Source: Grants Pass, Oregon USGS 100K Topo Quad, 1984.
Happy Camp, California USGS 100K Topo Quad, 1984.

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Vicinity Map

US Forest Service
Blue Ledge Mine
Rogue River-Siskiyou National Forest

Figure 1-1

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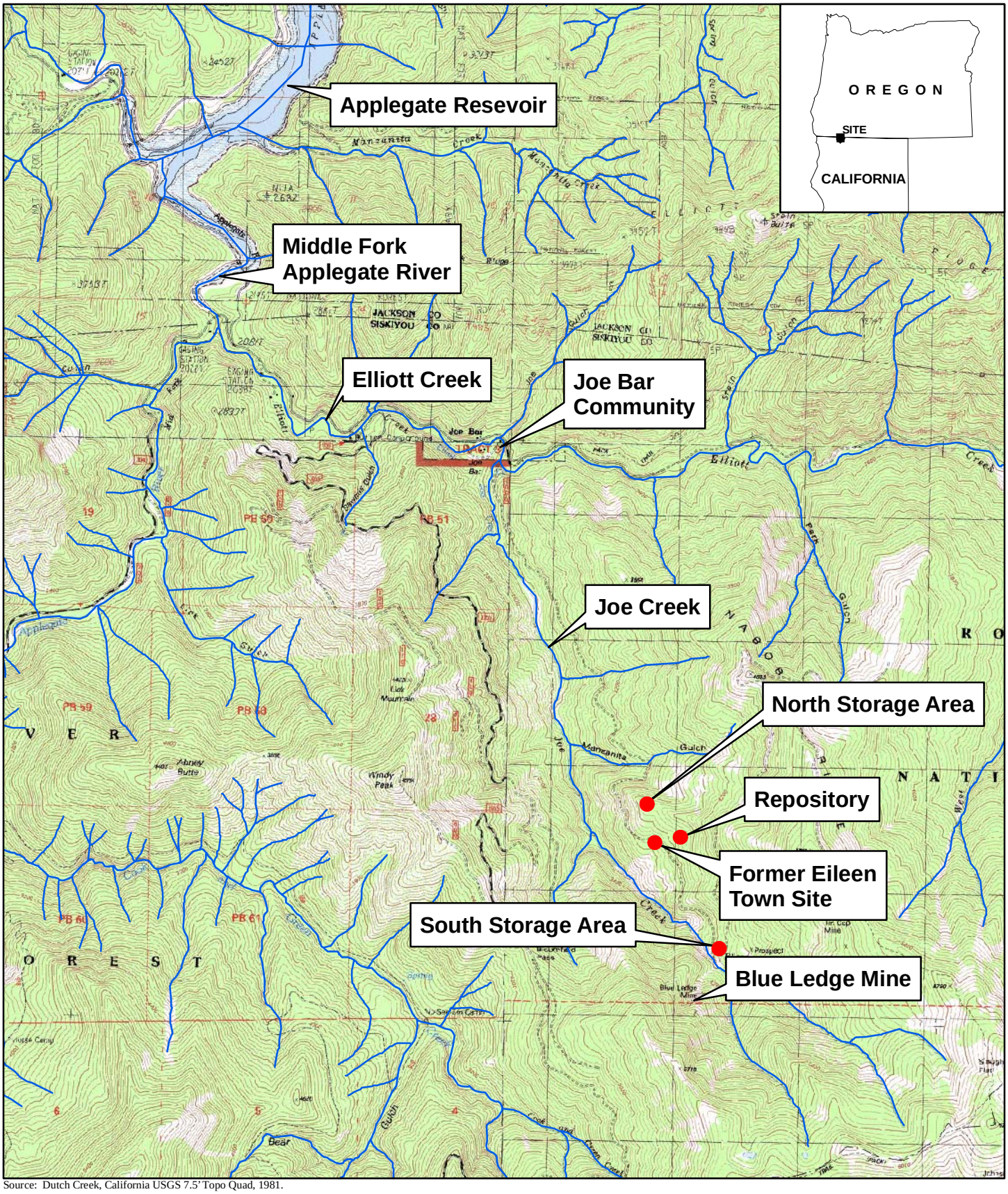

Source: Dutch Creek, California USGS 7.5' Topo Quad, 1981.
Kangaroo Mountain, California USGS 7.5' Topo Quad, 1981.
Squaw Lakes, Oregon USGS 7.5' Topo Quad, 1983.
Carberry Creek, Oregon USGS 7.5' Topo Quad, 1983.

0 0.5 1 Miles

Site Surroundings

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US Forest Service
Blue Ledge Mine
Rogue River-Siskiyou National Forest

Figure 1-2

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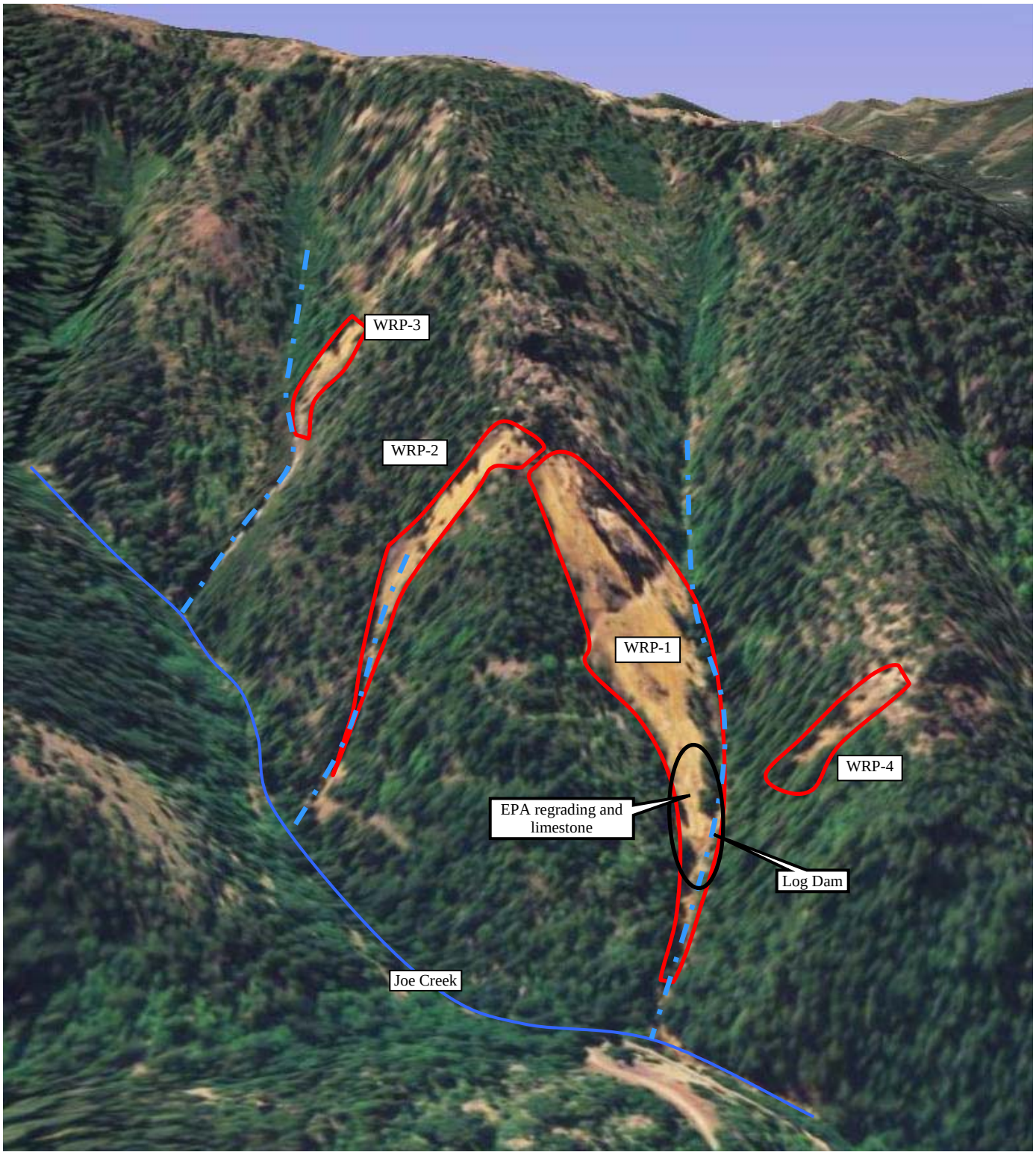

N

Creek

Ephemeral Drainageway

Waste Rock Areas

US Forest Service

April 2010 Blue Ledge Mine

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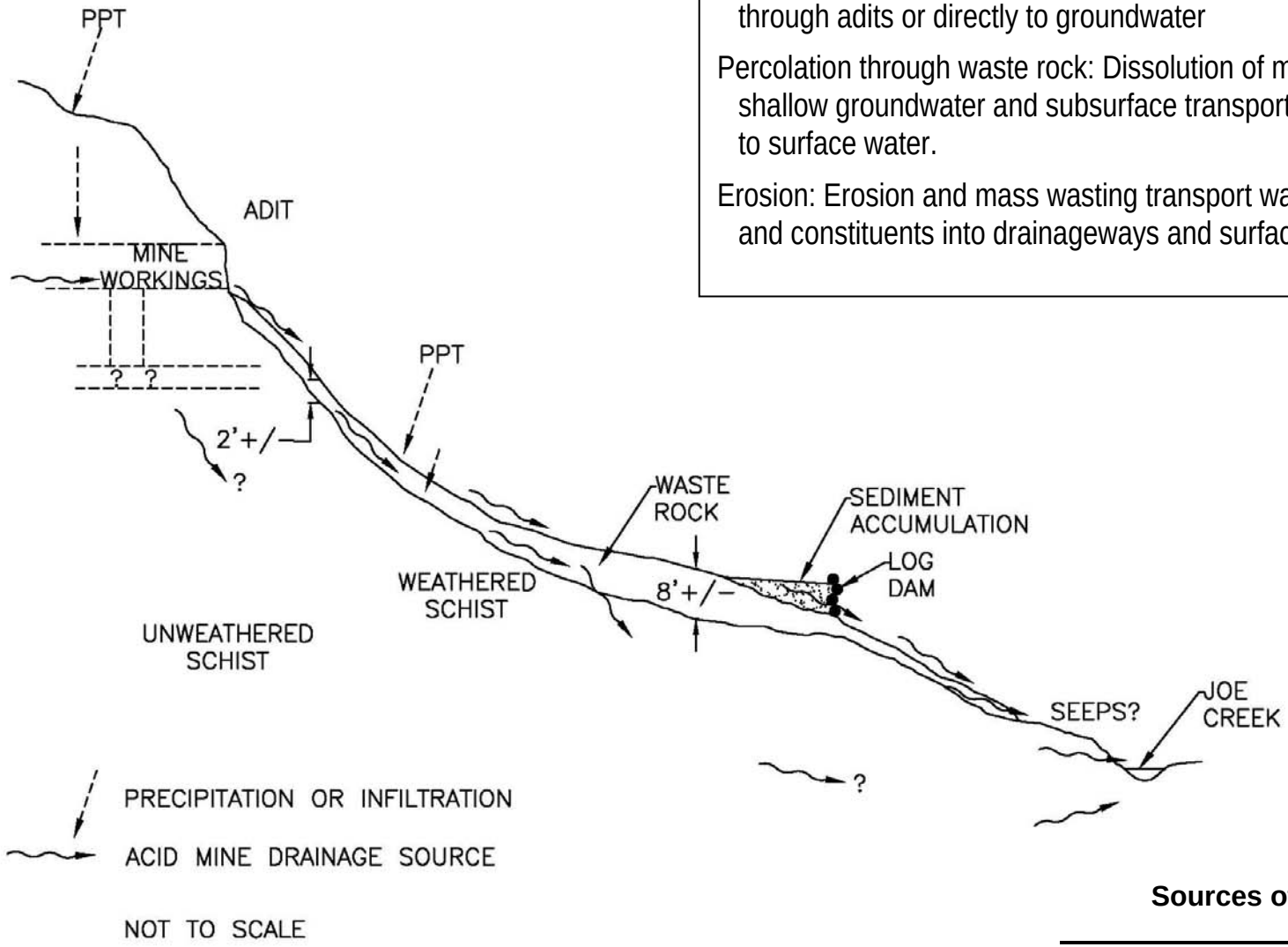
Figure 1-3

AMD AND TRANSPORT

Mine Workings: percolation of precipitations and discharge through adits or directly to groundwater

Percolation through waste rock: Dissolution of metals into shallow groundwater and subsurface transport to seep or to surface water.

Erosion: Erosion and mass wasting transport waste rock and constituents into drainageways and surface water.



Sources of AMD and Conceptual Hydrogeologic Model

US Forest Service
Blue Ledge Mine
Rogue River-Siskiyou National Forest

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Figure 2-1

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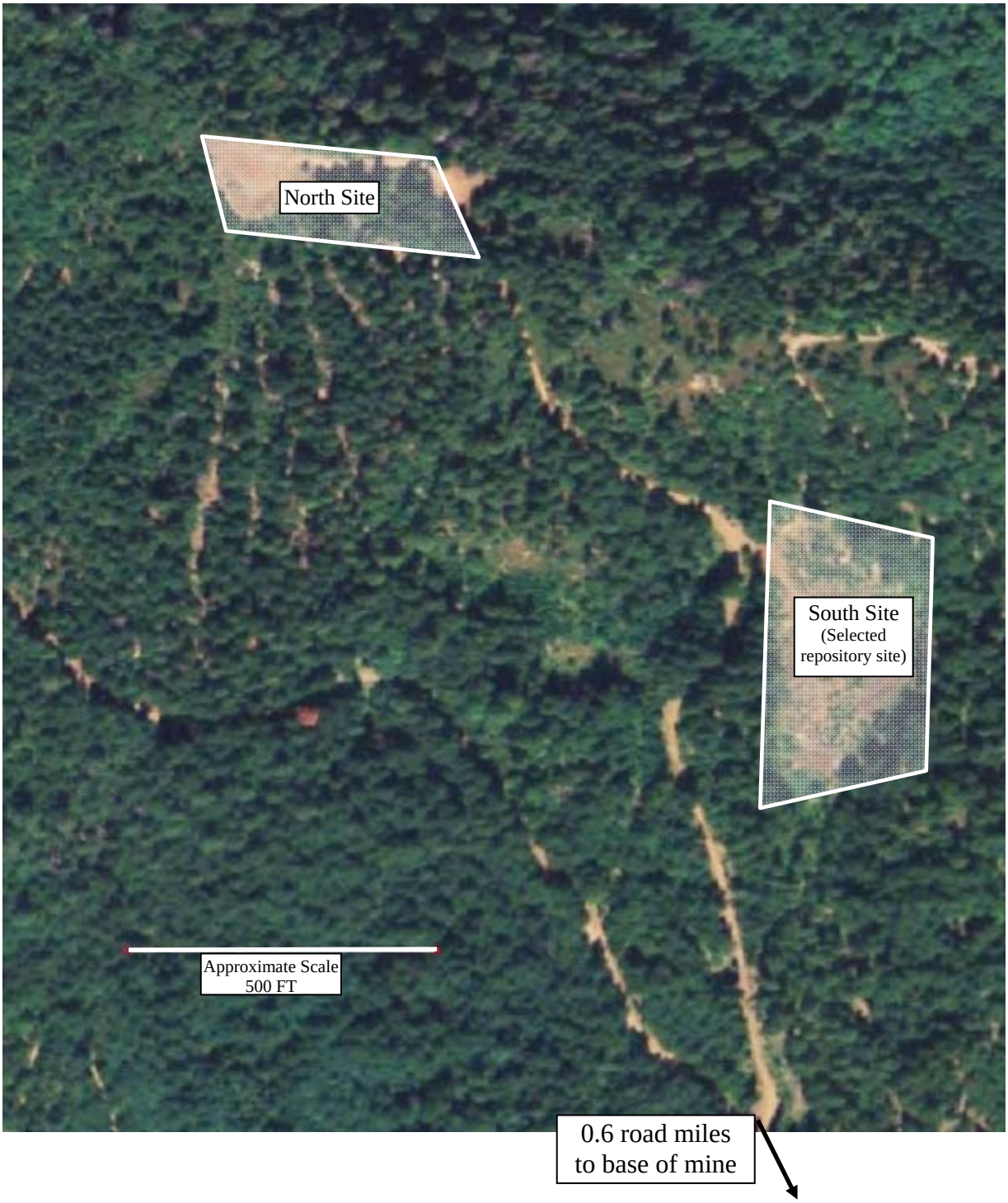

Alternative Waste Rock Repository Locations

US Forest Service
Blue Ledge Mine
Rogue River-Siskiyou National Forest

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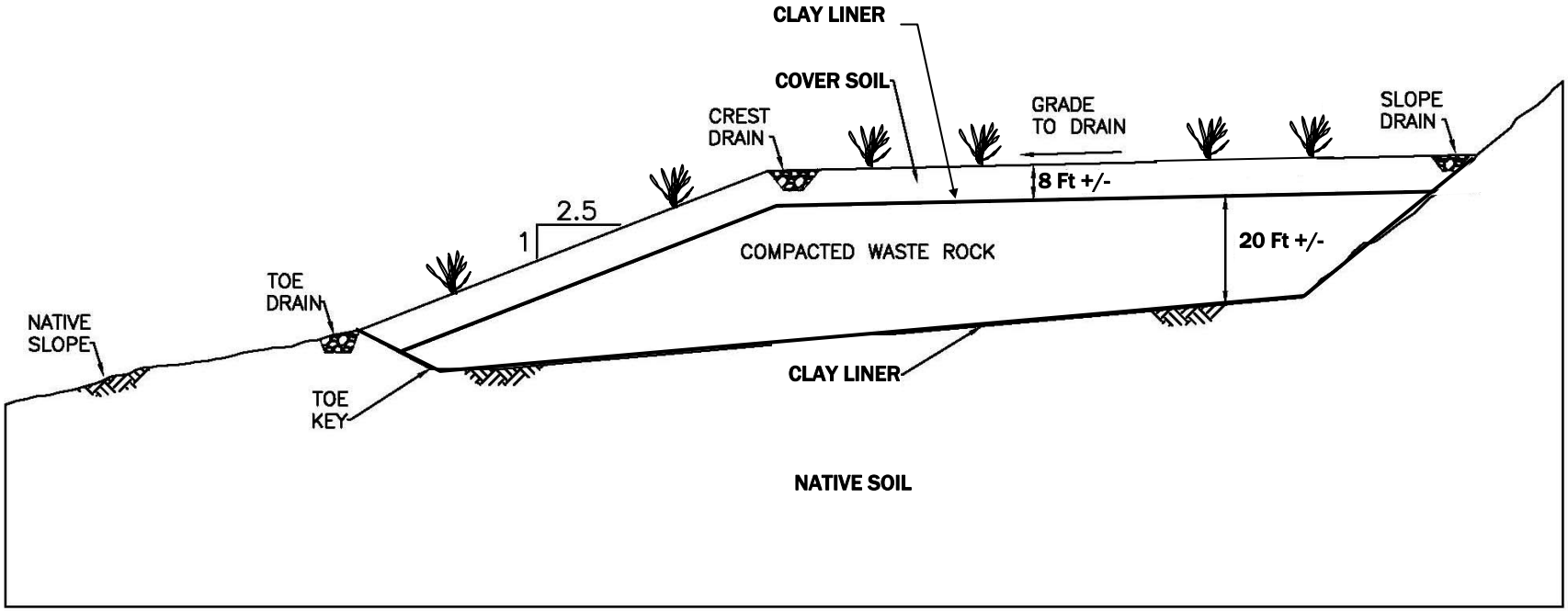
Figure 4-1



TYPICAL SECTION
NOT TO SCALE

Repository Site Schematic

US Forest Service
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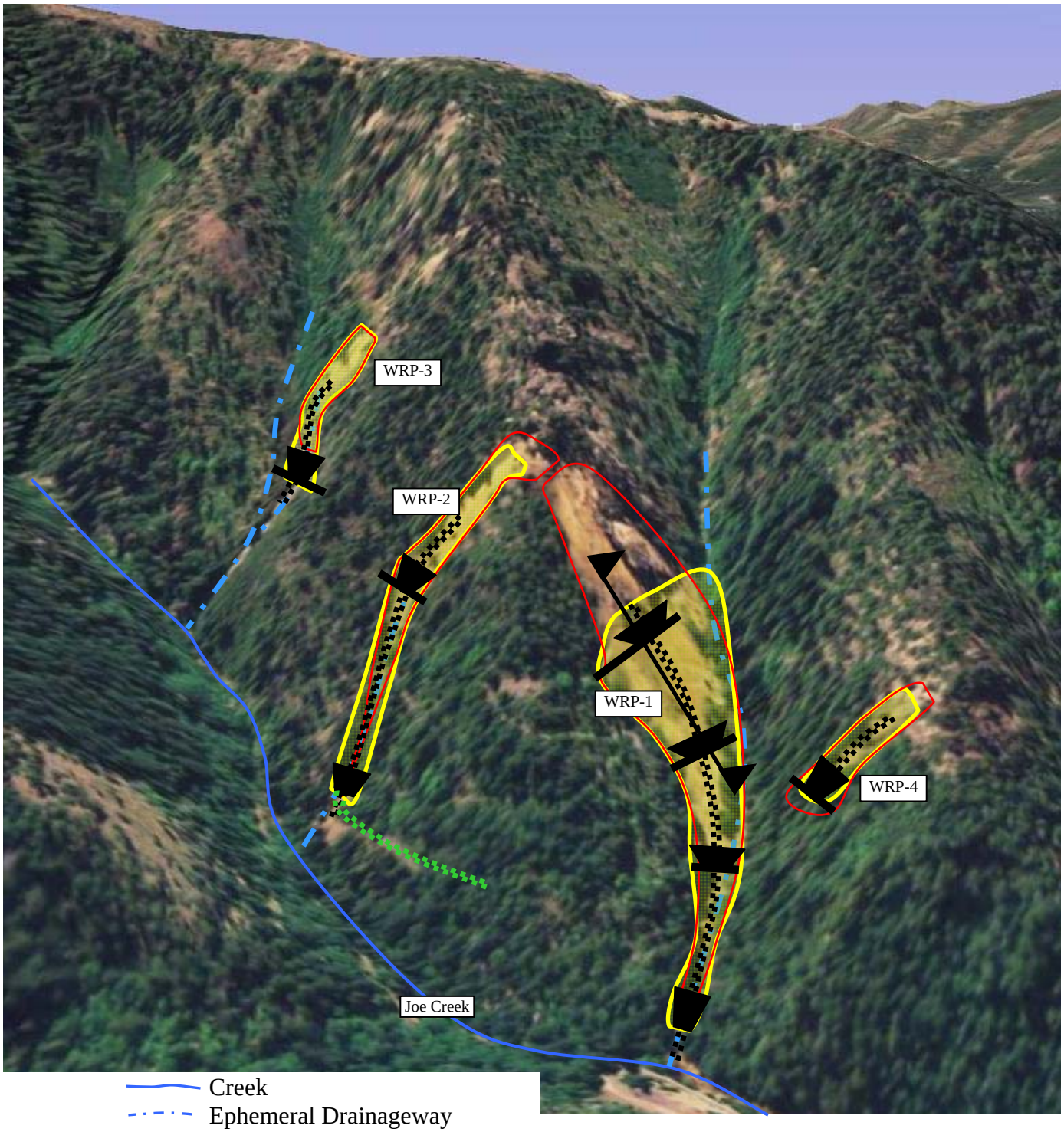
Figure 4-2



Creek
Ephemeral Drainageway
Waste Rock Area
Reclamation Area
Sedimentation Basin
Sedimentation Basin and Terrace
Armored Reclamation Channel
Locations and dimensions are approximate

Treatment Swale

Conceptual Reclamation Section (Fig. 4-4)

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Concept Reclamation Areas
US Forest Service
Blue Ledge Mine
Rogue River-Siskiyou National Forest

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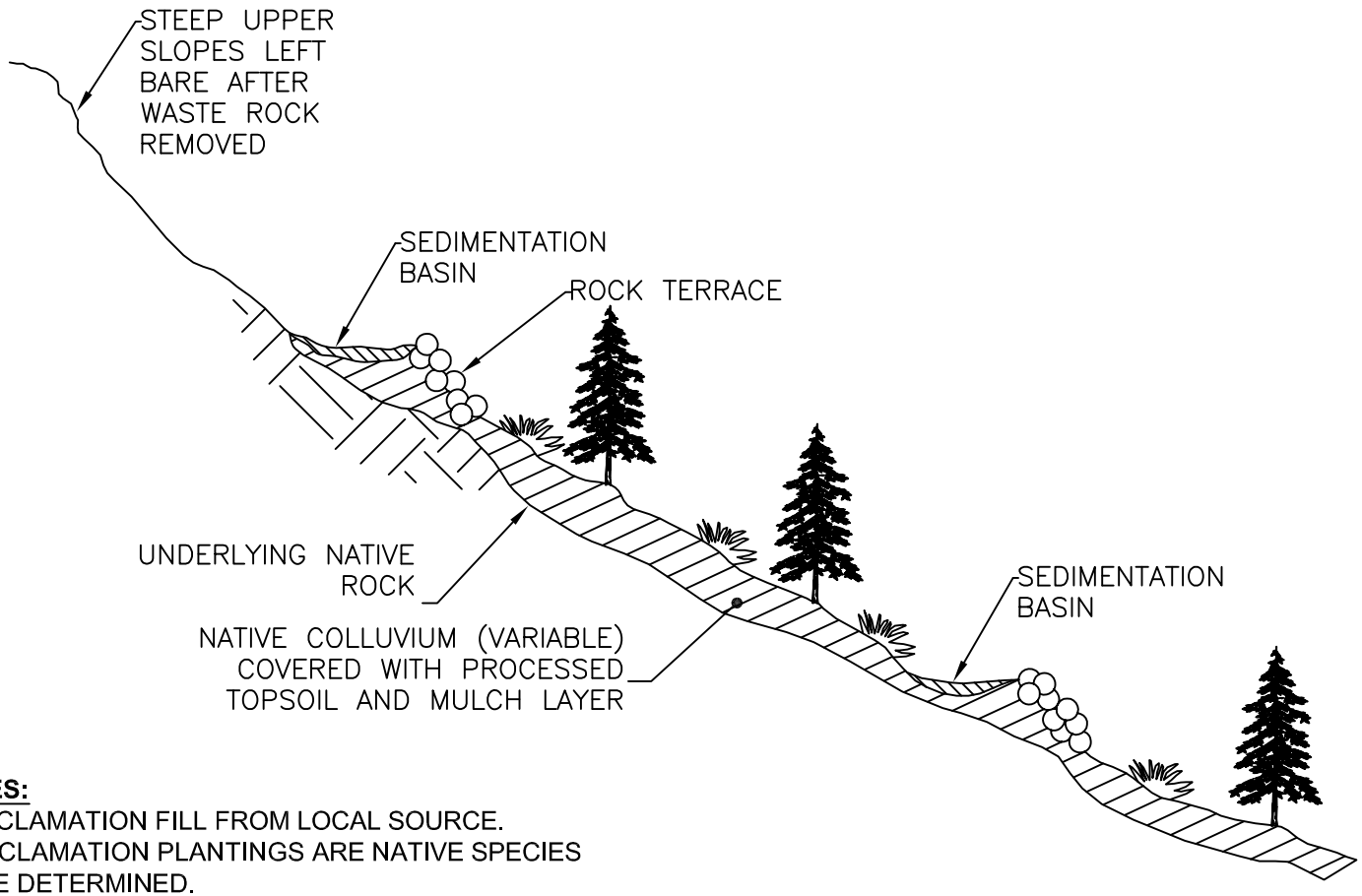
25696770

Figure 4-3



NOTES:
1. RECLAMATION FILL FROM LOCAL SOURCE.
2. RECLAMATION PLANTINGS ARE NATIVE SPECIES TO BE DETERMINED.

NOT TO SCALE
SEE FIGURE 4-3 FOR SECTION LOCATION

Concept Reclamation Section

US Forest Service
Blue Ledge Mine
Rogue River-Siskiyou National Forest

April 2010
25696770

URS

Figure 4-4

O:\25696770 Blue Ledge Mine\4000 Deliverables\EE-CA\Figures\CAD\Fig4-4.dwg Apr 21, 2010 - 5:57pm

URS	Appendix A: Photographic Log	
United States Forest Service	Blue Ledge Mine near Jacksonville, OR	Job No. 25696770

Photo No. 1	June 2008

Description:

Confluence of the Applegate River (right) and Elliott Creek. Stream flow measurements taken above and below confluence.

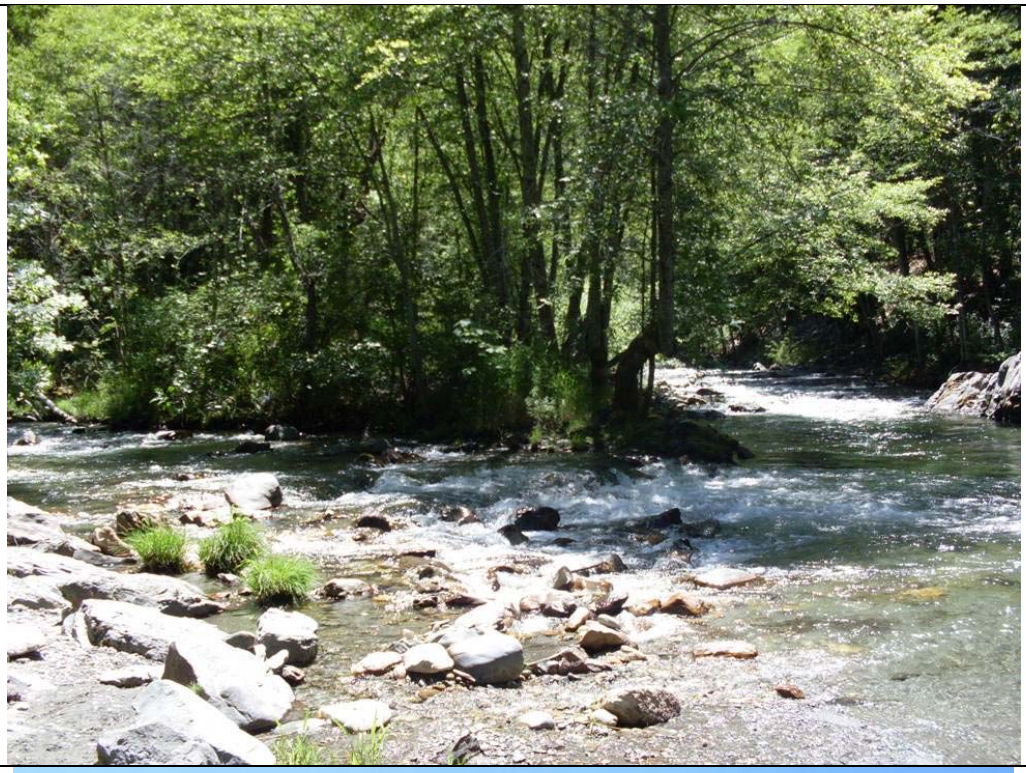


Photo No. 2	June 2008

Description:

View of Blue Ledge Mine from the old Eileen town site. WRP-1 (main pile).

Photo No. 3	June 2008
Description: View from the top of Blue Ledge Mine. Waste rock is visible in the foreground; adits 4A and 4b are present on the opposite hillside (not visible in this photo).	

Photo No. 4	June 2008
Description: Mid slopes of WRP-1 downhill from access road. Log dam and EPA regrading at bottom.	

Photo No. 5	August 2008
Description: Steep waste rock in chute west of WRP-1.	

Photo No. 6	June 2008

Description:

Mid slopes of WRP-1 (main pile) and rock outcrop. The large outcrop at top right borders the access road.

Photo No. 7	June 2008

Description:

Steep upper slopes of WRP-1, viewed from the access road.

Photo No. 8	June 2008

Description:

Steep upper slopes of WRP-1 viewed from the top near adits. Old town site visible in top right corner.

Photo No. 9	June 2008

Description:

Access road on WRP-1.

Photo No. 10	June 2008
Description: WRP-2 from bottom. Second largest waste rock pile.	

Photo No. 11	June 2008
Description: WRP-2 from top. Similar elevation to top of main waste rock, further east.	

Photo No. 12	August 2008

Description:

Log dam and limestone boulders. Near bottom of WRP-1.

Photo No. 13	June 2008

Description:

Anoxic sediment from Joe Creek.

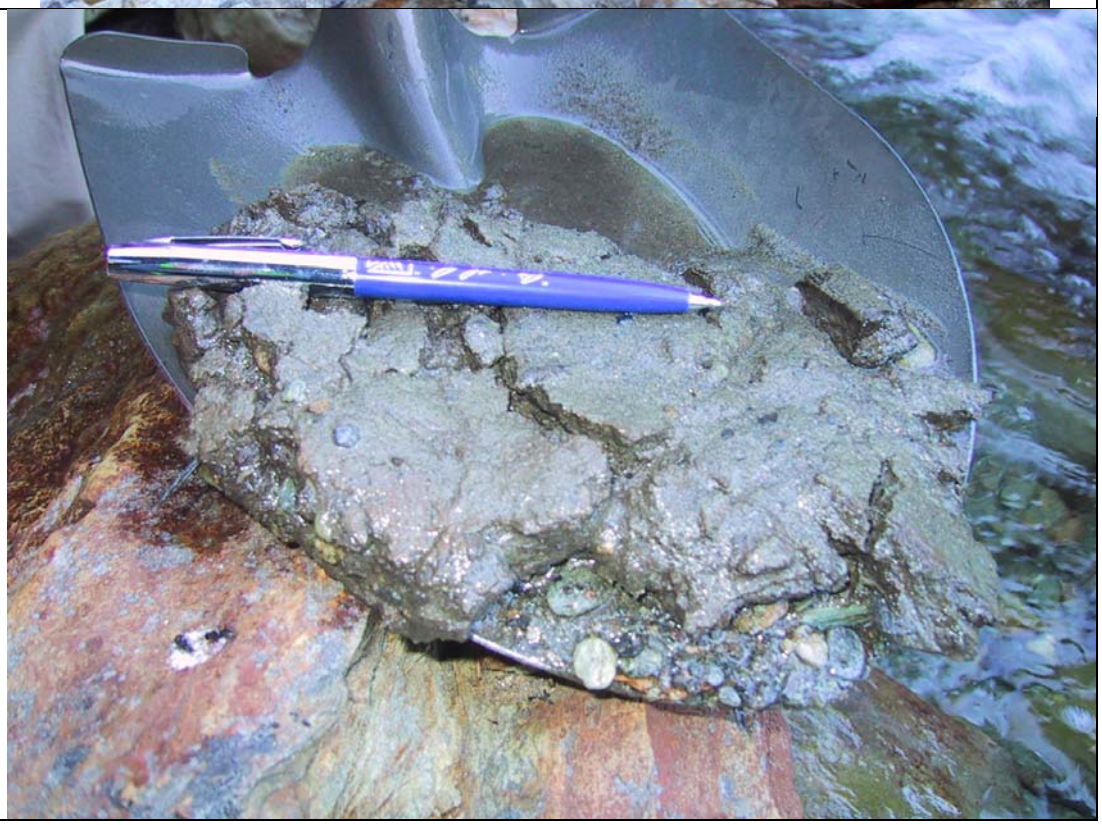


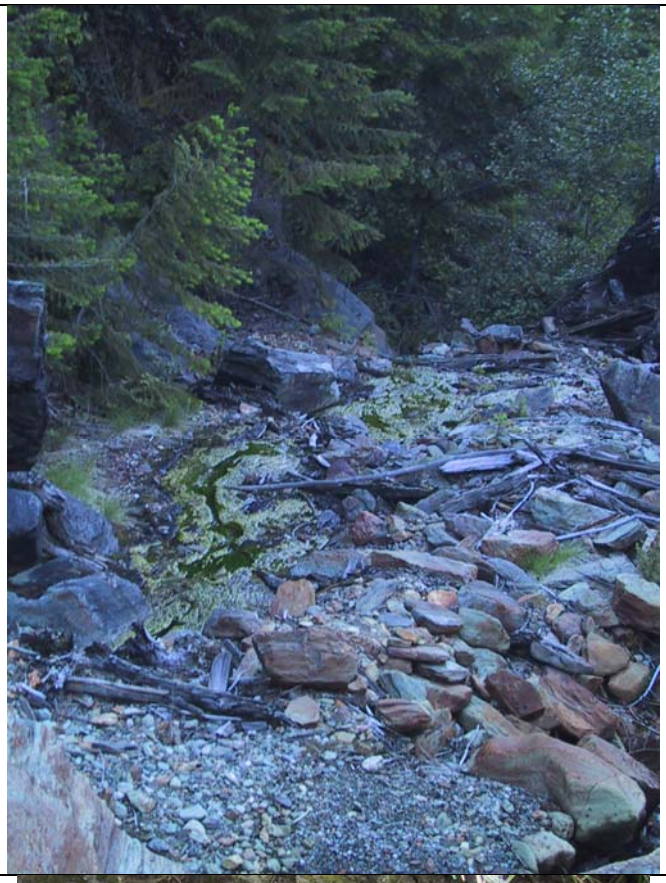
Photo No. 14	June 2008	
Description: Stream conditions in Joe Creek.		
Photo No. 15	June 2008	
Description: Discolored groundwater from seep near Joe Creek.		

Photo No. 16	August 2008

Description:

Stained rock in drainage below log dam.

Photo No. 17	June 2008

Description:

EPA lined channel, regrading, and sedimentation basin.

Photo No. 18	June 2008

Description:

EPA lined channel, regrading, and sedimentation basin.

Photo No. 19	August 2008

Description:

Marble rock blinded by mineral deposits.

Photo No. 20	August 2008

Description:

Sedimentation basin filled with sediment.

Photo No. 21	June 2008

Description:

Adit 1B, along path that leads to waste rock access road. Water flows out to WRP-1 west chute and down hillside.

Photo No. 22	August 2008

Description:

Adits 4a (productive) and 4b (exploratory).

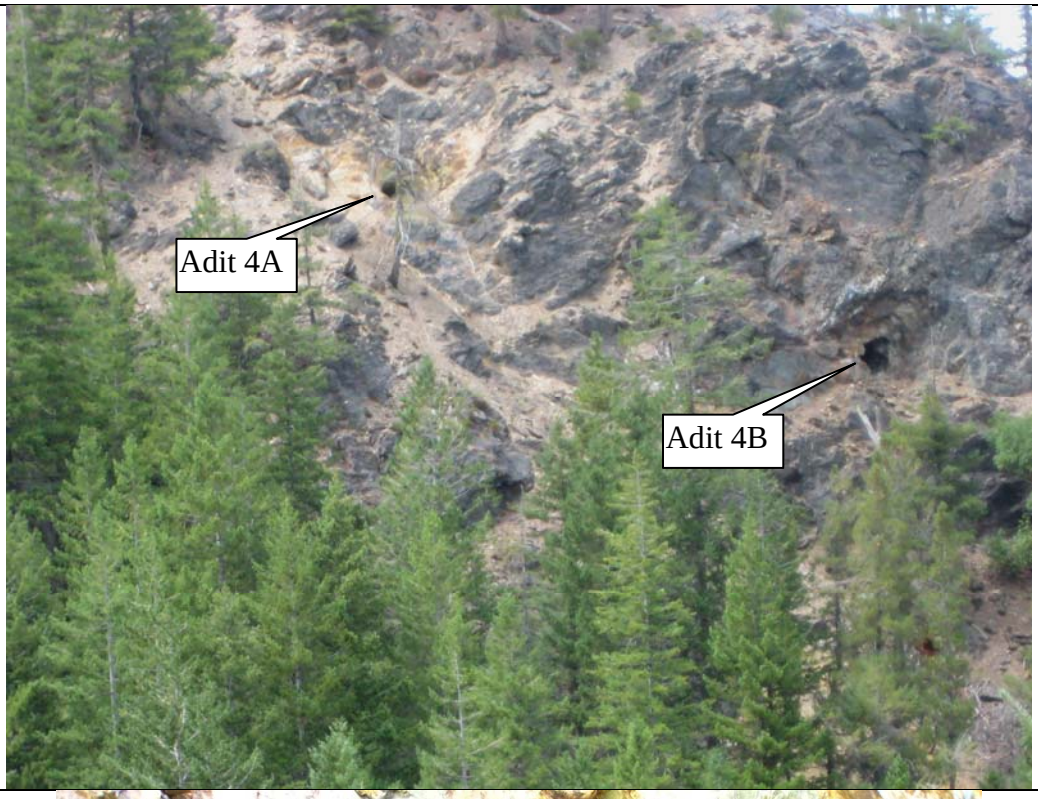


Photo No. 23	June 2008

Description:

Typical Adit.

Photo No. 24	June 2008

Description:

Typical Adit.

Photo No. 25	June 2008

Description:

Typical Adit.

Photo No. 26	June 2008

Description:

Typical Adit.

Photo No. 27	August 2008

Description:

WRP-1 eroded to underlying bed rock.

Photo No. 28	August 2008
Description: WRP-1 eroded to underlying bed rock.	

Photo No. 29	June 2008
Description: Typical waste rock in situ.	

Photo No. 30	July 2008

Description:

Excavations at north repository site.

Photo No. 31	July 2008

Description:

North repository site.

Photo No. 32	July 2008
Description: Southeast slopes of north repository site.	

Photo No. 33	August 2008
Description: South repository site.	

Photo No. 34	June 2008

Description:

View of Applegate Lake.

Memorandum

URS

To: Blue Ledge Mine Project Team

From: Brad Rawls

Date: January 2, 2009

Subject: Summary of aquatic macroinvertebrate sampling

BACKGROUND

As part of the EE/CA process, URS collected aquatic macroinvertebrates to support the screening-level human health risk assessment and the screening-level ecological risk assessment and to supplement existing baseline data on benthic community composition in the Elliot Creek drainage. The number, distribution, and species composition of aquatic macroinvertebrates have been demonstrated to be reliable indicators of water quality and general stream health (Barbour, et al, 1999). Aquatic macroinvertebrates were collected from four locations in the project area. The sampling locations were designed to allow assessment of benthic community composition in response to water quality parameters, including the presence of metals in runoff from waste rock piles associated with the Blue Ledge Mine site.

SAMPLING DESIGN

Aquatic macroinvertebrate collection occurred on September 9, 2008. The sites were established to allow paired comparison between benthic communities downstream and upstream of potential mine runoff influences. The four sites sampled are as follows:

1. Elliott Creek downstream from the confluence with Joe Creek.
2. Elliott Creek upstream from the confluence with Joe Creek.
3. Joe Creek downstream of mine runoff contribution.
4. Joe Creek upstream of mine runoff contribution.

Figure 1 shows the sample locations.

Samples were collected in accordance with the EPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition* (Barbour, et al, 1999). Each sample was comprised of the composite of five subsamples (or "kicks"). This method achieves statistical significance by holding uniform the area surveyed and the effort (time) expended per unit area. A 12-inch diameter, 500-micron mesh size D-net was used to collect specimens. Each kick comprised a sample area of one square foot, totaling five square feet representing the sample location. Kicks were collected in suitable riffle, rapid, or cascade stream habitat types. Two kicks each were collected from areas near the right and left streambanks and one subsample was collected from a mid-channel location. The five kicks were combined into a single "composite" sample representing the entire sample location.

Specimen collection consisted of holding the base of the D-net to the stream substrate, facing upstream into the stream current, and gently scrubbing gravels and cobbles with a soft nylon brush in the net opening. Organic matter, such as leaves, twigs, and branches were scrubbed in a similar manner. The surface benthos was then disturbed in the fixed area by gently brushing the substrate towards the net opening. Finally, a small pry bar was used to disturb the benthos by loosening buried benthic material. All material collected in the net was then transferred to a sterile 1-liter Nalgene bottle. The net was carefully cleaned using forceps and/or a squirt bottle to remove attached organisms. All collected specimens were preserved in 90% ethanol.

Samples were shipped to Rhithron Associates, Inc. of Missoula, Montana for analysis. The laboratory typed specimens to the highest taxonomic classification possible and constructed a Benthic Index of Biotic Integrity (B-IBI) to analyze sample locations against each other and expected conditions, based on watershed disturbance. Raw sampling results and the B-IBI are summarized in Appendix B of this report.

RESULTS

The results of the survey indicate that macroinvertebrate communities in Joe Creek downstream of the waste rock piles are significantly degraded, as compared to the upstream control sample. . Differences in community are largely between species that are susceptible to metals toxicity and water temperature. Because water temperature was similar between sites, the results indicate that metals contamination from the mine site is adversely impacting the macroinvertebrate community in Joe Creek.

Macroinvertebrate communities in Elliott Creek varied slightly between samples collected downstream of the confluence with Joe Creek and the control located upstream. Community response gives no clear indication that assemblages were responding to the presence of metals. While this does not rule out an influence from metals, metrics were not sensitive enough to make such a correlation.

CONCLUSIONS

The aquatic macroinvertebrate survey clearly indicates that discharges from the mine (i.e., sediment erosion, surface water discharge, and/or groundwater discharge) are impacting aquatic biota assemblages in Joe Creek. Species composition, total numbers of a species, trophic distribution, and diversity of species all show a response to water quality impairment. Impacts to Elliott Creek are uncertain. Variations within Elliott Creek aquatic macroinvertebrate assemblages were not statistically significant; as such, analytical models were unable to discern if aquatic macroinvertebrate assemblages were responding to water quality contributed by Joe Creek.

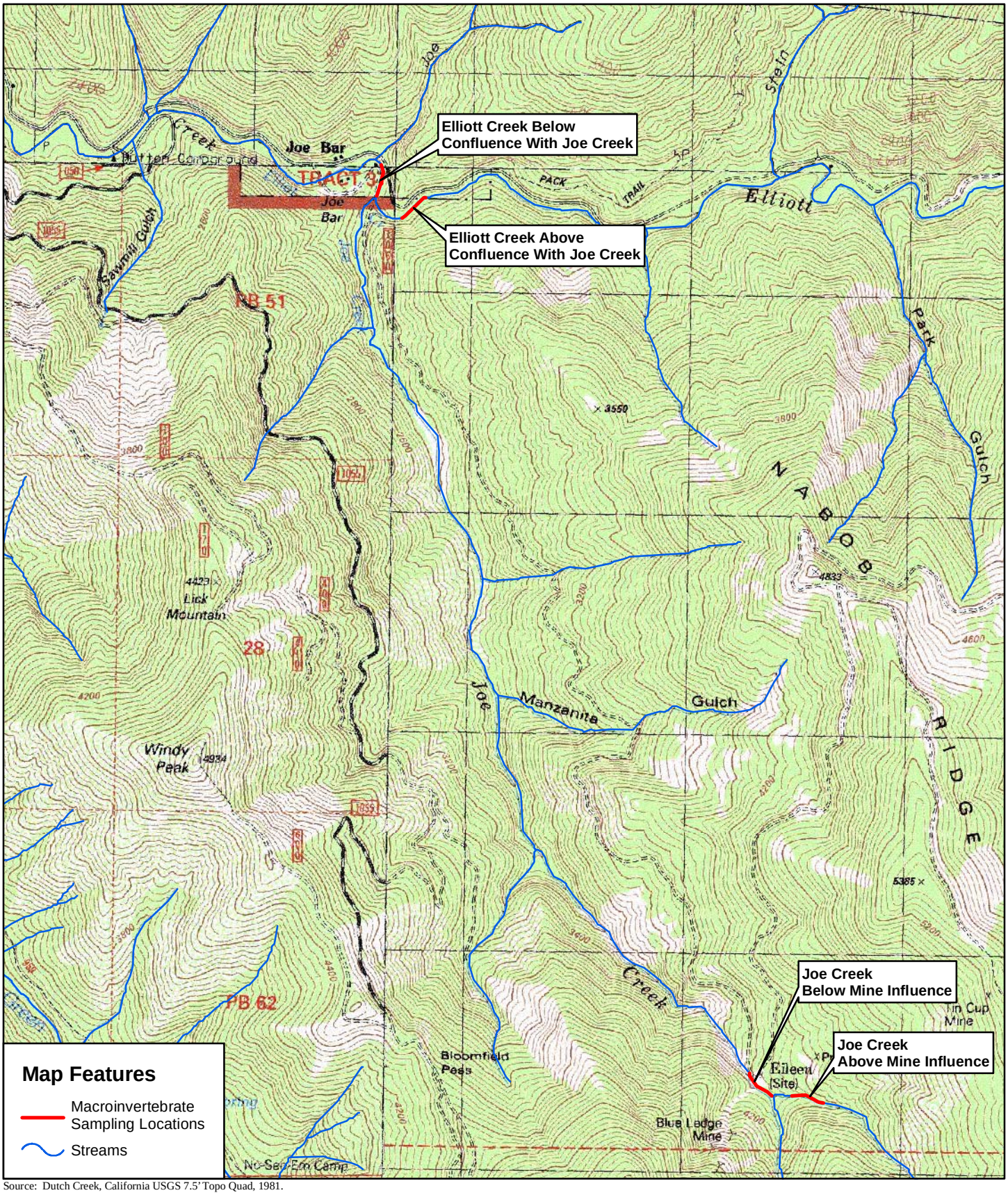
ATTACHMENTS

Figure 1 - Sampling Locations

Laboratory Report - Rhithron Associates, Biological assessment of sites on Joe Creek and Elliott Creek, Siskiyou County, California

REFERENCE

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.



