United States

Department of Agriculture

ENGINEERING EVALUATION/COST ANALYSIS

DRAFT FINAL

HOPE MINE

WHITE RIVER NATIONAL FOREST

PITKIN COUNTY, COLORADO

FEBRUARY 2013

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List of Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below Ground Surface
BLM	Bureau of Land Management
BPA	US Forest Service, Rocky Mountain Region Blanket Purchasing Agreement
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulation
cfs	Cubic Feet per Second
CMC	Colorado Mountain College
CL	Clay
CO	State of Colorado
COC	Constituent of Concern
COR	Contracting Officer's Representative
CY	Cubic yards
EE/CA	Engineering Evaluation and Cost Analysis
EPA	United States Environmental Protection Agency
ft	Feet
GC	Clayey Gravel
HazWOper	Hazardous Waste Operations Training , 29 CFR 1910.120
HAS	Hollow Stem Auger
HSP	Health and Safety Plan
HMB	Hope Mine Background
HMND	Hope Mine North Dump
HMSD	Hope Mine South Dump
NTP	Notice to Proceed
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
PA	Preliminary Assessment
pcf	Pounds per cubic foot
psf	Pounds per square foot
RG	Registered Geologist
SI	Site Inspection
SSL	Soil Screening Level
TEC	Cardno TEC Inc.
TLI	TLI Solutions, Inc.
US	United States
USDA	United States Department of Agriculture
USFS	United States Department of Agriculture, Forest Service
WRNF	White River National Forest
WP	Work Plan

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SECTION 1 INTRODUCTION

The United States Department of Agriculture, Forest Service (USFS) has contracted Cardno TEC Inc. (TEC) to complete an Engineering Evaluation and Cost Analyses (EE/CA) including support documentation for the Hope Mine located along Castle Creek in the White River National Forest (WRNF), Pitkin County, Colorado. This work is contracted under the USFS, Rocky Mountain Region Blanket Purchasing Agreement (BPA), Activity 3 Contract for environmental site investigations and reporting at USFS locations throughout the region, Contract Number AG-82X9-B-10-0011, Task Order AG-82X9-K-12-0022.

1.1 SITE DESCRIPTION AND HISTORICAL BACKGROUND

The Hope Mine (Site) is located approximately six miles south of Aspen, CO from Highway 82, on NFSR #102 (Castle Creek Road) within the WRNF. The Site is located adjacent to the east of Castle Creek on the west aspect of Richmond Hill, below Annie Basin (Figure 1-1). The site is found on the USGS quadrangle map (Hayden Peak, 1987) within T 115N, R 85W, Section 12, 6th P.M. The Site is located at an elevation of approximately 8,700 feet.

Based on the historical overview and chronology of the Hope Mine conducted by the Colorado Mountain College (CMC), there have been multiple owners, leasers, and managers to keep the mine active. The mining activity associated with the Site was focused on underground hard-rock exploration and extraction of silver-bearing and lead-bearing ore. The mine site and associated claim holdings were owned and leased by the Hope Mining, Milling, and Leasing Co, from 1916 to 1953. The mining claims were relinquished in 1956 after a mineral validity examination by the Forest Service (CMC, 2010).

The Hope Mine, also called the Hope Tunnel, was located in the Richmond Hill Mining District. The earliest records found for the Site were from 1916. Records from the Colorado State Bureau of Mines Inspection Reports revealed the Hope Mining, Milling, and Leasing Co. (Hope M, M, & L Co.) owned and operated the mine and associated claims and leased the property occasionally. Other patented mine claims associated with the Hope M, M, & L Co. were the Little Annie group, Climax group, Slide group, and the Hurrah group. Unpatented claims were the Hope 1, 2, 3, 4 and mill site (CMC, 2010).

The mine was drifted into what was called the Annie Contact; between shale and porphyry units with the shale overlying the porphyry. Records state that the drift was 6,000 feet by 1916 with 1,252 feet driven in that year and no ore produced. The Site had a power house, cook house, and bunkhouse. I n August of 1919, the drift cut through the little Annie Contact into the Richmond Contact at 7,000 feet. During this time the drift encountered a large amount of water thought to be coming from the Little Annie workings. The inspector estimated the amount of water at five hundred gallons per minute. During this time the drift was identified as cutting through the Maroon formation about 2,400 feet, Weber grits and shale 1,300 feet, Gypsum 300 feet, then into 400 feet of shale and limestone into the quartz porphyry. This contact was followed north to an ore deposit. The ore vein was encountered at 8,000 feet with an average of 101 ounces per ton of silver (polybasite and native) with some lead value (CMC, 2010).

A new bunkhouse, a two story boarding house, and a number of small buildings were constructed and completed in 1921. One hundred fifty eight and a half tons of ore was sold with an average of seventy ounces of silver. In 1922, an electric driven air compressor was on site to furnish ventilation and drilling. Previously seven cars of ore were shipped but lost. Ore was taken to Aspen by wagon and shipped by rail to the Arkansas Valley plant in Leadville, CO for processing. In 1923, the mine was leased to two individuals who were unnamed. Seven tons of ore were sold containing an average of ninety five ounces of silver with eight percent lead during the lease to the unnamed individuals. A new board of directors was elected for the Hope M, M, & L Co. in 1923 (CMC, 2010).

A considerable amount of repairs and timbering were completed in 1924 with no ore production documented. In 1925, a phone was installed on the property and the mine purchased a storage battery motor capable of hauling four one ton cars per trip. At this time there was nine thousand feet of drifts, cross-cuts, and raises accessible throughout the mine. The mine started employing a larger number of men, up to fifteen, and ore production started to increase when an ore vein was discovered at 6500 feet from the portal. During the summer of 1926, ore production averaged one hundred fifty to two hundred tons per month with an average of forty to fifty ounces of silver per ton (CMC, 2010).

In 1927, the mine was leased to James Heatherly and Associates, and in 1928 it was leased to Jim Herron and Associates. During the Herron Lease the Hope M, M, & L Co. opened negotiations for the construction of a 50-ton mill at the site. Forty tons of silver ore were produced at forty ounces a ton during the Herron Lease. In March of 1929, the mine was under lease to the Cross Creek Mining and Milling Company. During this time the 50-ton concentration and floatation mill was near completion and was projected to start operation the 1st of April. On July 21, 1929 the new mill was operational and ran for about two hours before it caught fire and was destroyed (CMC, 2010).

1.2 Draft EE/CA Preparation and Reporting

This document develops removal action alternatives for the Hope Mine North Mine Waste Pile, which currently presents an unacceptable risk to human health and the environment due to its current physical instability and toxicity. In its current state and location, situated on the steeply sloping western embankment of Castle Creek the North Waste Rock Pile toe is seasonally eroded by elevated creek water levels and flow rates associated with spring snow melt. Further erosion of the base of the steep pile toe presents a risk for slope failure which will result in a significant portion of the 12,000 cubic yard (cy) pile to slide into Castle Creek, which is a source of drinking water for Aspen Colorado.

This document uses criteria from U.S. Environmental Protection Agency [EPA] EE/CA Guidance to arrive at a preferred alternative. The purpose of the EE/CA is to recommend a remedial alternative that minimizes releases or the threat of releases at concentrations that produce an unacceptable impact on human health or the into the environment, as outlined in 40 CFR 300.415(b)(2)(i)-(viii). This EE/CA evaluates remedial alternatives with respect to site-specific Removal Action Objectives (RAOs), and presents a removal action that can provide a cost-effective means to “abate, prevent, minimize, stabilize, mitigate or eliminate the release or the threat of a release” (40 CFR 300.415).

Figure 1-1. Site Location Map