Source: Dutch Creek, California USGS 7.5' Topo Quad, 1981.
Kangaroo Mountain, California USGS 7.5' Topo Quad, 1981.

0 500 1,000 2,000 Feet

URS

US FOREST SERVICE: ROGUE-SISKIYOU NATIONAL FOREST

OCTOBER 2008
25696770

BLUE LEDGE MINE - MACROINVERTEBRATE SAMPLING LOCATIONS
ELLIOTT AND JOE CREEKS

FIGURE 1

O:\25696770 Blue Ledge Mine\5000 Technical\GIS\MXD\Fig # Macroinvertebrate Sampling Locations.mxd

Biological assessment of sites on Joe Creek and Elliott Creek
Siskiyou County, California
Report to URS Corporation: Brad Rawls, Project Manager

by
W. Bollman
Rhithron Associates, Inc.
Missoula, Montana

INTRODUCTION

Spatial comparisons of aquatic invertebrate communities are frequently used to assess the presence and intensity of heavy metals contamination in streams. Invertebrates are well-suited to this type of analysis for several reasons. Field studies and controlled experiments demonstrate that composition and functional characteristics of aquatic invertebrate assemblages are influenced by metals contamination. The effects of copper, lead, and zinc have been well-studied, but community changes associated with exposure to other metals, including aluminum, cadmium, cobalt, nickel and silver are also documented. Because invertebrates are relatively long-lived and are less motile than fish, evidence of water quality impairment is likely to be persistent, unlike the "snapshot" results of chemical tests. Invertebrate assemblages may exhibit both direct and indirect responses to metals contamination; responses include poisoning and death or avoidance and drift. Direct effects are related to metal uptake from the water column by means of diffusion or absorption through gills or integument. Toxicity may also be related to uptake via food in the form of metals bound to sediment particles; recent studies have suggested that food may be the primary route of uptake for some metals (Munger and Hare 2000 and Roy and Hare, 1999). Indirect effects may include disruption of food webs; for example, alteration of predation rates has been demonstrated when concentrations of metals increase in streams (Clements et al. 1989).

Various studies have shown that aquatic invertebrate community responses to metals contamination are predictable and distinctive. Kiffney and Clements (1994, 1996) demonstrated that mayfly abundance, especially abundance in the family Heptageniidae, was a highly sensitive and reliable metric for assessment of metals impact. This result has been confirmed in many studies, and Heptageniid mayfly abundance and richness are among the most frequently used and cited metrics for the assessment of metals impacts. Heptageniid mayflies have several risk factors for susceptibility to metals accumulation; these include external platelike gills (Kiffney and Clements 2003) and reliance on periphyton as their major food source. Periphyton and other biofilms have been shown to have high metals concentrations when contamination is present (Farag et al. 1998).

In addition to the Heptageniids, other mayflies scrape algal biofilms from stony substrates; the scraper feeding group includes taxa among the caddisflies and beetles. An alteration in the functional composition of invertebrate assemblages may result from lower abundance of scrapers when metal contamination is present (Kiffney and Clements 1993).

Other studies suggest that overall taxa richness also diminishes with metals contamination, however, it must be noted that this metric is responsive

to many other stressors as well. Tolerant midges, especially among the sub-family Orthocladiinae, and worms (Oligochaeta) are known to increase in abundance in metals contaminated systems (Mebane 2003), although the mechanisms for this increase are not well-documented.

The metals tolerance index developed by McGuire (MDEQ 1998) provides an indication of overall assemblage tolerance to metals. The index was demonstrated to be useful at metals contaminated sites in western Montana, but it has also been applied successfully elsewhere. Tolerance values were determined for individual taxa, based on their presence or absence from sites with known levels of water and sediment contamination. Those values, weighted by taxon abundances, are averaged to arrive at an assemblage tolerance score. Higher scores indicate higher tolerance to heavy metals.

METHODS

For this study, sites on 2 streams were sampled for aquatic invertebrates. Samples were collected by URS Corporation personnel. Samples were processed and identified by Rhithron Associates. Laboratory technical procedures and quality assurance protocols applied to this project are described in the Appendix.

The 2 sampled sites on Joe Creek included a "reference" site above the influence of waste rock from a metal mine, and a test site below the mine. On Elliott Creek, a "reference" site above the confluence with Joe Creek was sampled for comparison with a test site below the confluence.

RESULTS

Joe Creek

The sample collected above the waste rock site contained a total of approximately 481 organisms. Below the waste rock site, sampling yielded only about 176 organisms. Assuming that sampling efforts were equivalent between sites, it is apparent that invertebrate density was much lower at the downstream site. Because of the patchy distribution of invertebrates in riffles, some variation in densities is expected, but it is noteworthy that the lower site supported less than half the number of organisms as the "reference" site.

Table 1 summarizes the metals-related compositional, functional, and tolerance measures for the Joe Creek sites. Heptageniid mayflies (*Cinygma* sp., *Cinygmula* sp., *Epeorus grandis*, *Ironodes* sp., and *Rhithrogena* sp.) were common in the sample collected at the "reference" site, but were nearly extirpated below the mine influence. Only 2 taxa persisted at the lower site. Overall mayfly abundance diminished from 162 individuals to 26 individuals.

The precipitous increase in the metals tolerance index value at the downstream site strongly suggests that the assemblage below the mine influence was highly metals-tolerant. The 3 dominant taxa above the mine were all pollution-sensitive taxa: the caddisfly *Anagapetus* sp., the mayfly *Drunella doddsii*, and the stonefly *Yoraperla brevis*. Together, these taxa accounted for 35% of sampled animals at the site. Below the mine however, orthocladine midges (*Orthocladius (Orthocladius)* and *Orthocladius (Euorthocladius)* spp., and *Eukiefferiella gracei*) were dominant, making up 43% of the sampled animals. Midges in all taxa accounted for 63% of animals collected below the mine

influence, while midges accounted for only 13% of animals collected at the "reference" site.

Both sampled sites on Joe Creek supported all expected functional components. However, the sharp decline in scrapers at the downstream site is notable.

Taxa richness decreased by nearly half at the downstream site compared to the "reference" site. There were particularly acute taxa losses among mayflies, stoneflies, and riffle beetles. Oligochaetes were present at the "reference" site, but were not collected below the mine influence; this is not the expected response to metals contamination. However, the worms present above the mine (*Enchytraeus* sp. and *Mesenchytraeus* sp.) are not tolerant taxa. Instead, they are characteristic of cold, unpolluted montane streams; their tolerance of heavy metals is not documented.

Table 1. Metals associated metrics, expected responses when contamination is present, and responses at the downstream (below waste rock) site on Joe Creek.

Metric	Expected response	Response in Joe Creek	Metric values	
			above waste rock	below waste rock
B-IBI	decrease	decrease	44	36
Heptageniid abundance	decrease	decrease	15%	3%
Mayfly abundance	decrease	decrease	34%	15%
Chironomid abundance	increase	increase	13%	63%
Orthocladiinae abundance	increase	increase	25	99
Oligochaete abundance	increase	decrease	19	absent
Taxa richness	decrease	decrease	63	33
Scraper abundance	decrease	decrease	43%	11%
Metals tolerance index	increase	increase	1.49	4.15

Elliott Creek

Invertebrate density at both of the Elliott Creek sites was typical of montane streams; there were between 700 and 900 specimens in each of the samples. Density apparently did not diminish below the confluence with Joe Creek.

Table 2 summarizes the metals-related compositional, functional, and tolerance measures for the Elliott Creek sites. The abundance of heptageniid mayflies (*Cinygmula* sp. and *Rhithrogena* sp.) at the "reference" site was very low; only 6 individuals were collected there. No heptageniid mayflies were collected at the downstream site. The significance of this small shift in taxonomic composition is difficult to assess; sampling variability may account

for the absence of these taxa. However, the influence of metals cannot be ruled out.

There was a shift in dominant taxa between the upstream and downstream site on Elliott Creek. Above the Joe Creek confluence, the 3 most abundant taxa were the caddisfly *Glossosoma* sp. and the tanytarsine midges *Rheotanytarsus* sp. and *Micropsectra* sp. These animals accounted for 30% of organisms in the sample. At the site below the confluence, the orthocladine midges in *Orthocladius (Orthocladius)* spp., the caddisfly *Neophylax occidentalis*, and the elmid beetle *Zaitzevia parvula* were the dominant taxa, accounting for 34% of sampled animals. There was only a slight increase in the overall abundance of midges, but the number of orthocladine midges in the downstream sample was much higher than the sample collected at the upstream site. Taxa richness was slightly higher below the Joe Creek confluence.

The very slight increase in the metals tolerance index at the lower site is within the typical variability of the index. This result provides no evidence that the invertebrate assemblage below the confluence is more metals tolerant than the assemblage collected at the "reference" site.

All expected functional components were present at both Elliott Creek sites. There was a slight shift in shredder abundance, but the contribution of scrapers to the functional mix was only slightly different between the sites.

Oligochaetes in the family Enchytraeidae were collected at both sites on Elliott Creek; however, 3 taxa were collected at the site above the confluence, and only 1 taxon was collected below the confluence. Oligochaetes were not abundant at either site.

Table 2. Metals associated metrics, expected responses when contamination is present, and responses at the downstream (below the confluence with Joe Creek) site on Elliott Creek.

Metric	Expected response	Response in Elliott Creek	Metric values	
			above confluence	below confluence
B-IBI	decrease	slight decrease	44	42
Heptageniid abundance	decrease	decrease	1.2%	absent
Mayfly abundance	decrease	decrease	12%	7%
Chironomid abundance	increase	increase	30%	37%
Orthocladiinae abundance	increase	increase	47	125
Oligochaete abundance	increase	decrease	8	4
Taxa richness	decrease	slight increase	60	63
Scraper abundance	decrease	slight decrease	30%	27%
Metals tolerance index	increase	slight increase	2.52	2.83

DISCUSSION

Other abiotic factors besides metals may have influenced the invertebrate assemblages at the Joe Creek sites; for example, the natural variation in communities along the longitudinal upstream-to-downstream gradient may account for some of the differences in assemblage composition between sites. Stressors and natural gradients interact in complex ways making the detection and diagnosis of probable causes of impairment an inexact exercise. For these reasons, it is very difficult to specifically attribute changes in a benthic community to any particular stressor.

Invertebrate assemblages at Joe Creek site suggest cold water temperatures. More than half of the cold stenotherm taxa collected at the upstream site were not present in the sample collected at the downstream site. Metals contamination could account for the loss of these taxa, since cold stenotherms are often generally pollution-sensitive. But the possibility that water temperatures were warmer at this site cannot be ruled out. "Clinger" taxa were very diverse at the site above the waste rock influence; at least 24 "clinger" taxa were supported here. Below the mine, only 14 "clinger" taxa were collected. Fine sediment deposition could account for the loss of these taxa. Diminished numbers of stonefly taxa at the lower site compared to the "reference" site may be related to reach-scale habitat degradation, such as streambank instability, loss of riparian zone integrity, or channel alteration.

Comparison of metric and community composition responses between upstream and downstream sites on Joe Creek strongly suggests impairment at the site below the mine influence. Responses were generally consistent with the expected invertebrate community responses to metals contamination. Similar comparisons between sites on Elliott Creek yielded less consistent results, with some metric responses either weak or nonexistent. Although metals contamination cannot be ruled out at the downstream site on Elliott Creek, the evidence is not as strong as it is at the downstream site on Joe Creek.

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Munger, C. and L. Hare. 2000. Influence of ingestion rate and food types on cadmium accumulation by the aquatic insect *Chaoborus*. *Canadian Journal of Fisheries and Aquatic Sciences*. 57: 327-332.

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Appendix

Technical summary of methods and quality assurance procedures
Taxa lists and metric summaries

Joe Creek
Elliott Creek

September 2008

Analysis of biological samples:
Technical summary of methods and quality assurance procedures

METHODS

Sample processing

Four macroinvertebrate samples were delivered to Rhithron's laboratory facility in Missoula, Montana on October 2, 2008. All samples arrived in good condition. Upon arrival, samples were unpacked and examined, and an inventory containing sample identification information was created. An electronic inventory spreadsheet was then created and sent to the Project Manager. This spreadsheet included project code and internal laboratory identification numbers and was verified by the Project Manager prior to upload into the Rhithron database.

Standard sorting protocols were applied to achieve representative subsamples of a minimum of 500 organisms. Caton sub-sampling devices (Caton 1991), divided into 30 grids, each approximately 5 cm by 6 cm were used. Each individual sample was thoroughly mixed in its jar(s), poured out and evenly spread into the Caton tray, and individual grids were randomly selected. The contents of each grid were examined under stereoscopic microscopes using 10x-30x magnification. All aquatic invertebrates from each selected grid were sorted from the substrate, and placed in 95% ethanol for subsequent identification. Grid selection, examination, and sorting continued until at least 500 organisms were sorted. The final grid was completely sorted of all organisms. All unsorted sample fractions were retained and stored at the Rhithron laboratory.

Organisms were individually examined by certified taxonomists, using 10x – 80x stereoscopic dissecting scopes (Leica S8E and S6E) and identified to the lowest possible level, using appropriate published taxonomic references and keys. Identification, counts, life stages, and information about the condition of specimens were recorded on bench sheets. To obtain accuracy in richness measures, organisms that could not be identified to the target level specified were designated as "not unique" if other specimens from the same group could be taken to target levels. Organisms designated as "unique" were those that could be definitively distinguished from other organisms in the sample. Identified organisms were preserved in 95% ethanol in labeled vials, and archived at the Rhithron laboratory.

Midges were carefully morphotyped using 10x – 80x stereoscopic dissecting microscopes (Leica S8E and S6E) and representative specimens were slide mounted and examined at 200x – 1000x magnification using an Olympus BX 51 compound microscope. Slide mounted organisms were archived at the Rhithron laboratory.

Quality control procedures

Quality control procedures for initial sample processing and subsampling involved checking sorting efficiency. These checks were conducted on 100% of the samples by independent observers who microscopically re-examined 20% of sorted substrate from each sample. All organisms that were missed were counted and this number was added to the total number obtained in the original sort. Sorting efficiency was evaluated by applying the following calculation:

$$SE = \frac{n_1}{n_{1+2}} \times 100$$

where: SE is the sorting efficiency, expressed as a percentage, n_1 is the total number of specimens in the first sort, and n_{1+2} is the total number of specimens in the first and second sorts combined.

Quality control procedures for taxonomic determinations of invertebrates involved checking accuracy, precision and enumeration. One sample was randomly selected and all organisms re-identified and counted by an independent taxonomist. Taxa lists and enumerations were compared by calculating a Bray-Curtis similarity

statistic (Bray and Curtis 1957) for the selected sample. Routinely, discrepancies between the original identifications and the QC identifications are discussed among the taxonomists, and necessary rectifications to the data are made. Discrepancies that cannot be rectified by discussions are routinely sent out to taxonomic specialists for identification. However, taxonomic certainty for identifications in this project was high and no external verifications were necessary.

Data analysis

Taxa lists and counts for each sample were constructed. Standard metric calculations for aquatic invertebrate assemblages were made using Rhithron's customized database software.

RESULTS

Quality Control Procedures

Results of quality control procedures for subsampling and taxonomy are given in Table 1. Sorting efficiency averaged 98.56% for macroinvertebrate samples, taxonomic precision for identification and enumeration was 95.81% for the randomly selected QA sample, and data entry efficiency averaged 100% for the project. These similarity statistics fall within acceptable industry criteria (Stribling et al. 2003).

Data analysis

Taxa lists and counts, and values and scores for standard bioassessment metrics are given in this Appendix.

Table 1. Results of internal quality control procedures for subsampling and taxonomy.

RAI Sample ID	Station name	Sorting efficiency	Bray-Curtis similarity for taxonomy and enumeration
URS08BLM001	Elliott Creek Below Confluence	100.00%	
URS08BLM002	Elliott Creek Above Confluence	99.04%	
URS08BLM003	Joe Creek Below Waste Rock Confluence	97.17%	
URS08BLM004	Joe Creek Above Waste Rock Confluence	98.03%	95.81%

REFERENCES

Bray, J. R. and J. T. Curtis. 1957. An ordination of upland forest communities of southern Wisconsin. Ecological Monographs 27: 325-349.

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Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM001

RAI No.: URS08BLM001 **Sta. Name:** Elliott Creek Below Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Non-Insect							
Enchytraeidae							
Enchytraeus sp.	4	0.80%	Yes	Immature		4	CG
Planariidae							
Polycelis coronata	1	0.20%	Yes	Unknown		1	OM
Ephemeroptera							
Ameletidae							
Ameletus sp.	1	0.20%	Yes	Larva	Damaged	0	CG
Baetidae							
Acentrella turbida	4	0.80%	Yes	Larva		4	CG
Baetis sp.	1	0.20%	Yes	Larva	Damaged	5	CG
Baetis tricaudatus	23	4.60%	Yes	Larva		4	CG
Ephemerellidae							
Drunella doddsii	1	0.20%	Yes	Larva		1	SC
Drunella grandis	1	0.20%	Yes	Larva		2	PR
Serratella tibialis	3	0.60%	Yes	Larva		2	CG
Plecoptera							
Chloroperlidae							
Suwallia sp.	1	0.20%	Yes	Larva		1	PR
Sweltsa sp.	2	0.40%	Yes	Larva		0	PR
Nemouridae							
Malenka sp.	7	1.40%	Yes	Larva		1	SH
Perlidae							
Calineuria californica	2	0.40%	Yes	Larva		2	PR
Hesperoperla pacifica	1	0.20%	Yes	Larva		1	PR
Perlidae	3	0.60%	No	Larva	Early Instar	2	PR
Perlodidae							
Perlinodes aurea	1	0.20%	Yes	Larva		1	PR
Skwala sp.	2	0.40%	Yes	Larva		3	PR

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM001

RAI No.: URS08BLM001 **Sta. Name:** Elliott Creek Below Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Trichoptera							
Apataniidae							
Apatania sp.	1	0.20%	Yes	Larva		3	SC
Brachycentridae							
Micrasema sp.	5	1.00%	Yes	Larva		1	SH
Calamoceratidae							
Heteroplectron californicum	1	0.20%	Yes	Larva		1	SH
Glossosomatidae							
Agapetus sp.	11	2.20%	Yes	Larva		0	SC
Glossosoma sp.	27	5.40%	Yes	Larva		0	SC
Glossosomatidae	19	3.80%	No	Pupa		0	SC
Hydropsychidae							
Hydropsyche Morosa Gr.	6	1.20%	Yes	Larva	Early Instar	4	CF
Lepidostomatidae							
Lepidostoma sp.	9	1.80%	Yes	Larva		1	SH
Limnephilidae							
Ecclisomyia sp.	2	0.40%	Yes	Larva		4	CG
Rhyacophilidae							
Rhyacophila sp.	2	0.40%	No	Pupa		1	PR
Rhyacophila Angelita Gr.	4	0.80%	Yes	Larva		0	PR
Rhyacophila Betteni Gr.	5	1.00%	Yes	Larva		0	PR
Rhyacophila Brunnea Gr.	4	0.80%	Yes	Larva		2	PR
Rhyacophila Hyalinata Gr.	1	0.20%	Yes	Larva		0	PR
Sericostomatidae							
Gumaga sp.	1	0.20%	Yes	Larva		3	SH
Uenoidae							
Neophylax occidentis	68	13.60%	Yes	Larva		3	SC
Uenoidae	1	0.20%	No	Pupa		0	SC
Coleoptera							
Dytiscidae							
Oreodytes obesus sp.	1	0.20%	Yes	Adult		5	PR
Elmidae							
Ampumixis dispar	1	0.20%	Yes	Adult		4	CG
Ampumixis dispar	10	2.00%	No	Larva		4	CG
Heterlimnius sp.	5	1.00%	No	Larva		3	CG
Heterlimnius koebelei sp.	1	0.20%	Yes	Adult		4	CG
Lara sp.	1	0.20%	Yes	Larva		1	SH
Optioservus sp.	2	0.40%	Yes	Larva		5	SC
Ordobrevia nubifera	5	1.00%	No	Larva		4	CG
Ordobrevia nubifera	1	0.20%	Yes	Adult		4	CG
Zaitzevia parvulus	12	2.40%	Yes	Adult		4	CG
Zaitzevia parvulus	15	3.00%	No	Larva		4	CG
Psephenidae							
Eubrianax edwardsi	4	0.80%	Yes	Larva		4	SC

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM001

RAI No.: URS08BLM001 **Sta. Name:** Elliott Creek Below Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Diptera							
Ceratopogonidae							
Mallochohelea sp.	8	1.60%	Yes	Larva		11	PR
Simuliidae							
Simulium sp.	2	0.40%	No	Pupa		6	CF
Simulium sp.	14	2.80%	Yes	Larva		6	CF
Tipulidae							
Antocha sp.	2	0.40%	Yes	Larva		3	CG
Hesperoconopa sp.	4	0.80%	Yes	Larva		1	CG
Chironomidae							
Chironomidae							
Brillia parva sp.	5	1.00%	Yes	Larva		5	SH
Cardiocladius obscurus	1	0.20%	Yes	Larva		5	PR
Cricotopus triannulatus	10	2.00%	Yes	Larva		7	SH
Eukiefferiella sp.	3	0.60%	No	Larva	Early Instar	8	CG
Eukiefferiella Brehmi Gr.	2	0.40%	Yes	Larva		8	CG
Eukiefferiella Claripennis Gr.	3	0.60%	Yes	Larva		8	CG
Eukiefferiella Pseudomontana Gr.	1	0.20%	Yes	Larva		8	CG
Micropsectra sp.	21	4.20%	Yes	Larva		4	CG
Micropsectra sp.	2	0.40%	No	Pupa		4	CG
Orthocladius (Euorthocladius) sp.	8	1.60%	Yes	Larva	Early Instar	6	CG
Orthocladius (Orthocladius) sp.	62	12.40%	Yes	Larva	Early Instar	6	CG
Orthocladius (Orthocladius) sp.	14	2.80%	No	Pupa	Damaged	6	CG
Pagastia orthogonia	1	0.20%	Yes	Larva		1	CG
Parametriocnemus sp.	6	1.20%	Yes	Larva		5	CG
Pentaneura inconspicua sp.	1	0.20%	Yes	Larva		6	PR
Polypedilum aviceps	3	0.60%	Yes	Larva		6	SH
Polypedilum Fallax Gr.	2	0.40%	Yes	Larva		6	CG
Polypedilum Scalaenum Gr.	1	0.20%	Yes	Larva		6	SH
Polypedilum tritum	1	0.20%	No	Pupa		6	CG
Polypedilum tritum	1	0.20%	Yes	Larva		6	CG
Potthastia Gaedii Gr.	5	1.00%	Yes	Larva		2	CG
Rheotanytarsus sp.	15	3.00%	Yes	Larva		6	CF
Tanytarsus sp.	1	0.20%	No	Pupa		6	CF
Tanytarsus sp.	4	0.80%	Yes	Larva		6	CF
Thienemannimyia Gr.	4	0.80%	Yes	Larva	Early Instar	5	PR
Tvetenia Bavarica Gr.	10	2.00%	Yes	Larva		5	CG
Sample Count	**500**						

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM002

RAI No.: URS08BLM002 **Sta. Name:** Elliott Creek Above Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Non-Insect							
Enchytraeidae							
Enchytraeus sp.	1	0.19%	Yes	Immature		4	CG
Fridericia sp.	1	0.19%	Yes	Immature		11	CG
Mesenchytraeus sp.	6	1.17%	Yes	Immature		4	CG
Ephemeroptera							
Baetidae							
Acentrella turbida	2	0.39%	Yes	Larva		4	CG
Baetis tricaudatus	46	8.93%	Yes	Larva		4	CG
Ephemerellidae							
Attenella delantala	2	0.39%	Yes	Larva		3	CG
Drunella doddsii	1	0.19%	Yes	Larva		1	SC
Drunella grandis	2	0.39%	Yes	Larva		2	PR
Serratella tibialis	3	0.58%	Yes	Larva		2	CG
Heptageniidae							
Cinygmula sp.	3	0.58%	Yes	Larva		0	SC
Rhithrogena sp.	3	0.58%	Yes	Larva		0	CG
Plecoptera							
Chloroperlidae							
Sweltsa sp.	4	0.78%	Yes	Larva		0	PR
Nemouridae							
Malenka sp.	1	0.19%	Yes	Larva		1	SH
Perlidae							
Calineuria californica	7	1.36%	Yes	Larva		2	PR
Hesperoperla pacifica	5	0.97%	Yes	Larva		1	PR
Perlodidae							
Perlinodes aurea	3	0.58%	Yes	Larva		1	PR
Perlodidae	2	0.39%	Yes	Larva	Early Instar	2	PR
Skwala sp.	17	3.30%	Yes	Larva		3	PR

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM002

RAI No.: URS08BLM002 **Sta. Name:** Elliott Creek Above Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Trichoptera							
Apataniidae							
Apatania sp.	2	0.39%	Yes	Larva		3	SC
Glossosomatidae							
Agapetus sp.	15	2.91%	Yes	Larva		0	SC
Glossosoma sp.	54	10.49%	Yes	Larva		0	SC
Glossosomatidae	46	8.93%	No	Pupa		0	SC
Hydropsychidae							
Arctopsyche grandis	4	0.78%	Yes	Larva		2	PR
Hydropsyche Morosa Gr.	16	3.11%	Yes	Larva	Early Instar	4	CF
Lepidostomatidae							
Lepidostoma sp.	2	0.39%	Yes	Larva		1	SH
Rhyacophilidae							
Rhyacophila sp.	12	2.33%	No	Pupa		1	PR
Rhyacophila Angelita Gr.	1	0.19%	Yes	Larva		0	PR
Rhyacophila Betteni Gr.	6	1.17%	Yes	Larva		0	PR
Rhyacophila Brunnea Gr.	1	0.19%	Yes	Larva		2	PR
Uenoidae							
Neophylax occidentis	24	4.66%	Yes	Larva		3	SC
Coleoptera							
Dytiscidae							
Oreodytes obesus sp.	2	0.39%	Yes	Adult		5	PR
Elmidae							
Ampumixis dispar	9	1.75%	No	Larva		4	CG
Ampumixis dispar	1	0.19%	Yes	Adult		4	CG
Heterlimnius sp.	2	0.39%	Yes	Larva		3	CG
Narpus concolor	1	0.19%	Yes	Adult		2	CG
Optioservus sp.	3	0.58%	No	Larva		5	SC
Optioservus seriatus	3	0.58%	Yes	Adult		4	SC
Zaitzevia parvulus	2	0.39%	Yes	Larva		4	CG
Psephenidae							
Eubrianax edwardsi	2	0.39%	Yes	Larva		4	SC

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM002

RAI No.: URS08BLM002 **Sta. Name:** Elliott Creek Above Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Diptera							
Ceratopogonidae							
Mallochohelea sp.	1	0.19%	Yes	Larva		11	PR
Empididae							
Clinocera sp.	1	0.19%	Yes	Larva		5	PR
Pelecorhynchidae							
Glutops sp.	1	0.19%	Yes	Larva		1	PR
Simuliidae							
Simulium sp.	1	0.19%	No	Pupa		6	CF
Simulium sp.	10	1.94%	Yes	Larva		6	CF
Tipulidae							
Antocha sp.	5	0.97%	Yes	Larva		3	CG
Antocha sp.	8	1.55%	No	Pupa		3	CG
Cryptolabis sp.	2	0.39%	Yes	Larva		11	SH
Hesperoconopa sp.	10	1.94%	Yes	Larva		1	CG
Hexatoma sp.	2	0.39%	Yes	Larva		2	PR
Chironomidae							
Chironomidae							
Brillia parva sp.	4	0.78%	Yes	Larva		5	SH
Eukiefferiella Brehmi Gr.	2	0.39%	Yes	Larva		8	CG
Eukiefferiella Claripennis Gr.	1	0.19%	Yes	Larva		8	CG
Eukiefferiella Devonica Gr.	1	0.19%	Yes	Larva		8	CG
Eukiefferiella Gracei Gr.	3	0.58%	Yes	Larva		8	CG
Eukiefferiella Pseudomontana Gr.	2	0.39%	Yes	Larva		8	CG
Lopescladius sp.	1	0.19%	Yes	Larva		2	CG
Micropsectra sp.	2	0.39%	No	Pupa		4	CG
Micropsectra sp.	48	9.32%	Yes	Larva		4	CG
Microtendipes Rydalensis Gr.	1	0.19%	Yes	Larva		6	CF
Orthocladius (Orthocladius) sp.	3	0.58%	No	Pupa	Damaged	6	CG
Orthocladius (Orthocladius) sp.	7	1.36%	Yes	Larva	Early Instar	6	CG
Parametriocnemus sp.	1	0.19%	Yes	Larva		5	CG
Polypedilum aviceps	6	1.17%	Yes	Larva		6	SH
Rheotanytarsus sp.	4	0.78%	No	Pupa		6	CF
Rheotanytarsus sp.	46	8.93%	Yes	Larva		6	CF
Tanytarsus sp.	1	0.19%	Yes	Larva		6	CF
Tanytarsus sp.	1	0.19%	No	Pupa		6	CF
Thienemanniella sp.	2	0.39%	Yes	Larva		6	CG
Thienemannimyia Gr.	1	0.19%	Yes	Larva	Early Instar	5	PR
Tvetenia sp.	1	0.19%	No	Pupa		5	CG
Tvetenia Bavarica Gr.	19	3.69%	Yes	Larva		5	CG
Sample Count	**515**						

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM003

RAI No.: URS08BLM003 **Sta. Name:** Joe Creek Below Waste Rock Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Ephemeroptera							
Baetidae							
Baetis tricaudatus	13	7.39%	Yes	Larva		4	CG
Ephemerellidae							
Drunella coloradensis	6	3.41%	Yes	Larva		0	SC
Drunella doddsii	2	1.14%	Yes	Larva		1	SC
Heptageniidae							
Epeorus grandis	3	1.70%	Yes	Larva		0	SC
Ironodes sp.	2	1.14%	Yes	Larva		0	SC
Plecoptera							
Capniidae							
Capniidae	1	0.57%	Yes	Larva	Damaged	1	SH
Nemouridae							
Malenka sp.	1	0.57%	Yes	Larva		1	SH
Perlidae							
Doroneuria baumanni	1	0.57%	Yes	Larva		1	PR
Perlodidae							
Perlinodes aurea	1	0.57%	Yes	Larva		1	PR
Perlodidae	1	0.57%	Yes	Larva	Early Instar	2	PR
Trichoptera							
Glossosomatidae							
Anagapetus sp.	7	3.98%	Yes	Larva		0	SC
Hydropsychidae							
Hydropsychidae	1	0.57%	Yes	Larva	Early Instar	4	CF
Limnephilidae							
Cryptochia sp.	2	1.14%	Yes	Larva		0	SH
Rhyacophilidae							
Rhyacophila sp.	10	5.68%	No	Pupa		1	PR
Rhyacophila Betteni Gr.	5	2.84%	Yes	Larva		0	PR
Rhyacophila grandis	1	0.57%	Yes	Larva		1	PR
Rhyacophila Hyalinata Gr.	1	0.57%	Yes	Larva		0	PR
Rhyacophila Vagrita Gr.	2	1.14%	Yes	Larva		0	PR
Coleoptera							
Dytiscidae							
Dytiscidae	1	0.57%	Yes	Larva	Early Instar	5	PR
Elmidae							
Lara sp.	1	0.57%	Yes	Larva		1	SH
Diptera							
Empididae							
Neoplasta sp.	1	0.57%	Yes	Larva		5	PR
Simuliidae							
Simulium sp.	1	0.57%	Yes	Pupa		6	CF
Tipulidae							
Dicranota sp.	1	0.57%	Yes	Larva		3	PR

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM003

RAI No.: URS08BLM003 **Sta. Name:** Joe Creek Below Waste Rock Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Chironomidae							
Chironomidae							
Brillia parva sp.	6	3.41%	Yes	Larva		5	SH
Chironomini	1	0.57%	No	Pupa	Damaged	6	CG
Cricotopus (Cricotopus) sp.	3	1.70%	Yes	Larva	Early Instar	7	SH
Diamesa sp.	1	0.57%	Yes	Larva		5	CG
Eukiefferiella Gracei Gr.	25	14.20%	Yes	Larva		8	CG
Eukiefferiella Pseudomontana Gr.	2	1.14%	Yes	Larva		8	CG
Micropsectra sp.	1	0.57%	Yes	Larva		4	CG
Orthocladius (Euorthocladius) sp.	29	16.48%	Yes	Larva	Early Instar	6	CG
Orthocladius (Euorthocladius) sp.	2	1.14%	No	Pupa	Damaged	6	CG
Orthocladius (Orthocladius) sp.	2	1.14%	No	Pupa	Damaged	6	CG
Orthocladius (Orthocladius) sp.	18	10.23%	Yes	Larva	Early Instar	6	CG
Pagastia orthogonia	9	5.11%	Yes	Larva		1	CG
Parorthocladius sp.	6	3.41%	Yes	Larva		6	CG
Parorthocladius sp.	1	0.57%	No	Pupa		6	CG
Tvetenia Bavarica Gr.	5	2.84%	Yes	Larva		5	CG
Sample Count	**176**						

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM004

RAI No.: URS08BLM004 **Sta. Name:** Joe Creek Above Waste Rock Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Non-Insect							
Enchytraeidae							
Enchytraeus sp.	2	0.42%	Yes	Immature		4	CG
Mesenchytraeus sp.	16	3.33%	Yes	Immature		4	CG
Haplotaxidae							
Haplotaxis sp.	1	0.21%	Yes	Immature		11	PR
Planariidae							
Polycelis coronata	3	0.62%	Yes	Unknown		1	OM
Ephemeroptera							
Ameletidae							
Ameletus sp.	1	0.21%	Yes	Larva	Damaged	0	CG
Baetidae							
Baetis tricaudatus	31	6.44%	Yes	Larva		4	CG
Ephemerellidae							
Caudatella hystrix	3	0.62%	Yes	Larva		0	SC
Drunella coloradensis	3	0.62%	Yes	Larva		0	SC
Drunella doddsii	38	7.90%	Yes	Larva		1	SC
Drunella spinifera	8	1.66%	Yes	Larva		0	PR
Ephemerella sp.	7	1.46%	Yes	Larva	Early Instar	1.5	SC
Heptageniidae							
Cinygma sp.	1	0.21%	Yes	Larva		0	SC
Cinygmula sp.	18	3.74%	Yes	Larva		0	SC
Epeorus grandis	30	6.24%	Yes	Larva		0	SC
Ironodes sp.	6	1.25%	Yes	Larva		0	SC
Rhithrogena sp.	15	3.12%	Yes	Larva		0	CG
Leptophlebiidae							
Leptophlebiidae	1	0.21%	Yes	Larva	Damaged	2	CG
Plecoptera							
Chloroperlidae							
Sweltsa sp.	1	0.21%	Yes	Larva		0	PR
Leuctridae							
Despaxia augusta	1	0.21%	Yes	Larva		0	SH
Moselia infuscata	1	0.21%	Yes	Larva		0	SH
Nemouridae							
Visoka cataractae	17	3.53%	Yes	Larva		0	SH
Zapada columbiana	6	1.25%	Yes	Larva		2	SH
Peltoperlidae							
Sierraperla cora	9	1.87%	Yes	Larva		1	SH
Yoraperla brevis	34	7.07%	Yes	Larva		0	SH
Perlidae							
Doroneuria baumanni	7	1.46%	Yes	Larva		1	PR
Perlodidae							
Megarcys sp.	1	0.21%	Yes	Larva		1	PR
Salmoperla sylvanica sp.	1	0.21%	Yes	Larva		11	PR
Skwala sp.	1	0.21%	Yes	Larva		3	PR
Taeniopterygidae							
Taeniopterygidae	4	0.83%	Yes	Larva	Early Instar	2	SH

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM004

RAI No.: URS08BLM004 **Sta. Name:** Joe Creek Above Waste Rock Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Trichoptera							
Glossosomatidae							
Anagapetus sp.	98	20.37%	Yes	Larva		0	SC
Glossosoma sp.	1	0.21%	Yes	Larva		0	SC
Hydropsychidae							
Hydropsychidae	2	0.42%	No	Larva	Early Instar	4	CF
Parapsyche elsis	3	0.62%	Yes	Larva		1	PR
Limnephilidae							
Ecclisomyia sp.	9	1.87%	Yes	Larva		4	CG
Philopotamidae							
Dolophilodes sp.	2	0.42%	Yes	Larva		0	CF
Rhyacophilidae							
Rhyacophila Betteni Gr.	9	1.87%	Yes	Larva		0	PR
Rhyacophila Hyalinata Gr.	1	0.21%	Yes	Larva		0	PR
Rhyacophila Vagrita Gr.	1	0.21%	Yes	Larva		0	PR
Coleoptera							
Elmidae							
Ampumixis dispar	1	0.21%	Yes	Larva		4	CG
Heterlimnius sp.	2	0.42%	No	Larva		3	CG
Heterlimnius koebelei sp.	3	0.62%	Yes	Adult		4	CG
Lara sp.	3	0.62%	Yes	Larva		1	SH
Zaitzevia parvulus	1	0.21%	Yes	Larva		4	CG
Diptera							
Ceratopogonidae							
Mallochohelea sp.	5	1.04%	Yes	Larva		11	PR
Dixidae							
Dixa sp.	1	0.21%	Yes	Larva		1	CG
Empididae							
Chelifera sp.	1	0.21%	Yes	Larva		5	PR
Empididae	1	0.21%	No	Pupa		6	PR
Neoplasta sp.	1	0.21%	Yes	Larva		5	PR
Pelecorhynchidae							
Glutops sp.	3	0.62%	Yes	Larva		1	PR
Psychodidae							
Pericoma / Telmatoscopus	3	0.62%	Yes	Larva		4	CG
Simuliidae							
Simulium sp.	1	0.21%	Yes	Larva		6	CF
Simulium sp.	1	0.21%	No	Pupa		6	CF

Taxa Listing

Project ID: URS08BLM
RAI No.: URS08BLM004

RAI No.: URS08BLM004 **Sta. Name:** Joe Creek Above Waste Rock Confluence
Client ID:
Date Coll.: 9/9/2008 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Unique	Stage	Qualifier	BI	Function
Chironomidae							
Chironomidae							
Boreochlus sp.	1	0.21%	Yes	Larva		1	CG
Brillia parva sp.	1	0.21%	Yes	Larva		5	SH
Cricotopus triannulatus	1	0.21%	Yes	Larva		7	SH
Diamesa sp.	2	0.42%	Yes	Larva		5	CG
Eukiefferiella Brehmi Gr.	1	0.21%	Yes	Larva		8	CG
Eukiefferiella Gracei Gr.	1	0.21%	Yes	Larva		8	CG
Limnophyes sp.	1	0.21%	Yes	Larva		8	CG
Micropsectra sp.	1	0.21%	No	Pupa		4	CG
Micropsectra sp.	31	6.44%	Yes	Larva		4	CG
Orthocladius (Euorthocladius) sp.	2	0.42%	Yes	Larva	Early Instar	6	CG
Orthocladius (Orthocladius) sp.	1	0.21%	Yes	Larva	Early Instar	6	CG
Pagastia orthogonia	1	0.21%	Yes	Larva		1	CG
Parametriocnemus sp.	1	0.21%	No	Pupa		5	CG
Parametriocnemus sp.	7	1.46%	Yes	Larva		5	CG
Parorthocladius sp.	1	0.21%	Yes	Larva		6	CG
Parorthocladius sp.	1	0.21%	No	Pupa		6	CG
Thienemanniella sp.	1	0.21%	Yes	Larva		6	CG
Tvetenia Bavarica Gr.	6	1.25%	Yes	Larva		5	CG
Sample Count	**481**						

Metrics Report

Project ID: URS08BLM
RAI No.: URS08BLM001
Sta. Name: Elliott Creek Below Confluence
Client ID:
STORET ID:
Coll. Date: 9/9/2008

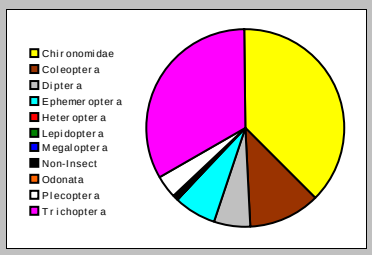
Abundance Measures

Sample Count: 500
Sample Abundance: 833.33 60.00% of sample used

Coll. Procedure:
Sample Notes:

Taxonomic Composition

Category	R	A	PRA
Non-Insect	2	5	1.00%
Odonata			
Ephemeroptera	7	34	6.80%
Plecoptera	7	19	3.80%
Heteroptera			
Megaloptera			
Trichoptera	14	167	33.40%
Lepidoptera			
Coleoptera	8	58	11.60%
Diptera	4	30	6.00%
Chironomidae	21	187	37.40%

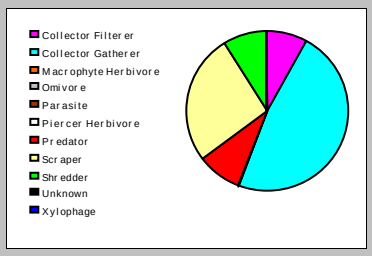


Dominant Taxa

Category	A	PRA
Orthocladius (Orthocladius)	76	15.20%
Neophylax occidentis	68	13.60%
Zaitzevia parvulus	27	5.40%
Glossosoma	27	5.40%
Micropsectra	23	4.60%
Baetis tricaudatus	23	4.60%
Glossosomatidae	19	3.80%
Simulium	16	3.20%
Rheotanytarsus	15	3.00%
Ampumixis dispar	11	2.20%
Agapetus	11	2.20%
Tvetenia Bavarica Gr.	10	2.00%
Cricotopus triannulatus	10	2.00%
Lepidostoma	9	1.80%
Orthocladius (Euorthocladius)	8	1.60%

Functional Composition

Category	R	A	PRA
Predator	16	44	8.80%
Parasite			
Collector Gatherer	25	236	47.20%
Collector Filterer	4	42	8.40%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	7	134	26.80%
Shredder	10	43	8.60%
Omivore	1	1	0.20%
Unknown			

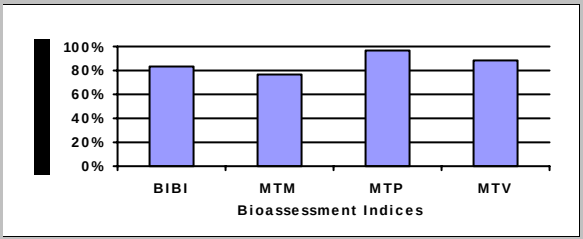


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	63	5	3		3
Non-Insect Percent	1.00%				
E Richness	7	3		3	
P Richness	7	3		3	
T Richness	14	5		3	
EPT Richness	28		3		3
EPT Percent	44.00%		2		1
Oligochaeta+Hirudinea Percent	0.80%				
Baetidae/Ephemeroptera	0.824				
Hydropsychidae/Trichoptera	0.036				
Dominance					
Dominant Taxon Percent	15.20%		3		3
Dominant Taxa (2) Percent	28.80%				
Dominant Taxa (3) Percent	34.20%	5			
Dominant Taxa (10) Percent	61.00%				
Diversity					
Shannon H (loge)	3.315				
Shannon H (log2)	4.783		3		
Margalef D	10.277				
Simpson D	0.065				
Evenness	0.037				
Function					
Predator Richness	16		3		
Predator Percent	8.80%	1			
Filterer Richness	4				
Filterer Percent	8.40%			2	
Collector Percent	55.60%		3		3
Scraper+Shredder Percent	35.40%		3		1
Scraper/Filterer	3.190				
Scraper/Scraper+Filterer	0.761				
Habit					
Burrower Richness	2				
Burrower Percent	2.40%				
Swimmer Richness	4				
Swimmer Percent	5.80%				
Clinger Richness	25	5			
Clinger Percent	50.00%				
Characteristics					
Cold Stenotherm Richness	5				
Cold Stenotherm Percent	15.20%				
Hemoglobin Bearer Richness	2				
Hemoglobin Bearer Percent	0.80%				
Air Breather Richness	2				
Air Breather Percent	1.20%				
Voltinism					
Univoltine Richness	25				
Semivoltine Richness	9	5			
Multivoltine Percent	38.00%		3		
Tolerance					
Sediment Tolerant Richness	1				
Sediment Tolerant Percent	0.40%				
Sediment Sensitive Richness	1				
Sediment Sensitive Percent	5.40%				
Metals Tolerance Index	2.825				
Pollution Sensitive Richness	6	5		3	
Pollution Tolerant Percent	6.60%	5		2	
Hilsenhoff Biotic Index	3.695		3		2
Intolerant Percent	24.80%				
Supertolerant Percent	1.80%				
CTQa	56.889				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	42	84.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	29	96.67%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	16	88.89%	None
MTM	Montana DEQ Mountains (Bukantis 1998)	16	76.19%	Slight



Metrics Report

Project ID: URS08BLM
RAI No.: URS08BLM002
Sta. Name: Elliott Creek Above Confluence
Client ID:
STORET ID:
Coll. Date: 9/9/2008

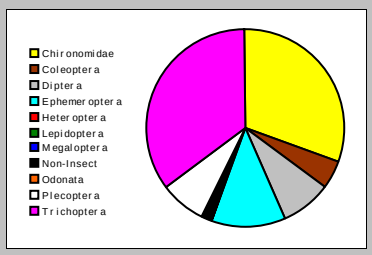
Abundance Measures

Sample Count: 515
Sample Abundance: 735.71 70.00% of sample used

Coll. Procedure:
Sample Notes:

Taxonomic Composition

Category	R	A	PRA
Non-Insect	3	8	1.55%
Odonata			
Ephemeroptera	8	62	12.04%
Plecoptera	7	39	7.57%
Heteroptera			
Megaloptera			
Trichoptera	10	183	35.53%
Lepidoptera			
Coleoptera	7	25	4.85%
Diptera	8	41	7.96%
Chironomidae	17	157	30.49%

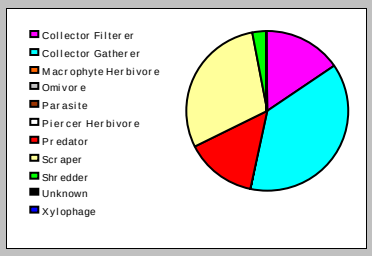


Dominant Taxa

Category	A	PRA
Glossosoma	54	10.49%
Rheotanytarsus	50	9.71%
Micropsectra	50	9.71%
Glossosomatidae	46	8.93%
Baetis tricaudatus	46	8.93%
Neophylax occidentis	24	4.66%
Tvetenia Bavarica Gr.	19	3.69%
Skwala	17	3.30%
Hydropsyche Morosa Gr.	16	3.11%
Agapetus	15	2.91%
Antocha	13	2.52%
Rhyacophila	12	2.33%
Simulium	11	2.14%
Orthocladius (Orthocladius)	10	1.94%
Hesperoconopa	10	1.94%

Functional Composition

Category	R	A	PRA
Predator	17	72	13.98%
Parasite			
Collector Gatherer	25	195	37.86%
Collector Filterer	5	80	15.53%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	8	153	29.71%
Shredder	5	15	2.91%
Omivore			
Unknown			

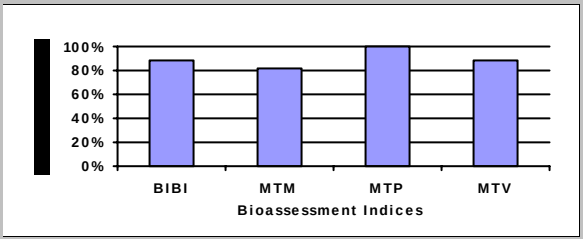


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	60	5	3		3
Non-Insect Percent	1.55%				
E Richness	8	3		3	
P Richness	7	3		3	
T Richness	10	5		3	
EPT Richness	25		3		3
EPT Percent	55.15%		3		2
Oligochaeta+Hirudinea Percent	1.55%				
Baetidae/Ephemeroptera	0.774				
Hydropsychidae/Trichoptera	0.109				
Dominance					
Dominant Taxon Percent	10.49%		3		3
Dominant Taxa (2) Percent	20.19%				
Dominant Taxa (3) Percent	29.90%	5			
Dominant Taxa (10) Percent	65.44%				
Diversity					
Shannon H (loge)	3.234				
Shannon H (log2)	4.666		3		
Margalef D	9.749				
Simpson D	0.063				
Evenness	0.039				
Function					
Predator Richness	17		3		
Predator Percent	13.98%	3			
Filterer Richness	5				
Filterer Percent	15.53%			1	
Collector Percent	53.40%		3		3
Scraper+Shredder Percent	32.62%		3		1
Scraper/Filterer	1.913				
Scraper/Scraper+Filterer	0.657				
Habit					
Burrower Richness	5				
Burrower Percent	3.11%				
Swimmer Richness	2				
Swimmer Percent	9.32%				
Clinger Richness	27	5			
Clinger Percent	56.70%				
Characteristics					
Cold Stenotherm Richness	5				
Cold Stenotherm Percent	7.38%				
Hemoglobin Bearer Richness	1				
Hemoglobin Bearer Percent	1.17%				
Air Breather Richness	4				
Air Breather Percent	5.24%				
Voltinism					
Univoltine Richness	28				
Semivoltine Richness	9	5			
Multivoltine Percent	37.86%		3		
Tolerance					
Sediment Tolerant Richness	2				
Sediment Tolerant Percent	2.91%				
Sediment Sensitive Richness	2				
Sediment Sensitive Percent	11.26%				
Metals Tolerance Index	2.515				
Pollution Sensitive Richness	5	5		3	
Pollution Tolerant Percent	1.94%	5		3	
Hilsenhoff Biotic Index	3.008		3		2
Intolerant Percent	36.89%				
Supertolerant Percent	1.75%				
CTQa	57.775				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	44	88.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	30	100.00%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	16	88.89%	None
MTM	Montana DEQ Mountains (Bukantis 1998)	17	80.95%	Slight



Metrics Report

Project ID: URS08BLM
RAI No.: URS08BLM003
Sta. Name: Joe Creek Below Waste Rock Confluence
Client ID:
STORET ID:
Coll. Date: 9/9/2008

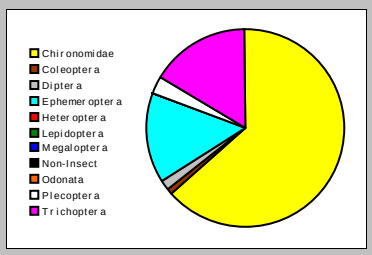
Abundance Measures

Sample Count: 176
Sample Abundance: 176.00 100.00% of sample used

Coll. Procedure:
Sample Notes:

Taxonomic Composition

Category	R	A	PRA
Non-Insect			
Odonata			
Ephemeroptera	5	26	14.77%
Plecoptera	5	5	2.84%
Heteroptera			
Megaloptera			
Trichoptera	7	29	16.48%
Lepidoptera			
Coleoptera	2	2	1.14%
Diptera	3	3	1.70%
Chironomidae	11	111	63.07%

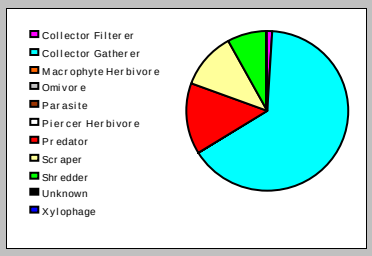


Dominant Taxa

Category	A	PRA
Orthocladius (Euorthocladius)	31	17.61%
Eukiefferiella Gracei Gr.	25	14.20%
Orthocladius (Orthocladius)	20	11.36%
Baetis tricaudatus	13	7.39%
Rhyacophila	10	5.68%
Pagastia orthogonia	9	5.11%
Parorthocladius	7	3.98%
Anagapetus	7	3.98%
Drunella coloradensis	6	3.41%
Brillia parva	6	3.41%
Tvetenia Bavarica Gr.	5	2.84%
Rhyacophila Betteni Gr.	5	2.84%
Epeorus grandis	3	1.70%
Cricotopus (Cricotopus)	3	1.70%
Ironodes	2	1.14%

Functional Composition

Category	R	A	PRA
Predator	10	25	14.20%
Parasite			
Collector Gatherer	10	115	65.34%
Collector Filterer	2	2	1.14%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	5	20	11.36%
Shredder	6	14	7.95%
Omivore			
Unknown			

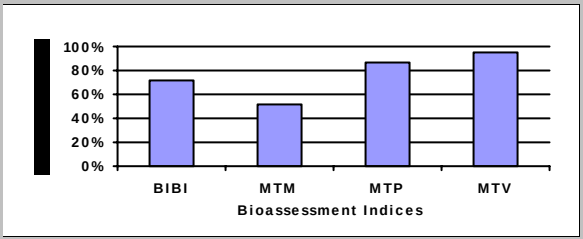


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	33	3	3		3
Non-Insect Percent	0.00%				
E Richness	5	3		2	
P Richness	5	3		3	
T Richness	7	3		3	
EPT Richness	17		3		2
EPT Percent	34.09%		2		0
Oligochaeta+Hirudinea Percent					
Baetidae/Ephemeroptera	0.500				
Hydropsychidae/Trichoptera	0.034				
Dominance					
Dominant Taxon Percent	17.61%		3		3
Dominant Taxa (2) Percent	31.82%				
Dominant Taxa (3) Percent	43.18%	5			
Dominant Taxa (10) Percent	76.14%				
Diversity					
Shannon H (loge)	2.833				
Shannon H (log2)	4.087		3		
Margalef D	6.305				
Simpson D	0.084				
Evenness	0.054				
Function					
Predator Richness	10		3		
Predator Percent	14.20%	3			
Filterer Richness	2				
Filterer Percent	1.14%			3	
Collector Percent	66.48%		2		2
Scraper+Shredder Percent	19.32%		2		0
Scraper/Filterer	10.000				
Scraper/Scraper+Filterer	0.909				
Habit					
Burrower Richness	2				
Burrower Percent	1.70%				
Swimmer Richness	1				
Swimmer Percent	7.39%				
Clinger Richness	14	3			
Clinger Percent	26.14%				
Characteristics					
Cold Stenotherm Richness	6				
Cold Stenotherm Percent	9.66%				
Hemoglobin Bearer Richness					
Hemoglobin Bearer Percent					
Air Breather Richness	2				
Air Breather Percent	1.14%				
Voltinism					
Univoltine Richness	17				
Semivoltine Richness	4	3			
Multivoltine Percent	44.32%		2		
Tolerance					
Sediment Tolerant Richness	1				
Sediment Tolerant Percent	0.57%				
Sediment Sensitive Richness	1				
Sediment Sensitive Percent	3.98%				
Metals Tolerance Index	4.149				
Pollution Sensitive Richness	7	5		3	
Pollution Tolerant Percent	0.57%	5		3	
Hilsenhoff Biotic Index	4.313		3		1
Intolerant Percent	31.82%				
Supertolerant Percent	15.34%				
CTQa	58.900				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	36	72.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	26	86.67%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	17	94.44%	None
MTM	Montana DEQ Mountains (Bukantis 1998)	11	52.38%	Moderate



Metrics Report

Project ID: URS08BLM
RAI No.: URS08BLM004
Sta. Name: Joe Creek Above Waste Rock Confluence
Client ID:
STORET ID:
Coll. Date: 9/9/2008

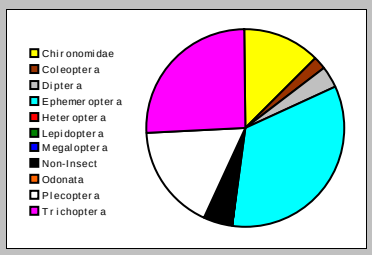
Abundance Measures

Sample Count: 481
Sample Abundance: 481.00 100.00% of sample used

Coll. Procedure:
Sample Notes:

Taxonomic Composition

Category	R	A	PRA
Non-Insect	4	22	4.57%
Odonata			
Ephemeroptera	13	162	33.68%
Plecoptera	12	83	17.26%
Heteroptera			
Megaloptera			
Trichoptera	8	126	26.20%
Lepidoptera			
Coleoptera	4	10	2.08%
Diptera	7	17	3.53%
Chironomidae	15	61	12.68%

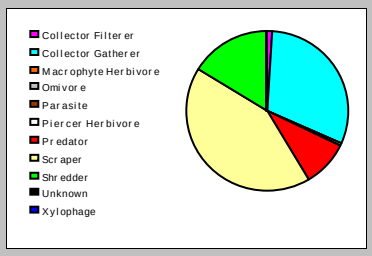


Dominant Taxa

Category	A	PRA
Anagapetus	98	20.37%
Drunella doddsii	38	7.90%
Yoraperla brevis	34	7.07%
Micropsectra	32	6.65%
Baetis tricaudatus	31	6.44%
Epeorus grandis	30	6.24%
Cinygmula	18	3.74%
Visoka cataractae	17	3.53%
Mesenchytraeus	16	3.33%
Rhithrogena	15	3.12%
Sierraperla cora	9	1.87%
Rhyacophila Betteni Gr.	9	1.87%
Ecclisomyia	9	1.87%
Parametriocnemus	8	1.66%
Drunella spinifera	8	1.66%

Functional Composition

Category	R	A	PRA
Predator	15	45	9.36%
Parasite			
Collector Gatherer	25	145	30.15%
Collector Filterer	2	6	1.25%
Macrophyte Herbivore			
Piercer Herbivore			
Xylophage			
Scraper	10	205	42.62%
Shredder	10	77	16.01%
Omivore	1	3	0.62%
Unknown			

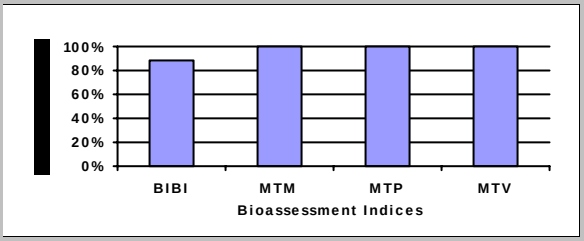


Metric Values and Scores

Metric	Value	BIBI	MTP	MTV	MTM
Composition					
Taxa Richness	63	5	3		3
Non-Insect Percent	4.57%				
E Richness	13	5		3	
P Richness	12	5		3	
T Richness	8	3		3	
EPT Richness	33		3		3
EPT Percent	77.13%		3		3
Oligochaeta+Hirudinea Percent	3.95%				
Baetidae/Ephemeroptera	0.191				
Hydropsychidae/Trichoptera	0.040				
Dominance					
Dominant Taxon Percent	20.37%		3		3
Dominant Taxa (2) Percent	28.27%				
Dominant Taxa (3) Percent	35.34%	5			
Dominant Taxa (10) Percent	68.40%				
Diversity					
Shannon H (loge)	3.186				
Shannon H (log2)	4.597		3		
Margalef D	10.070				
Simpson D	0.074				
Evenness	0.039				
Function					
Predator Richness	15		3		
Predator Percent	9.36%	1			
Filterer Richness	2				
Filterer Percent	1.25%			3	
Collector Percent	31.39%		3		3
Scraper+Shredder Percent	58.63%		3		3
Scraper/Filterer	34.167				
Scraper/Scraper+Filterer	0.972				
Habit					
Burrower Richness	4				
Burrower Percent	2.08%				
Swimmer Richness	3				
Swimmer Percent	6.86%				
Clinger Richness	24	5			
Clinger Percent	62.16%				
Characteristics					
Cold Stenotherm Richness	19				
Cold Stenotherm Percent	56.55%				
Hemoglobin Bearer Richness					
Hemoglobin Bearer Percent					
Air Breather Richness	0				
Air Breather Percent	0.00%				
Voltinism					
Univoltine Richness	36				
Semivoltine Richness	6	5			
Multivoltine Percent	19.75%		3		
Tolerance					
Sediment Tolerant Richness	0				
Sediment Tolerant Percent	0.00%				
Sediment Sensitive Richness	4				
Sediment Sensitive Percent	21.62%				
Metals Tolerance Index	1.485				
Pollution Sensitive Richness	20	5		3	
Pollution Tolerant Percent	0.42%	5		3	
Hilsenhoff Biotic Index	1.459		3		3
Intolerant Percent	70.48%				
Supertolerant Percent	0.62%				
CTQa	60.179				

Bioassessment Indices

BioIndex	Description	Score	Pct	Rating
BIBI	B-IBI (Karr et al.)	44	88.00%	
MTP	Montana DEQ Plains (Bukantis 1998)	30	100.00%	None
MTV	Montana Revised Valleys/Foothills (Bollman 1998)	18	100.00%	None
MTM	Montana DEQ Mountains (Bukantis 1998)	21	100.00%	None



PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT BLUE LEDGE MINE SISKIYOU COUNTY, CALIFORNIA

November 2008

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USDA Forest Service

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS I

1 INTRODUCTION 1-1
- 1.1 GENERAL 1-1
- 1.2 BACKGROUND 1-1

2 FIELD AND LABORATORY INVESTIGATIONS 2-1
- 2.1 FIELD INVESTIGATION 2-1
  - 2.1.1 Visual Reconnaissance 2-1
  - 2.1.2 Waste Rock Characterization 2-1
  - 2.1.3 TEST PITS 2-2
- 2.2 LABORATORY TESTING 2-2

3 SITE DESCRIPTION 3-1
- 3.1 SURFACE CONDITIONS 3-1
  - 3.1.1 Region 3-1
  - 3.1.2 Mine Site 3-1
  - 3.1.3 Eileen Site 3-2
  - 3.1.4 North Repository Site 3-3
  - 3.1.5 South Repository Site 3-3
- 3.2 REGIONAL GEOLOGY 3-4
- 3.3 SUBSURFACE CONDITIONS 3-4
  - 3.3.1 Mine Site 3-5
  - 3.3.2 Eileen Site 3-5
  - 3.3.3 North Repository Site 3-5
  - 3.3.4 South Repository Site 3-6
- 3.4 GROUNDWATER CONDITIONS 3-7
  - 3.4.1 Mine Site 3-7
  - 3.4.2 Eileen Site 3-7
  - 3.4.3 North Repository Site 3-7
  - 3.4.4 South Repository Site 3-8
- 3.5 SEISMICITY 3-8

4 GEOTECHNICAL PROPERTIES AND CONSTRUCTION CONSIDERATIONS 4-1
- 4.1 MINE SITE 4-1
  - 4.1.1 Waste Rock Volume 4-1

4.1.2 Waste Rock Characterization 4-2
4.1.3 Construction Considerations 4-2
4.2 ROADWAY CONDITION REVIEW 4-3
4.3 BORROW MATERIALS 4-4
4.3.1 Eileen Site 4-4
4.3.2 Repository Sites 4-5
4.3.2.1 North Repository Site 4-5
4.3.2.2 South Repository Site 4-5
4.4 SLOPE STABILITY 4-6
4.4.1 North Repository Site 4-6
4.4.2 South Repository Site 4-7
4.5 DISPOSAL SITE SUITABILITY 4-8
4.5.1 Site Stability 4-9
4.5.1.1 North Repository Site 4-9
4.5.1.2 South Repository Site 4-9
4.5.2 Site Footprint 4-10
4.5.2.1 North Repository Site 4-10
4.5.2.2 South Repository Site 4-10
4.5.3 Repository Liner 4-10
4.5.4 Fill Slopes 4-10
4.5.5 Cover Design 4-10
4.5.6 Summary 4-11
4.5.6.1 North Repository Site 4-11
4.5.6.2 South Repository Site 4-11
5 CLOSURE 5-1
6 REFERENCES 6-1

LIST OF TABLES

Table 3-1 Seismic Design Peak Ground Accelerations (PGA) on Rock
Table 4-1 Waste Rock Volume Estimates
Table 4-2 North Repository Site Material Properties
Table 4-3 North Repository Site Slope Stability Results
Table 4-4 South Repository Site Material Properties
Table 4-5 South Repository Site Slope Stability Results

LIST OF FIGURES

Figure 1-1 Vicinity Map
Figure 2-1 Test Pit Locations
Figure 3-1 Surveyed Waste Rock Piles

LIST OF APPENDICES

Appendix A Test Pit Logs
Appendix B Laboratory Test Data
Appendix C Waste Rock Volume Calculations
Appendix D Slope Stability Analyses

1 INTRODUCTION

1.1 GENERAL

The United States Department of Agriculture Forest Service (USFS) is preparing an Engineering Evaluation/Cost Analysis (EE/CA) for the removal action at the Blue Ledge Mine site. The mine site is located in Siskiyou County, California, approximately 8 miles south of Applegate Reservoir on the Oregon/California border. The site is located within the Rogue-Siskiyou National Forest. A site vicinity map is shown on the attached Figure 1-1.

URS conducted preliminary geotechnical investigations to support the EE/CA. This report summarizes the local geologic conditions and the field and laboratory investigations and presents the data and the preliminary analyses. These analyses are intended to assist in a "fatal flaw" analysis of the removal-action alternatives and are not intended as a basis of design. Additional detailed analyses will be completed for final design of the selected alternative.

This report discusses geotechnical explorations conducted between June 24 and 27, 2008 and the associated geotechnical analyses. A supplementary geotechnical investigation was performed in November 2008 to assess stability of possible waste rock repository locations (see Appendix D).

1.2 BACKGROUND

The Blue Ledge ore body was discovered in 1898. Mining began soon thereafter and continued until the 1930s. During mining operations, waste rock materials were cast down the steep slopes and accumulated in piles below the mine adits. Erosion of the waste rock, and water infiltration and runoff has adversely impacted water quality in the watersheds downstream of the site. Two primary mitigation options include the following. :

- Stabilization of the waste rock in situ (physically and/or geochemically)
- Removal of waste rock from the site and disposing of it at an off-site location. Potential waste-rock repository sites have been identified near the mine site. After removal of the waste rock, the mine site may be restored by placement and planting of reclamation fill.

The removal-action approach presumed in this report is removal of the waste rock and placement in a repository near the site. This report focuses primarily on the characteristics of the waste rock and repository sites for the presumed alternative. This report does not discuss geotechnical considerations of an in-situ stabilization alternative or placement of restoration fill on the mine site.

2 FIELD AND LABORATORY INVESTIGATIONS

2.1 FIELD INVESTIGATION

Field work completed in June 2008 included the following tasks:

- Visual reconnaissance and characterization of the mine site and repository areas.
- Characterization and development of a thickness profile of the existing waste rock material at the mine site.
- Excavation of 9 test pits. Figure 2-1 shows test pit locations.
- Collection of soil samples from test pits and waste rock piles for laboratory characterization.

Additional geotechnical investigation was performed between November 3 and November 8, 2008. The additional investigation included drilling five borings, more detailed visual reconnaissance, additional laboratory testing, and analysis of slope stability. Appendix D provides details of the slope stability testing. The analysis demonstrates that identified repository locations would be sufficiently stable.

2.1.1 Visual Reconnaissance

Visual reconnaissance was performed at following sites:

- The Blue Ledge Mine site.
- The Eileen site.
- Two potential repository sites located about 1 mile north of the mine site.

The visual reconnaissance consisted of visual assessments of the site conditions, topography, accessibility, and basic geomorphology.

2.1.2 Waste Rock Characterization

A total of four waste rock piles have been identified and are considered a part of the Blue Ledge Mine site. Figure 2-1 shows the approximate limits of the waste-rock piles. Waste rock at the mine site was characterized in the following manner:

- Completing a detailed survey (5-foot elevation resolution) of the two largest waste rock piles at the mine site. This survey was performed by OBEC Consulting Engineers of

Medford, Oregon. Survey data is presented on Figure 3-1 (overlaying USGS map data).

- Measuring the waste rock thickness at discrete locations throughout the slopes.
- Identifying the approximate location of rock outcrops.
- Identifying and making approximate measurements of the limits of the waste rock.
- Visually classifying the waste rock materials in general accordance with ASTM D 2488.

2.1.3 TEST PITS

The subsurface investigation included excavating nine test pits to depths ranging from 9 feet to 14 feet below ground surface (bgs). The location of the test pits are shown in Figure 2-1. Bradley Excavation of Medford, Oregon excavated the test pits using a Case 580 backhoe. URS directed the excavation, logged the excavations, and collected representative soil samples from the test pits as they were excavated. The test pits were backfilled with excavated soils upon completion. Detailed test pit logs are presented in Appendix A.

2.2 LABORATORY TESTING

Physical properties of the soil from the test pits were analyzed at URS' soil laboratory in Portland, Oregon. The laboratory analyses included the following tests conducted in general accordance with the listed ASTM methods:

- Soil classification, ASTM D 2487.
- Moisture content tests, ASTM D 2216.
- Amount of material finer than the No. 200 Sieve, ASTM D 1140.
- Grain Size Analysis Mechanical Testing, ASTM Test Method D 422 and D 1140.
- Liquid and plastic limits (Atterberg Limits), ASTM D 4318.
- Laboratory compaction characteristics of soil using standard effort, ASTM D 698.

Selected results of the physical laboratory tests conducted are summarized on the test pit logs in Appendix A. Complete laboratory test results are presented in Appendix B.

3 SITE DESCRIPTION

3.1 SURFACE CONDITIONS

3.1.1 Region

The site is located approximately 35 miles southwest of Jacksonville, Oregon within the Rogue-Siskiyou National Forest. The site vicinity map is shown in Figure 1-1. The terrain in the vicinity of the site is characterized as follows:

- The region is characterized by steep valleys and ridges, with few areas of level ground.
- Elevations range from about 2,000 to over 6,000 feet mean sea level (msl).
- Natural slopes range from 4H:1V (horizontal:vertical) to 1H:1V, with local near-vertical cliff exposures.
- Slopes are generally forested except in areas of rock outcrop.
- The area is generally undeveloped except for timber harvesting and historic mining activities.
- Access to the area is provided by gravel-surfaced roads.

3.1.2 Mine Site

The mine site is located near the headwaters of Joe Creek, as shown on Figure 1-1. The mine site consists of a number of adits located near the ridge crest with waste rock piles extending down slope.

- Elevations at the site range from about 4,000 to 5,200 feet msl. Mine adits are located at approximately 4,800 feet msl.
- Ungraded slopes at the mine site range from about 1.5H:1V to 1H:1V. Slopes tend to be steepest above elevation 4,450 feet msl.
- Local rock outcrops within the slopes at the site are near vertical.
- Waste rock materials were deposited during mining operations by casting material down slopes from mine adits, forming waste rock piles.
- There are four waste rock piles at the mine site, referred to as WRP-1 through WRP-4. Figure 2-1 shows the WRP locations. Waste-rock areas WRP-1 and WRP-2 comprise most of the waste rock. Two smaller piles, WRP-3 and WRP-4, are located within 1,000

feet of the main piles.

- Waste rock thickness is highly variable across the slopes. Locally, drainage rivulets have eroded through the waste rock piles to bedrock. Waste rock piles are up to an estimated 8 feet thick.
- Access to WRP-1 is provided by construction roads that reach the base of the pile and the center of the pile at approximate elevation 4,450 feet. These roads are accessed by Forest Service Road 1060.
- There is no developed access above 4,450 feet at the site, nor is there any access to WRP-2, WRP-3, or WRP-4.
- The EPA regraded lower portion of WRP-1 in 2006. These modifications included the following:
  - Regrading slopes to approximately 2H:1V between elevation 4,280 and 4,150 feet msl.
  - Construction of a lined channel through the regraded area to control surface water flow.
  - Construction of a settling pond at the base of the regraded area to treat surface and groundwater flowing through this drainage. Both the pond and the channel were lined with limestone.

3.1.3 Eileen Site

The Eileen site is located in the Joe Creek valley at the base of the mine (Figure 2-1). The site is a former town that serviced the mine during its operation. There are no apparent remnants of the town. The USFS has identified the area of the former town site as a potential borrow area for site restoration and repository area cap materials. The site is characterized as follows:

- Overall, the site is relatively level for the region, with slopes ranging from 3H:1V to 4H:1V. However, surficial topography is irregular.
- The site is an area of approximately 3.5 acres.
- Elevations at the site range from about 4,020 to 4,160 feet msl, sloping downward to the southwest to Joe Creek.
- The site is covered in young trees and dense brush.
- The USFS suspects that the area is a landslide deposit (Jones, 2008). URS agrees with that observation on the basis of reviews of aerial photographs and topographic maps that indicate potential landslide geomorphology upslope and west of the site.

3.1.4 North Repository Site

The north repository site is located approximately 1 mile north of the mine site (Figure 2-1). The site was formerly used as a landing for logging operations. The USFS (Jones, 2008) reports that logging occurred during the 1980s. The north repository site is characterized as follows:

- The site is situated along a relatively flat ridge crest.
- The site area is approximately 2 acres.
- Elevations range from about 3,850 to 3,900 feet msl. Creek basins below the site (representing the toe of slopes extending from the crest) extend below 3,000 feet msl.
- Slopes below the site to the north and west are generally steep, and range from 1H:1V to 2H:1V. Immediately east of the site the ridgeline gradually gains elevation at grades of 4H:1V to 5H:1V. To the south, grades drop from the ridge and range from about 3H:1V to 5H:1V.
- The landing area and ridge crest is clear of brush and trees and is covered in aggregate surfacing with some grass. Down slope of the landing, the slopes are covered with open, second-growth forest and light brush.
- Spur Road 400 off of Forest Service Road 1060 provides access.

3.1.5 South Repository Site

The south repository site is located approximately 1,000 feet south of the north repository site (Figure 2-1). The site was formerly used as a landing for logging operations during the 1980s. The south repository site is characterized as follows:

- The site is situated on a relatively flat bench within a continuous slope.
- The site area is approximately 4 acres.
- Elevations of the site range from approximately 3,840 to 3,880 feet msl. Elevations range from between about 3,100 to 4,600 feet msl between the valley bottom below and ridge line above the site.
- Slopes above the site to the east range from 1H:1V to 2H:1V. Below the site slopes generally range from 2H:1V to 2.5H:1V. Immediately west of the site (below the access road), slopes are locally as steep as 1.4H:1V.
- The landing is partially covered in brush and young trees. Upslope and down slope of the site are covered with a mix of mature and second-growth forest. The USFS estimates that

the larger trees in the area are at least 300 years old (Jones, 2008). A number of large, old growth stumps were observed in excess of 4 feet in diameter.

- The area is suspected to be a part of an old, large landslide. Review of aerial photographs and topographic maps indicate potential landslide geomorphology upslope and west-southwest of the site.
- Road access to the site provided by the Spur Road 300 off of Forest Road 1060.

3.2 REGIONAL GEOLOGY

The site is located within the Klamath Mountains Physiographic province that extends from northwest California to southwest Oregon. This province is bounded by the Oregon Coast Range to the north and the Cascade Mountains to the east. The province is composed of fragments of exotic terrains that were previously parts of ocean crust or island arc environments (Orr and Orr, 2000, Elliott, et. al. 2007). These terrains were carried eastward toward the North American continent where they collided and were accreted. The series of accreted terrains are separated by fault zones and were later intruded by granitic rock. Local geologic features include the following:

- The site is located within the Condrey Mountain subterrain, which is composed of schist (Orr and Orr, 2000). The Condrey Mountain Schist consists of three primary rock types, black schist, green schist and serpentinite (Van Nieuwenhuyse, 1983).
- The region around the site consists of a series of fold belts, with fold axes generally trending to the north-northeast/south-southwest. These folds are generally steeply dipping (Van Nieuwenhuyse, 1983).
- Schist in the vicinity of the mine site has an average strike of N10E and dip of 60 degrees west (Hundhausen, 1947).
- Observation of foliation in rock outcrops near the repository sites indicate a general north-south strike and dip of 60 to 90 degrees to the west.

3.3 SUBSURFACE CONDITIONS

The subsurface conditions were observed in test pits, as described below. Appendix A includes logs of test pits. Appendix B summarizes results of laboratory analyses of soil samples from the test pits. Boring logs and laboratory data obtained during the supplementary investigation in November 2008 will be reported later.

3.3.1 Mine Site

Explorations at the mine site consisted of reconnaissance measurements of waste rock thicknesses across waste areas. In general, 3 to 6 feet of waste rock overlies intact bedrock. The thickness of WRP-1 (Figure 3-1) is estimated to be 8 to 9 feet near its base, but the waste rock has been eroded to the underlying bed rock higher on the slope. The three other waste rock piles were estimated to have a maximum thickness of 3 feet. The waste rock material consisted of reddish brown silty gravel with sand. There is some variability in the grain size distribution of the waste rock, and it is expected to range from silty sand to sandy gravel with silt. Underlying the waste rock is intact schist bedrock.

3.3.2 Eileen Site

Test pit TP-9 was excavated at the Eileen site (Figure 2-1). The soils encountered at this site were colluvial. The soils are described as follows:

- *Topsoil:* Approximately 1 foot of organic soil and forest duff.
- *Colluvial Soil*: Brown, clayey gravel with sand to clayey sand with gravel. Up to 20% cobble-sized, consisting of fresh to moderately weathered schist clasts. Individual clasts as large as 2 feet. Material encountered to 9 feet bgs, the maximum depth explored. The colluvium is interpreted to be landslide debris.

Seepage was observed on the test pit wall at a depth of 2 feet bgs.

3.3.3 North Repository Site

Explorations at the north repository site included test pits TP-1 through TP-6 (Figure 2-1).[1] In general, the soils at the north site consisted of near-surface fill overlaying weathered schist bedrock. The soils are described as follows:

- *Gravel*: 6 inches of 2-inch diameter round aggregate. Gravel found over most of the landing area, but not in TP-5 and TP-6 which were located east of the landing.
- *Fill*: 1 to 4 feet of fill in the landing area. Fill not found in TP-5 and 6, east of the landing. Fill was likely placed to level the landing area. Fill consisted of light brown silty sand with gravel. 5 to 10% of fill consisted of cobble-sized fragments in situ. Fragments broke

[1] Two borings were advanced in this area to depths of up to 41.5 feet during the supplementary investigations conducted in November 2008. The results of the supplemental investigations will be reported later.

down into sand and gravel-sized particles during sieve testing in the laboratory. Fill material was similar to the weathered schist found below. Remnant organic material and a color change at the base of the fill indicated the original ground surface.

- *Weathered Schist*: Below the fill, weathered schist consisting of reddish brown, dense to very dense, silty sand with gravel to a depth of 14 feet bgs, the maximum depth in TP-5 and TP-6. This material was encountered to depths of 41.5 feet bgs in the supplementary investigation. The soil consists of schist bedrock that has weathered to soil in situ. Composition varied from sandy silt to silty gravel with sand in localized lenses. The schist soil differed from the gravel fill by color and the presence of remnant rock fabric. Some gravel and cobble-sized fragments could be broken down into smaller sizes under finger pressure. In general, this material became more competent (more dense) with depth. Excavation refusal within the residual schist was not reached – excavation depths were limited by the length of the equipment used for excavation. In the supplementary investigation, Standard Penetration Test refusal (greater than 50 blows for 6 inches of penetration) was reached between depths of 10 to 30 feet bgs).

No groundwater was observed.

3.3.4 South Repository Site

Explorations at the south repository site included Test Pits 7 and 8 (Figure 2-1).[2] The soils encountered at the south site consisted of colluvium overlying residual schist. The soils are described as follows:

- *Topsoil/Debris*: 6 inches to 2 feet of organic-rich sand and gravel. Material interpreted to reflect historical area grading for logging operations and wood debris accumulation.
- *Colluvial Soil*: Brown, medium dense silty sand with gravel. Approximately 5 to 15% cobble-sized, consisting of fresh to moderately weathered schist rock fragments. Individual clasts as large as 3 feet. Soil matrix did not have remnant rock fabric. This material was encountered to the maximum depths explored, 13 feet. The supplementary investigation indicated these soils extended to depths of 20 to 60 feet bgs. These soils are interpreted to be landslide debris or colluvium deposited on a displaced rock mass.
- *Residual Schist*: Extremely to completely weathered dark gray schist. This material was dense to very dense and maintained a remnant foliation. However, this foliation generally

[2] Three borings were advanced in this area to depths of up to 76.5 feet during the supplementary investigations conducted in November 2008. The results of the supplemental investigations are reported in Appendix D.

did not match the regional foliation. This schist is preliminarily interpreted to be large blocks displaced during an old (in excess of 300 years, minimally) landslide event.

No seepage or groundwater was observed during the explorations.

3.4 GROUNDWATER CONDITIONS

3.4.1 Mine Site

Water was observed seeping from several of the adits. No seepage was observed within the waste rock piles.

3.4.2 Eileen Site

Groundwater seeped from the wall of the test pit advanced at the Eileen site at a depth of approximately 2 feet. The seep is interpreted to be perched groundwater and not indicative of a regional groundwater level. Several observations indicate that shallow soils could become seasonally saturated:

- The area is relatively flat, promoting surface infiltration.
- The site has a large catchment area above it. Surface water runoff moving down slope may tend to collect and infiltrate in this area.
- The soils are interpreted to be landslide debris. By their nature, these soils are heterogeneous and unconsolidated. There are likely permeable zones with low levels of fines that will promote infiltration, as well as low permeability soils that may hold perched water.

3.4.3 North Repository Site

Groundwater was not encountered is test pits excavated in June or in borings advanced to more that 40 feet in November. Shallow groundwater is not expected at this location due to the following factors:

- The site is located on a ridgeline.
- There are no substantial infiltration areas.
- The soils are primarily dense to very dense residual schist rock. The soils maintain their remnant rock fabric in situ and have fines content between 30 and 50%, minimizing infiltration.

3.4.4 South Repository Site

Groundwater was not encountered is test pits excavated in June or in borings advanced to more that 76 feet in November. Several observations indicate that shallow soils could become seasonally saturated:

- The site is relatively flat over its area of approximately 250 feet by 750 feet, promoting surface infiltration.
- The site has a large catchment area above it. Surface water runoff moving down slope will tend to collect and infiltrate in this area.
- The soils are interpreted to be old landslide debris. By their nature, these soils are heterogeneous and unconsolidated. There are likely permeable zones with low levels of fines that will promote infiltration, as well as low permeability soils that may hold perched water.

3.5 SEISMICITY

The Pacific Northwest has four principle types of seismic sources. These sources include (Wong and Silva, 1998):

- The subduction zone megathrust, which represents the boundary (interface) between the downgoing Juan de Fuca plate and the overriding North American plate.
- Faults located within the Juan de Fuca plate (referred to as the intraplate or intraslab region).
- Crustal faults principally in the North American plate.
- Volcanic sources beneath the Cascade Range.

Probabilistic analyses conducted by the United States Geological Survey (USGS) in support of the 2002 National Seismic Hazard Maps indicate that the ground motions from the subduction zone earthquake dominate the seismic hazards for this site. The nearest mapped quaternary fault is approximately 50 miles from the site.

Probabilistic ground motions for the site have been obtained from the current USGS Seismic Hazard Maps (http://eqhazmaps.usgs.gov/, based on Frankel et al., 2002). The probabilistic peak ground accelerations on bedrock for the 475-year and 2,475-year return period events are presented in Table 3-1.

Table 3-1
Seismic Design Peak Ground Accelerations (PGA) on Rock

Design Ground Motion	USGS PGA
475-year return period	0.13g
2475-year return period	0.28g

Note: Source for USGS data: http://eqint.cr.usgs.gov/eq-men/html/deaggint2002-06.html (lookup lat. =41.962, long. = -123.1065)

4 GEOTECHNICAL PROPERTIES AND CONSTRUCTION CONSIDERATIONS

4.1 MINE SITE

4.1.1 Waste Rock Volume

Four waste rock piles were found at the mine site, identified as WRP-1, WRP-2, WRP-3 and WRP-4 (Figure 2-1). A detailed field survey was completed for piles WRP-1 and WRP-2. Survey data are presented in Figure 3-1. Area measurements were made for WRP-3 and WRP-4 by visual inspection, reconnaissance measurement, and aerial photo review. A future survey of WRP-3 and WRP-4 and the surrounding areas will support the removal design.

Waste rock thickness measurements made at discrete locations throughout the piles were interpolated between points to estimate thickness. Thickness estimates were combined with surveyed or estimated areas to calculate waste rock volumes. The estimated waste rock volumes of each waste rock pile are presented in Table 4.1. Appendix C shows volume calculations.

Table 4-1
Waste Rock Volume Estimates

Waste Rock Pile ID	Location	Volume (cubic yards)
WRP-1	Slope north of main mine site	20,000
WRP-2	Slope east of main mine site	5,000
WRP-3	1,000 feet south of main mine site	5,000
WRP-4	Across drainage north of main mine site	1,000

The total estimated waste rock volume is approximately 31,000 cubic yards. In many cases, thicknesses were estimated by comparing local rock outcrop elevations (where erosion rivulets had formed) with the undisturbed waste rock slope face. There may be considerable variability between the interpolated thicknesses and actual thickness due to bedrock surface irregularity. Given the uncertainty of the estimates, we consider the volume estimates to be accurate within a range of plus/minus 25%. Accordingly, for construction estimating purposes, the estimated waste rock volume ranges from approximately 23,000 to 39,000 cubic yards.

4.1.2 Waste Rock Characterization

Typical waste-rock properties were developed based on field observations and laboratory testing. In general, the waste rock is a silty gravel with sand with the following properties:

- Friction angle ranging from 36 to 42 degrees (based on the orientation of natural slopes present at the mine site).
- An in situ moisture content of 5 to 8%.
- A silt content of up to 20%.
- A maximum dry density of about 115 pounds per cubic foot at an optimum moisture content of 12.5%, as measured by the Standard Proctor Test (ASTM D 698).

4.1.3 Construction Considerations

The primary difficulty for the likely removal-action approach ─ waste-rock removal and placement in a repository ─ is excavating the waste rock from the steep and rocky terrain with limited developed access. Possible placement of restoration fill over the waste rock areas would present a similar difficulty.

The waste rock materials are situated on slopes that range from 1.5H:1V to 1H:1V, over an 800-foot elevation range. The only developed access to the site is a disused construction road that leads to the approximate midpoint of WRP-1. In its current condition, this road can be negotiable only by off-highway earthmoving equipment (such as dozers and loaders). The road would require regrading and possibly widening to handle on- and off-highway haul trucks. The road does not provide access to WRP-2, WRP-3, or WRP-4. New haul roads would be required to access these sites. WRP-3 will require significant effort to access due to its distance from developed roads and the very steep terrain.

The steep slopes at each of the waste-rock sites limit the use of standard earthmoving equipment for removal of the waste rock materials. Potential methods to remove waste rock include:

- *Anchored Heavy Equipment*: This would involve an excavator or dozer pushing material down slope to a collection point where it could be hauled to the disposal site. Due to the steep terrain, equipment would have to be anchored to the top of the slope with cables. Anchorage could be provided by another piece of construction equipment or by drilling anchors into rock.
- *Dragline*: This would involve installing dragline equipment to scrape material off of the slope. This system would require anchorage and equipment placed at the top of the slope.

- *Terracing*: The use of terracing techniques may be applicable in some areas to allow access by conventional earthmoving equipment.

It is expected that the bedrock below the waste rock surface is uneven. Cleanly removing all of the waste rock from the bedrock surface will be extremely difficult. Clean removal may require excavation with small earthmoving equipment or manual excavation.

The waste rock material is well-suited for placement in a disposal repository. The material is dry of the optimum moisture content in situ (during the dry season). Moisture would be added to attain its maximum density, an operation that is easier than drying soils that are too wet. Due to its granular nature, this material also should not be highly moisture sensitive.

4.2 ROADWAY CONDITION REVIEW

Access to the site from Applegate Reservoir is provided by Forest Service (FS) Roads 1050 and 1060. Overall, these roads are in good condition and are passable by passenger vehicles, but local improvements will likely be required to accommodate construction equipment. The final modifications required will depend upon the Contractor's selected construction methods. Specific observations on the roadway conditions include the following:

- FS Road 1060 may require local widening between Joe Bar and the project area to accommodate heavy construction equipment. The distance between Joe Bar and the project area is approximately 3 miles.
- FS Road 1060-400 provides access from FS Road 1060 to the repository sites. The length of FS Road 1060-400 is approximately 1,000 feet. Portions of this road are currently too steep for highway trucks. This road may require regrading. The road also may need widening for off-highway construction traffic.
- It is anticipated that FS Road 1060 will be the primary haul road between the mine site and the repository sites. In its current condition, this road is not wide enough to accommodate two-way off-highway or large highway construction traffic. The distance from the mine site to the repository site is about 1 mile. At a minimum, turnouts would need to be added to provide passing areas for vehicles traveling in opposite directions. Further, an additional rock cut will be required approximately 1,000 feet south of FS Road 1060-400 to allow truck passage through a narrow turn.

4.3 BORROW MATERIALS

Borrow materials are needed necessary to cover waste rock repositories and support revegetation. Borrow material may also be placed over the waste rock areas to support restoration of the hillsides.

Required borrow volumes were estimated assuming that repositories would be covered by approximately three feet of soil and a vegetative cover. The potential north and south repository areas are 2 and 4 acres, respectively. If the former waste-rock areas were reclaimed, the estimated average depth of cover is 2.5 to 3 feet over approximately 80% of the 4.6 acres of waste-rock piles. Substantial rock outcrops and the very steep upper portions of WRP-1 would not be covered.

The calculated cover volumes needed for repositories and reclamation are as follows:

- 9,700 cubic yards for north repository area.
- 19,300 cubic yards for south repository area.
- 16,000 cubic yards reclamation fill for waste-rock areas.

It is likely that the cover material for a repository could come mostly from excavating the area in preparation for fill placement. Reclamation fill for waste rock areas would have to come from a borrow site, such as the Eileen site.

4.3.1 Eileen Site

The Eileen site has been identified as a potential borrow source for repository site cap and mine site restoration materials. This source is favorable due to its proximity to the mine site. The site may be readily accessed by construction equipment after clearing of the trees and brush. The material in the upper 9 feet (and likely deeper) is potentially suitable for disposal site cover material and for site restoration. However, there are a number of issues to consider if this material is selected for use:

- Limited exploration (one test pit) indicates that the soils are highly heterogeneous, ranging from sandy clay to boulders. It is likely that oversized material would have to be screened before use as cover material.
- It is likely that soil from the Eileen site would have to be dried before placement to achieve optimum moisture and maximum compaction.
- Shallow water may interfere with construction operations.

Assuming that the potential Eileen borrow area is 3.5 acres and the usable deposits are up to 6

feet deep, the total available borrow is approximately 33,000 cubic yards. Additional exploration would be needed to confirm the volume estimate and the quality of the potential borrow. This estimate is greater than the estimated requirements for repository cover or restoration fill.

4.3.2 Repository Sites

Near-surface soils present at the repository sites are potential borrow sources for cap and/or liner materials. These sources are more desirable as repository material sources than the Eileen site for repository cover because hauling would be minimized or eliminated. In addition, material excavated from within the repository site footprints could increase the storage capacity of the site. Suitable cap materials are present at both repository sites, though material from the north site might require less processing than the south site.

4.3.2.1 North Repository Site

Soils at the north repository site consist of silty sand with gravel (residual schist) to depths of 10 to 15 feet bgs. The fines content of this material varies from about 25 to 50%, and in situ moisture contents range from about 10 to 25%. Soils with higher moisture contents typically had higher fines contents. Groundwater was not encountered at this site to depths of 41.5 feet.

This material is anticipated to perform well as a cap and/or liner material for the disposal sites. The material is expected to have the following characteristics:

- The in situ moisture content is expected to be within 5 to 10% of the optimum compaction moisture, depending on the time of year when construction occurs. Thus, extensive moisture conditioning for compaction will not likely be required.
- The material will provide a relatively strong cap and/or liner material when compacted.
- The material also has sufficient fines content to provide a relatively low permeability cap and/or liner material when compacted. Final design requirements may necessitate the use of soil amendments to meet permeability requirements.

4.3.2.2 South Repository Site

Soils at the south repository site generally consist of silty sand with gravel and cobbles. The fines content of this material ranged from 20 to 40%, and in situ moisture contents ranged from about 10 to 20%. However, this material is interpreted to be landslide debris and is expected to be highly heterogeneous. In addition, individual clasts as large as 3 feet in length are anticipated.

This material is suitable as a cap material for the disposal sites. However, due to the presence of oversized clasts, additional processing and screening may be required for use. The screened material is expected to have the following characteristics:

- The in situ moisture content is expected to be within 5% to 10% of the optimum compaction moisture, depending on the time of year when construction occurs. Thus, extensive moisture conditioning for compaction will not likely be required.
- The material will provide a relatively strong cap and/or liner material when compacted.
- The material also has sufficient fines content to provide a relatively low permeability cap and/or liner material when compacted. However, it is expected that this colluvium will have localized areas with relatively low fines contents. Final design requirements may necessitate the use of soil amendments to meet permeability requirements.

4.4 SLOPE STABILITY

Preliminary stability analyses were performed for both repository sites. The analysis considered the most critical slope section. Two stability analyses were performed for each site under static loading conditions. The two analyses consisted of the existing slope geometry (as measured by topographic maps) and that of an assumed repository fill geometry. Fifteen feet of waste rock fill was considered for the repository, although substantially less loading is likely. Seismic stability analyses using a psuedostatic approach will be performed as data from the supplementary investigation is analyzed. The results of these analyses are reported in Appendix D.

Stability analyses were performed using the limit equilibrium method based on the Morgenstern-Price method of slices using the commercial software SLOPE/W (2006). Using this methodology, the factor of safety (FOS) for a given geometry is calculated as the ratio of resisting forces to driving forces on a particular trial failure surface.

The material properties used in the stability analyses were selected based on subsurface exploration and laboratory data. The selected material properties and groundwater assumptions are presented in the following sections. Typical minimum static factors of safety for new fills range from 1.3 to 1.5. The final design criteria have not been established.

4.4.1 North Repository Site

The test critical slope was oriented approximately northeast-southwest through the north repository site. Slopes below the repository site ranged from about 2H:1V to 3H:1V. Final slope geometries of the disposal fill were modeled to be 2.5H:1V. Table 4-2 lists the material

properties used for the stability analyses. Groundwater was conservatively assumed to be at a depth of 10 feet bgs (groundwater was not encountered during the explorations to depths of 41.5 feet bgs).

Table 4-2
North Repository Site Material Properties

Material Type	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (ϕ)
Waste Fill	130*	10	36
Residual Schist Soil	120	50	32
Highly Weathered Schist	135	500	32

* Compacted in place

The results of the stability analyses are presented in Table 4-3. The proposed disposal facility exceeds typical minimum factors of safety.

Table 4-3
North Repository Site Slope Stability Results

Condition	Static Factor of Safety
Existing Condition	2.0
Post-Construction Condition	1.8

4.4.2 South Repository Site

The critical slope selected was oriented approximately east-west through the repository site. Slopes below the repository site ranged from about 1.8H:1V to 2H:1V. Final slope geometries of the disposal fill were modeled to be 2.5H:1V. Table 4-4 lists the material properties used for the stability analyses. The subsurface profile was estimated based on an assumed slide mass geometry and the observed residual soil profile. Groundwater was conservatively assumed to be at a depth of 10 feet bgs (groundwater was not encountered during the explorations to depths of 76.5 feet bgs).

Table 4-4
South Repository Site Material Properties

Material Type	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (phi)
Waste Fill	130*	10	36
Landslide Debris	120	50	32
Residual Schist Soil	120	50	32
Highly Weathered Schist	135	500	32

* Compacted in place

The results of the stability analyses are presented in Table 4-5.

Table 4-5
South Repository Site Slope Stability Results

Condition	Static Factor of Safety
Existing Condition	1.3
Post Construction Condition	1.3

The proposed facility at this site falls near the low end of acceptable factors of safety for fills of this type. However, the analyses performed also indicate that the proposed facility has a negligible affect on the overall stability of the site. Thus, if the existing stability can be shown to have an adequate factor of safety, it is likely that the facility will as well. More detailed analyses of stability were performed using data from the supplementary geotechnical investigation. Stability analysis is discussed in Appendix D.

4.5 DISPOSAL SITE SUITABILITY

Both the north and south sites appear to be feasible waste-rock repository locations. General design considerations and characteristics of each site are described in the sections below. Final design requirements for the repositories (such as cap permeability, leachate collection, etc.) have not yet been determined. Detailed design evaluation of the sites should consider these requirements.

4.5.1 Site Stability

Slope stability is inferred from site observations and reconnaissance test pits and drilling and from preliminary slope-stability analyses. Information obtained from drilling conducted in November 2008 is being used to model slope stability. Those analyses are not complete but are not expected to substantially alter the conclusions drawn below.

4.5.1.1 North Repository Site

The north repository site is situated on a ridge crest. The anticipated repository would extend from the ridge crest to the south and east down the moderate slopes. Reconnaissance inspection of the area around the proposed site shows no signs of instability such as cracks, scarps, displaced or hummocky ground, settlement, or rotated/pistol-butted trees. Preliminary review of aerial photos and topographic maps do not show signs of instability within the repository site footprint. Further, the subsurface soils are predominantly weathered schist soils that still maintain remnant rock fabric, indicating the soil has weathered in place from bedrock. Site reconnaissance and pre-design explorations and analysis indicate that the site is sufficiently stable for the proposed repository.

4.5.1.2 South Repository Site

The south repository site is located on a relatively level bench within a continuous slope above and below the site. The anticipated repository would be constructed across this bench. Reconnaissance inspection of the area around the proposed site showed no signs of recent instability such as cracks, scarps, displaced or hummocky ground, settlement, or rotated/pistol-butted trees. Trees in close proximity to the site are estimated to be more than 300 years old and show no signs of historical earth movement. Review of aerial photos and topographic maps, however, indicates that bench feature may be a part of a larger landslide complex that extends upslope and potentially as far down slope as Joe Creek, approximately 700 vertical feet below. Subsurface exploration at the site indicated the soils are colluvial, composed of a mix of silt, sand, gravel and cobbles. Cobble-sized fragments are generally fresh to slightly weathered schist fragments. These soils are not uniformly weathered as those found at the north site. These soils are interpreted to be landslide debris or colluvium. Although the area may be part of an ancient landslide, there were no signs that the slide has been active recently (since the development of the forest that currently occupies the area). Furthermore, the proposed repository may not have a significant affect on the stability of the larger ancient slide feature. Accordingly, the site is interpreted to be sufficiently stable for the proposed repository.

4.5.2 Site Footprint

4.5.2.1 North Repository Site

The north repository would cover an area of approximately 2 acres, assuming a footprint of approximately 600 feet by 150 feet (see Figure 4-1 of the EE/CA). The anticipated repository area would extend along the ridge crest and down the moderate slopes to the south. Depending on the final design requirements (maximum height, maximum slopes, etc), the footprint of the site could be extended to the south. Expansion to the south would require more site preparation such as forest clearing and benching into the existing slopes.

4.5.2.2 South Repository Site

The south repository would cover an area of approximately 4 acres, assuming a footprint of approximately 700 feet by 250 feet (see Figure 4-1 of the EE/CA). The final configuration of the repository will be developed based on the final design requirements. Fill may be placed such that the final repository cap is level or sloped. Figure 4-2 of the EE/CA shows a conceptual section. The south site is potentially favorable to the north site due to its larger, flatter footprint and potential flexibility in the placement of sloping fill if additional storage space is required.

4.5.3 Repository Liner

An engineered, synthetic liner is a possible element of a repository design. This assessment does not consider the need for or design elements of a possible liner. The need for a liner depends on the chemical characteristics of the fill material and the regulatory requirements of the permitting agencies.

4.5.4 Fill Slopes

The waste rock materials have shown relatively high shear strength properties, as described in Section 4.1.2, and will support final slopes as steep as 2H:1V. Final slopes are anticipated to range from 2H:1V to 3H:1V and will be determined by drainage and erosion control considerations, as well as final stability requirements.

4.5.5 Cover Design

The repositories will be covered with an evapotranspiration cover (ET cover) to minimize infiltration into the waste rock. In general, the ET cover will consist of three to four feet of suitable cover soil planted with trees. Infiltration into the fill would be minimized by sloping and

drainage. Evaporation and transpiration from the cover and trees would dry the soil during the growing season. Water storage capacity in the cover would minimize the potential for infiltration of water through the cover and into the waste rock during the wet season. The final design will specific design elements to meet performance criteria.

Soil excavated to prepare the repository sites or soil from the Eileen borrow site (see Section 4.3) would be suitable cover material. The fines content of the soils in the potential borrow sites is greater than 20%. Soils from the Eileen site and from Repository Area 2, however, are highly heterogeneous with significant amounts of oversized fragments. These soils will likely require screening before use as cover material. Soils from north repository site generally have higher fines content and are more homogeneous, thus requiring less processing.

4.5.6 Summary

Both the north and south sites appear to be feasible as repository sites for the waste rock. There are advantages and disadvantages to either site. These considerations are summarized below.

4.5.6.1 North Repository Site

- The north site is smaller than the south site.
- The north site may require more foundation preparation than the south site before waste fill placement.
- Soils beneath the site are more consistent and potentially less permeable than the south site.
- Native material excavated from the site may readily be used as cover fill.
- The site is sufficiently stable for the proposed repository.

4.5.6.2 South Repository Site

- The south site is larger than the north site
- The site will require little preparation before construction other than clearing and grubbing.
- Soils beneath the site are anticipated to be heterogeneous.
- Native material excavated from the site will require processing before use as cover fill.
- The site may have geotechnical stability issues. However, analyses to date indicate the proposed repository does not significantly affect site stability.

5 CLOSURE

The preliminary design and construction recommendations presented in this report have been developed utilizing limited subsurface and reconnaissance data. A second phase of geotechnical exploration was completed in November of 2008 to better characterize the subsurface conditions at the two repository sites. Appendix D of the EE/CA presents analyses of the November 2008 data. The analyses indicates that either north or the south repository site would be sufficiently stable.

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FIGURES

Source: Grants Pass, Oregon USGS 100K Topo Quad, 1984.
Happy Camp, California USGS 100K Topo Quad, 1984.

0 1 2 Miles

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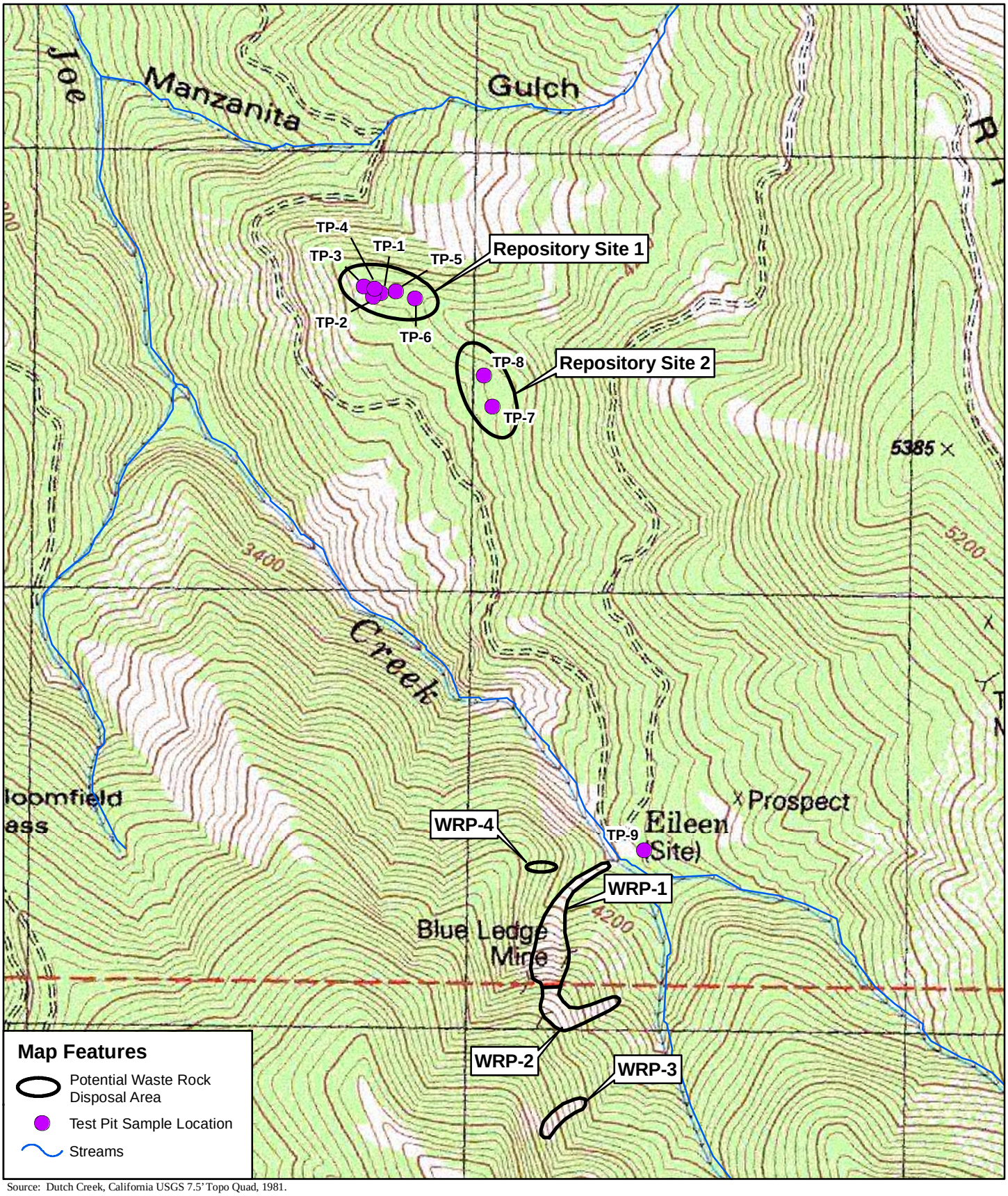
VICINITY MAP

UNITED STATES FOREST SERVICE
BLUE LEDGE MINE
BLUE LEDGE, CALIFORNIA

SEPTEMBER 2008
25696770

FIGURE 1-1

O:\25696770 Blue Ledge Mine\5000 Technical\GIS\MXD\Fig1 Vicinity Map.mxd



Source: Dutch Creek, California USGS 7.5' Topo Quad, 1981.
Kangaroo Mountain, California USGS 7.5' Topo Quad, 1981.

0 250 500 1,000 Feet

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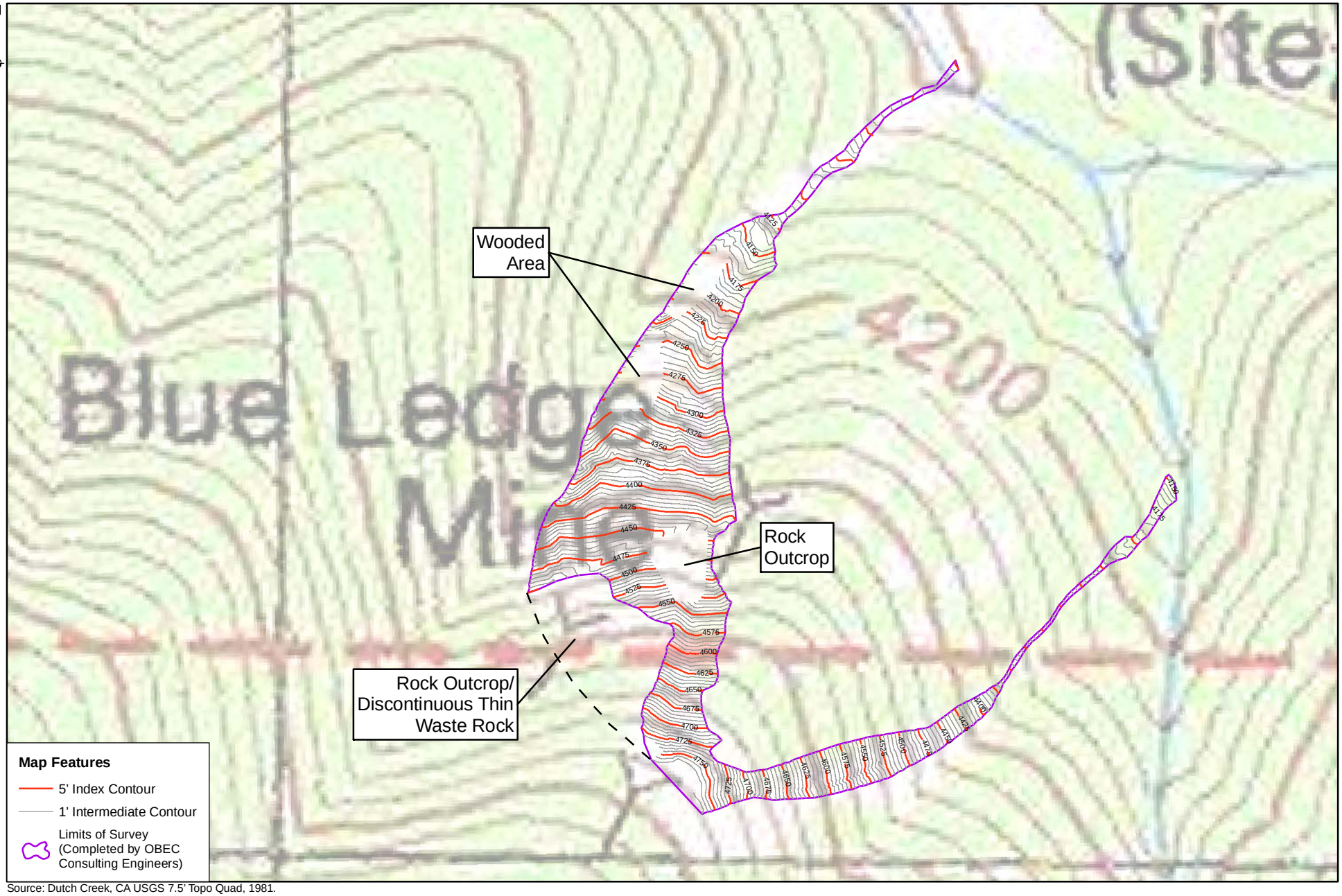
NOVEMBER 2008
25696770

TEST PIT LOCATIONS

UNITED STATES FOREST SERVICE
BLUE LEDGE MINE
BLUE LEDGE, CALIFORNIA

FIGURE 2-1

O:\25696770 Blue Ledge Mine\5000 Technical\GIS\MXD\New Folder\Fig 2-1 Test Pit Locations.mxd



Source: Dutch Creek, CA USGS 7.5' Topo Quad, 1981.

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SURVEYED WASTE ROCK PILE

UNITED STATES FOREST SERVICE
BLUE LEDGE MINE
BLUE LEDGE, CALIFORNIA

NOVEMBER 2008
25696770

FIGURE 3-1

O:\25696770 Blue Ledge Mine\5000 Technical\GIS\MXD\Fig 3-1 Surveyed Waste Rock Pile.mxd

APPENDIX A

TEST PIT LOGS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Key to Log of Test Pit

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Water Content	REMARKS AND OTHER TESTS
1	2	3	4	5		6	7	8

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

6 **Material Description:** Description of material encountered; may include color, moisture, grain size, and density/consistency.

7 **Moisture Content, %:** Moisture content as determined in general accordance with ASTM D2216

8 **Remarks and Other Tests:** Comments and observations regarding excavation or sampling made by driller or field personnel. Field and laboratory test results (other than water content), using abbreviations explained below.

TYPICAL MATERIAL GRAPHIC SYMBOLS

Well graded gravel with silt.

Silty gravel with sand.

SIlty sand with gravel.

Poorly graded gravel with silt and sand.

SIlty sand.

Sandy silt with gravel.

Sandy silt.

Clayey gravel with sand.

Clayey sand with gravel.

TYPICAL SAMPLER GRAPHIC SYMBOLS

Grab sample.

OTHER GRAPHIC SYMBOLS

TYPICAL LABORATORY TEST ABBREVIATIONS

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific test pit locations and at the time the test pits were excavated; they are not warranted to be representative of subsurface conditions at other locations or times.

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Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-1**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**16 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,890 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				**WELL GRADED GRAVEL WITH SILT [GW-GM]**, light brown, dry, medium dense, gravel fine to coarse, sand well graded, fine to coarse, subangular. [TOPSOIL]		
			S-1		**SILTY GRAVEL WITH SAND [GM]**, light brown, moist, medium dense, gravel fine to coarse, predominately less than 2", sand ifne to coarse, subangular, 20% fines, 30% sand, 5% cobbles (up to 6"), fines are platy. [FILL]	11.1	
			S-2		**SILTY SAND WITH GRAVEL [SM]**, reddish brown, moist, medium DENSE, sand and gravel fine to coarse grained, about 35% sand, 20% gravel, few cobbles to 6" (in situ), fines are platy, organics present [NATIVE GROUND].	20.7	
	5		S-3			20.3	
					Increasing density with depth.		
			S-4		*Grades to light brown, cobble-sized clasts have remnant rock fabric (can be broken down to sand by hand). [COMPLETELY WEATHERED SCHIST]*	15	
	10				*Increase in consistency of rock fabric.*		
					Test pit terminated at 14.0 feet bgs.		
	15						
	20						
	25						

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Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-2**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**14 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,890 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				**WELL GRADED GRAVEL WITH SILT [GW-GM]**, light brown, dry, medium dense, gravel fine to coarse, sand well graded, fine to coarse, subangular. [TOPSOIL].		
					SILTY SAND WITH GRAVEL [SM], light brown, moist, medium dense, sand and gravel fine to coarse, subangular, 30% silt, 35% sand, 35% gravel and cobbles (up to 6"), fines are platy [FILL].		
			S-1			13.5	
	5				*Grades to reddish brown [NATIVE GROUND].*		
			BS-1				
			S-2		*Grades to brown.*	15.7	
	10		S-3			16.8	
					Grades to increased fines content, gravel and cobble sized clasts have remnant rock fabric (can be broken down to sand by hand). [COMPLETELY WEATHERED SCHIST]		
			S-4		*Grades to harder material.*	16.4	
					Test pit terminated at 14.0 feet bgs. Limit of equipment reach.		
	15						
	20						
	25						

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Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-3**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,890 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				Aggregate surfacing - 1 to 2" diameter rounded gravel.		
					SILTY SAND WITH GRAVEL [SM], light brown, medium dense, sand and gravel fine to coarse, 25% silt, 40% sand, 25% gravel, 10% cobbles to 6", fines are platy [FILL].		
					Grades to reddish brown, few organics [NATIVE GROUND].		
			S-1			14	
	5						
			S-2		*Grades to brown to light brown, gravel and cobble sized clasts have remnant rock fabric, (can be broken down by hand to sand), [COMPLETELY WEATHERED SCHIST].*	12.2	
	10						
			S-3		*Grades to harder material.*	14	
					Test pit terminated at 14.0 feet bgs.		
	15						
	20						
	25						

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Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-4**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**9.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,890 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				Aggregate surfacing - 2 to 1" rounded gravel.		
					SILTY SAND WITH GRAVEL [SM], light brown, medium dense, sand and gravel fine to coarse, 30% silt, 40% sand, 10% cobbles up to 6", fines are platy [FILL]. *Grades to reddish brown [COMPLETELY WEATHERED SCHIST].*		
	5		BS-1		*Grades to harder material with depth.*		
					Test pit terminated at 9.0 feet bgs.		Backhoe having difficulty excavating.
	10						
	15						
	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-5**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**10.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,890 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				**POORLY GRADED GRAVEL WITH SILT AND SAND [GP-GM]**, topsoil, roots and other organics.		
			S-1		**SILTY SAND WITH GRAVEL [SM]**, light brown, dry, 15% silt, 25% sand, 50% gravel, 10% cobbles, sand and cobbles have rock fabric, can be broken down by hand [COMPLETELY WEATHERED SCHIST]. *Grades to harder material, more cobble fragments (30-40%).*	11.6	
	5		S-2		*Grades to harder material with depth.*	25.4	
			S-3		**SILTY SAND [SM]**, reddish brown, moist, medium stiffness to soft, low plasticity, still maintains rock fabric. [COMPLETELY WEATHERED SCHIST].	10.2	
	10				Test pit terminated at 10.0 feet bgs.		Slower excavation.
	15						
	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-6**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**14 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,890 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				**SILTY SANDY WITH GRAVEL [SM]**, light brown to brown, max gravel size is 1", organics, [TOPSOIL].		
			S-1		**SANDY SILT WITH GRAVEL [ML]**, reddish brown, low plasticity, moist, medium stiff, sand fine to coarse grained, gravel less than 0.5", about 10% sand, 10% gravel.	20.8	
			BS-1				
	5		BS-2		**SILTY SAND WITH GRAVEL [SM]**, brown, medium dense, moist, sand predominantly fine grained, gravel to 2", 30% silt, 50% sand, 20% gravel, 10% sand, gravel has remnant rock fabric, can be broken into sand by hand, [COMPLETELY WEATHERED SCHIST].		
			S-2			22.3	
			S-3		**SANDY SILT [ML]**, medium stiff, moist, ~25% sand, fine grained, material has remnant rock fabric, [COMPLETELY WEATHERED SCHIST].	39.9	
	10				**SILTY SAND WITH GRAVEL [SM]**, brown to light brown, medium density to dense, moist, sand fine grained, 25% gravel, gravel has remnant rock fabric, can be broken down by hand into sand, 20% silt. [COMPLETELY WEATHERED SCHIST].		
					Test pit terminated at 14.0 feet bgs. More competent, unable to break down by hand.		
	15						
	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-7**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**14 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**13.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,870 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**South Disposal Site**			Surface Condition	**Brushy Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				[TOPSOIL]		
			S-1		**SANDY GRAVEL WITH SILT [GP-GM]**, dark brown, dry, dense, sand fine to coarse, gravel up to 1", subangular to subrounded, organics present [debris from landing site].	8.6	
					SILTY SAND WITH GRAVEL [SM], medium dense, moist, ~35% sand, 40% silt, 30% gravel, few cobbles, sand fine to coarse, gravel well graded, cobbles up to 6", soil does not have remnant rock fabric, intact fragments bluish gray, occassional 1'+ size clasts [SLIDE DEBRIS/COLLUVIUM].		
	5						
			S-2			14.8	
	10		BS-1		*Large clasts (1' +) of fresh schist.*		
					Large intact schist fragment in sidewall (3'+).		
					Test pit terminated at 13.0 feet bgs.		
	15						
	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-8**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**12.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3,870 feet**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**South Disposal Site**			Surface Condition	**Brushy Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				TOPSOIL		
					SILTY SAND WITH GRAVEL [SM], brown, medium dense, ~45% sand, 20% silt, 25% gravel, 10% cobbles, gravel and cobbles are moderate to slightly weathered schist (different composition than sand and silt, slide debris) [SLIDE DEBRIS/COLLUVIUM].		
			S-1			9.4	
					Increased cobble content, occassional boulders up to 1.5'.		
	5						
			S-2			13.5	
					Decrease in silt content, absense of boulders.		
	10						
					Test pit termianted at 12.0 feet bgs.		
	15						
	20						
	25						

Report: PORT_TP_W; File: BLUELE~1.GPJ; 11/21/2008 TP-8

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-9**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**12 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**9.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**4,010 feet**
Water Observations	**2 feet bgs on 6/26/08**			Weather	**Sunny, 80's**
Location	**Eileen Townsite**			Surface Condition	**Brushy Forest**

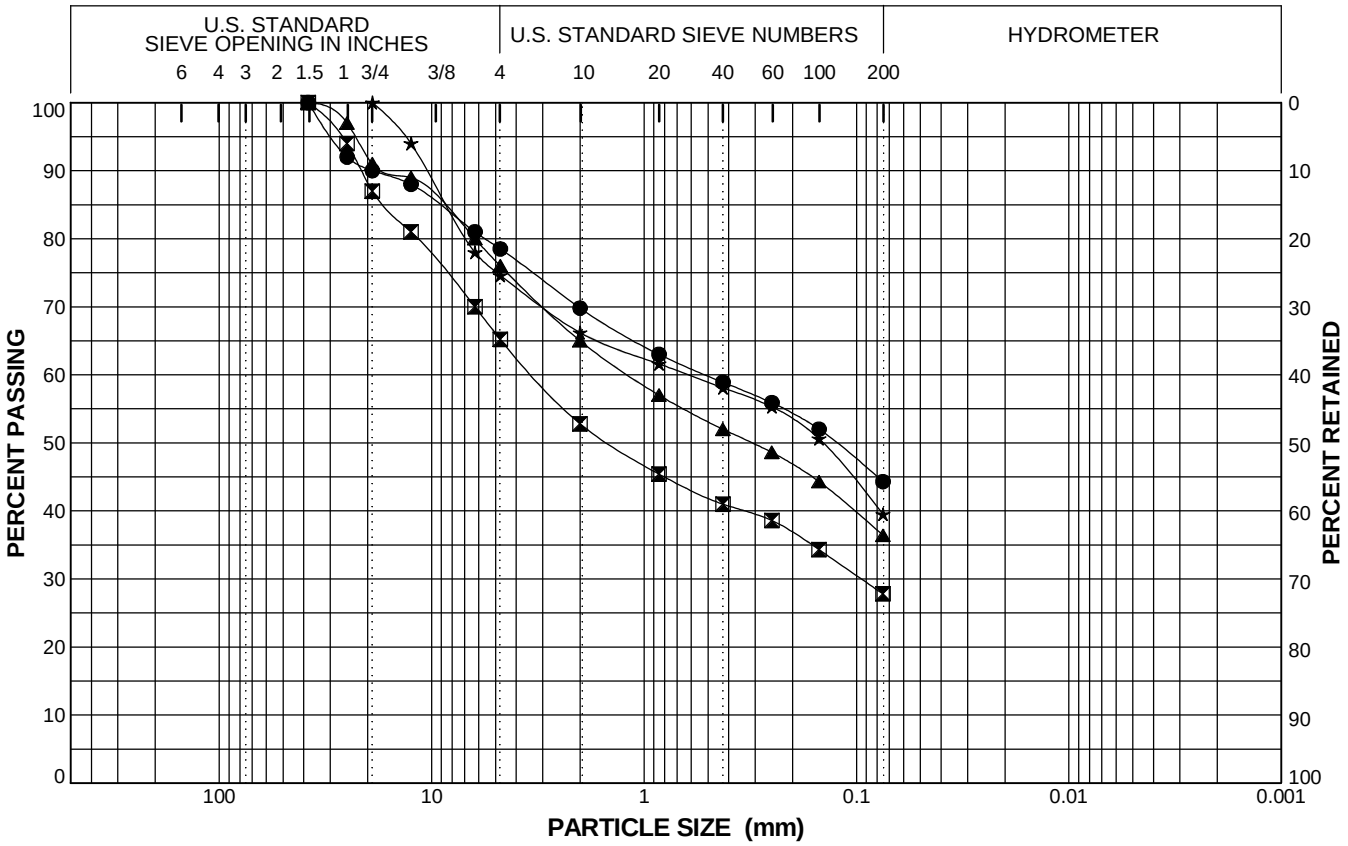
Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
	0				ORGANIC DUFF AND TOPSOIL.		
			S-1		**CLAYEY GRAVEL WITH SAND [SP]**, wet, medium dense, sand is fine to coarse (predominately coarse), gravel well graded fine to coarse, 30% clay, 20% sand, 30% gravel, 20% cobbles, cobbles and gravel bluish gray schist clasts sub angular, few boulders (2' max). [SLIDE DEBRIS/COLLUVIUM].	15.6	Wall is seeping.
	5						
			S-2		**CLAYEY SAND WITH GRAVEL [CL]**, brown, medium plasticity, wet, mottled bluish green, about 45% clay, 35% sand, 20% gravel, sand is coarse grained, gravel less than 1", few up to 3". [SLIDE DEBRIS/COLLUVIUM].	22	
	10				Test pit terminated at 9.0 feet bgs.		
	15						
	20						
	25						

URS

APPENDIX B

LABORATORY TEST DATA

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
TP-1		4.5			●	23	4	21.5	34.2	44.3	SILTY SAND WITH GRAVEL [SM]
TP-2	S-1	3.0	13.5		⊠			34.8	37.4	27.8	SILTY SAND WITH GRAVEL [SM]
TP-2	S-3	10.0	16.8		▲			24.0	39.6	36.4	SILTY SAND WITH GRAVEL [SM]
TP-3	S-2	6.0	12.2		★			25.4	35.1	39.5	SILTY SAND WITH GRAVEL [SM]

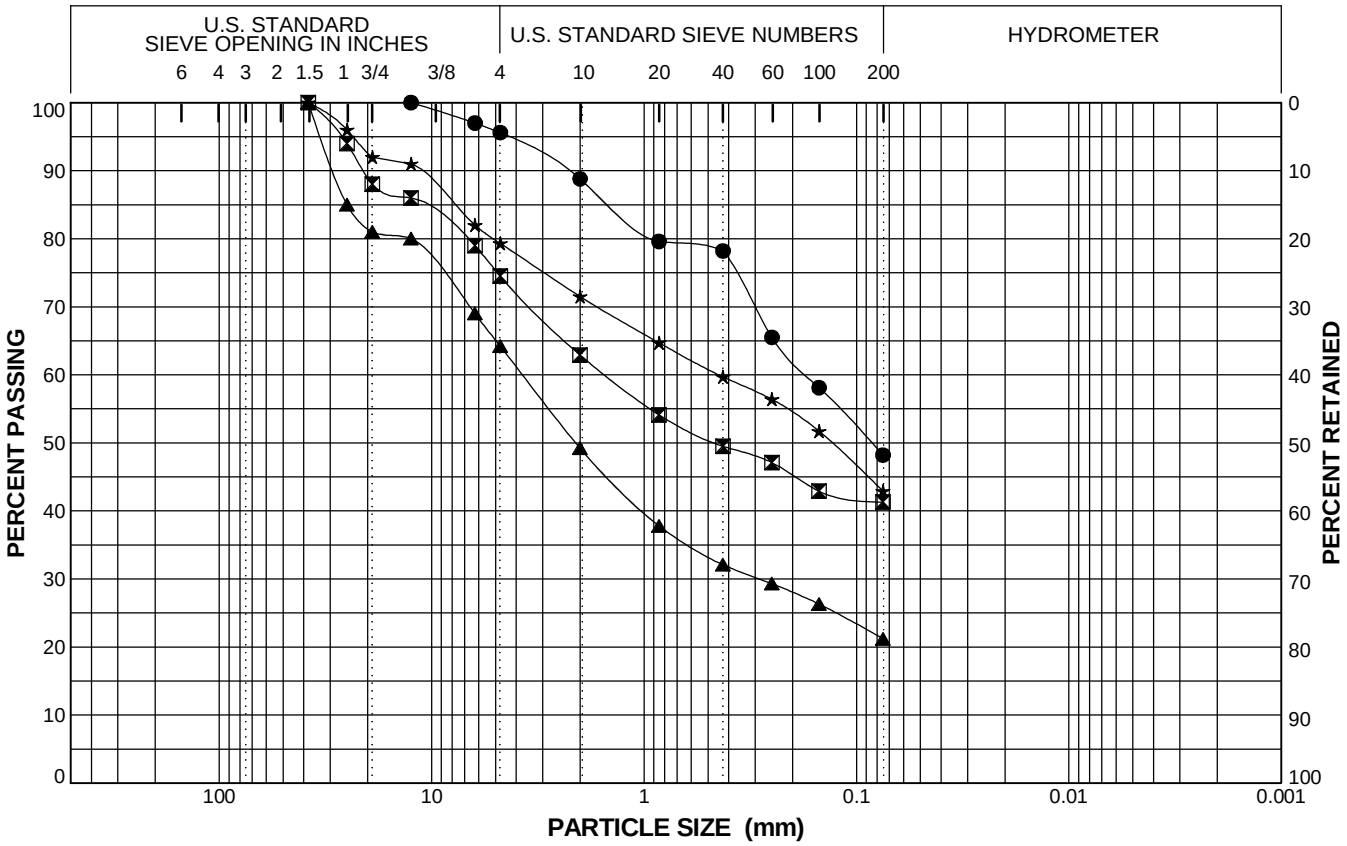
Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 11/21/2008 TP-3

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
TP-5		5.5			●			4.4	47.4	48.2	SILTY SAND [SM]
TP-7		7.5			⊠			25.5	33.2	41.3	SILTY SAND WITH GRAVEL [SM]
TP-8		3.5			▲			35.8	43.0	21.2	SILTY SAND WITH GRAVEL [SM]
TP-9		8.5			★			20.7	36.4	42.9	SILTY SAND WITH GRAVEL [SM]

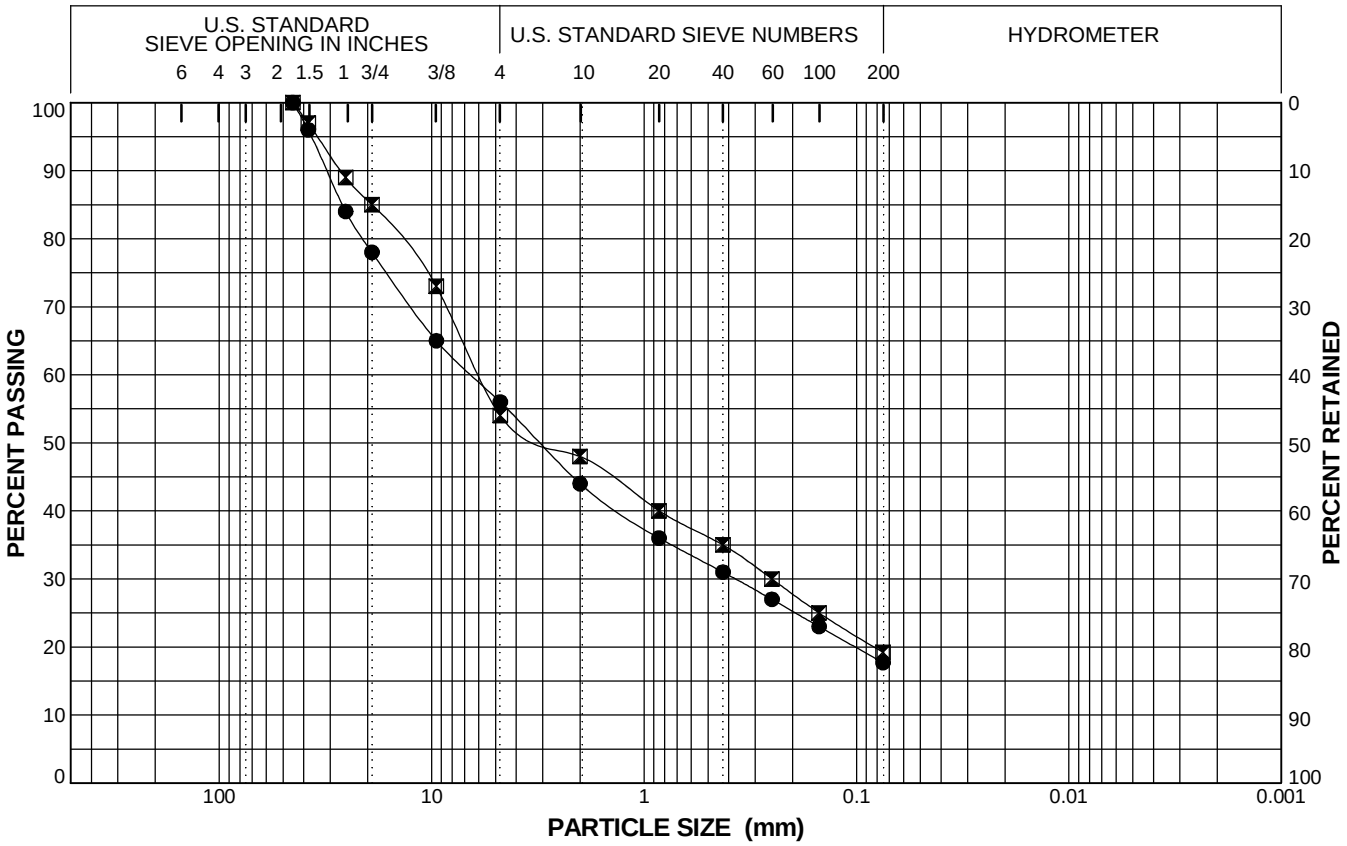
Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 11/21/2008 TP-9

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



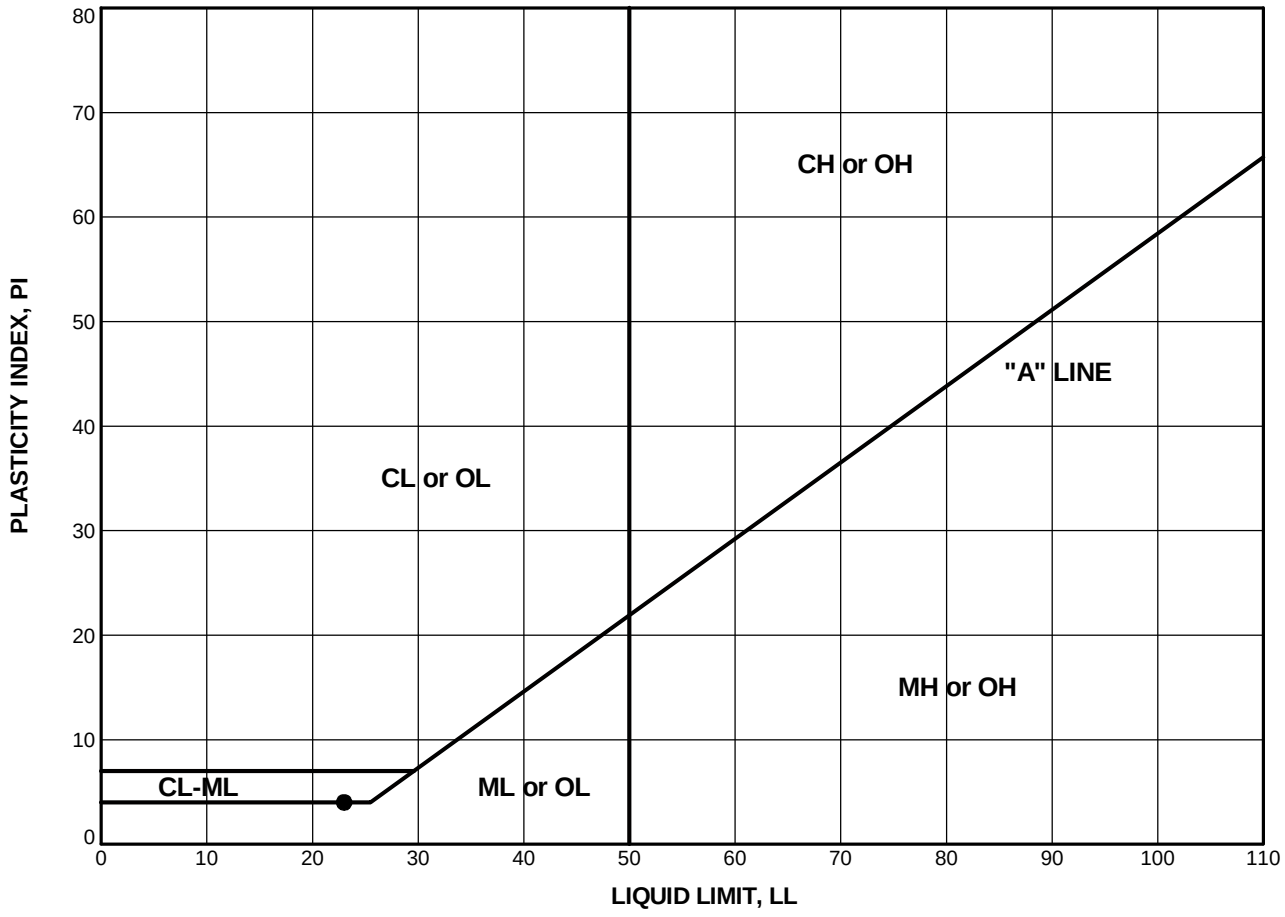
Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
Waste Rock-1		1.0	7.1		●			44.0	38.3	17.7	Silty Gravel with Sand [GM]
Waste Rock-2		1.0	5.2		⧗			46.0	34.8	19.2	Silty Gravel with Sand [GM]

Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 11/21/2008 Waste Rock-2



Boring ID	Sample #	Depth (feet)	Symbol	Sample Moisture %	LL	PL	PI	Classification
TP-1		4.5	●		23	19	4	SILTY SAND WITH GRAVEL [SM]

Blue Ledge Mine
Siskiyou County, CA
25696770

PLASTICITY CHART

URS

Report: ATTERBERG_PLOT_12 PTS; File: BLUELE~1.GPJ; 11/21/2008 TP-1

APPENDIX C

WASTE ROCK VOLUME CALCULATIONS

URS	JOB NO. 25696770	PAGE 1 OF 5
	DATE 11/17/08 BY BJD	CHECKED BY (date) JDD 11/18/08
	CLIENT USFS	

PROJECT BLUE LEDGE MINE

SUBJECT FINAL WASTE ROCK VOLUME QUANTITIES

OBJECTIVE: DETERMINE VOLUME OF WASTE ROCK AT BLUE LEDGE MINE SITE BASED ON SURVEY AND FIELD MEASUREMENTS.

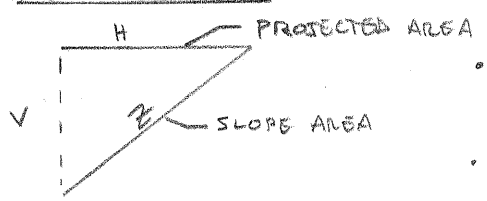
ASSUMPTIONS:
- ATTACHED SURVEY DATA COVERS AREA OF WASTE ROCK PILES (WRPs) 1 AND 2.
- AREAS FOR WRP-3 + 4 BASED ON FIELD MEASUREMENTS + OBSERVATIONS.
- WRP THICKNESSES BASED ON FIELD MEASUREMENTS + ESTIMATES.
- VOLUMES CALCULATED BY DETERMINING SURFACE AREA + MULTIPLYING BY THICKNESS EST. PORTIONS OF WRP-1 CALCULATED BY SURFACE-GENERATION SOFTWARE.

CALCULATIONS: WRP-1 + WRP-2 VOLUMES

SUB-AREA	PROJECTED AREA (ft²)[4]	SLOPE FACTOR[2]	SLOPE AREA (ft²)[3]	THICKNESS (ft)	VOLUME (ft³)	VOLUME (cy)
A	NA →			→	25,704	952
B	NA →			→	328,806	12,178
C	9,135	1.28	11,693	6	70,158	2,598
D	27,455	1.28	35,142	3	105,426	3,905
E	30,331	1.26	38,217	3	114,651	4,246
F	5,487	1.12	6,145	3	18,435	683

NOTES
1. AREA A & B VOLUMES CALCULATED BY LDD.
2. SLOPE FACTOR IS CONVERSION BETWEEN PROJECTED AREA AND AREA ON 3D SLOPE. (SEE BELOW)
3. SLOPE AREA = PROJECTED AREA X SLOPE FACTOR
4. PROJECTED AREA CALCULATED BY AUTOCAD.

SLOPE FACTOR



SLOPE FACTOR = Z/H

- FOR AREAS C + D, AVG SLOPE = 1.25H:1V
  SLOPE FACTOR = $(1.25^2 + 1^2)^{0.5}$ = 1.6/1.25 = 1.28
- FOR AREA E, AVG SLOPE = 1.3H:1V
  SLOPE FACTOR = $(1.3^2 + 1^2)^{0.5}$ = 1.64/1.3 = 1.26
- FOR AREA F, AVG SLOPE = 2H:1V
  SLOPE FACTOR = $(2^2 + 1^2)^{0.5}$ = 2.24/2 = 1.12

URS	JOB NO. 25696770	PAGE 2 OF 5
	DATE 11/17/08 BY BJD	CHECKED BY (date) LWD 11/18/08
	CLIENT USFS	

PROJECT BLUE LEDGE MINE

SUBJECT FINAL WASTE ROCK VOLUME QUANTITIES

CALCULATIONS: CONT'D

WRP-1 = A + B + C + D = 952 + 12,178 + 2,598 + 3,905

WRP-1 = 19,633 cy

WRP-2 = E + F = 4,246 + 683 cy

WRP-2 = 4,929 cy

WRP-3 & 4

- NO SURVEY DATA FOR WRP-3 + 4; ONLY VISUAL RECON + TOPOMAP / PHOTO INTERPRETATION; WRP-3 ~ EQUAL TO WRP-2
- WRP-4 SIGNIFICANTLY SMALLER; ESTIMATE ~ 1,000 cy

TOTAL VOLUMES

WASTE ROCK PILE	VOLUME
WRP-1	~20,000 cy
WRP-2	~5,000 cy
WRP-3	~5,000 cy
WRP-4	~1,000 cy

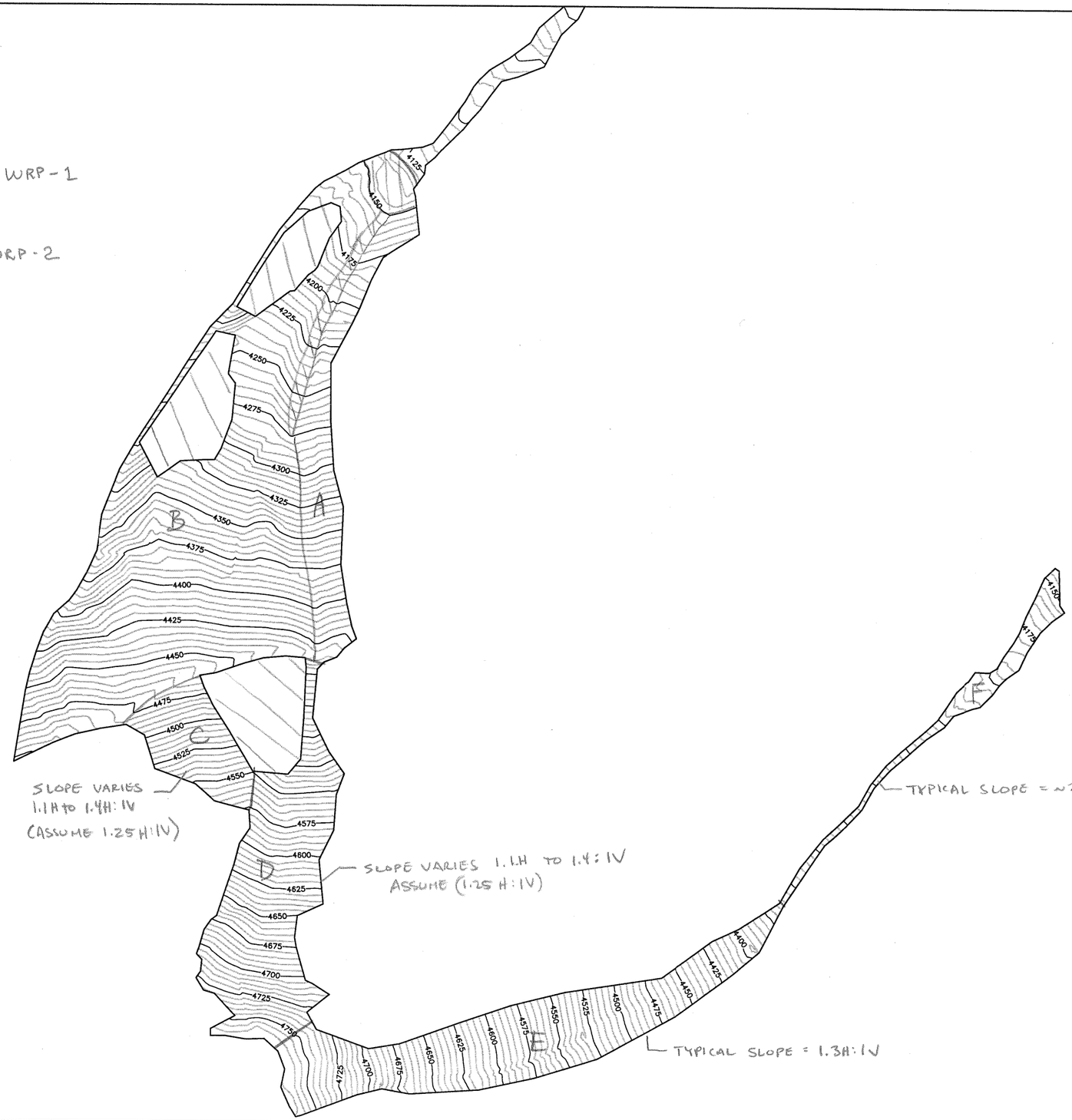
ROCK OUTCROP

- AREAS A + B HAVE VARIABLE THICKNESSES (SHOWN ON NEXT PAGE)
- AREA C - AVG. THICKNESS = 6'
- AREA D - AVG. THICKNESS = 3'

} WRP-1

- AREA E - AVG. THICKNESS = 3'
- AREA F - AVG THICKNESS = 3'

} WRP-2



NOTES:

1. 5' CONTOUR INTERVALS.

60 0 60 120
SCALE IN FEET

PROJECT NAME: MINE WASTE ROCK PILES AT BLUE LEDGE MINE
CITY: N/A
COUNTY: SISKIYOU
W.O.C. NUMBER: N/A
ATA NUMBER: N/A
KEY NUMBER: N/A
HORIZONTAL DATUM: NAD 83(CORS96) EPOCH 2002 (INTERNATIONAL FEET)
VERTICAL DATUM: NAVD 88 (INTERNATIONAL FEET)
SCALE: 1"=50'
COMPUTER FILES: M:/PROJECTS/654/6540003/SURVEY/FINAL
FILE NAMES: 654003pnts.dwg
DRAFTED BY: ERIK BLAKE (OBEC)
PROJECT MANAGER: ARON CUTSFORTH, PLS (OBEC)
CONTACT PERSON: ANDY AUSLAND, PLS (OBEC)
TELEPHONE: OBEC CONSULTING ENGINEERS, INC. 541-774-5590
JULY, 2008

No.	DATE	BY	REVISION
A	07/24/08	PCF	FOR REVIEW

JOB No. XXXXX
SCALE: AS NOTED
DESIGNED:
DRAWN BY: PCF
CHECKED BY:
PROJ. ENGINEER:
APPROVED BY:
DATE: JULY 2008

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

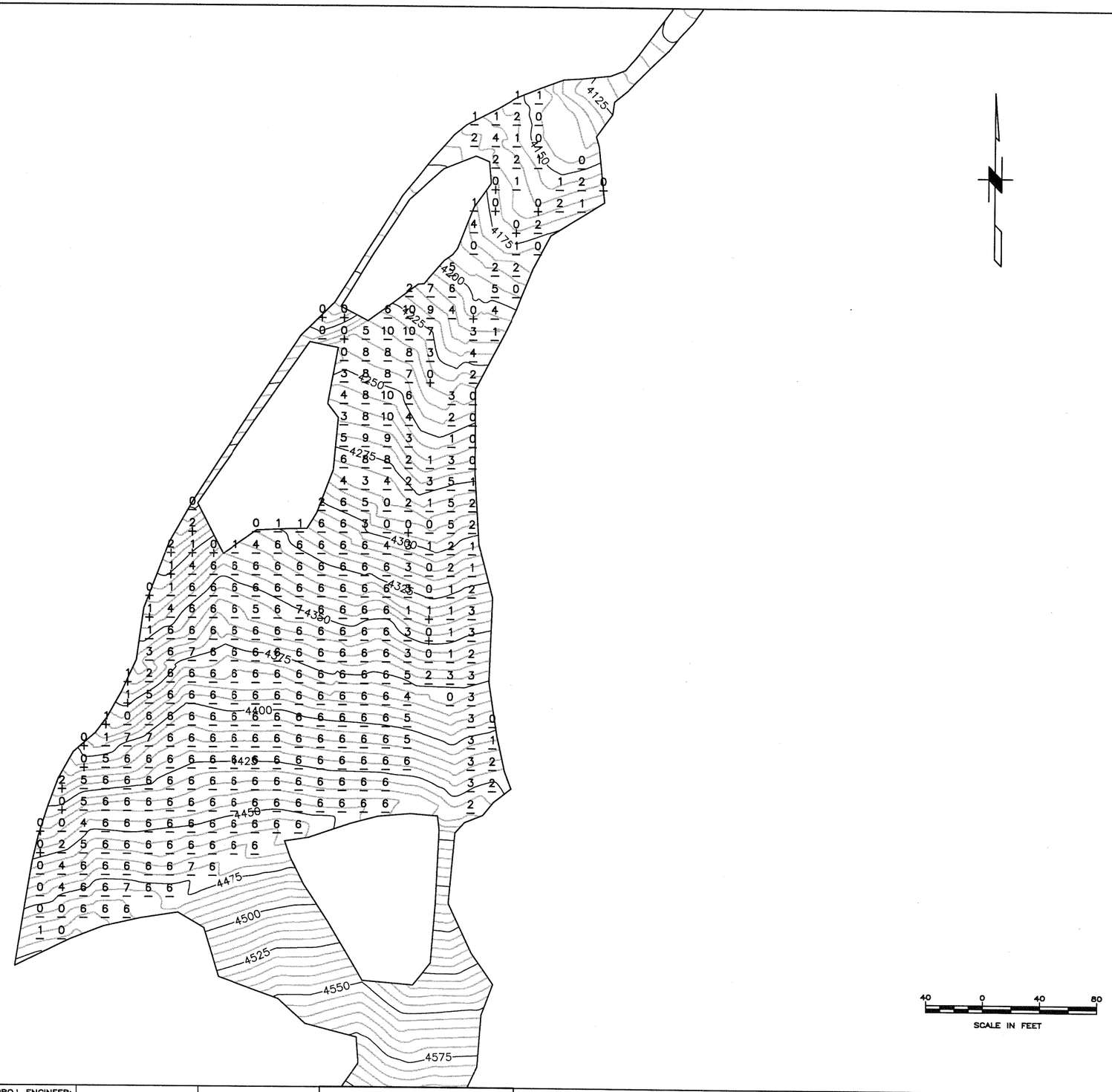
URS
111 SW Columbia, Suite 1500
Portland, Oregon 97201-5814
(tel) 503-222-7200
(fax) 503-222-4292
www.urscorp.com

BLUE LEDGE MINE

EXISTING CONDITIONS PLAN
WASTE ROCK PILES

DRAWING NUMBER: Figure 1
CAD FILE NUMBER: Figure1
SHEET: OF
REV. A

O:\25696770 Blue Ledge Mine\5000 Technical\CAD\LDD-URS\dwg\Figure1.dwg User:Paul_Flury Plotted:Nov 17, 2008 - 12:03pm Last Save:Jul 24, 2008 - 10:07am



No.	DATE	BY	REVISION
A	07/24/08	PCF	FOR REVIEW

JOB No. XXXXX	DESIGNED:	PROJ. ENGINEER:
SCALE: AS NOTED	DRAWN BY: PCF	APPROVED BY:
	CHECKED BY:	DATE: JULY 2008

WARNING
0 1/2 1
IF BAR DOES NOT MEASURE 1" AT FULL SIZE, THEN SCALES ON DRAWING NOT TO SCALE.

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BLUE LEDGE MINE

EXISTING CONDITIONS PLAN
WASTE ROCK PILES

DRAWING NUMBER: Figure 1
CAD FILE NUMBER:
SHEET: OF
REV. A

O:\25696770 Blue Ledge Mine\5000 Technical\CAD\LDD-URS\dwg\Figure1.dwg User:Paul_Flury Plotted:Nov 17, 2008 - 12:05pm Last Save:Jul 24, 2008 - 10:07am

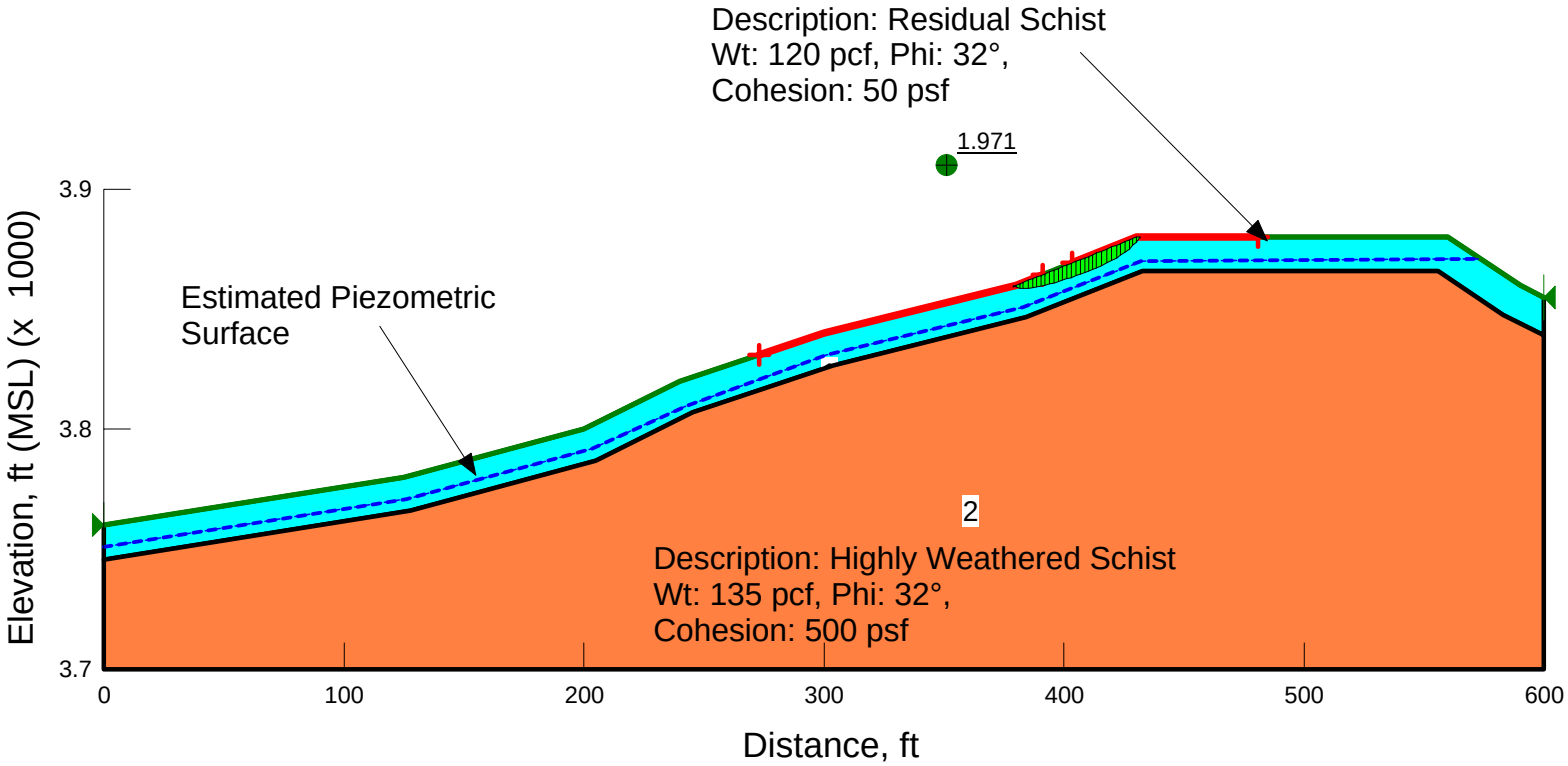
Site Volume Table: Unadjusted

Site	Stratum	Surf1	Surf2	Cut yards	Fill yards	Net yards		Method
a and b								
	area-a	eg-july_2008	bottom-a					
				861	1	861	(C)	Grid
LDD-URS								
	area-a	eg-july_2008	bottom-a					
				873	0	873	(C)	Grid
				958	6	952	(C)	Composite
	areab	eg-july_2008	bottom-b					
				11989	105	11885	(C)	Grid
				12337	158	12178	(C)	Composite

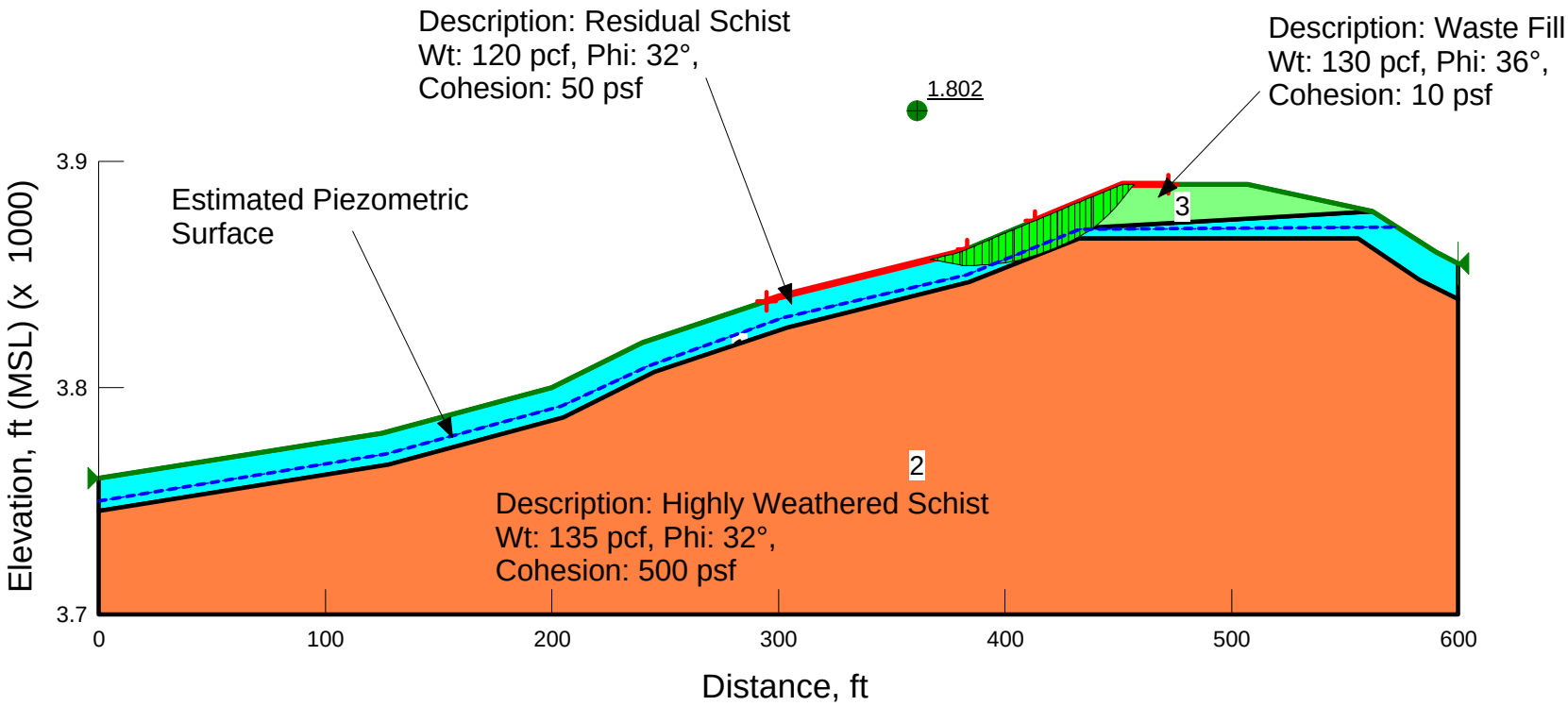
5/5

APPENDIX D

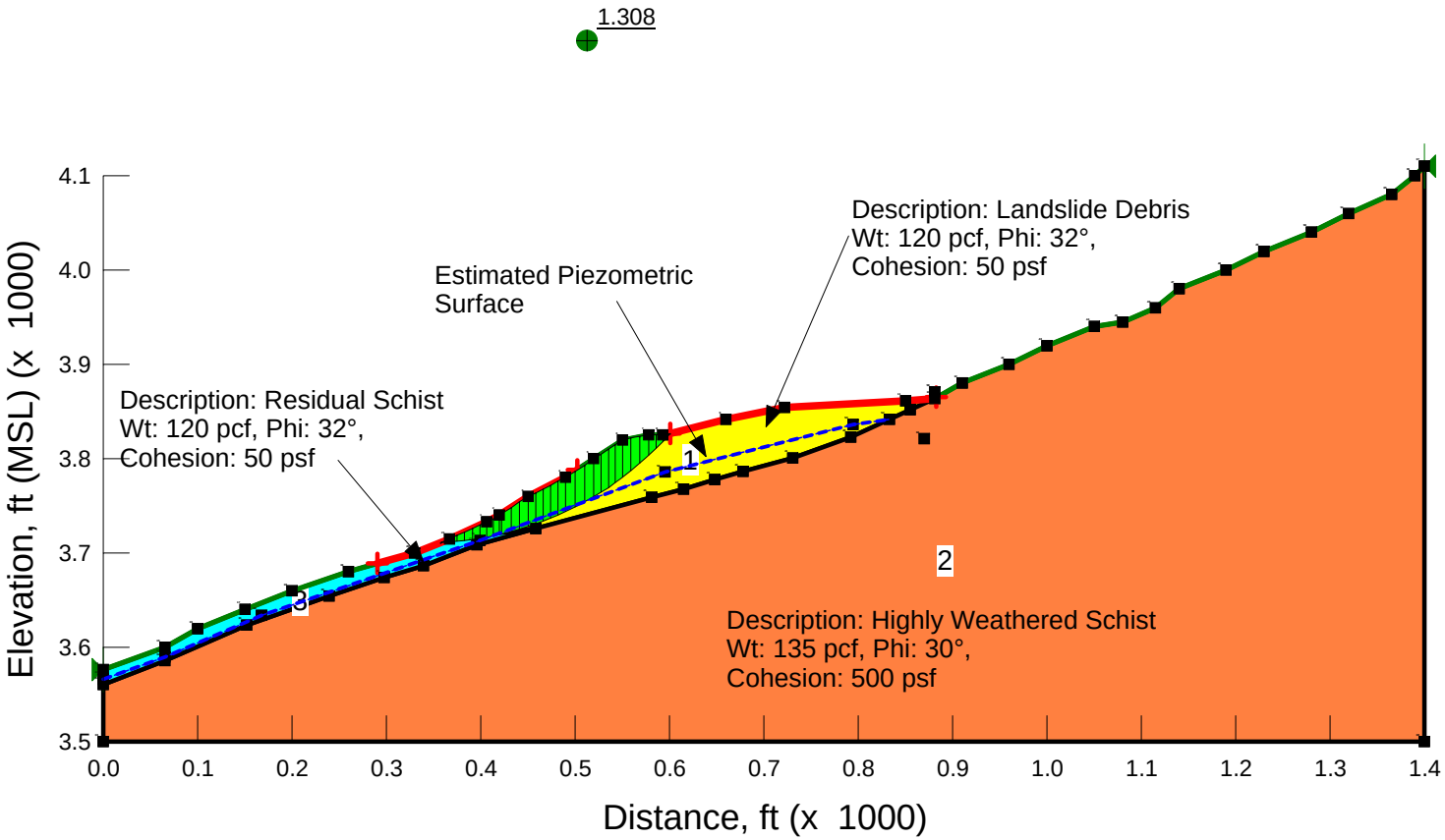
SLOPE STABILITY ANALYSES



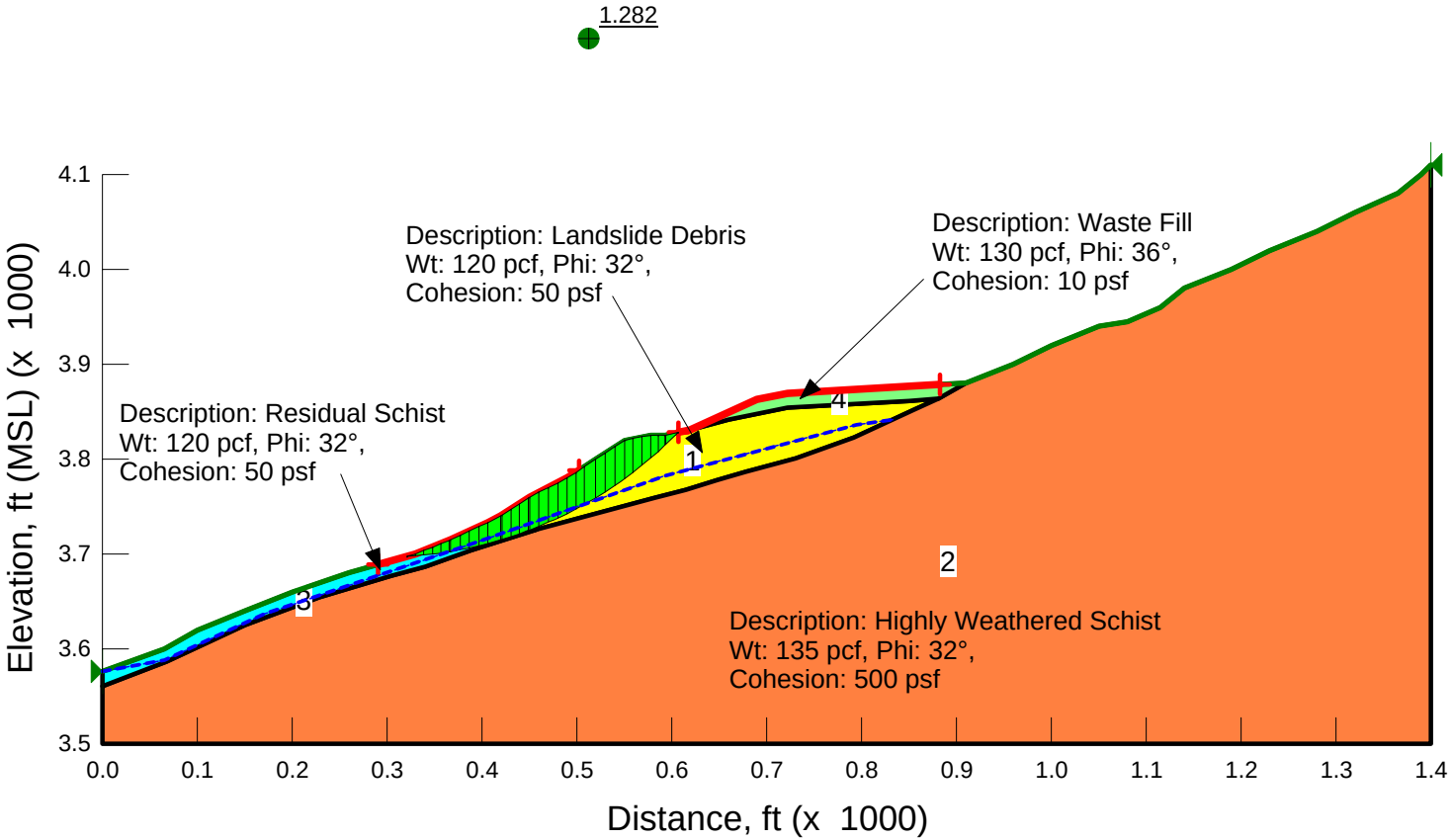
Blue Ledge Mine
North Repository Site
Static Stability - Existing Condition



Blue Ledge Mine
North Repository Site
Static Stability - Post-Construction



Blue Ledge Mine
South Repository Site
Static Stability - Existing Condition



Blue Ledge Mine
South Repository Area
Static Stability - Post-Construction

SUPPLEMENTARY GEOTECHNICAL INVESTIGATION & STABILITY ANALYSIS BLUE LEDGE MINE SISKIYOU COUNTY, CALIFORNIA

December 2008

Prepared for:
USDA Forest Service

Prepared by:

111 SW Columbia, Suite 1500

Portland, Oregon 97201-5850

25696770

INTRODUCTION

This memo presents the results of a supplementary geotechnical investigation and slope stability analyses performed for two repository sites being considered for waste rock materials present at the Blue Ledge Mine site. The location of the project area is shown on the attached Figure 1. More detailed plan views of the repository site are shown in the attached Figures 2 and 3. This memo amends previously submitted subsurface data and analyses presented in the Preliminary Geotechnical Investigation Report, Blue Ledge Mine, Siskiyou County, CA (URS, 2008).

SUPPLEMENTARY GEOTECHNICAL INVESTIGATION

An initial field investigation was performed in June 2008. The preliminary investigation included the excavation of 8 test pits within the two repository areas and preliminary geologic reconnaissance of the sites. The locations of the test pits are shown on the attached Figure 2. The June 2008 investigation is described in detail in the URS (2008) report. A supplementary geotechnical investigation was performed between November 3 and November 8, 2008. The additional investigation included drilling five borings, a more detailed visual reconnaissance of the potential repository sites, and laboratory testing of soil samples collected during the investigation. Note that the intent of the supplementary investigation was to assess the geotechnical stability of the site relative to the proposed modifications, and not to fully characterize possible landslide features in the project area.

Supplementary Subsurface Investigation

Five borings were advanced at the north and south repository sites in November, 2008. The depths of the borings are presented in Table 1. The locations of the borings are shown on Figure 3. Drilling was performed by Boart Longyear of Tualatin, Oregon using a track-mounted CME 850 drill rig.

Table 1: Summary of URS Borings

Exploration ID	Total Depth Completed (feet)	Location
B-1-2008	40.3	North Repository
B-2-2008	31.0	North Repository
B-3-2008	45.0	South Repository
B-4-2008	76.5	South Repository
B-5-2008	71.5	South Repository

Sampling of the subsurface soil was performed using the Standard Penetration Test (SPT) and the Dames & Moore Type U Sampler in general accordance with ASTM Standard D 1586 and ASTM Standard D 3550, respectively. Sampling of the soil was generally conducted at 5-foot intervals throughout the depth of the boreholes. For the SPT test, the number of blows required to drive a 2-inch outside diameter split-barrel sampler the last 12 inches of an 18-inch drive with a 140-lb automatic hammer dropping 30 inches was recorded as the uncorrected blows per foot (Blow Count). This is also referred to as the Standard Penetration Resistance (N) value. For the Dames & Moore sampling, the number of blows required to drive the 3¼-inch outside diameter split-barrel sampler the last 12 inches of an 18-inch drive with a 140-lb automatic hammer dropping 30 inches was recorded as the uncorrected blows per foot. The blows per foot are used to estimate the in-situ relative density of granular soils, the consistency of cohesive soils, and the hardness of weathered bedrock (Winterkorn and Fang, 1975). Uncorrected SPT and Type U blows per foot are presented on the boring logs.

Triple tube rock coring with an HQ-sized barrel (2.406 inch diameter) was used to advance a portion of Boring B-3-2008. Coring runs were typically 5 feet in length.

Appendix A presents the borehole logs developed by URS. The stratigraphic contacts indicated within the borehole logs represent the approximate boundaries between soil and rock types; actual transitions may be more gradual and indistinct. The subsurface and groundwater conditions depicted are only for the specific dates and locations reported, and therefore, are not necessarily representative of other locations and times.

Reconnaissance Survey

The visual reconnaissance consisted of visual assessments of the site conditions, topography, accessibility, basic geomorphology and inspection of the area for signs of instability.

Laboratory Testing

Physical properties of the soil collected from the exploratory borings were analyzed at URS' soil laboratory in Portland, Oregon. The laboratory analyses included the following tests conducted in general accordance with the listed ASTM methods:

- Soil classification, ASTM D 2487.
- Moisture content tests, ASTM D 2216.
- Amount of material finer than the No. 200 Sieve, ASTM D 1140.
- Grain Size Analysis Mechanical Testing, ASTM Test Method D 422 and D 1140.

- Liquid and plastic limits (Atterberg Limits), ASTM D 4318.

Selected results of the physical laboratory tests conducted are summarized on the boring logs in Appendix A. Complete laboratory test results are presented in Appendix B.

REGIONAL GEOMORPHOLOGY

URS conducted a review of stereoscopic aerial photos of the proposed repository areas. The photo set reviewed was flown in July of 1989. The geomorphology surrounding the proposed sites consists of narrow ridgelines with steep descending slopes, locally interrupted by flatter topographic benches. The ridgelines are locally arcuate in plan.

The geomorphology strongly suggests previous (ancient) landslide activity in the area of the south repository site and on both sides of the north repository site ridgeline. There is no obvious indication of recent, large-scale landslide activity in the photos (fresh scarps, sag ponds, hummocky terrain). Field reconnaissance detected no landslide or extensive slope creep in the vicinity of either site. The reconnaissance noted no typical indicators of active or recent slope instability, such as pistol-butted trees, open fissures, or ponding surface water. Trees observed in close proximity to the south repository site are estimated to be more than 300 years old.

North Repository Site

The geomorphology at the north repository site suggests that the site is located on an intact ridgeline located between drainages that have experienced previous landslide activity. The borehole information (discussed below) indicates that intact schist bedrock is located at relatively shallow depths.

South Repository Site

The South Repository Site is located within an area of subdued topography that appears to represent the surface of a back-rotated landslide block. The area is located below a steepened slope that is interpreted to be the degraded head scarp of a large landslide complex. The ridge line above the scarp includes the north repository Site. Boreholes advanced in the area of the south repository site penetrated 20 to 65 feet of silt, sand and gravel, most of which is interpreted to represent a wedge of colluvial material that has eroded from the landslide head scarp. The degree of scarp degradation and thickness of the colluvial wedge, coupled with a lack of evidence for recent movement, suggest that the landslide complex has been dormant for at least a few centuries.

The toe of the landslide is located at, or slightly above the level of Joe Creek. Continued downward erosion of the creek through the landslide toe and underlying bedrock has the potential to reactivate the larger slide complex.

The southern boundary of the landslide is marked by what appears to be debris flow deposits emanating from a steep-sided drainage located above the top of the larger landslide scarp. The age of the debris flow deposits are not known, but the geomorphology suggests that they are younger, and possibly superimposed onto the southern margin of the landslide. The presence of mature conifer growth within the debris flow zone indicates that major debris flow activity has been minimal over the past several hundred years.

The interpreted limits of the landslide complex and debris flow zone are shown on Figure 3. A cross sectional interpretation of the landslide is shown on Figure 5.

SUBSURFACE CONDITIONS

The subsurface conditions were observed in test pits and borings, as described below. Appendix A includes logs of test pits and borings. Appendix B presents results of laboratory analyses of soil samples from the explorations.

North Repository Site

Explorations at the north repository site included test pits TP-1 through TP-6 and Borings B-1-08 and B-2-08. The approximate locations of the explorations are shown on the attached Figures 2 and 3. In general, the soils at the north site consist of near-surface fill and schist residuum overlaying weathered schist bedrock. A generalized cross section through the site is shown in Figure 4. The detailed subsurface conditions are described as follows:

- *Gravel*: 6 inches of 2-inch diameter round aggregate. Gravel was found over most of the landing area (the west end of the ridgeline crest), but not in TP-5 and TP-6 which were located east of the landing. Gravel was not encountered in Borings B-1-08 and B-2-08.
- *Fill*: 1 to 4 feet of fill in the landing area. Fill was only encountered in TP-1 through TP-4. No fill was encountered east of the landing. This fill was likely placed to level the landing area. Fill consists of light brown silty sand with gravel. Five to 10% of the fill consists of cobble-sized fragments in situ. Fragments broke down into sand and gravel-sized particles during sieve testing in the laboratory. Fill material is similar to the weathered schist found below. Remnant organic material and a color change at the base of the fill indicated the original ground surface.
- *Residual Schist*: This material was found below the fill and at the ground surface east of the landing. The soil consists of schist bedrock that has weathered to soil

in situ. This material generally extended to depths of 10 to 25 feet bgs and consists of reddish brown dense to very dense silty sand with gravel, with some sandy silt lenses. The schist soil differs from the gravel fill by color and the presence of remnant rock fabric. Some gravel and cobble-sized fragments could be broken down into smaller sizes under finger pressure. In general, this material becomes more competent (more dense) with depth.

- *Weathered Schist*: Extremely to highly weathered schist was encountered below the residual schist to depths of 41.5 feet bgs (the maximum depth explored). This material is similar in composition to the residual schist but is more competent. The transition to weathered schist was indicated by Standard Penetration Test refusal (greater than 50 blows for 6 inches of penetration).

No groundwater was observed during either investigation.

South Repository Site

Explorations at the south repository site included Test Pits TP-7 and 8 as well as borings B-3 through B-5-08. The approximate locations of these explorations are shown in Figures 2 and 3. The soils encountered at the south site generally consisted of colluvium overlying schist (interpreted to be a part of a landslide block). A generalized cross section is shown in Figure 5. The detailed subsurface conditions are described as follows:

- *Topsoil/Debris*: 6 inches to 2 feet of organic-rich sand and gravel. Material interpreted to reflect historical area grading for logging operations and wood debris accumulation.

- *Colluvial Soil*: Brown, medium dense silty sand with gravel. Approximately 5 to 15% cobble-sized, consisting of fresh to moderately weathered schist rock fragments. Individual clasts as large as 3 feet. Soil matrix does not have remnant rock fabric. This material was encountered from depths of about 20 to 65 feet bgs. The thickness of this material increases to the east, moving toward the interpreted landslide scarp as shown in Figure 5. These soils are interpreted to be landslide debris or colluvium deposited on a displaced rock mass.

- *Landslide Block*: Extremely to completely weathered dark gray schist. This material is dense to very dense and maintains a remnant foliation. However, this foliation generally does not match the regional foliation. This material was penetrated to a maximum depth of 35 feet in Boring B-5-08. This schist is interpreted to be within large blocks displaced during an old (in excess of 300 years, based on old growth trees present in area) landslide event.

No seepage or groundwater was observed during either investigation.

SEISMICITY

Probabilistic analyses conducted by the United States Geological Survey (USGS) in support of the 2002 National Seismic Hazard Maps indicate that the ground motions from the Cascadia Subduction Zone earthquake dominate the seismic hazards for this site. The nearest mapped quaternary fault is approximately 50 miles from the site.

Probabilistic ground motions for the site have been obtained from the current USGS Seismic Hazard Maps (http://eqhazmaps.usgs.gov/, based on Frankel et al., 2002). The probabilistic peak ground accelerations on bedrock for the 475-year and 2,475-year return period events are presented in Table 2.

Table 2: Peak Ground Accelerations (PGA) on Rock

Design Ground Motion	USGS PGA
475-year return period	0.13g
2475-year return period	0.28g

Note: Source for USGS data: http://eqint.cr.usgs.gov/eq-men/html/deaggint2002-06.html (lookup lat. =41.962, long. = -123.106

SLOPE STABILITY ANALYSES

Stability analyses were performed for both repository sites considering the most critical slope section. Two geometries were considered at each location: the existing slope geometry (as measured by topographic maps) and that of an assumed repository fill geometry. Fifteen feet of waste rock/cover fill was considered for the final fill conditions for each repository. Stability analyses were performed for each geometry for static and seismic loading conditions. Output from the slope stability analyses discussed herein is presented in Appendix C.

Stability analyses were performed using the limit equilibrium method based on the Morgenstern-Price method of slices using the commercial software SLOPE/W (2006). Using this methodology, the factor of safety (FOS) for a given geometry is calculated as the ratio of resisting forces to driving forces on a particular trial failure surface. Pseudo-static analyses were performed to assess the slope stability under seismic loading conditions. Per Kramer (1996), the pseudo-static coefficient is equal to ½ of the maximum PGA during the design seismic event. For this site, a pseudo-static coefficient of 0.065 g was selected for analysis based on the 475-year event.

The material properties used in the stability analyses were selected based on subsurface exploration and laboratory data. The selected material properties and groundwater

assumptions are presented in the following sections. Typical minimum static factors of safety for new fills range from 1.3 to 1.5. The final design criteria have not been established at this time.

North Repository Site

The critical slope selected for analysis was oriented approximately northeast-southwest through the north repository site. Native slopes southwest of the repository site ranged from about 2.5H:1V to 3H:1V. A cross section through the critical slope is shown in Figure 4. Final slope geometries of the disposal fill were modeled to be 2.5H:1V. Table 3 presents the material properties used for the stability analyses. Groundwater was not modeled in the analyses as none was encountered during exploration to depths of 41.5 feet. Sensitivity analyses showed that groundwater does not affect the global stability unless it is within 15 feet of ground surface, which is not anticipated.

Table 3: North Repository Site Material Properties

Material Type	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (ϕ)
Waste Fill	130	10	36
Residual Schist Soil	130	200	36
Highly Weathered Schist	130	400	36

The results of the stability analyses are presented in Table 4. The proposed disposal facility exceeds typical minimum factors of safety. Note that reduction in the factors of safety from the existing to the final condition is not indicative of a global reduction in stability. Critical failure planes in the final condition occur within the waste fill material and are representative of fill geometry. Factors of safety can be increased by flattening repository fill slopes.

Table 4: North Repository Site Slope Stability Results

Condition Analyzed	Static Factor of Safety
Existing Condition - Static	2.6
Existing Condition - Seismic	2.2
Final Condition - Static	1.9
Final Condition - Seismic	1.6

South Repository Site

Stability analyses were performed to investigate the effect of the new repository on a regional scale as well as near-site for the south repository site. The critical slope selected was oriented approximately east-west through the repository site. Slopes below the repository site ranged from about 1.2H:1V to 2H:1V. A cross section through the critical slope is shown in Figure 5. Final slope geometries of the disposal fill were modeled to be 2.5H:1V. The subsurface profile used for stability analyses was based on the shallower of the two possible slide mass geometries shown in Figure 5. Table 5 lists the material properties used for the stability analyses. Groundwater was conservatively assumed to be 10 feet above the contact between the colluvium and the slide block (groundwater was not encountered during the explorations to depths of 76.5 feet bgs) for the near-site analyses.

Table 5: South Repository Site Material Properties

Material Type	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (phi)
Waste Fill	130	10	36
Colluvium	125	50	34
Landslide Block	130	400	36
Highly Weathered Schist	130	400	36

Regional Stability

A back analysis of the landslide block was first performed to determine the critical friction angle along the assumed slide plane. This analysis considered a factor of safety of 1.1 under seismic loading for the 475-year event (note that a factor of safety of 1.0 indicates equilibrium at the moment of impending failure). Under these conditions, the critical friction angle of the assumed slide plane was determined to be approximately 22 degrees. The static factor of safety was then calculated for regional landslide model considering the existing and final conditions. These analyses showed that the proposed repository has a negligible effect on the regional stability. The results of these analyses are presented in Table 6.

Table 6: South Repository Site Regional Slope Stability Results

Condition	Factor of Safety
Existing Condition – Seismic (back analysis)	1.1
Existing Condition - Static	1.35
Final Condition - Static	1.35
Final Condition - Seismic	1.1

Near-Site Stability

The results of the near-site stability analyses are presented in Table 7. The critical failure surface falls outside of the area influenced by the repository fill. Forcing the failure surface deeper into the slope to affect proposed repository results in higher factors of safety. The results of these analyses show that the proposed repository has a negligible effect on the site stability. In addition, the proposed disposal facility exceeds typical minimum factors of safety.

Table 7: South Repository Site Near-Site Slope Stability Results

Condition	Failure Surface Location	Factor of Safety
Existing Condition – Static[1]	Shallow	1.4
Existing Condition– Seismic[1]	Shallow	1.2
Existing Condition - Static	Deep	1.51
Final Condition - Static	Deep	1.50
Existing Condition– Seismic	Deep	1.29
Final Condition - Seismic	Deep	1.29

Note 1: Shallow failure surface factor of safety is unchanged between existing and final conditions.

Stability Analysis Summary

Typical minimum static factors of safety for new fills range from 1.3 to 1.5 depending on the nature of the fill material and potential failure hazard it poses. The failure hazard of the proposed repository structures is relatively low. In our judgment, appropriate factors of safety for this type of earth structure are 1.3 and 1.1 for static conditions seismic loading conditions, respectively. The slope stability analyses performed indicate that the north and south sites are adequately stable for the proposed waste fill repository. If final design criteria are established that differ from those assumed, slope stability should be reevaluated.

ATTACHMENTS

Figure 1 Vicinity Map
Figure 2 Test Pit Locations
Figure 3 Site Map
Figure 4 Geologic Cross Section – North Repository
Figure 5 Geologic Cross Section – South Repository
Appendix A: Subsurface Exploration Logs
Appendix B: Laboratory Test Data
Appendix C: Slope Stability Analyses

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URS, 2008. *Preliminary Geotechnical Investigation Report, Blue Ledge Mine, Siskiyou County, California*. Prepared for the USDA Forest Service.

Winterkorn, H.F. and Fang, H-Y., 1975. *Foundation Engineering Handbook*, Van Nostrand Reinhold Company, New York, New York.

FIGURES

Source: Grants Pass, Oregon USGS 100K Topo Quad, 1984.
Happy Camp, California USGS 100K Topo Quad, 1984.

0 1 2 Miles

URS

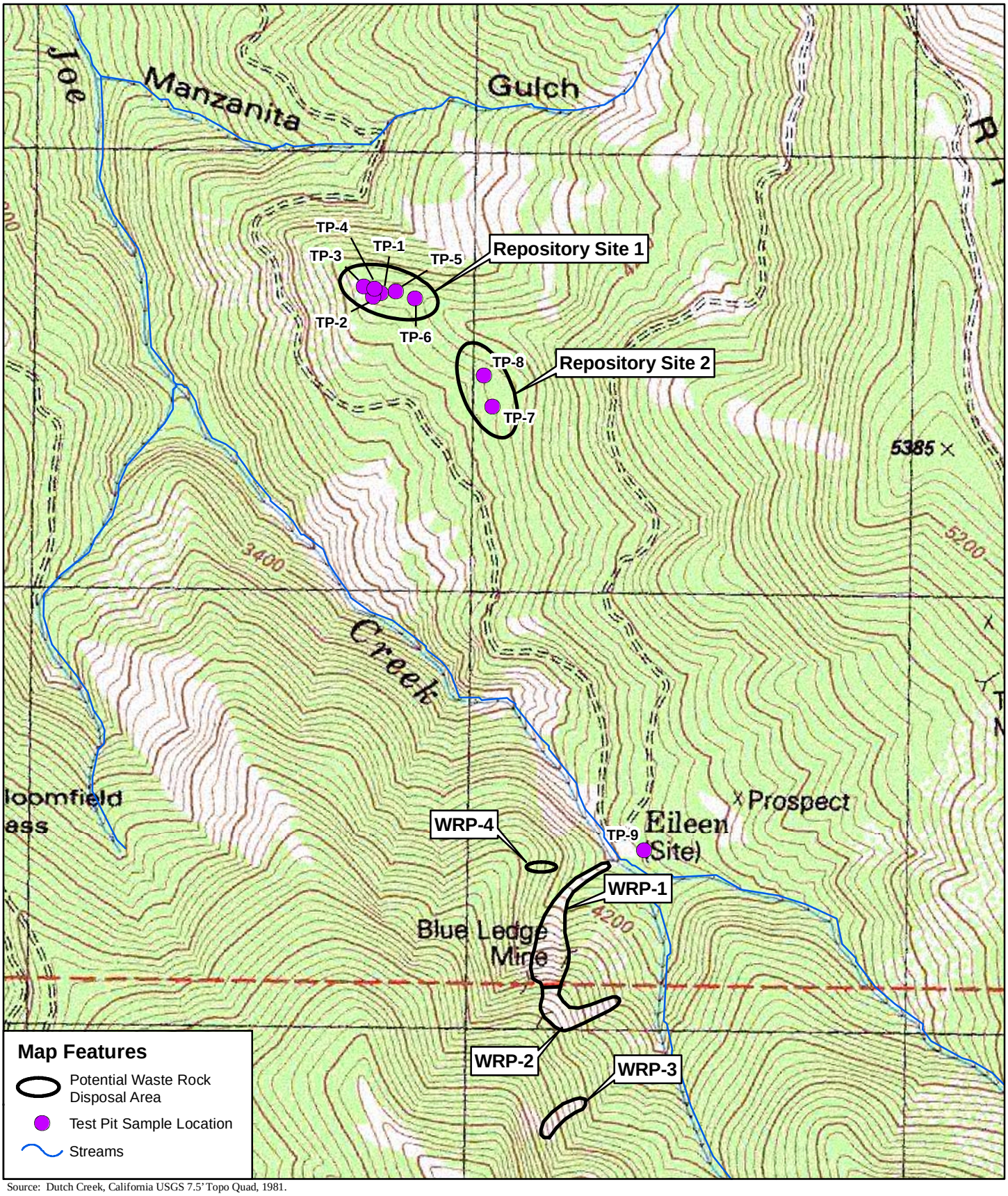
VICINITY MAP

DECEMBER 2008
25696770

UNITED STATES FOREST SERVICE
BLUE LEDGE MINE
BLUE LEDGE, CALIFORNIA

FIGURE 1

O:\25696770 Blue Ledge Mine\5000 Technical\GIS\MXD\New Folder\Fig1 Vicinity Map.mxd



Source: Dutch Creek, California USGS 7.5' Topo Quad, 1981.
Kangaroo Mountain, California USGS 7.5' Topo Quad, 1981.

0 250 500 1,000 Feet

URS

DECEMBER 2008
25696770

TEST PIT LOCATIONS

UNITED STATES FOREST SERVICE
BLUE LEDGE MINE
BLUE LEDGE, CALIFORNIA

FIGURE 2

O:\25696770 Blue Ledge Mine\5000 Technical\GIS\MXD\New Folder\Fig 2 Test Pit Locations.mxd

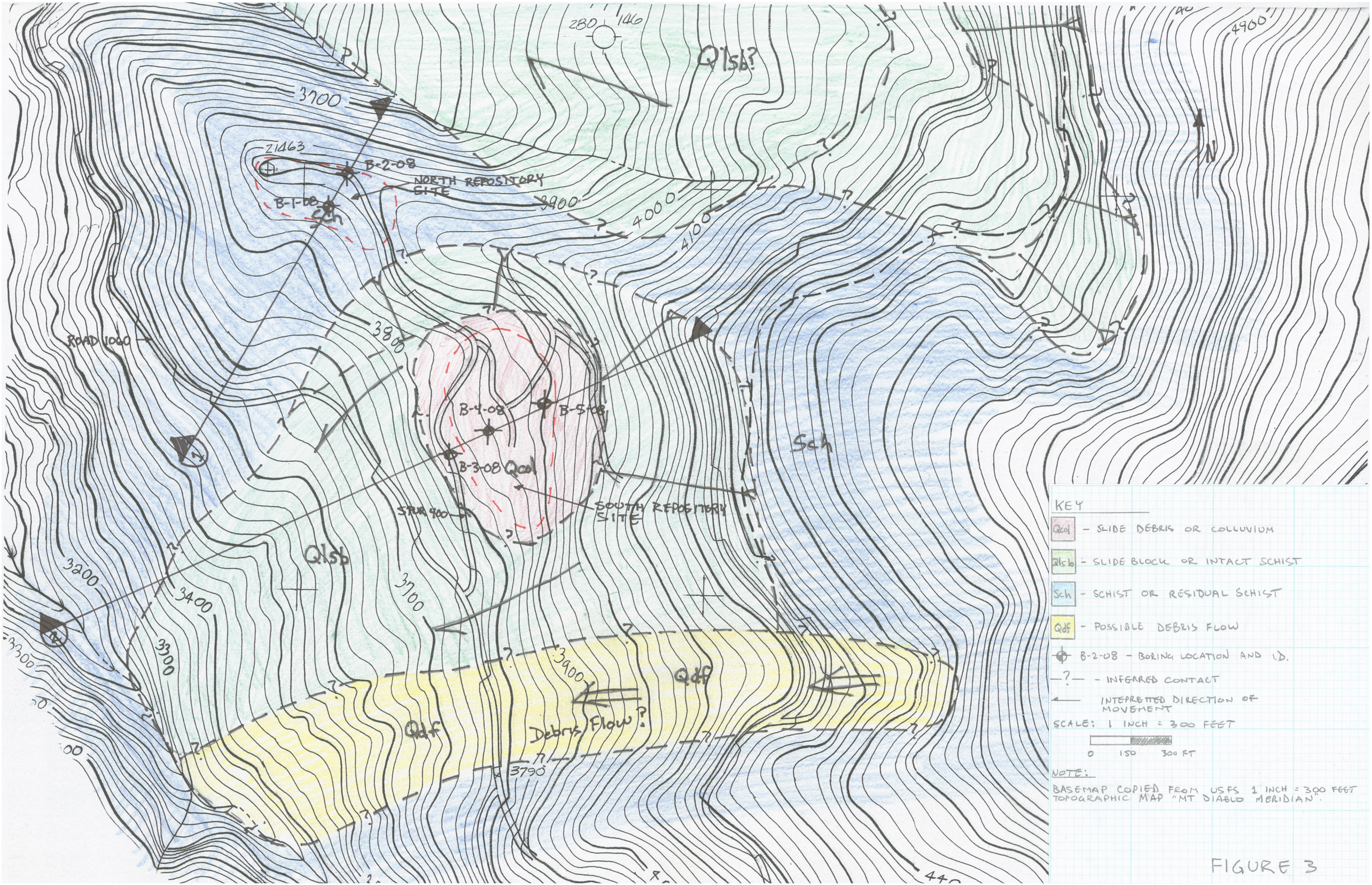
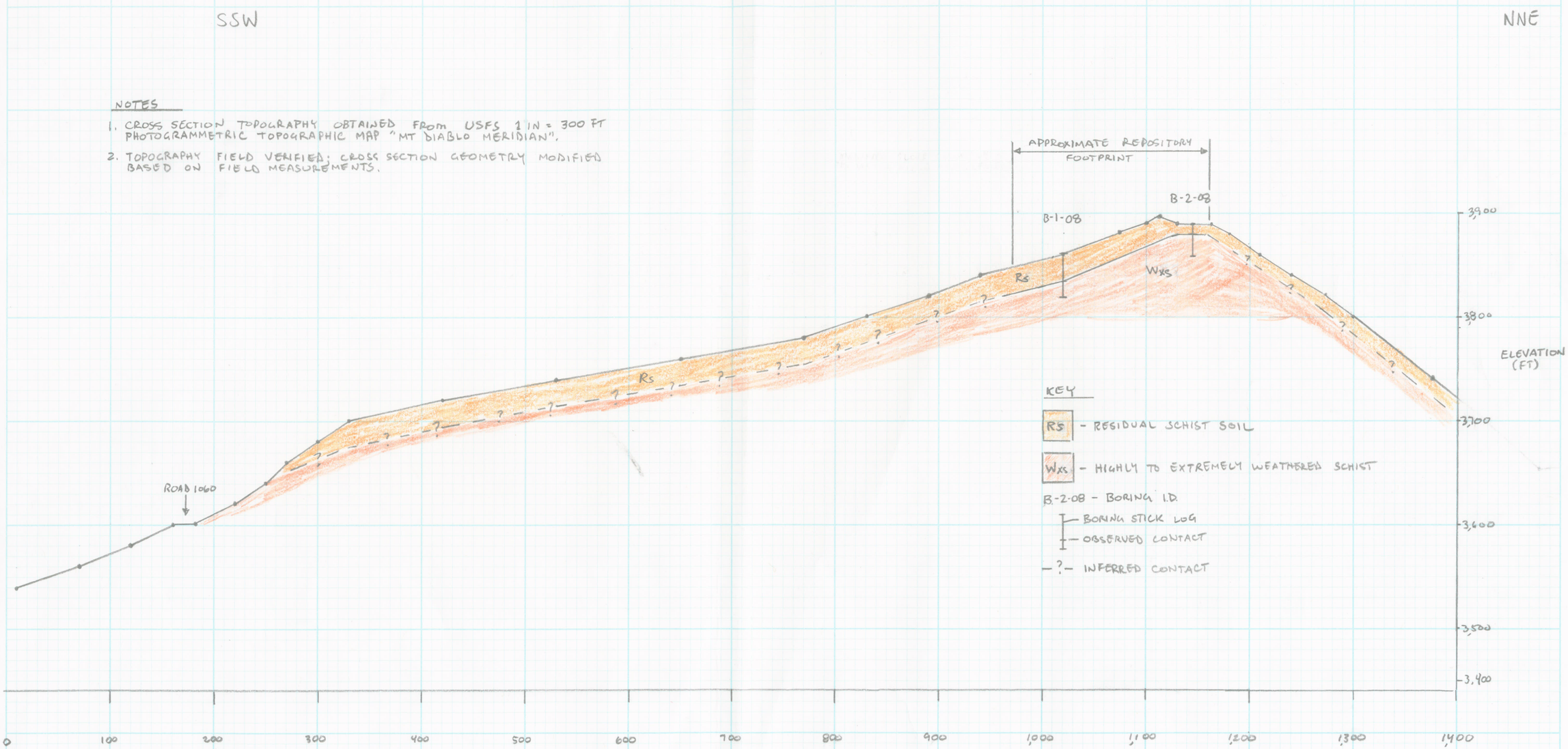

280
146
Qlsb?
3700
21463
B-2-08
NORTH REPOSITORY SITE
B-1-08
3900
4000
4100
4900
N
ROAD 1060
3800
B-4-08
B-5-08
B-3-08
Qcol
Sch
SPUR 900
SOUTH REPOSITORY SITE
Qlsb
3200
3400
3300
3700
3400
Qdf
Qdf
Debris Flow?
3790
KEY
Qcol - SLIDE DEBRIS OR COLLUVIUM
Qlsb - SLIDE BLOCK OR INTACT SCHIST
Sch - SCHIST OR RESIDUAL SCHIST
Qdf - POSSIBLE DEBRIS FLOW
B-2-08 - BORING LOCATION AND I.D.
- INFERRED CONTACT
INTERPRETED DIRECTION OF MOVEMENT
SCALE: 1 INCH = 300 FEET
0 150 300 FT
NOTE:
BASEMAP COPIED FROM USFS 1 INCH = 300 FEET TOPOGRAPHIC MAP "MT DIABLO MERIDIAN".

FIGURE 3

GEOLOGIC CROSS SECTION 1
NORTH REPOSITORY SITE



NOTES

1. CROSS SECTION TOPOGRAPHY OBTAINED FROM USFS 1 IN = 300 FT PHOTOGRAMMETRIC TOPOGRAPHIC MAP "MT DIABLO MERIDIAN".
2. TOPOGRAPHY FIELD VERIFIED; CROSS SECTION GEOMETRY MODIFIED BASED ON FIELD MEASUREMENTS.

1 INCH = 100 FEET

FIGURE 4

URS

JOB NO. 25696770
DATE 12/17/08 BY BJD
CLIENT USFS
PROJECT BLUE LEDGE MINE
SUBJECT CROSS SECTION - NORTH REPOSITORY
CHECKED BY (date)
PAGE OF

GEOLOGIC CROSS SECTION 2

SOUTH REPOSITORY SITE

NOTES

1. CROSS SECTION TOPOGRAPHY OBTAINED FROM USFS 1 IN = 300 FT PHOTOGRAMMETRIC TOPOGRAPHIC MAP "MT DIABLO MERIDIAN".
2. TOPOGRAPHY FIELD VERIFIED EAST OF ROAD 1060; CROSS SECTION GEOMETRY MODIFIED BASED ON FIELD MEASUREMENTS.

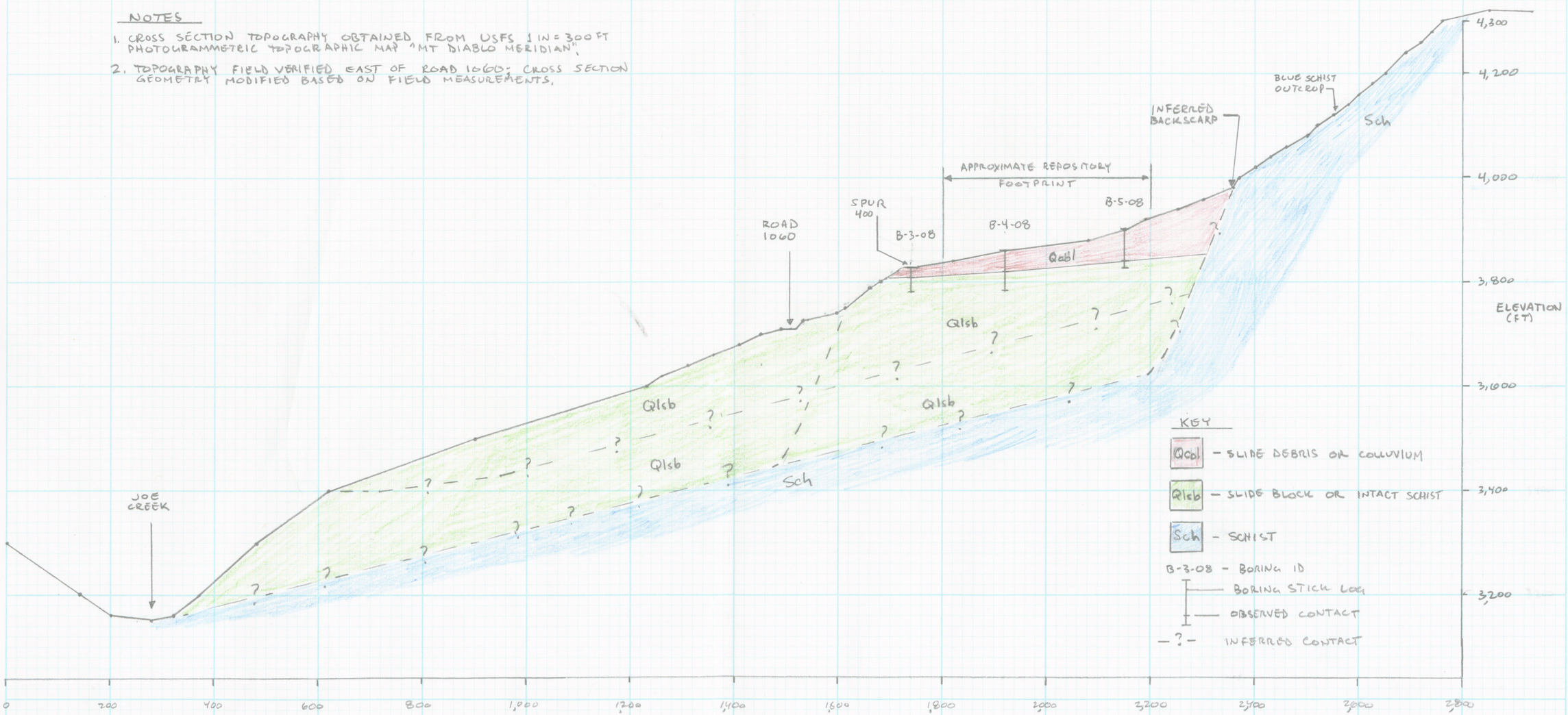


FIGURE 5

URS

JOB NO. 25646770
DATE 12/18/08 BY BJD
CHECKED BY (date)
CLIENT USFS
PROJECT BLUE LEDGE MINE
SUBJECT CROSS SECTION A-A': SOUTH REPOSITORY SITE
PAGE OF

APPENDIX A

SUBSURFACE EXPLORATION LOGS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Key to Log of Test Pit

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Water Content	REMARKS AND OTHER TESTS
1	2	3	4	5		6	7	8

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

6 **Material Description:** Description of material encountered; may include color, moisture, grain size, and density/consistency.

7 **Moisture Content, %:** Moisture content as determined in general accordance with ASTM D2216

8 **Remarks and Other Tests:** Comments and observations regarding excavation or sampling made by driller or field personnel. Field and laboratory test results (other than water content), using abbreviations explained below.

TYPICAL MATERIAL GRAPHIC SYMBOLS

Well graded gravel with silt.

Silty gravel with sand.

SIlty sand with gravel.

Poorly graded gravel with silt and sand.

SIlty sand.

Sandy silt with gravel.

Sandy silt.

Clayey gravel with sand.

Clayey sand with gravel.

TYPICAL SAMPLER GRAPHIC SYMBOLS

Grab sample.

OTHER GRAPHIC SYMBOLS

TYPICAL LABORATORY TEST ABBREVIATIONS

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific test pit locations and at the time the test pits were excavated; they are not warranted to be representative of subsurface conditions at other locations or times.

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-1**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**16 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3890.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3890	0				**WELL GRADED GRAVEL WITH SILT [GW-GM]**, light brown, dry, medium dense, gravel fine to coarse, sand well graded, fine to coarse, subangular. [FILL]		
			S-1		**SILTY GRAVEL WITH SAND [GM]**, light brown, moist, medium dense, gravel fine to coarse, predominately less than 2", sand fine to coarse, subangular, 20% fines, 30% sand, 5% cobbles (up to 6"), fines are platy. [FILL]	11.1	
			S-2		**SILTY SAND WITH GRAVEL [SM]**, reddish brown, moist, medium DENSE, sand and gravel fine to coarse grained, about 35% sand, 20% gravel, few cobbles to 6" (in situ), fines are platy, organics present [RESIDUAL SOIL].	20.7	
	5		S-3			20.3	
					Increasing density with depth.		
			S-4		*Grades to light brown, cobble-sized clasts have remnant rock fabric (can be broken down to sand by hand). [COMPLETELY WEATHERED SCHIST]*	15	
3880	10				*Increase in consistency of rock fabric.*		
					Test pit terminated at 14.0 feet bgs.		
	15						
3870	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-2**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**14 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3890.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3890	0				**WELL GRADED GRAVEL WITH SILT [GW-GM]**, light brown, dry, medium dense, gravel fine to coarse, sand well graded, fine to coarse, subangular. [FILL].		
					SILTY SAND WITH GRAVEL [SM], light brown, moist, medium dense, sand and gravel fine to coarse, subangular, 30% silt, 35% sand, 35% gravel and cobbles (up to 6"), fines are platy [FILL].		
			S-1			13.5	
	5				*Grades to reddish brown [RESIDUAL SOIL].*		
			BS-1				
			S-2		*Grades to brown.*	15.7	
3880	10		S-3			16.8	
					Grades to increased fines content, gravel and cobble sized clasts have remnant rock fabric (can be broken down to sand by hand). [COMPLETELY WEATHERED SCHIST]		
			S-4		*Grades to harder material.*	16.4	
					Test pit terminated at 14.0 feet bgs. Limit of equipment reach.		
	15						
3870	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-3**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3890.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3890	0				Aggregate surfacing - 1 to 2" diameter rounded gravel.		
					SILTY SAND WITH GRAVEL [SM], light brown, medium dense, sand and gravel fine to coarse, 25% silt, 40% sand, 25% gravel, 10% cobbles to 6", fines are platy [FILL].		
					Grades to reddish brown, few organics [RESIDUAL SOIL].		
			S-1			14	
	5						
			S-2		*Grades to brown to light brown, gravel and cobble sized clasts have remnant rock fabric, (can be broken down by hand to sand), [COMPLETELY WEATHERED SCHIST].*	12.2	
3880	10						
			S-3		*Grades to harder material.*	14	
					Test pit terminated at 14.0 feet bgs.		
	15						
3870	20						
	25						

URS

Report: PORT_TP_W; File: BLUELE~1.GPJ; 1/2/2009 TP-3

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-4**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**9.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3890.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3890	0				Aggregate surfacing - 2 to 1" rounded gravel.		
					SILTY SAND WITH GRAVEL [SM], light brown, medium dense, sand and gravel fine to coarse, 30% silt, 40% sand, 10% cobbles up to 6", fines are platy [FILL]. *Grades to reddish brown [COMPLETELY WEATHERED SCHIST].*		
	5		BS-1		*Grades to harder material with depth.*		
					Test pit terminated at 9.0 feet bgs.		Backhoe having difficulty excavating.
3880	10						
	15						
3870	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-5**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**10.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3890.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3890	0				**POORLY GRADED GRAVEL WITH SILT AND SAND [GP-GM]**, topsoil, roots and other organics.		
			S-1		**SILTY SAND WITH GRAVEL [SM]**, light brown, dry, 15% silt, 25% sand, 50% gravel, 10% cobbles, sand and cobbles have rock fabric, can be broken down by hand [COMPLETELY WEATHERED SCHIST]. *Grades to harder material, more cobble fragments (30-40%).*	11.6	
	5		S-2		*Grades to harder material with depth.*	25.4	
			S-3		**SILTY SAND [SM]**, reddish brown, moist, medium dense, low plasticity, still maintains rock fabric. [COMPLETELY WEATHERED SCHIST].	10.2	
3880	10				Test pit terminated at 10.0 feet bgs.		Slower excavation.
	15						
3870	20						
	25						

Report: PORT_TP_W; File: BLUELE~1.GPJ; 1/2/2009 TP-5

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-6**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**14 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**14.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3890.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**North Disposal Site**			Surface Condition	**Cleared Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3890	0				**SILTY SANDY WITH GRAVEL [SM]**, light brown to brown, max gravel size is 1", organics, [TOPSOIL].		
			S-1		**SANDY SILT WITH GRAVEL [ML]**, reddish brown, low plasticity, moist, medium stiff, sand fine to coarse grained, gravel less than 0.5", about 10% sand, 10% gravel.	20.8	
			BS-1				
	5		BS-2		**SILTY SAND WITH GRAVEL [SM]**, brown, medium dense, moist, sand predominantly fine grained, gravel to 2", 30% silt, 50% sand, 20% gravel, 10% sand, gravel has remnant rock fabric, can be broken into sand by hand, [COMPLETELY WEATHERED SCHIST].		
			S-2			22.3	
			S-3		**SANDY SILT [ML]**, medium stiff, moist, ~25% sand, fine grained, material has remnant rock fabric, [COMPLETELY WEATHERED SCHIST].	39.9	
3880	10				**SILTY SAND WITH GRAVEL [SM]**, brown to light brown, medium dense to dense, moist, sand fine grained, 25% gravel, gravel has remnant rock fabric, can be broken down by hand into sand, 20% silt. [COMPLETELY WEATHERED SCHIST].		
					Test pit terminated at 14.0 feet bgs. More competent, unable to break down by hand.		
	15						
3870	20						
	25						

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-7**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**14 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**13.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3870.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**South Disposal Site**			Surface Condition	**Brushy Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3870	0				**SANDY GRAVEL WITH SILT [GP-GM]**, dark brown, dry, dense, sand fine to coarse, gravel up to 1", subangular to subrounded, organics present [DEBRIS FROM LANDING SITE].		
			S-1			8.6	
					SILTY SAND WITH GRAVEL [SM], medium dense, moist, ~35% sand, 40% silt, 30% gravel, few cobbles, sand fine to coarse, gravel well graded, cobbles up to 6", soil does not have remnant rock fabric, intact fragments bluish gray, occassional 1'+ size clasts [SLIDE DEBRIS/COLLUVIUM].		
	5						
			S-2			14.8	
3860	10		BS-1		*Large clasts (1' +) of fresh schist.*		
					Large intact schist fragment in sidewall (3'+).		
					Test pit terminated at 13.0 feet bgs.		
	15						
3850	20						
	25						

Report: PORT_TP_W; File: BLUELE~1.GPJ; 1/2/2009 TP-7

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-8**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**13 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**12.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**3870.0**
Water Observations	**None observed on 6/26/08**			Weather	**Sunny, 80's**
Location	**South Disposal Site**			Surface Condition	**Brushy Logging Landing**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
3870	0				TOPSOIL		
					SILTY SAND WITH GRAVEL [SM], brown, medium dense, ~45% sand, 20% silt, 25% gravel, 10% cobbles, gravel and cobbles are moderate to slightly weathered schist (different composition than sand and silt, slide debris) [SLIDE DEBRIS/COLLUVIUM].		
			S-1			9.4	
					Increased cobble content, occassional boulders up to 1.5'.		
	5						
			S-2			13.5	
					Decrease in silt content, absense of boulders.		
3860	10						
					Test pit termianted at 12.0 feet bgs.		
	15						
3850	20						
	25						

Report: PORT_TP_W; File: BLUELE~1.GPJ; 1/2/2009 TP-8

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Test Pit TP-9**

Date(s) Excavated	**6/26/08**	Logged By	**BJD**	Checked By	**JOD**
Length of Excavation	**12 feet**	Width of Excavation	**2 feet**	Depth of Excavation	**9.0 feet**
Excavation Equipment	**CASE 580**	Excavation Contractor	**Bradley Excavation**	Approximate Surface Elevation	**4010.0**
Water Observations	**2 feet bgs on 6/26/08**			Weather	**Sunny, 80's**
Location	**Eileen Townsite**			Surface Condition	**Brushy Forest**

Elevation feet	Depth, feet	Sample Type	Sample Number	Graphic Log	MATERIAL DESCRIPTION	Moisture Content	REMARKS AND OTHER TESTS
4010	0				ORGANIC DUFF AND TOPSOIL.		
			S-1		**CLAYEY GRAVEL WITH SAND [SP]**, wet, medium dense, sand is fine to coarse (predominately coarse), gravel well graded fine to coarse, 30% clay, 20% sand, 30% gravel, 20% cobbles, cobbles and gravel bluish gray schist clasts sub angular, few boulders (2' max). [SLIDE DEBRIS/COLLUVIUM].	15.6	Wall is seeping.
	5						
			S-2		**CLAYEY SAND WITH GRAVEL [CL]**, brown, medium plasticity, wet, mottled bluish green, about 45% clay, 35% sand, 20% gravel, sand is coarse grained, gravel less than 1", few up to 3". [SLIDE DEBRIS/COLLUVIUM].	22	
4000	10				Test pit terminated at 9.0 feet bgs.		
	15						
3990	20						
	25						

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Key

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows / foot	Recovery, inches	Sample Length, feet	FIELD NOTES AND LAB TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation (in feet) referenced to mean sea level (MSL).

2 **Depth:** Distance (in feet) below the collar of the borehole.

3 **Run No.:** Number of the individual coring interval.

4 **Box No.:** Number of the core box which contains core from the corresponding run.

5 **Recovery:** Amount (in percent) of core recovered from the coring interval; calculated as length of core recovered divided by length of run.

6 **Fractures per Foot:** (Fracture Frequency) The number of naturally occurring fractures in each foot of core; does not include mechanical breaks (induced by drilling) or healed fractures. "NA" indicates not applicable due to lack of core recovery.

7 **R Q D:** (Rock Quality Designation) Amount (in percent) of intact core (pieces of sound core greater than 4 inches in length) in each coring interval; calculated as the sum of lengths of intact core divided by length of core run. RQD of moderately weathered/altered rock does not meet soundness requirements, but provides some indication of rock quality with respect to the degree of fracturing.

8 **Fracture Drawing:** Sketch of the naturally occurring fractures and mechanical breaks, showing the angle of the fractures relative to the cross-sectional axis of the core. "NR" indicates no recovery.

9 **Fracture Number:** Location of each naturally occurring fracture (numbered) and mechanical break (labeled "M"). Naturally occurring fractures are described in Column 11 (keyed by number) using descriptive terms defined on Sheet 2 (Items a through g).

10 **Lithology:** A graphic log of material encountered using symbols to represent differing soil and types; graphic symbols are explained below.

11 **Description:** Lithologic description in this order: rock type, color, texture, grain size, weathering, strength, and other features; descriptive terms are defined on Sheet 2. A detailed description of overburden material is not necessarily provided. Also, abbreviated description of fractures numbered in Column 9 using terms defined on Sheet 2.

12 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

13 **Sample Number:** Sample identification number.

14 **Blows / foot:** Number of blows to advance driven sampler each 12-inch drive interval, or distance noted, using a 140-lb hammer with a 30-inch drop (unless otherwise noted).

15 **Recovery:** Actual soil recovery in driven sampler in inches.

16 **Sample Length, feet:** Length the sampler was driven in feet.

17 **Field Notes and Lab Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel. Lab tests are indicated using abbreviations explained below.

TYPICAL MATERIAL GRAPHIC SYMBOLS

Sandy silt with gravel
Silty Sand with Gravel
Siltysand
Sandy silt
Clayey sand with gravel
Forest duff
Lean clay with sand
Silty gravel with sand
Schist

TYPICAL SAMPLER GRAPHIC SYMBOLS

Wireline Coring
Standard Penetration Test

LABORATORY TEST ABBREVIATIONS

OTHER GRAPHIC SYMBOLS

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

URS

Project: Blue Ledge Mine Project Location: Siskiyou County, CA Project Number: 25696770	Key

KEY TO DESCRIPTIVE TERMS USED ON CORE LOGS

DISCONTINUITY DESCRIPTORS

a Dip of discontinuity, measured relative to a plane normal to the core axis.

b **Discontinuity Type:**

- F - Fault
- J - Joint
- Sh - Shear
- Fo - Foliation
- V - Vein
- B - Bedding

c **Aperture (inches):**

- W - Wide (0.5-2.0)
- MW - Moderately Wide (0.1-0.5)
- N - Narrow (0.05-0.1)
- VN - Very Narrow (<0.05)
- T - Tight (0)

d **Type of Infilling:**

- Cl - Clay
- Ca - Calcite
- Ch - Chlorite
- Fe - Iron Oxide
- Gy - Gypsum
- H - Healed
- Mn - Manganese Oxide
- No - None
- Py - Pyrite
- Qz - Quartz
- Sd - Sand

e **Amount of Infilling:**

- Su - Surface Stain
- Sp - Spotty
- Pa - Partially Filled
- Fi - Filled
- No - None

f **Surface Shape of Joint:**

- Pl - Planar
- Wa - Wavy
- St - Stepped
- Ir - Irregular

g **Roughness of Surface:**

- Slk - Slickensided [surface has smooth, glassy finish with visual evidence of striations]
- S - Smooth [surface appears smooth and feels so to the touch]
- SR - Slightly Rough [asperities on the discontinuity surfaces are distinguishable and can be felt]
- R - Rough [some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive]
- VR - Very Rough [near-vertical steps and ridges occur on the discontinuity surface]

ROCK WEATHERING / ALTERATION

Description	Recognition
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Completely Weathered/Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although original fabric may be intact; material can be granulated by hand
Highly Weathered/Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 2-inch-diameter sample can be broken readily by hand across rock fabric
Moderately Weathered/Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 2-inch-diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered/Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh/Unweathered	Rock shows no discoloration, loss of strength, or other effect of weathering/alteration

ROCK STRENGTH

Description	Recognition
Extremely Weak Rock	Can be indented by thumbnail
Very Weak Rock	Can be peeled by pocket knife
Weak Rock	Can be peeled with difficulty by pocket knife
Moderately Strong Rock	Can be indented 5 mm with sharp end of pick
Strong Rock	Requires one hammer blow to fracture
Very Strong Rock	Requires many hammer blows to fracture
Extremely Strong Rock	Can only be chipped with hammer blows

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Key to Log of Boring

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance Blows/12 in.	SAMPLES Recovery [in]	Graphic Log	Lithology Log (USCS Code)	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pcf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11	12

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Sampling Resistance:** Number of blows required to advance driven sampler 12 inches beyond first 6-inch drive interval, or distance noted, using a 140-lb hammer with a 30-inch drop; hydraulic down-pressure for tube sampler.

6 **Recovery [in]**

7 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

8 **Lithology Log:** Unified Soil Classification Code (USCS) for corresponding lithologic unit.

9 **Material Description:** Description of material encountered; may include color, moisture, grain size, and density/consistency.

10 **Water Content:** Water content of soil sample measured in laboratory, expressed as percentage of dry weight of specimen.

11 **Dry Density:**

12 **Remarks and Other Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel. Other field and laboratory test results, using the following abbreviations:

TYPICAL MATERIAL GRAPHIC SYMBOLS

Sandy silt with gravel
Silty Sand with Gravel
Siltysand
Sandy silt
Clayey sand with gravel
Forest duff
Lean clay with sand
Silty gravel with sand
Schist

TYPICAL SAMPLER GRAPHIC SYMBOLS

Dames and Moore Type U
Standard Penetration Test
Wireline Coring

OTHER GRAPHIC SYMBOLS

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

Project: Blue Ledge Mine **Project Location: Siskiyou County, CA** **Project Number: 25696770**	**Log of Boring B-1-08** Sheet 1 of 2

Date(s) Drilled	**11/04/08**	Logged By	**BJD**	Checked By	**DBM**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**8" O.D./4 1/4" I.D.**	Total Depth of Borehole	**41.5 FT**
Drill Rig Type	**CME 850 Track Mounted**	Drilling Contractor	**Boart Longyear**	Approximate Surface Elevation	**3,860 feet MSL**
Groundwater Level and Date Measured	**None observed on 11/06/2008**	Sampling Method(s)	**SPT/Dames & Moore**	Hammer Data	**140 lb Auto Hammer**
Borehole Backfill	**Bentonite Chips**	Location	**North Repository Area**		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3860	0							*Forest Duff*			Start 13:15
							ML	**SANDY SILT WITH GRAVEL [ML]**, light brown, low to non plasticity, dry, very stiff, some gravel fragments are cemented silt, cannot break down gravel with finger pressure.			
			S-1	32	14				5.1		
3855	5		S-2	71	12			*Grades to hard with 56.8% silt, 35.8% sand, 7.4% gravel* *Remant Rock Fabric @ 6.0'*	9.8	116.9	
							SM	**SILTY SAND WITH GRAVEL [SM]**, pale yellowish brown (10YR 6/2), dry, very dense, sand primarily medium to fine grained, ~30% silt, ~50% sand, ~20% gravel, gravel fragments have intact fabrc, gravel can be broken down under finger pressure.			
3850	10		S-3	87/11"	14				9.5		More difficult drilling @ 11.0', 14:10 Alternating harder and softer
3845	15		S-4	68	12			*Increase in silt to ~40%, gravel to ~ 10%; material has residual foliation dipping ~60 degrees. [DECOMPOSED SCHIST]*	8.2	120.6	14:25
3840	20		S-5	54	18		SM	**SILTY SAND [SM]**, pale yellowish brown (10YR 6/2), dry, very dense, sand fine to medium grained, trace gravel, weak cementing, maintains remant rock fabric, foliation/bedding present, foliation planes "waxy" when broken down by finger pressure. [DECOMPOSED SCHIST]	13.3		14:45 Broken fitting-Rig down/15:10 Running again
3835	25										

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-1-08

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3835	25		S-6	184/9"	16		SM	**SILTY SAND WITH GRAVEL [SM]**, pale yellowish brown (10YR 6/2), dry, very dense, sand fine to medium grained, ~30% silt, 40% sand, 30% gravel, weak cementation, maintains remnant fabric, foiliation/bedding present; larger clasts can be broken down with finger pressure. [DECOMPOSED SCHIST]	9.2	114.7	
3830	30		S-7	60/4"	3			*Grades to light brownish gray (5YR 6/1), <20% gravel (sample pulverized by SPT)*	6.9		
3825	35		S-8	100/3"	0						15:45 Increased drilling difficultyj. However, still advances with out problem.
3820	40		S-9	50/3"	3		SM	**SILTY SAND [SM]**, light brownish gray (5YR 6/1), dry, very dense, sand fine to medium grained, ~50% silt, 50% sand, weak cementation can be broken down with finger pressure, remnant rock fabric. [DECOMPOSED SCHIST]	6.6		16:15
								Bottom of Boring @ 41.5 feet on 11/04/2008. Backfilled with bentonite chips on 11/06/2008.			
3815	45										
3810	50										

URS

Project: Blue Ledge Mine **Project Location: Siskiyou County, CA** **Project Number: 25696770**	**Log of Boring B-2-08** Sheet 1 of 2

Date(s) Drilled	**11/05/08**	Logged By	**BJD**	Checked By	**DBM**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**8" O.D./4 1/4" I.D.**	Total Depth of Borehole	**31.0 FT**
Drill Rig Type	**CME 850 Track Mounted**	Drilling Contractor	**Boart Longyear**	Approximate Surface Elevation	**3,890 feet MSL**
Groundwater Level and Date Measured	**None observed on 11/06/2008**	Sampling Method(s)	**SPT/Dames & Moore**	Hammer Data	**140 lb Auto Hammer**
Borehole Backfill	**Bentonite Chips**	Location	**North Repository Site-Ridge Line**		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3890	0						SM	**SILTY SAND WITH GRAVEL [SM]**, light brown (5YR 6/4), moist, medium dense, sand fine to coarse grained, fine gravel, ~30% silt, 40% sand, 30% gravel, few aggregate rocks.			Start 09:00
			S-1	24	12			*Grades to grayish orange (10YR 7/4), sand predominately fine grained, gravel up to 1"*	2.3		
3885	5		S-2	180	18			*Grades to pale yellowish brown (10YR 6/2), very dense, gravel fragments less than 1" can be broken down with finger pressure, has remant fabric, some foliation exposed in sample, dipping 10-20 degrees. [DECOMPOSED SCHIST]*	3.7	120.5	
3880	10		S-3	50/4"	10		SM	**SILTY SAND [SM]**, pale yellowish brown (10YR 6/2), moist, very dense, ~40% silt, 60% sand, trace gravel less than 1", can be broken down with finger pressure. [DECOMPOSED SCHIST]	6.1		
3875	15		S-4	115/5"	0						10:06
3870	20		S-5	97	18		ML	**SANDY SILT [ML]**, pale yellowish brown (10YR 6/2), dry, hard trace gravel, 62.9% silt, 32.3% sand, 4.8% gravel, gravel can be broken down by finger pressure, weakly cemented, has remnant rock fabric, remant foliation 10-20 degrees. [DECOMPOSED SCHIST]	8.6	126.0	
3865	25										

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-2-08

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3865	25		S-6	60/4"	3		ML	**SANDY SILT [ML]**, pale yellowish brown (10YR 6/2), dry, hard trace gravel, 62.9% silt, 32.3% sand, 4.8% gravel, gravel can be broken down by finger pressure, weakly cemented, has remnant rock fabric, remant foliation 10-20 degrees. [DECOMPOSED SCHIST]	7.3		
3860	30		S-7	150/6"	6			*some gravel-sized quartz fragments in shoe*	4.5	113.2	11:00
								Bottom of Boring @ 31.0 feet on 11/05/2008. Backfilled with bentonite chips on 11/06/2008.			
3855	35										
3850	40										
3845	45										
3840	50										

URS

Project: Blue Ledge Mine **Project Location: Siskiyou County, CA** **Project Number: 25696770**	**Log of B-3-08** Sheet 1 of 3

Date(s) Drilled	**11/05/08**	Logged By	**BJD**	Checked By (Date)	**DBM**
Drilling Method	**Mud Rotary/ HQ Triple Tube Wireline**	Drill Bit Size/Type	**4 7/8" Tri-Cone/HQ Core**	Total Depth Drilled (feet)	**45.0 feet**
Drill Rig Type	**CME 850 Track Mounted**	Drilling Contractor	**Boart Longyear**	Approximate Surface Elevation	**3,820 feet MSL**
Groundwater Level	**None observed on 11/06/2008**	Location	**South Repository Site-Road 1060-400**	Inclination from Horizontal/Bearing	**90**
Borehole Completion	**Bentonite Chips**			Hammer Data	**140 lb Auto Hammer**

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	RQD, %	Number of Fractures	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows / foot	Recovery, in	Moisture, %	Dry Density, pcf	FIELD NOTES AND LAB TESTS
3820	0.0								**CLAYEY SAND WITH GRAVEL [SC]**, dark yellowish brown (10YR 4/2), low plasticity, moist, medium dense, well graded up to 2", 20% clay, 50% sand, 30% gravel, angular, [road base mixed with native soils].							Start 12:45 Gravel in cuttings 0.5'
	1.0															
3818	2.0								**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, 40% sand, 40% silt, 20% gravel, sand is fine grained, few angular gravel fragments (consistency of gray schist). [SLIDE DEBRIS/COLLUVIUM?]							
	3.0															
3816	4.0															
	5.0															
3814	6.0										S-1	20	10	16.1		Harder drilling @ 6.0'
	7.0															
3812	8.0															
	9.0															Softer drilling @ 9.0'
3810	10.0								**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, very stiff, 42.3% silt, 33.0% sand, 24.7% gravel, sand fine to coarse grained, few extra waxy schist fragments that can be broken with finger pressure, also some medium gray (N5), fragmnets to 1", cannot be broken by hand, few roots. [SLIDE DEBRIS/COLLUVIUM?]							
	11.0										S-2	44	12	12.7	110.5	
3808	12.0															
	13.0															

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of B-3-08

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	RQD, %	Number of Fractures	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows / foot	Recovery, in	Moisture, %	Dry Density, pcf	FIELD NOTES AND LAB TESTS
	13.0								**SANDY SILT WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, very stiff, 42.3% silt, 33.0% sand, 24.7% gravel, sand fine to coarse grained, few extra waxy schist fragments that can be broken with finger pressure, also some medium gray (N5), fragmnets to 1", cannot be broken by hand, few roots. [SLIDE DEBRIS/COLLUVIUM?]							
3806	14.0															
	15.0								**SILTY SAND WITH GRAVEL [SM]**, grayish brown (5YR 3/2) to brownish black (5YR 2/1), mottled light brown (5YR 5/6), moist, medium dense, ~40% sand, 30% silt, 30% gravel, well graded coarse to fine grained, gravel up to 1", gravel is intact schist in silty sand matrix, few roots. [SLIDE DEBRIS/COLLUVIUM?]		S-3	15	10	17.9		13:28
3804	16.0															
	17.0															
3802	18.0															
	19.0															
3800	20.0								**SCHIST**, medium dark gray (N4), moderately weathered, soft (R2), can be scratched with pick, laminated/foliated, foliation, dipping 60-70 degrees. [LANDSLIDE BLOCK/BEDROCK?]							14:10 Difficult drilling @ 21.0'
	21.0										S-4	151	14	4.3	134.7	
3798	22.0															
	23.0															
3796	24.0															
	25.0								*Grades to moderately weathered to predominately decomposed, extremely soft, foliation dipping 25-40 degrees (can be broken down with fingers), foliation surfaces are "greasy". [LANDSLIDE BLOCK/BEDROCK?]*							14:30
3794	26.0										S-5	35	12	15.7		
	27.0															
3792	28.0															
	29.0															

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of B-3-08

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	RQD, %	Number of Fractures	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows / foot	Recovery, in	Moisture, %	Dry Density, pcf	FIELD NOTES AND LAB TESTS
	29.0								**SCHIST**, medium dark gray (N4), moderately weathered, soft (R2), can be scratched with pick, laminated/foliated foliation, dipping 60-70 degrees. [LANDSLIDE BLOCK/BEDROCK?]							
3790	30.0								*Foliation Dipping ~30 degrees*							14:50 Switch to HQ Core
	31.0										S-6	97	12	13.2	118.6	
					0				*No recovery 31.5 feet to 33.5 feet*							Begin HQ coring
3788	32.0															
	33.0	1		30	0	0.0			*Completely Decomposed Schist, dark gray, extremely soft (sandy clay-no intact fabric could be due to drilling-to weak to core.*							
3786	34.0															
					0				*No recovery 34.5 feet to 39.5 feet*							
	35.0								*Contact at 34.4 - Grades to light brown, some foliage intact*							15:36 End run 1 15:45 Start run 2
3784	36.0															
	37.0	2		9.1	0	0.0										Driller notes in and out of hard zones
3782	38.0															
	39.0															
					0				**SILTY SAND [SM]**, few intact schist fragments (possibly ground up by coring), moderate yellowish brown, sand is fine to medium grained, angular. [SLIDE DEBRIS?] *No recovery 40 feet to 43.2 feet*							
3780	40.0															15:55 End run 2 14:00 Start run 3
					0											
	41.0															
3778	42.0															Driller notes materia varies in hardness
		3		36	0	0.0			*Few core fragments*							
	43.0								*Grades to Silty Sand, medium dark gray, few intact fragments >0.5"*							
					0											
3776	44.0															14:10 End run 3
					0				Bottom of Boring @ 45.0 feet on 11/05/2008. Backfilled with bentonite chips on 11/06/2008.							
	45.0															

URS

Project: Blue Ledge Mine **Project Location:** Siskiyou County, CA **Project Number:** 25696770	**Log of Boring B-4-08** Sheet 1 of 3

Date(s) Drilled	**11/06/08**	Logged By	**BJD**	Checked By	**DBM**
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**4 7/8" Tri-Cone**	Total Depth of Borehole	**76.5 FT**
Drill Rig Type	**CME 850 Track Mounted**	Drilling Contractor	**Boart Longyear**	Approximate Surface Elevation	**3,860 feet MSL**
Groundwater Level and Date Measured	**None observed on 11/07/2008**	Sampling Method(s)	**SPT/Dames & Moore**	Hammer Data	**140 lb Auto Hammer**
Borehole Backfill	**Bentonite Chips**	Location	**South Repository Site**		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3860	0							*Forest Duff*			Start 09:40
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, well graded up to ~1", gravel and coarse sand are gray schist fragments, some can be broken down by hand. [SLIDE DEBRIS/COLLUVIUM?]			
3855	5		S-1	19	12				12.2		
3850	10		S-2	42	14			*Grades with 38.6% sand, 36.2% silt, 25.2% gravel, (2.5" Schist Fragment in shoe)*	9.6	116.7	10:00
3845	15		S-3	22	16			*Gravel angular to subangular, some gravel is dark gray schist, no intact fabric*	15.8		
3840	20		S-4	29	10				14.5	120.8	10:26
3835	25										

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-4-08

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3835	25		S-5	15	10		ML	**SANDY SILT WITH GRAVEL [ML]**, dark yellowish brown (10YR 4/2)mottled gray and red, moist, medium dense, ~50% silt, 40% sand, 10% gravel, well graded up to 0.5", clasts subangular, material is weathered schist orgin, no intact fabric. [SLIDE DEBRIS/COLLUVIUM?]	15.6		
							CL	**LEAN CLAY WITH SAND [CL]**, olive gray (5Y 4/1), moist, stiff, ~10% sand, fine grained. [SLIDE DEBRIS/COLLUVIUM?]			
3830	30		S-6a		5		ML	**SANDY SILT [ML]**, dark gray (N3), moist, very stiff, with gravel, 48.1% silt, 40.7% sand, 11.2% gravel, well graded to 0.5", clast subangular to angular, no intact fabric, fines graphitic. [SLIDE DEBRIS/COLLUVIUM?]	25.7	99.0	11:00, Pocket Pen 1.75 tsf
			S-6	40	6				22.4	111.5	Driller indicates softer drilling @ 32'
3825	35		S-7	15	14			*Has very weak remnant fabric*	27.8		
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark gray (N3), moist, medium dense, 40% silt, 40% sand, 20% gravel, has remnant foilation. [DECOMPOSED BLACK SCHIST]			
3820	40		S-8	53	18				16.1	117.2	
								SCHIST, predominately decomposed, extremely soft (phi), laminated-very fine beds-foliation is remnant easily braeks down to silty sand/sandy silt with finger pressure. [LANDSLIDE BLOCK/BEDROCK?]			11:50 Driller indicates harder drilling @ 42'
3815	45		S-9	45	14				13.4		12:05-12:30 Re-Fill mud tub
3810	50		S-10	85	15			*Grades to moderate yellowish brown (10YR 5/4), harder (R0-R1), no distinct foliation, sample breaks into silty sand with gravel, few intact fragments to 1".*	6	138.1	12:40-12:50 Progressively harder drilling
											13:05-13:15 Re-Fill transmission fluid

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-4-08

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3805	55		S-11	38	12			**SCHIST**, moderate yellowish brown (10YR 5/4), predominately decomposed, extremely soft to very soft (R0 to R1), no distinct foliation in schist, sample breaks into silty sand with gravel, few intact fragments to 1". [LANDSLIDE BLOCK/BEDROCK?]	10.7		13:25
3800	60		S-12	72	13			*Grades to pale yellowish brown (10YR 6/2), completely decomposed, extremely soft (R0) schist, (behaves as stiff sandy silt [ML], 30% sand, 70% silt), remnant rock fabric, breaks down completely under finger pressure*	14.6	122.5	14:05 Easier drilling @ 62'
3795	65		S-13	58	15			*Grades to medium dark gray (N4), predominately decomposed, soft (R0), laminated to very fine, remnant foliation, breaks down to sandy silt with finger pressure.*	17.8		14:25
3790	70		S-14	96	13			*Grades to grayish black (N2) fresh, extremely soft to soft (R0-R1), laminated very fine beds, foliation dipping ~30 degrees, ~50% can be broken down with finger pressure*	12.8	126.4	15:00
3785	75		S-15	104	12			*Grades to medium dark gray (N4), extremely soft (R0)*	11.6		15:25
								Bottom of Boring @ 76.5 feet on 11/06/2008. Backfilled with bentonite chips on 11/07/2008.			
3780	80										

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-5-08

Date(s) Drilled	11/07/2008	Logged By	BJD	Checked By	DBM
Drilling Method	Mud Rotary	Drill Bit Size/Type	4 7/8" Tri-Cone	Total Depth of Borehole	71.5 FT
Drill Rig Type	CME 850 Track Mounted	Drilling Contractor	Boart Longyear	Approximate Surface Elevation	3,900 feet MSL
Groundwater Level and Date Measured	None observed on 11/07/2008	Sampling Method(s)	SPT/Dames & Moore	Hammer Data	140 lb Auto Hammer
Borehole Backfill	Bentonite Chips	Location	South Repository Site		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3900	0							*Forest Duff*			Start 07:50
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, 35% silt, 45% sand, 20% gravel, well graded to 0.5", coarse grained sand and gravel is subangular. [SLIDE DEBRIS/COLLUVIUM?]			
			S-1	20	8				15.7		07:55
3895	5		S-2	17	10				12.6	119.8	
3890	10		S-3	19	10			*Gravel Fragments are schist*	14		08:15
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, 35% silt, 45% sand, 20% gravel, well graded to 0.5", coarse grained sand and gravel is subangular. [SLIDE DEBRIS/COLLUVIUM?]			
3885	15		S-4	43	11				11.3	127.4	08:30
3880	20		S-5	30	15				17		08:42
3875	25										

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-5-08

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3875	25		S-6	62	12		GM	**SILTY GRAVEL WITH SAND [GM]**, dark yellowish brown (10YR 4/2), moist, medium dense, poorly graded, all sizes in sample, ---gravel from 0.5"-1", gravel is highly weathered schist (but cannot be broken down). [SLIDE DEBRIS/COLLUVIUM?]	7.6	134.9	09:00
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, well graded to 0.5", ~30% silt, 50% sand, 20% gravel, gravel subangular. [SLIDE DEBRIS/COLLUVIUM?]			
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, well graded to 0.5", ~30% silt, 50% sand, 20% gravel, gravel subangular. [SLIDE DEBRIS/COLLUVIUM?]			
3870	30		S-7	25	13				13.3		
3865	35		S-8	59	13			*Grades with 38.2% sand, 32.9% silt, and 28.9% gravel*	11.9	128.5	09:40
3860	40		S-9	21	15				14.9		
3855	45		S-10	83	12		GM	**GRAVEL WITH SAND [GM]**, dark yellowish brown (10YR 4/2), moist, dense, poorly graded, ~20% silt, 20% sand, 60% gravel, gravel subangular, fragments show variable weathering (vary in color from medium gray to light brown). [SLIDE DEBRIS/COLLUVIUM?]	9.8	134.0	10:20
							SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, poorly graded, ~20% silt, 60% sand, 20% gravel, gravel subangular, fragments show variable weathering (vary in color from medium gray to light brown). [SLIDE DEBRIS/COLLUVIUM?]			
3850	50		S-11	27	14				14.2		

URS

Project: Blue Ledge Mine
Project Location: Siskiyou County, CA
Project Number: 25696770

Log of Boring B-5-08

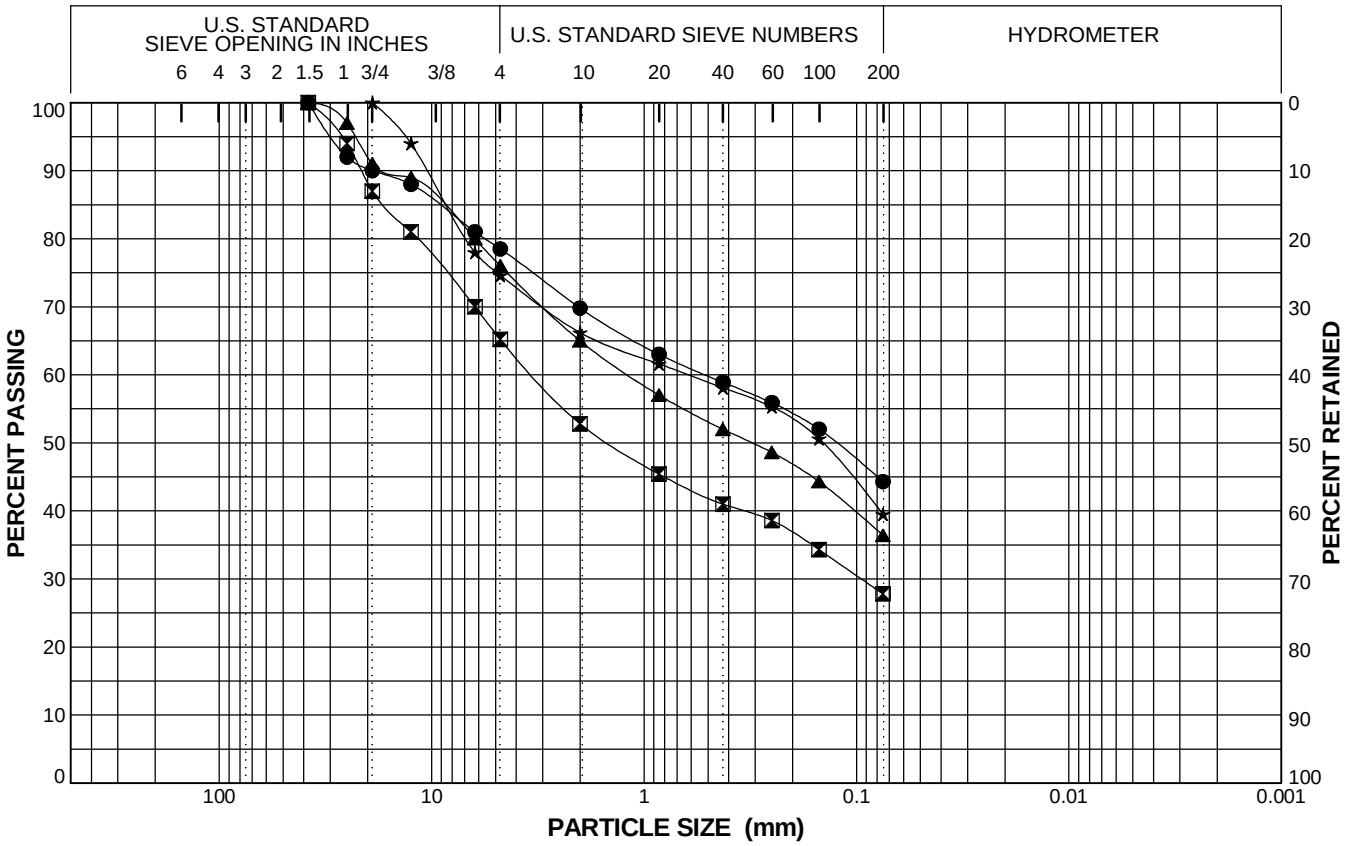
Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows/ft	Recovery [in]	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	Moisture Content	Dry Density, pcf	REMARKS
3845	55		S-12	64	12		SM	**SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, poorly graded, ~20% silt, 60% sand, 20% gravel, gravel subangular, fragments show variable weathering (vary in color from medium gray to light brown). [SLIDE DEBRIS/COLLUVIUM?] *-Dark yellowish residual schist in shoe-Has remnant fabric-Breaks down to silty sand with finger pressure. Material is clast.*	11.2	131.5	
3840	60		S-13	40	14		SM	*Heterogenous schist clasts in silty sand matrix* **SILTY SAND WITH GRAVEL [SM]**, dark yellowish brown (10YR 4/2), moist, medium dense, poorly graded, ~20% silt, 60% sand, 20% gravel, gravel subangular, fragments show variable weathering (vary in color from medium gray to light brown). [SLIDE DEBRIS/COLLUVIUM?]	14.1		11:35
3835	65		S-14	124	12			*4" decomposed Schist clast in shoe, dark yellowish orange, remnant fabric (66.2').* **SCHIST**, dark yellowish orange (10YR 6/6) to medium dark gray (N4), decomposed, extremely soft (R0), schsit sample breaks down to silty sand with finger pressure, remnant fabric throughout sample. [LANDSLIDE BLOCK/BEDROCK?]	9.2	135.6	12:15 Harder drilling below 65'
3830	70		S-15	48					15.8		12:45
								Bottom of Boring @ 71.5 feet. Backfilled with bentonite chips on 11/07/2008.			
3825	75										
3820	80										

URS

APPENDIX B

LABORATORY TEST DATA

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
TP-1		4.5			●	23	4	21.5	34.2	44.3	SILTY SAND WITH GRAVEL [SM]
TP-2	S-1	3.0	13.5		⊠			34.8	37.4	27.8	SILTY SAND WITH GRAVEL [SM]
TP-2	S-3	10.0	16.8		▲			24.0	39.6	36.4	SILTY SAND WITH GRAVEL [SM]
TP-3	S-2	6.0	12.2		★			25.4	35.1	39.5	SILTY SAND WITH GRAVEL [SM]

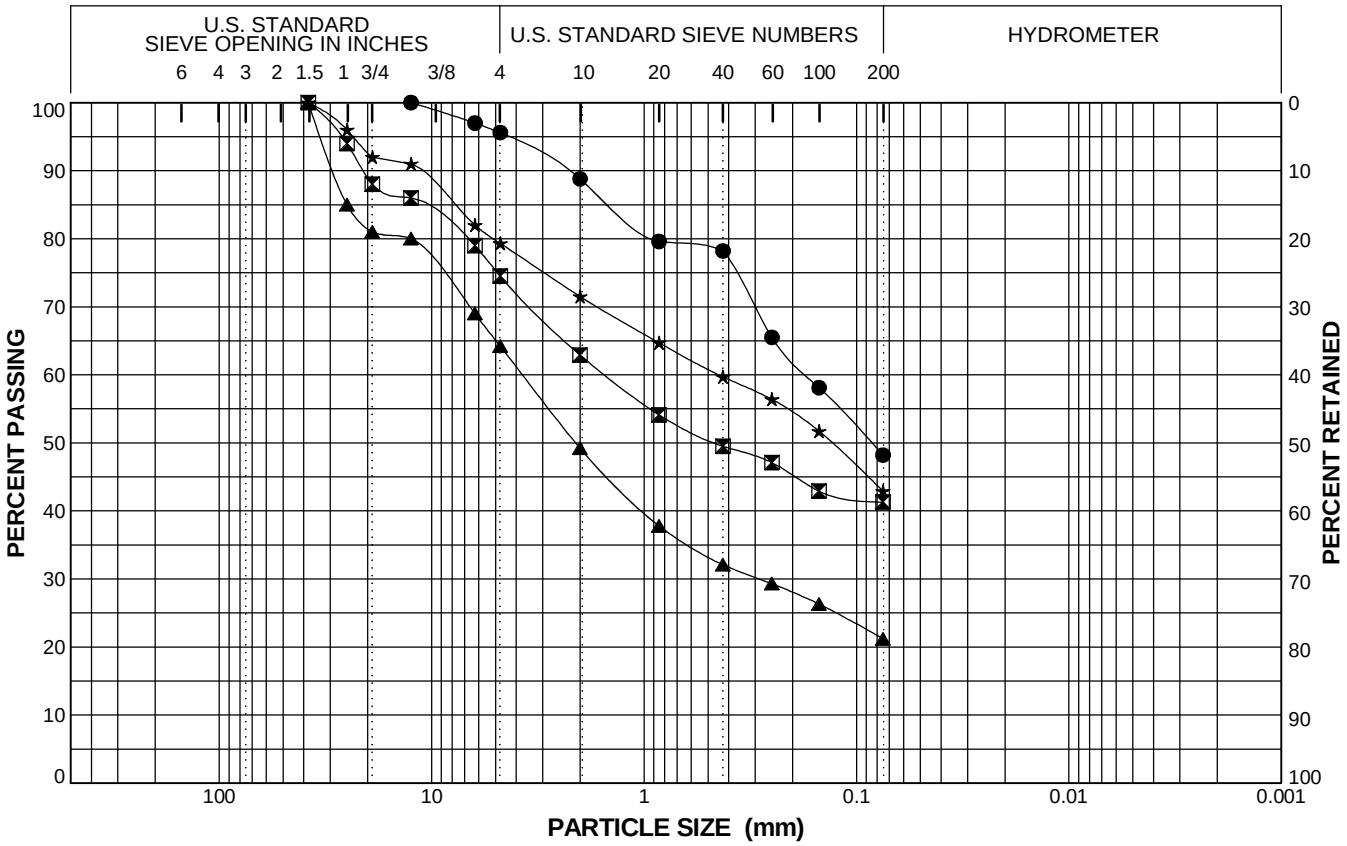
Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 11/21/2008 TP-3

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
TP-5		5.5			●			4.4	47.4	48.2	SILTY SAND [SM]
TP-7		7.5			⊠			25.5	33.2	41.3	SILTY SAND WITH GRAVEL [SM]
TP-8		3.5			▲			35.8	43.0	21.2	SILTY SAND WITH GRAVEL [SM]
TP-9		8.5			★			20.7	36.4	42.9	SILTY SAND WITH GRAVEL [SM]

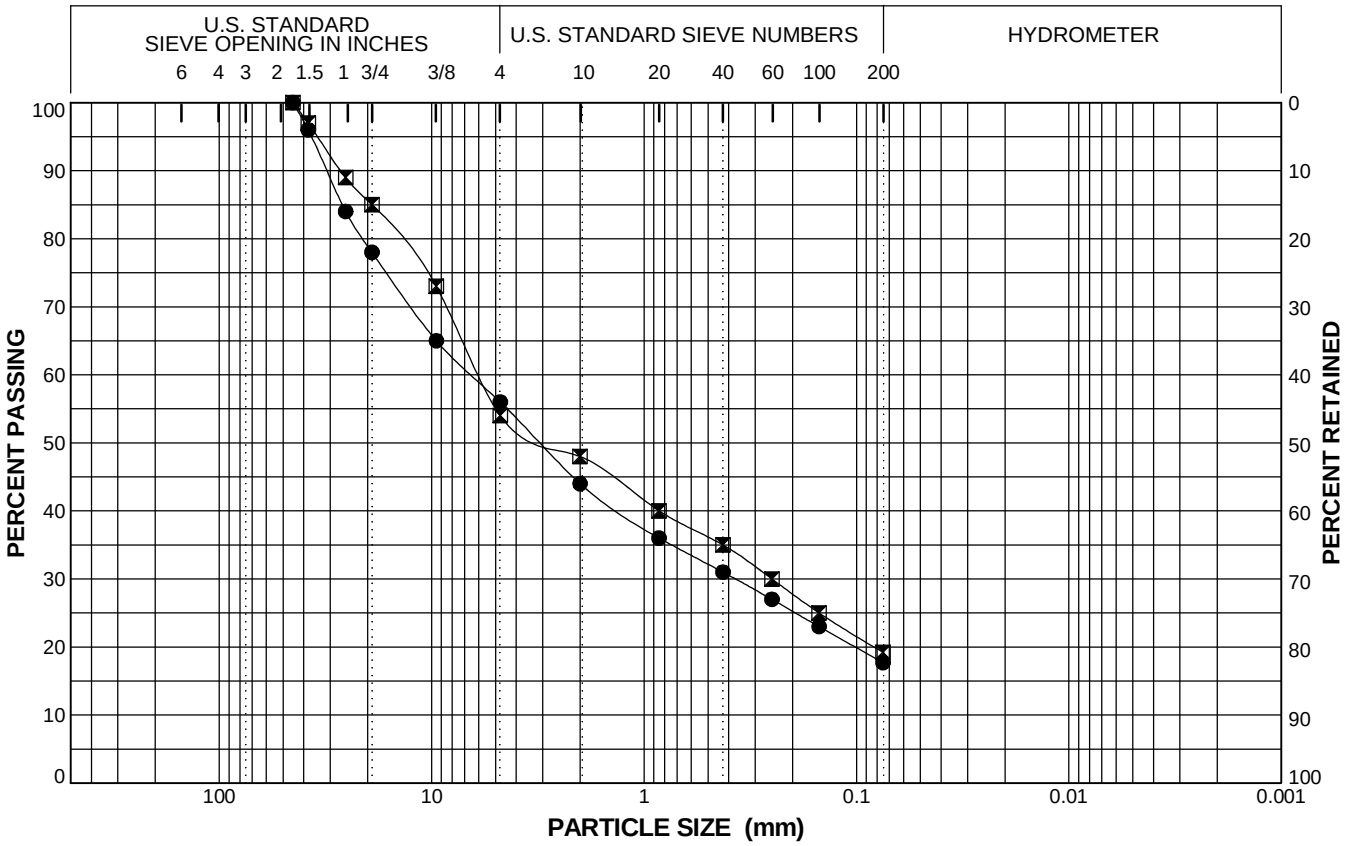
Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 11/21/2008 TP-9

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



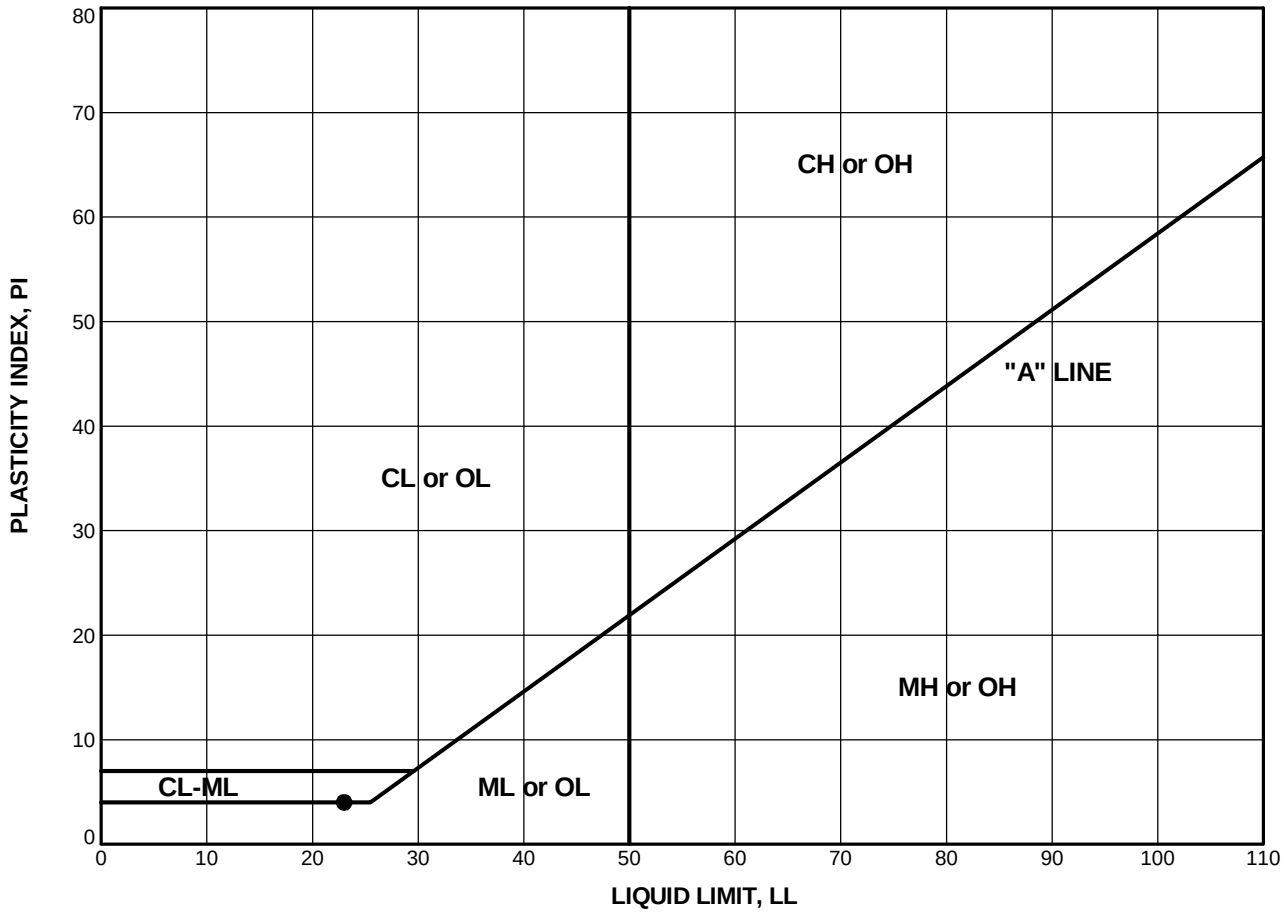
Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
Waste Rock-1		1.0	7.1		●			44.0	38.3	17.7	Silty Gravel with Sand [GM]
Waste Rock-2		1.0	5.2		⧗			46.0	34.8	19.2	Silty Gravel with Sand [GM]

Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 11/21/2008 Waste Rock-2



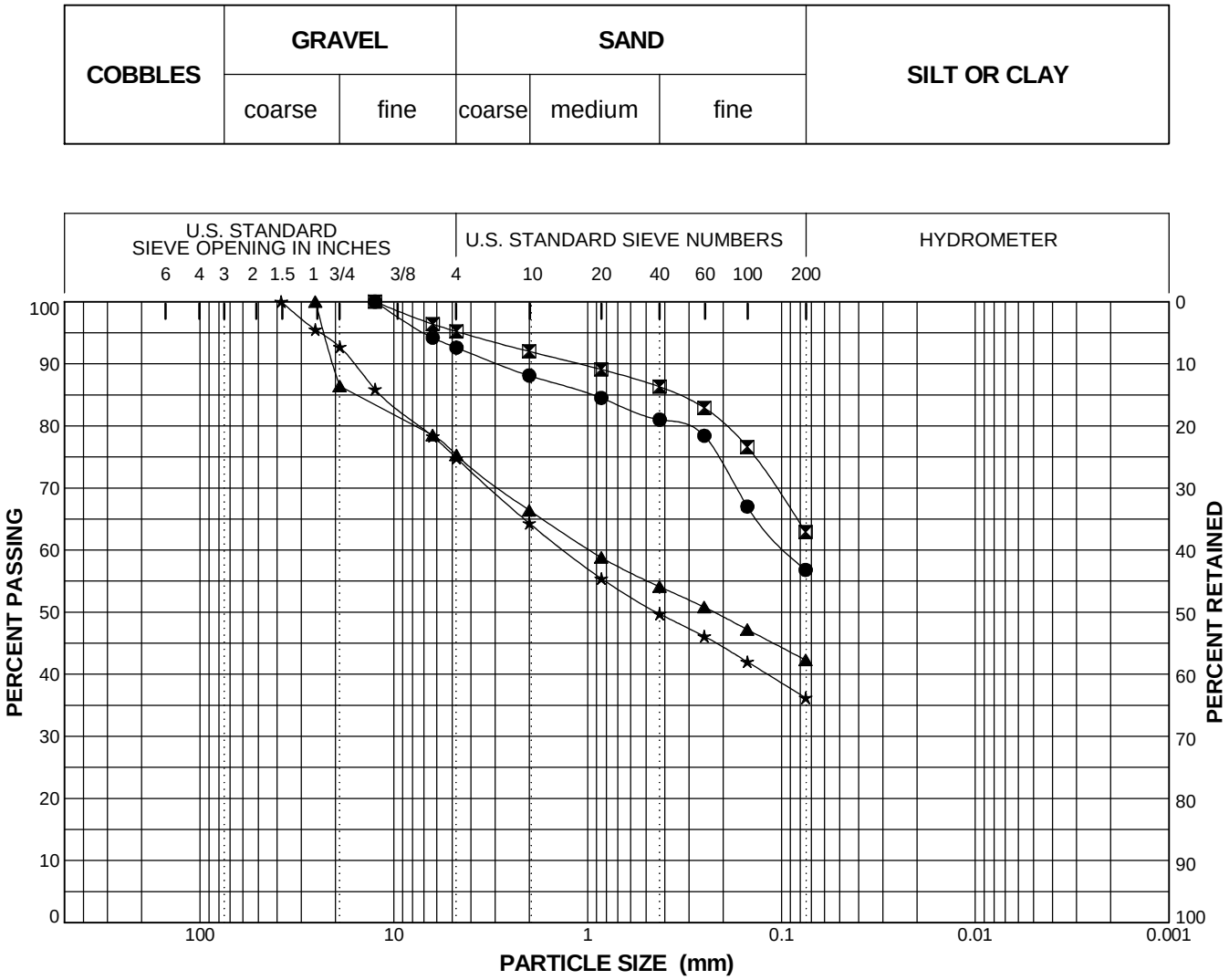
Boring ID	Sample #	Depth (feet)	Symbol	Sample Moisture %	LL	PL	PI	Classification
TP-1		4.5	●		23	19	4	SILTY SAND WITH GRAVEL [SM]

Blue Ledge Mine
Siskiyou County, CA
25696770

PLASTICITY CHART

URS

Report: ATTERBERG_PLOT_12 PTS; File: BLUELE~1.GPJ; 11/21/2008 TP-1



Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
B-1-08	S-2	5.0-6.0'	9.8	116.9	●	NP	NP	7.4	35.8	56.8	SANDY SILT [ML]
B-2-08	S-5	20.0-21.5'	8.6	126.0	⊠	35	1	4.8	32.3	62.9	SANDY SILT [ML]
B-3-08	S-2	10.0-11.0'	12.7	110.5	▲			24.7	33.0	42.3	SILTY SAND WITH GRAVEL [SM]
B-4-08	S-2	10.0-11.2'	9.6	116.7	★			25.2	38.6	36.2	SILTY SAND WITH GRAVEL [SM]

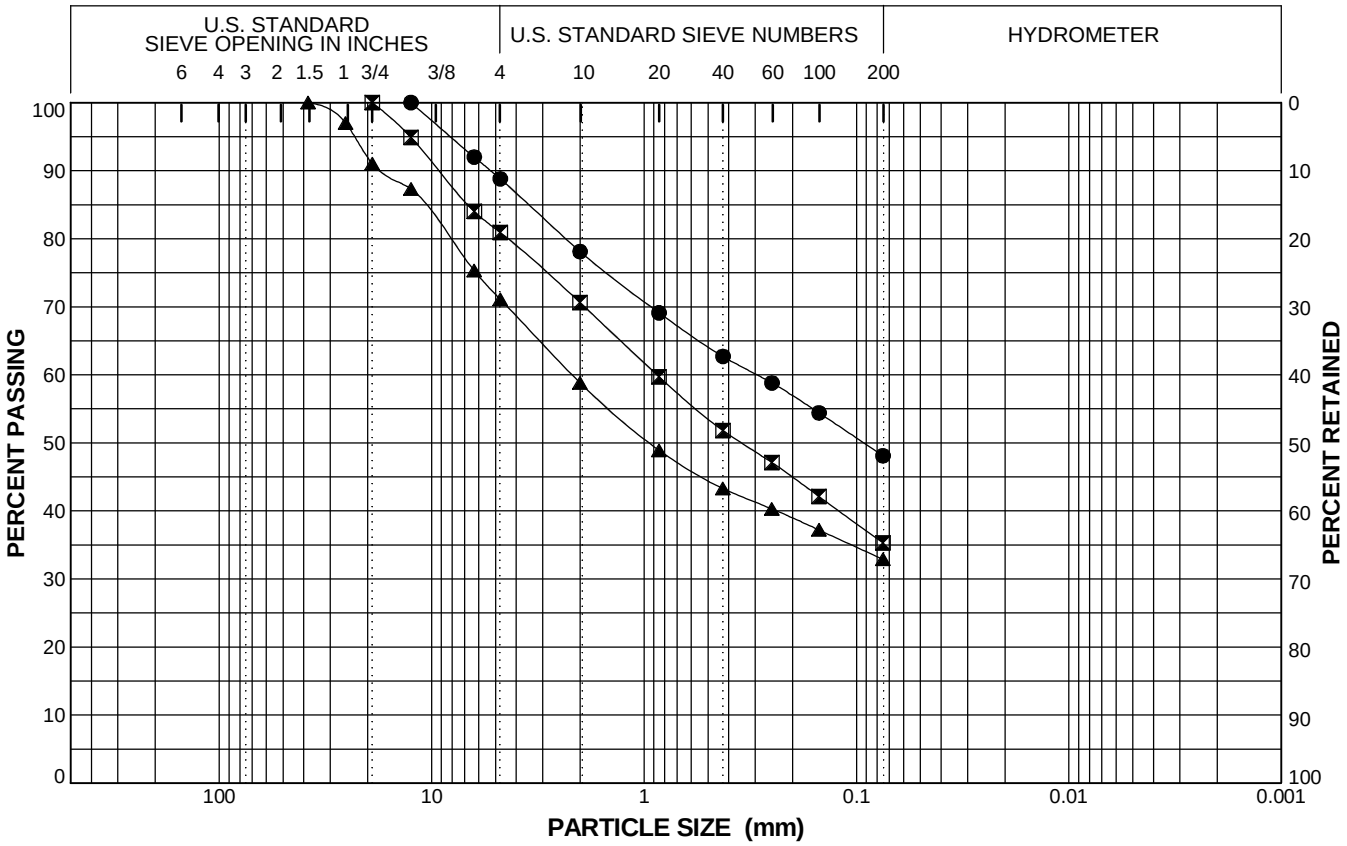
Blue Ledge Mine
Siskiyou County, CA
25696770

PARTICLE SIZE DISTRIBUTION CURVES

URS

Report: SIEVE_4_PORT_2; File: BLUELE~1.GPJ; 12/30/2008 B-4-08

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	



Boring ID	Sample #	Depth (feet)	Sample Moisture (%)	Dry Density (lbs/ft^3)	Symbol	LL	PI	% G	% S	% F	Classification
B-4-08	S-6	30.8-31.3'	22.4	111.5	●			11.2	40.7	48.1	SILTY SAND [SM]
B-5-08	S-2	5.0-5.83'	12.6	119.8	⊠			19.1	45.6	35.3	SILTY SAND WITH GRAVEL [SM]
B-5-08	S-8	35.0-36.0'	11.9	128.5	▲			28.9	38.2	32.9	SILTY SAND WITH GRAVEL [SM]

Blue Ledge Mine
Siskiyou County, CA
25696770

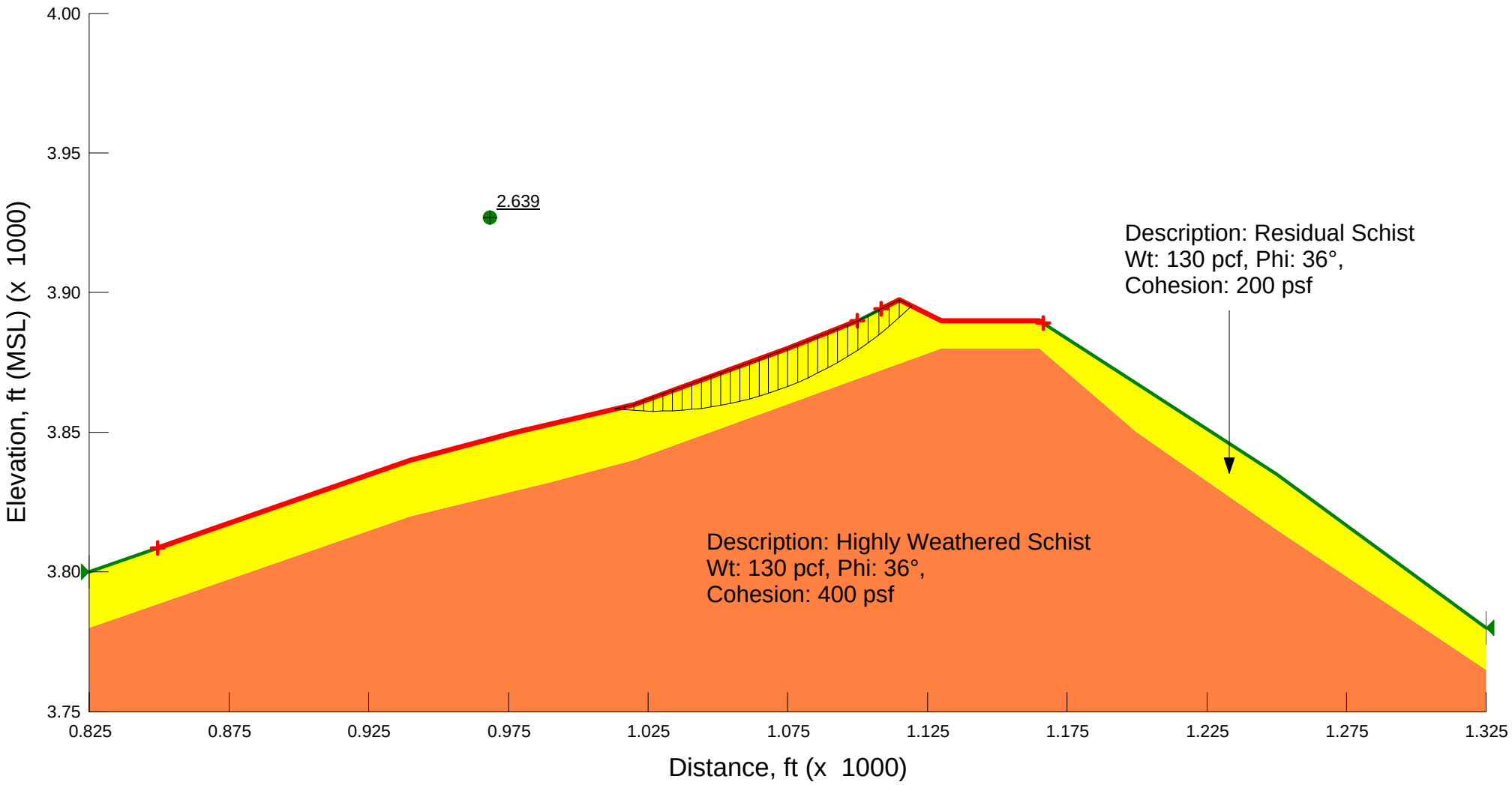
PARTICLE SIZE DISTRIBUTION CURVES

URS

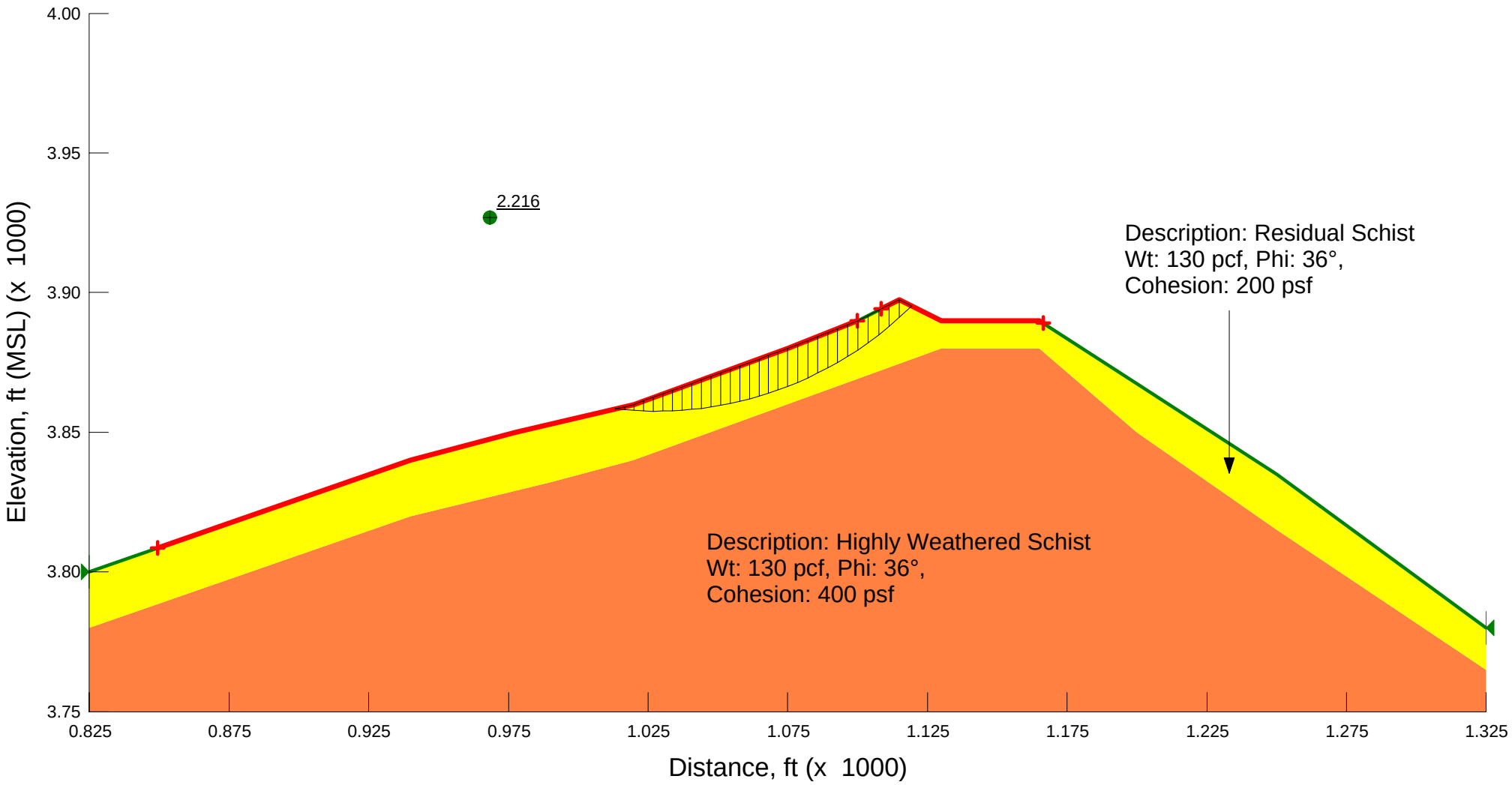
APPENDIX C

SLOPE STABILITY ANALYSES

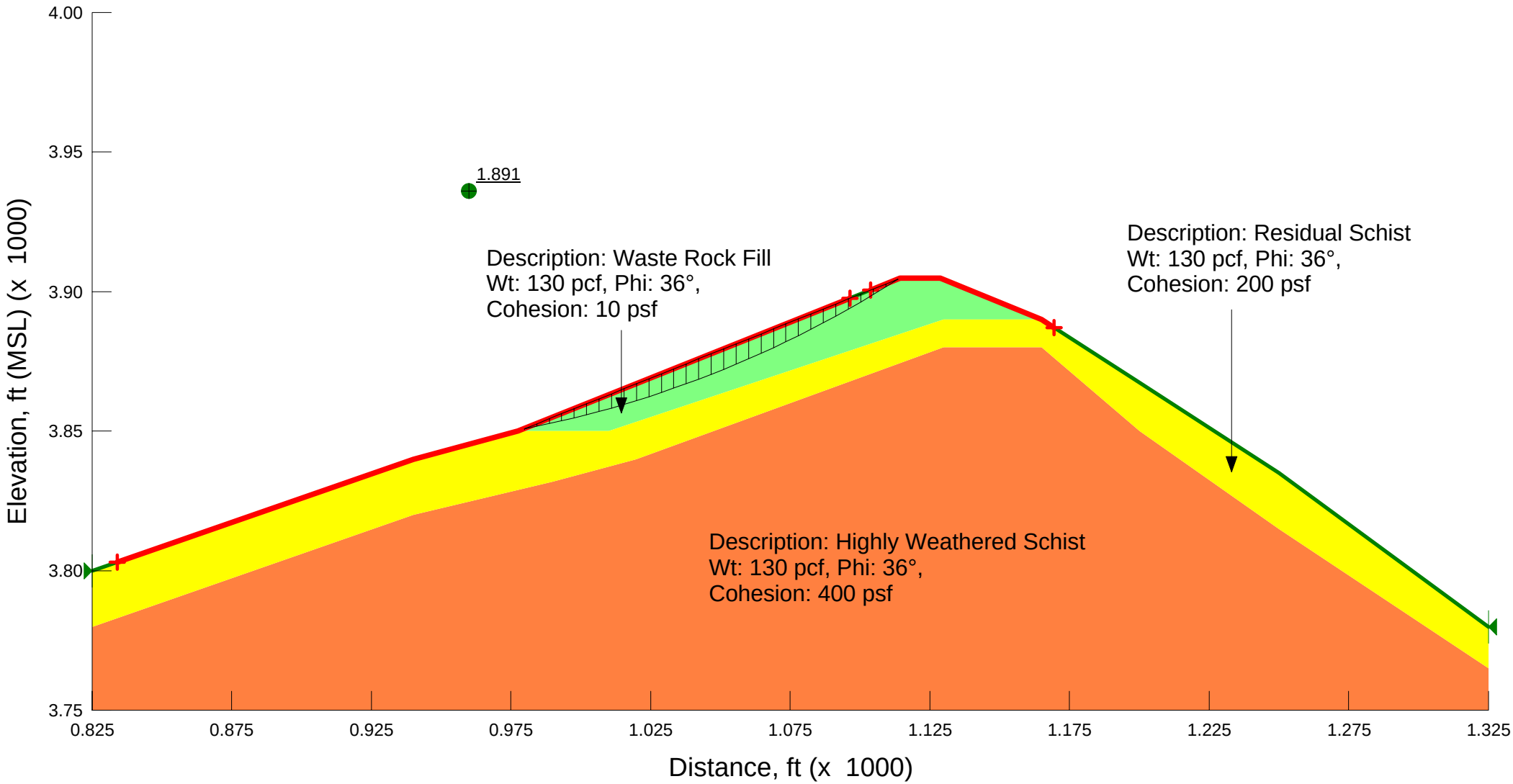
Blue Ledge Mine
North Repository (Existing Condition)
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 2.639



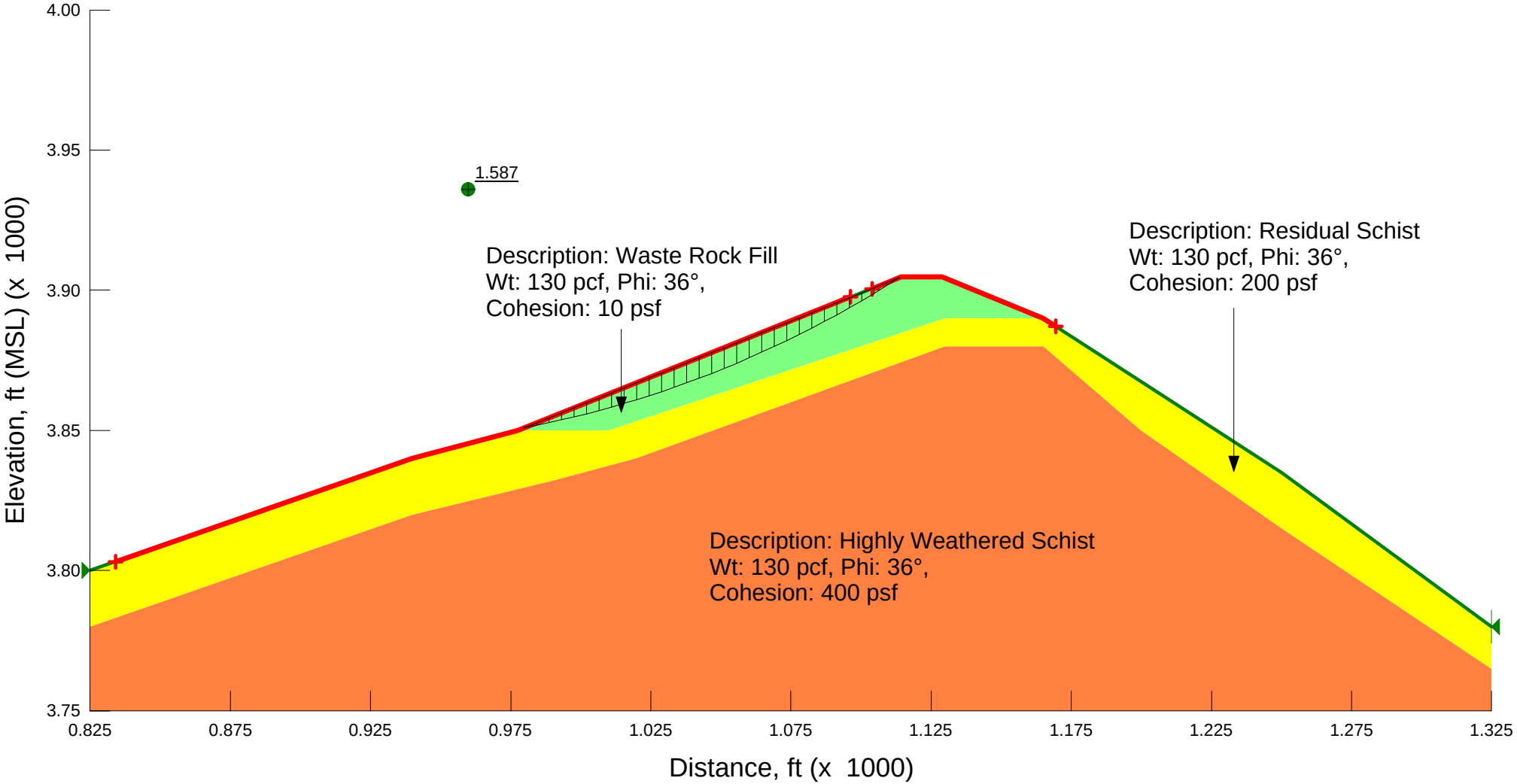
Blue Ledge Mine
North Repository (Existing Condition)
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 2.216

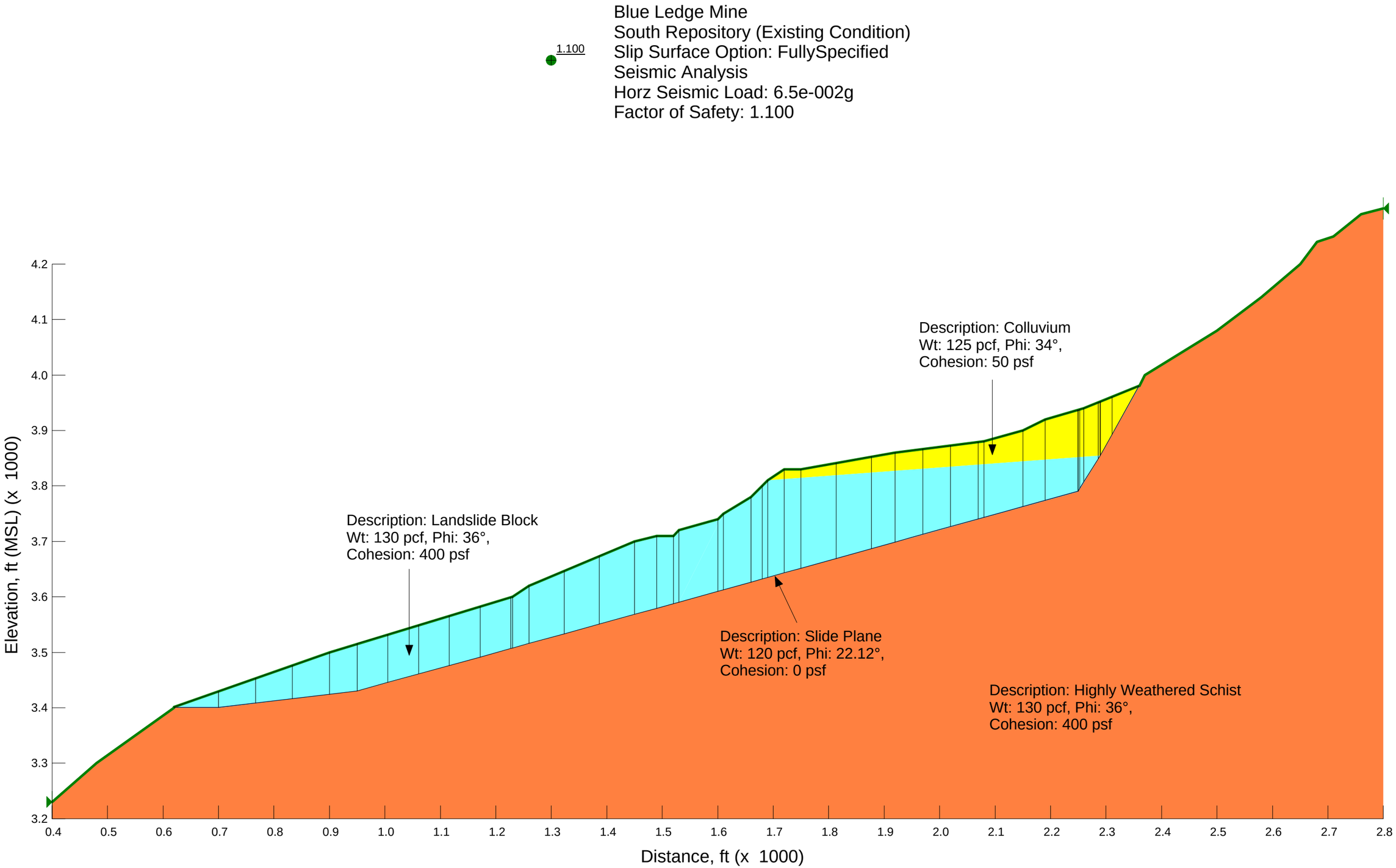


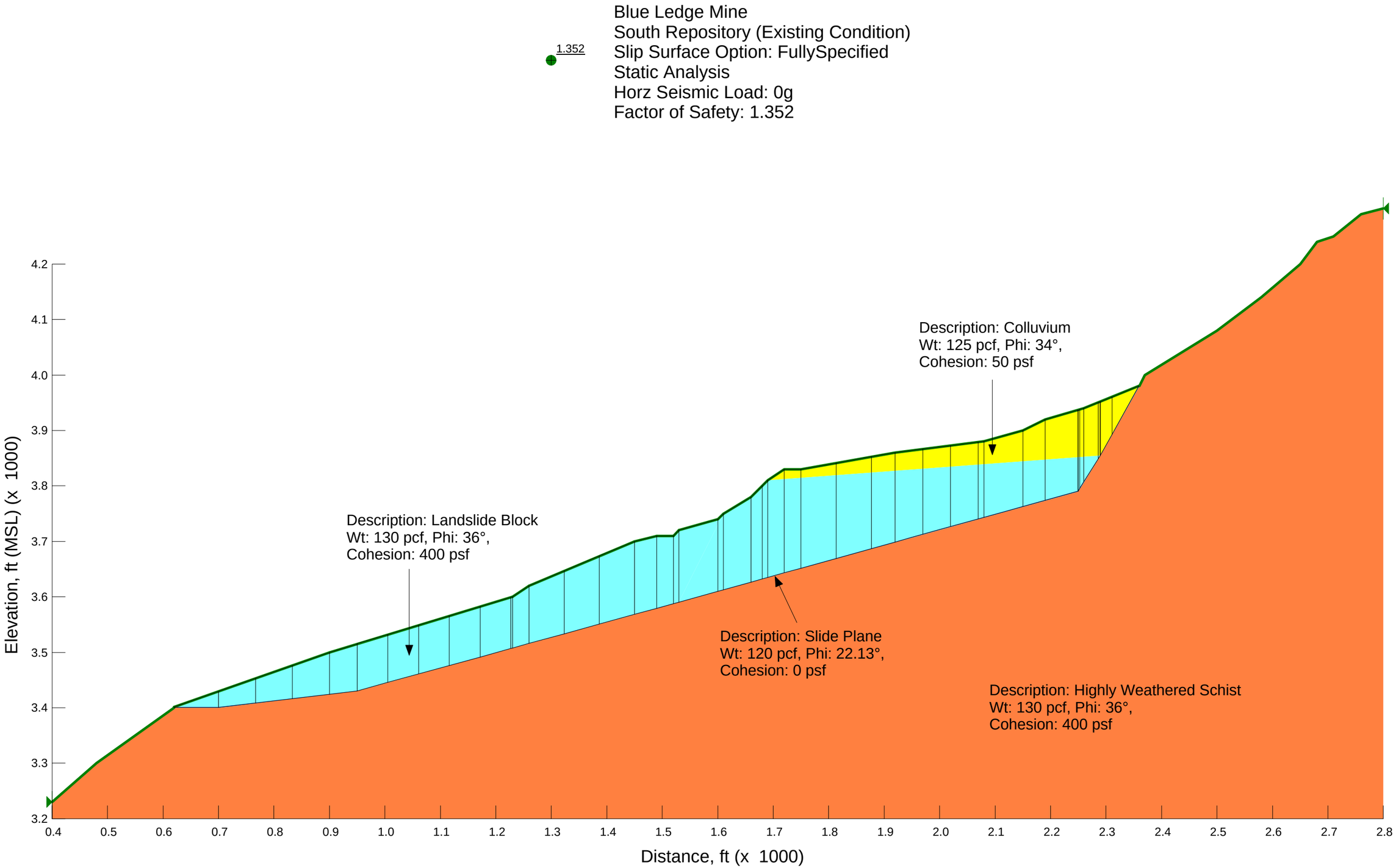
Blue Ledge Mine
North Repository (Final Condition)
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 1.891

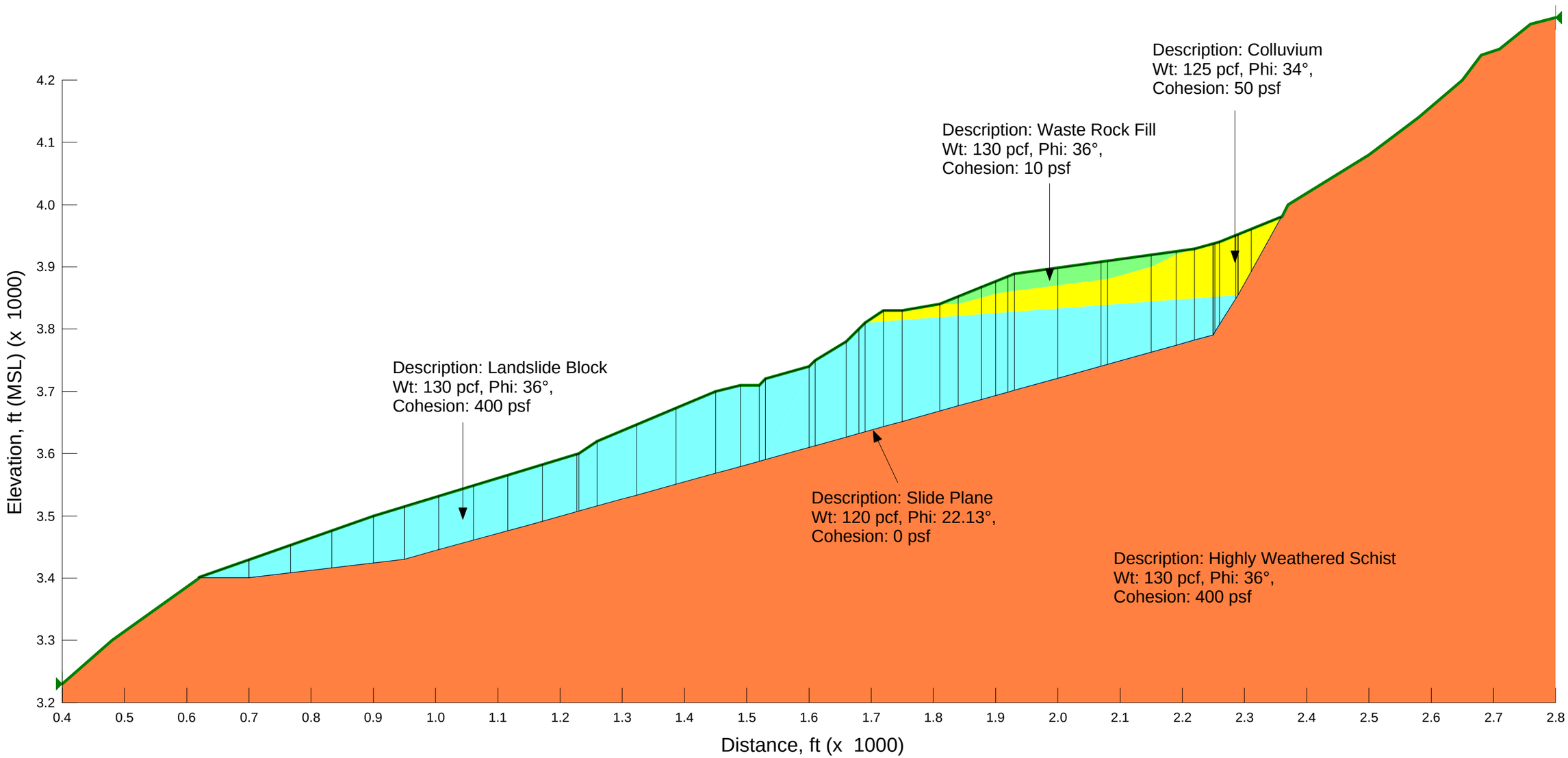


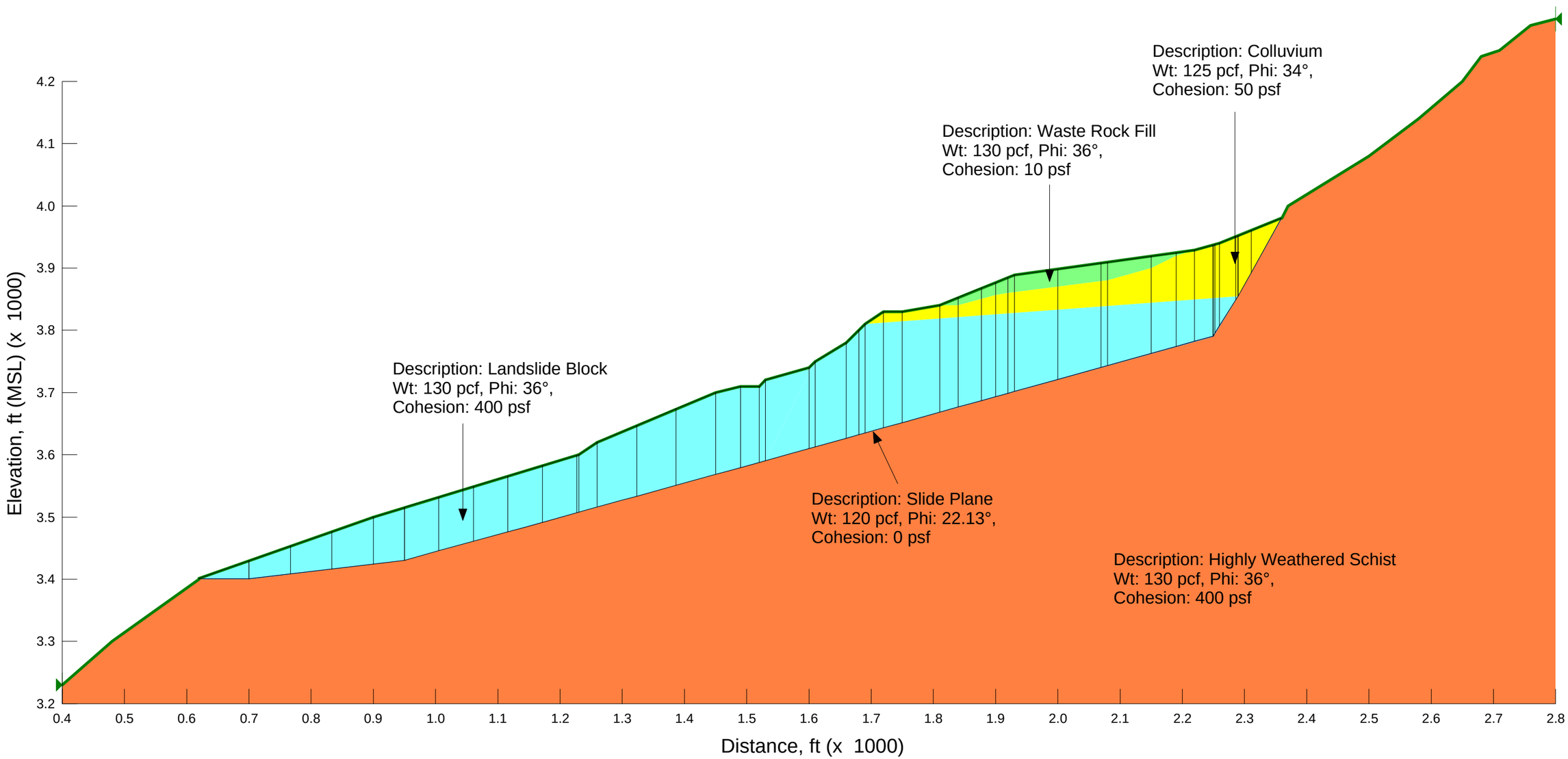
Blue Ledge Mine
North Repository (Final Condition)
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 1.587




1.100
Blue Ledge Mine
South Repository (Existing Condition)
Slip Surface Option: FullySpecified
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 1.100
Description: Colluvium
Wt: 125 pcf, Phi: 34°,
Cohesion: 50 psf
Description: Landslide Block
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Description: Slide Plane
Wt: 120 pcf, Phi: 22.12°,
Cohesion: 0 psf
Description: Highly Weathered Schist
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Elevation, ft (MSL) (x 1000)
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
Distance, ft (x 1000)


1.352
Blue Ledge Mine
South Repository (Existing Condition)
Slip Surface Option: FullySpecified
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 1.352
Description: Colluvium
Wt: 125 pcf, Phi: 34°,
Cohesion: 50 psf
Description: Landslide Block
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Description: Slide Plane
Wt: 120 pcf, Phi: 22.13°,
Cohesion: 0 psf
Description: Highly Weathered Schist
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Elevation, ft (MSL) (x 1000)
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
Distance, ft (x 1000)


1.356
Blue Ledge Mine
South Repository (Final Condition)
Slip Surface Option: FullySpecified
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 1.356
Description: Colluvium
Wt: 125 pcf, Phi: 34°,
Cohesion: 50 psf
Description: Waste Rock Fill
Wt: 130 pcf, Phi: 36°,
Cohesion: 10 psf
Description: Landslide Block
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Description: Slide Plane
Wt: 120 pcf, Phi: 22.13°,
Cohesion: 0 psf
Description: Highly Weathered Schist
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Elevation, ft (MSL) (x 1000)
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
Distance, ft (x 1000)


1.103
Blue Ledge Mine
South Repository (Final Condition)
Slip Surface Option: FullySpecified
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 1.103
Description: Colluvium
Wt: 125 pcf, Phi: 34°,
Cohesion: 50 psf
Description: Waste Rock Fill
Wt: 130 pcf, Phi: 36°,
Cohesion: 10 psf
Description: Landslide Block
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Description: Slide Plane
Wt: 120 pcf, Phi: 22.13°,
Cohesion: 0 psf
Description: Highly Weathered Schist
Wt: 130 pcf, Phi: 36°,
Cohesion: 400 psf
Elevation, ft (MSL) (x 1000)
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
0.4
0.5
0.6
0.7
0.8
0.9
1.0
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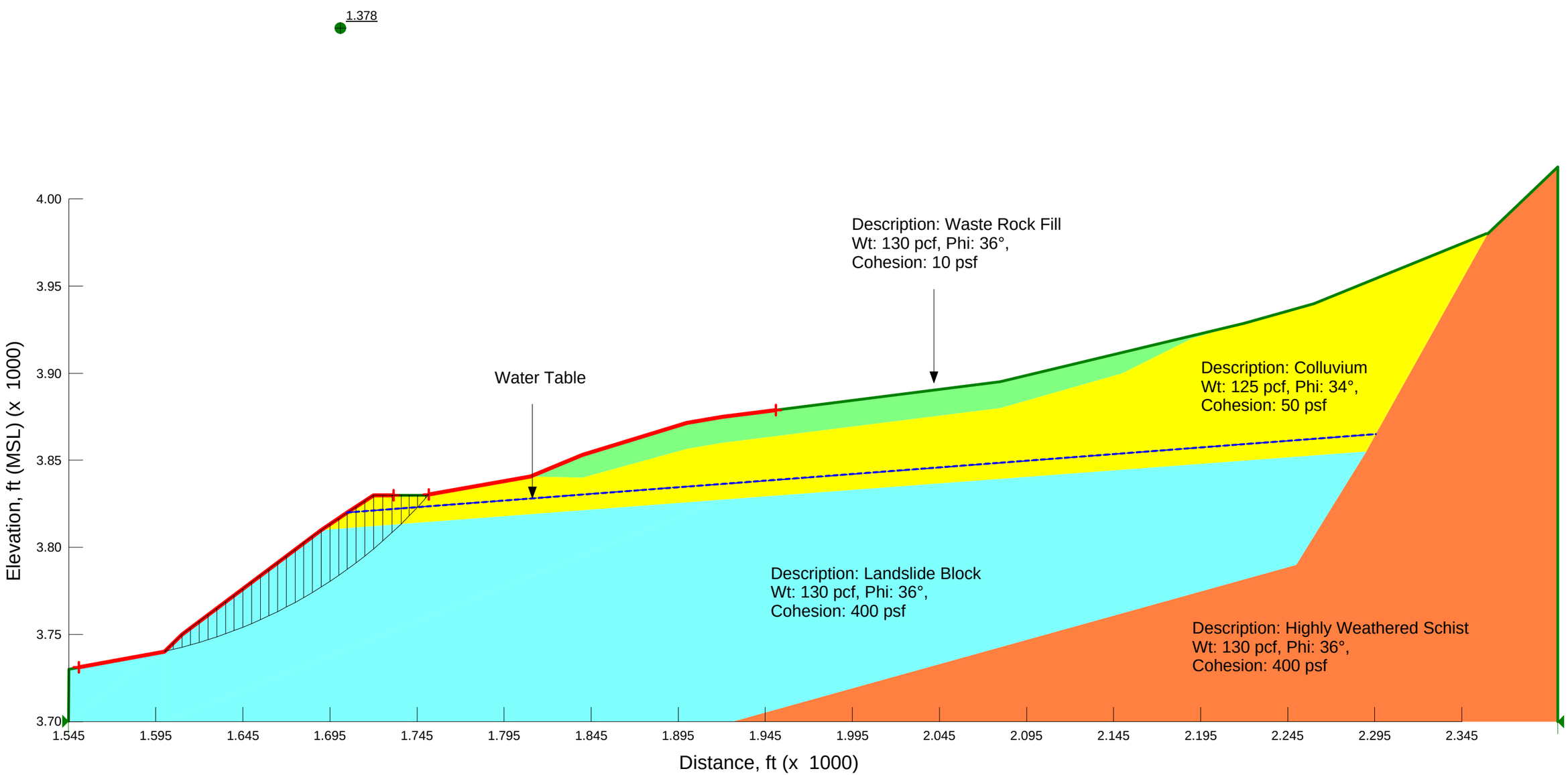
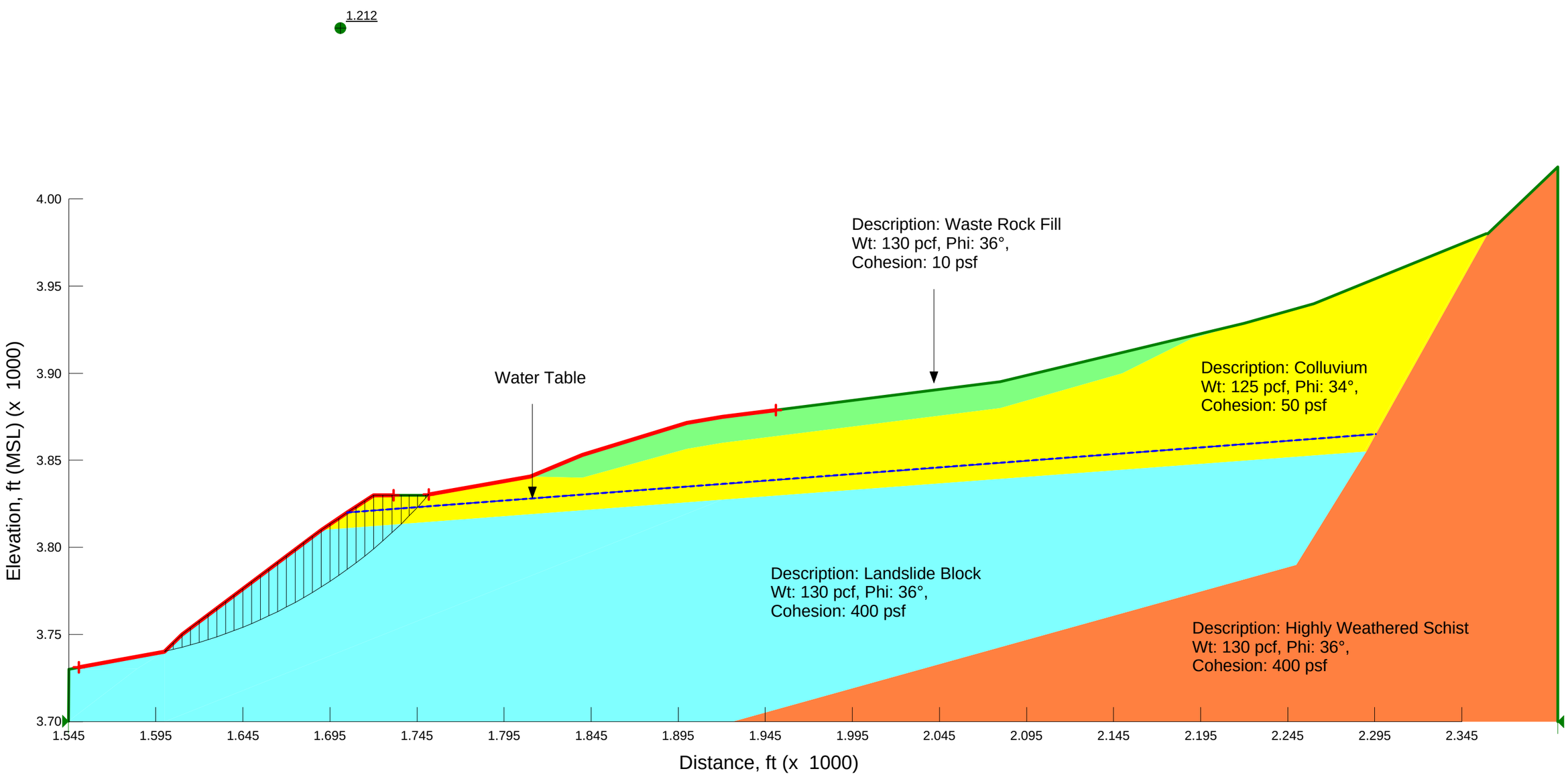
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
Distance, ft (x 1000)

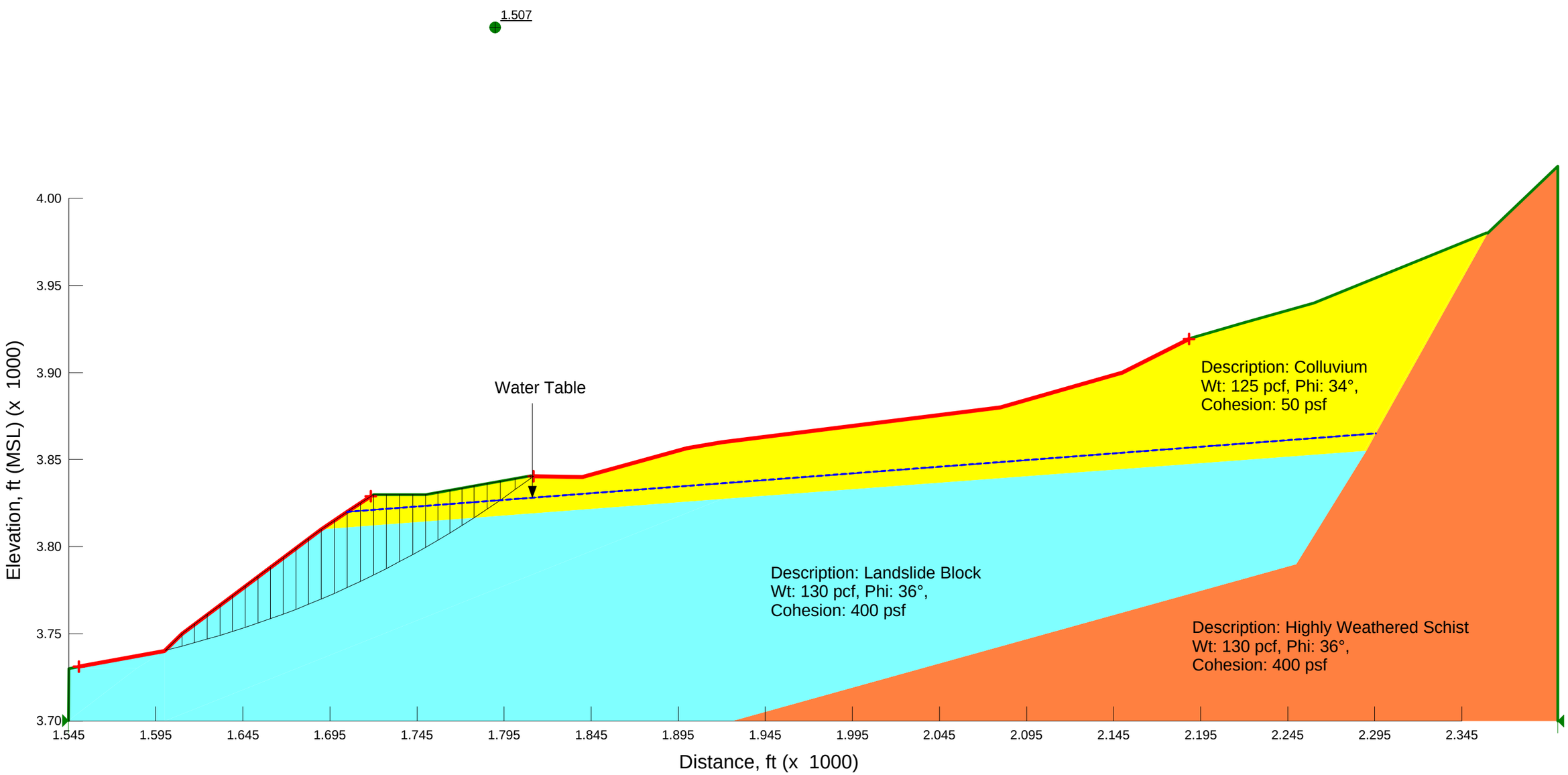
Blue Ledge Mine
South Repository (Final Shallow Failure Mode)
Cross Section Geometry: 1
Slip Surface Option: EntryAndExit
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 1.378



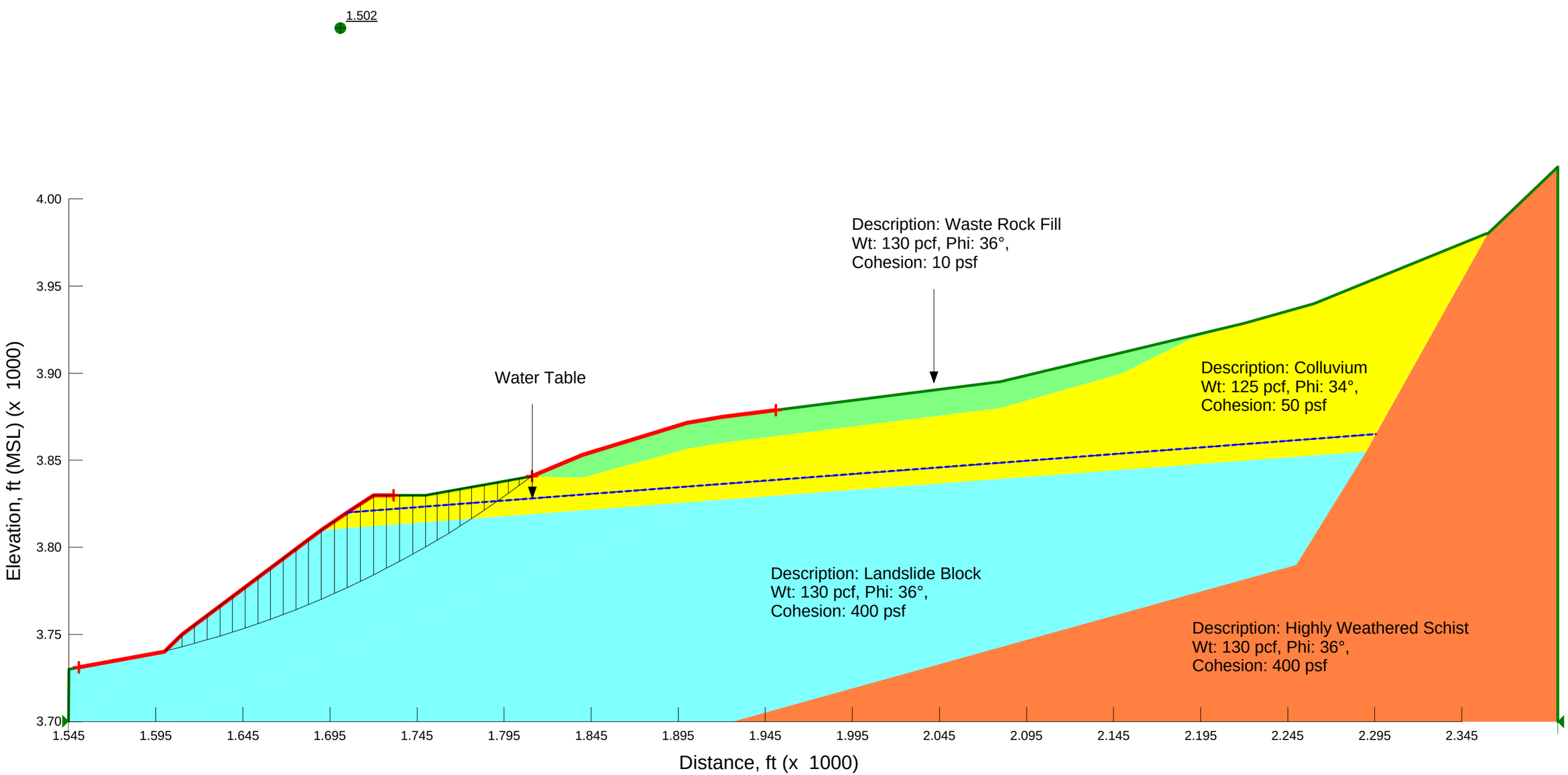
Blue Ledge Mine
South Repository (Final Shallow Failure Mode)
Cross Section Geometry: 1
Slip Surface Option: EntryAndExit
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 1.212



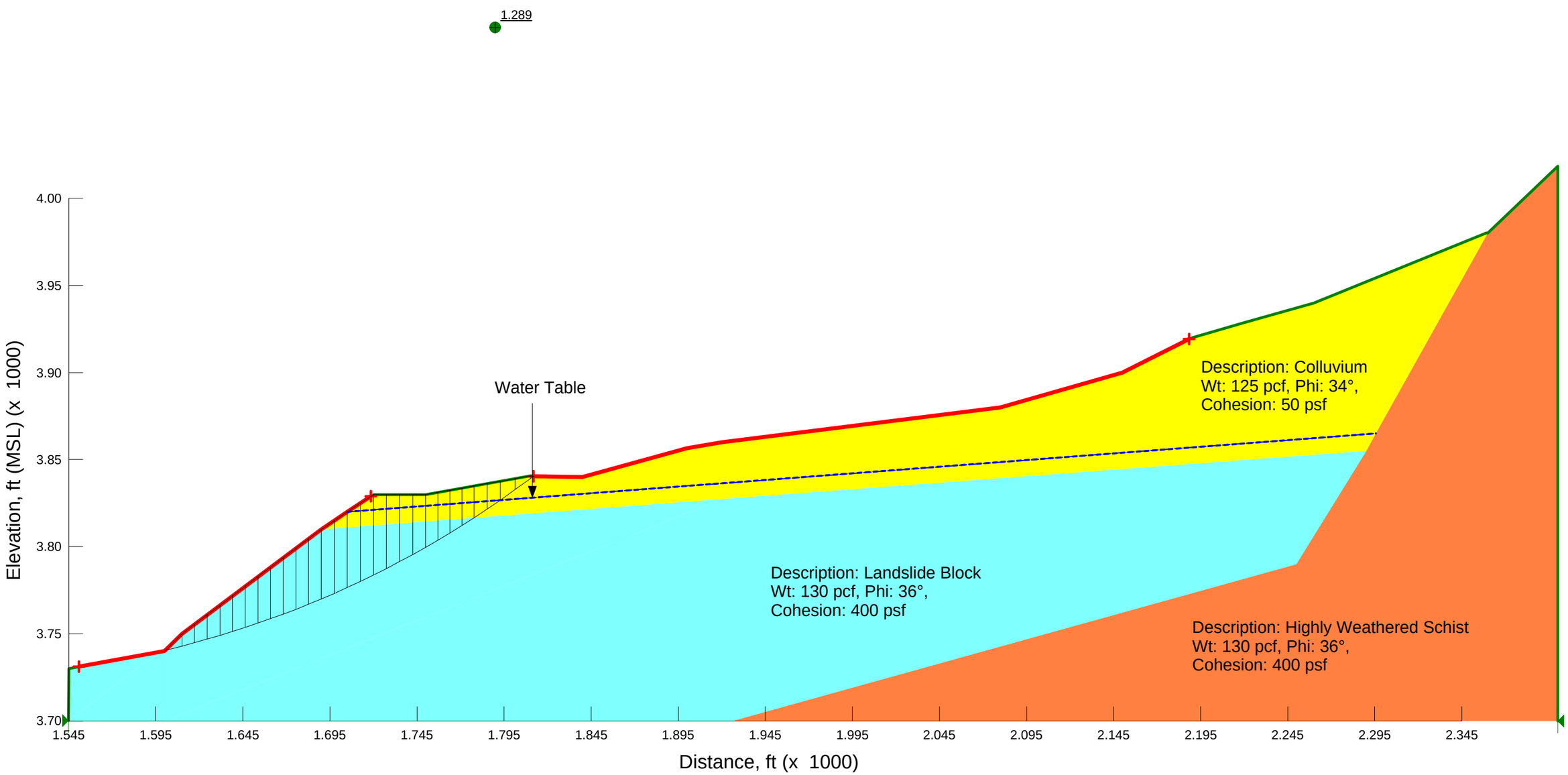
Blue Ledge Mine
South Repository (Existing Condition-Shallow Failure Mode)
Cross Section Geometry: 1
Slip Surface Option: EntryAndExit
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 1.507



Blue Ledge Mine
South Repository (Final Shallow Failure Mode)
Cross Section Geometry: 1
Slip Surface Option: EntryAndExit
Static Analysis
Horz Seismic Load: 0g
Factor of Safety: 1.502



Blue Ledge Mine
South Repository (Existing Condition-Shallow Failure Mode)
Cross Section Geometry: 1
Slip Surface Option: EntryAndExit
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 1.289



Blue Ledge Mine
South Repository (Final Shallow Failure Mode)
Cross Section Geometry: 1
Slip Surface Option: EntryAndExit
Seismic Analysis
Horz Seismic Load: 6.5e-002g
Factor of Safety: 1.287

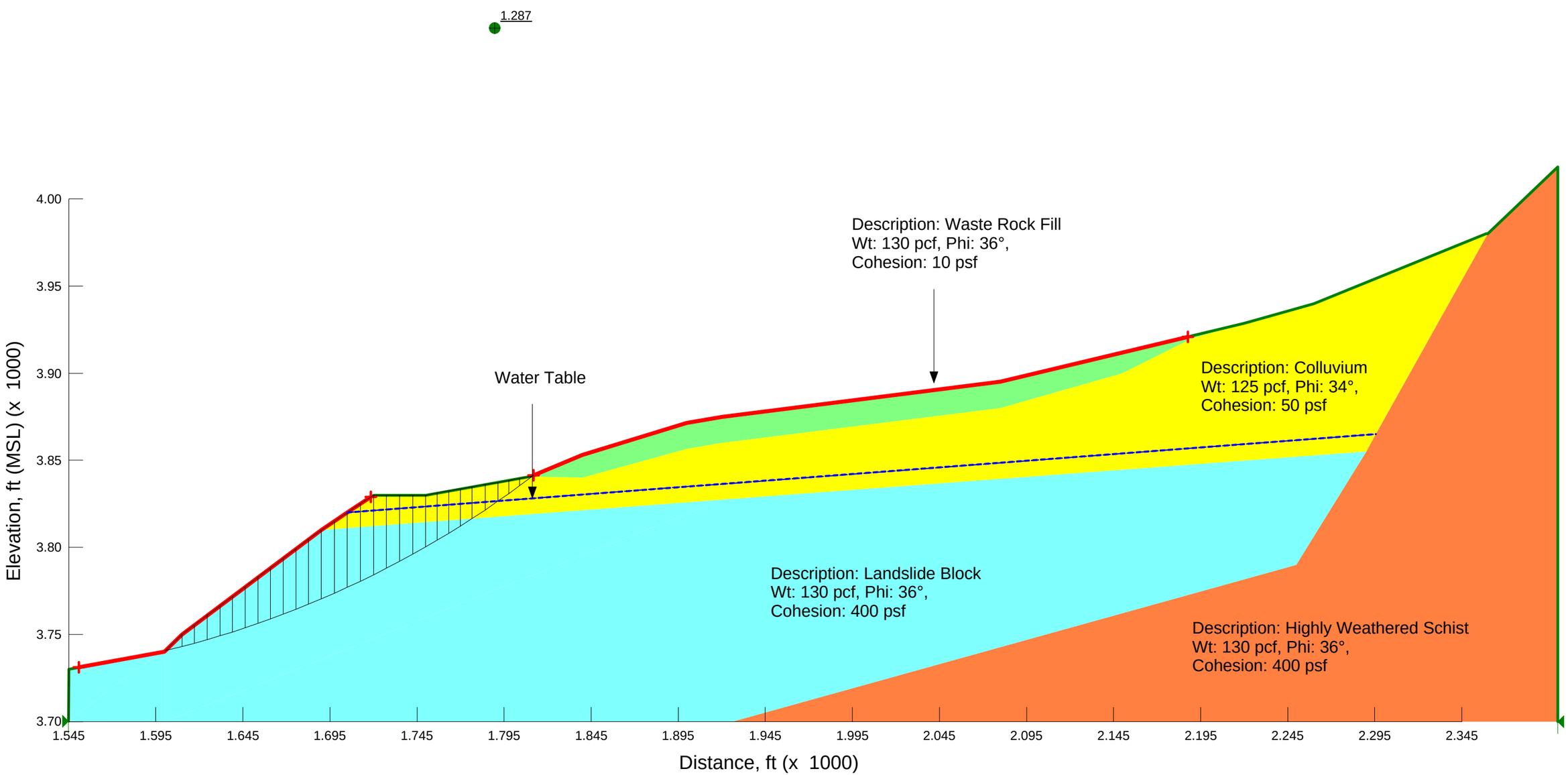


Table E-1
Waste Rock Removal Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Waste Rock Removal: Same all alternatives, except mobe/demobe -15% Alt 1					
Item	Assumptions	Unit Cost	Units	Quantity	Cost
Mobe, Demobe					
mobe 2009	contractor estimate	$170,000	lump	1	$170,000
demobe 2009	contractor estimate	$180,000	lump	1	$180,000
mobe 2010	contractor estimate	$150,000	lump	1	$150,000
demobe 2010	contractor estimate	$120,000	lump	1	$120,000
Site prep and Roads					
grade, repair existing roads	contractor estimate	$15,000	mile	10	$150,000
construct new access and work areas	contractor estimate	$500,000	mile	2.25	$1,125,000
drainage, grading	grading	$15.00	CY	10,000	$150,000
laydown areas and work pads	contractor estimate	$50,000	lump	1	$50,000
Waste Rock Removal					
WR removal Area 1 (A)	move with dozers, excavators; winch if necessary, consolidate at bottom; 45 days	$75	CY	35,000	$2,625,000
WR removal Area 2 (B)	as above; 20 days	$75	CY	5,000	$375,000
WR removal Area 3 (C)	as above; 20 days	$100	CY	4,600	$460,000
WR removal Area 4 (D)	as above; 20 days	$100	CY	2,100	$210,000
				Subtotal	**$5,765,000**

Table E-2
Repository and Disposal Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Alternative 1 Repository: No liner, GCL Cap

Item	Assumptions	Unit Cost	Units	Quantity	Cost
Preparation and placement					
clear, grub	prep repository area, stockpile topsoil	$3,000	acre	3	$9,000
excavation, prep	earthwork 3 acres, 2 feet, berms and surface drainage	$8.00	CY	39,400	$315,200
load, haul, and place	from loadout area to repository, 2mi RT	$10.00	CY	56,040	$560,400
Cover					
cover placement	earthwork 3 acres, 3 feet; load and haul from Eileen site; from Eileen town site includes prep, processing and placement of GCL cover	$12.00	CY	39,400	$472,800
planting	native plants for cap; includes plant procurement, transport, planting	$5,000	acre	4	$20,000
				Subtotal	**$1,377,000**

Alternative 2 Repository: GCL liner and cap, leachate collection

Item	Assumptions	Unit Cost	Units	Quantity	Cost
Preparation and placement					
clear, grub	prep repository area, 3 ac	$3,000	acre	3	$9,000
excavation, prep	earthwork 3 acres, 2 feet, berms and surface drainage	$8.00	CY	39,400	$315,200
load, haul, and place	from loadout area to repository, 2mi RT	$10.00	CY	56,040	$560,400
Liner and Cap					
Liner	liner and cap, ~0.5 MSW estimate	$200,000	acre	3	$600,000
Leachate collection and treatment	leachate management - batch treat and discharge	$50,000	lump	1	$50,000
planting	seeding, planting	$5,000	acre	4	$20,000
				Subtotal	**$1,555,000**

Alternative 3: Landfill Disposal

Item	Assumptions	Unit Cost	Units	Quantity	Cost
load	load at site	$0.75	CY	56,040	$42,030
haul	Dry Creek LF, 50 miles	$600.00	trip	2,802	$1,681,200
disposal	Dry Creek LF	$30.00	ton	70,050	$2,101,500
				Subtotal	**$3,825,000**

Table E-3
Leachate and Runoff Treatment Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Applies to runoff and drainage from former waste rock areas

Alternative 1

Item	Assumptions	Unit Cost	Units	Quantity	Cost
sedimentation basins	construct six basins	$50,000	ea	6	$300,000
		$0	lump	1	$0
				Subtotal	**$300,000**

Alternative 2

Item	Assumptions	Unit Cost	Units	Quantity	Cost
sedimentation basins	construct six basins	$50,000	ea	6	$300,000
constructed wetland	construct one wetland	$50,000	lump	1	$50,000
				Subtotal	**$350,000**

Alternative 3

Item	Assumptions	Unit Cost	Units	Quantity	Cost
sedimentation basins	construct six basins	$50,000	ea	6	$300,000
constructed wetlands	construct three wetlands	$50,000	lump	1	$50,000
				Subtotal	**$350,000**

Table E-4
Reclamation Cover Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Reclamation Cover: Same all alternatives					
Item	Assumptions	Unit Cost	Units	Quantity	Cost
Grading, Terracing					
Grading, terracing	blast	$100,000	lump	1	$100,000
Grading, terracing	excavate, grade	$200,000	lump	1	$200,000
Grading, terracing	rock walls; materials, place	$300,000	lump	1	$300,000
Cover					
load and haul	load and haul from local source	$30	CY	15,000	$450,000
place, compact, stabilize	use access built for removal	$20	CY	15,000	$300,000
plant					
	hydroseed (higher cost for steep slopes and remote site)	$10,000	acre	14	$135,000
	selective planting, trees, scrubs	$6,000	acre	11	$66,000
				Subtotal	**$1,551,000**

Table E-5
Adit Treatment and Closure Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Bat Gates: Same all alternatives					
Item	Assumptions	Unit Cost	Units	Quantity	Cost
Materials	8 gates, fabricated steel	$5,000	ea	8	$40,000
Construction	Installation	$15,000	ea	8	$120,000
				Subtotal	**$160,000**

Table E-6
Oversight and Consulting Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Engineering Oversight, CM, Consulting: -15% Alt 1, +0% Alt 2, -15% Alt 3					
Item	Assumptions	Unit Cost	Units	Quantity	Cost
Project Manager	0.5 time, two years	$145	hrs	2,000	$290,000
Resident Engineer	1.0 time, two years	$125	hrs	2,500	$312,500
Field Engineer	1.0 time, two years	$85	hrs	2,500	$212,500
Geologist/biologist	1.0 time, two years	$95	hrs	2,500	$237,500
Sr Consultant/mining engineer	T&M estimate	$150	hrs	200	$30,000
Health and Safety	1.0 time, two years	$100	hrs	2,500	$250,000
Administration	0.5 time, two years	$65	hrs	2,000	$130,000
Construction completion report	Engineer's estimate	$100,000	T&M est	1	$100,000
Expenses, Per Diem, Supplies	Two years	$400,000	LS	1	$400,000
				Subtotal	**$1,963,000**

Table E-7
CM, Planning Reporting, and IQAT Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

CM & IQAT: -25% Alt 1, +0% Alt 2, -25% Alt 3					
Item	Assumptions	Unit Cost	Units	Quantity	Cost
Construction Management		$487,000	LS	1	$487,000
IQAT		$571,000	LS	1	$571,000
				Subtotal	**$1,058,000**

Table E-8
Monitoring, Reporting, Operations Maintenance, and FS Oversight Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

No Action

Item	Assumptions	Years	Cost per Year or Event	Project Cost	
Performance Monitoring and Reporting					
Performance monitoring reporting	estimate 30 samples, 2 days sampling	3	$35,000	$105,000	
			Subtotal Performance Monitoring. Reporting		$105,000
Operation and Maintenance					
Road Maintenance	annual cost	3	$6,000	$18,000	
			Subtotal O&M		$18,000
			SUBTOTAL		**$123,000**

Alternative 1

Item	Assumptions	Years	Cost per Year or Event	Project Cost	
Performance Monitoring and Reporting					
Performance monitoring reporting	estimate 40 samples, 3 days sampling	2	$75,000	$150,000	
			Subtotal Performance Monitoring. Reporting		$150,000
Operation and Maintenance					
Maintain sedimentation basins	excavate and dispose in repository	3	$50,000	$150,000	
Maintain repository	repair, vegetate, leachate disposal	3	$50,000	$150,000	
Road Maintenance	annual cost	3	$10,000	$30,000	
Operation and Maintenance	assumption	3	$10,000	$30,000	
			Subtotal O&M		$360,000
			SUBTOTAL		**$510,000**

Table E-8
Monitoring, Reporting, Operations Maintenance, and FS Oversight Cost Details
Preliminary Removal Action Costs
Blue Ledge Mine

Alternative 2

Item	Assumptions	Years	Cost per Year or Event	Project Cost	
Performance Monitoring and Reporting					
Performance monitoring reporting	estimate 40 samples, 3 days sampling treatment sampling	3	$100,000	$300,000	
			Subtotal Performance Monitoring. Reporting		$300,000
Operation and Maintenance					
Maintain sedimentation basins	excavate and dispose	3	$75,000	$225,000	
Maintain constructed wetlands	grade, replace, repairs	3	$50,000	$150,000	
Maintain repository	repair, vegetate, leachate disposal	3	$50,000	$150,000	
Road Maintenance	annual cost	3	$10,000	$30,000	
Operation and Maintenance	assumption	3	$10,000	$30,000	
			Subtotal O&M		$585,000
			SUBTOTAL		**$885,000**

Alternative 3

Item	Assumptions	Years	Cost per Year or Event	Project Cost	
Performance Monitoring and Reporting					
Performance monitoring reporting	estimate 40 samples, 3 days sampling	3	$85,000	$255,000	
			Subtotal Performance Monitoring. Reporting		$255,000
Operation and Maintenance					
Maintain sedimentation basins	excavate and haul off site	3	$75,000	$225,000	
Maintain constructed wetlands	grade, replace, repairs	3	$50,000	$150,000	
Road Maintenance	annual cost	3	$6,000	$18,000	
Operation and Maintenance	assumption	3	$10,000	$30,000	
			Subtotal O&M		$423,000
			SUBTOTAL		**$678,000**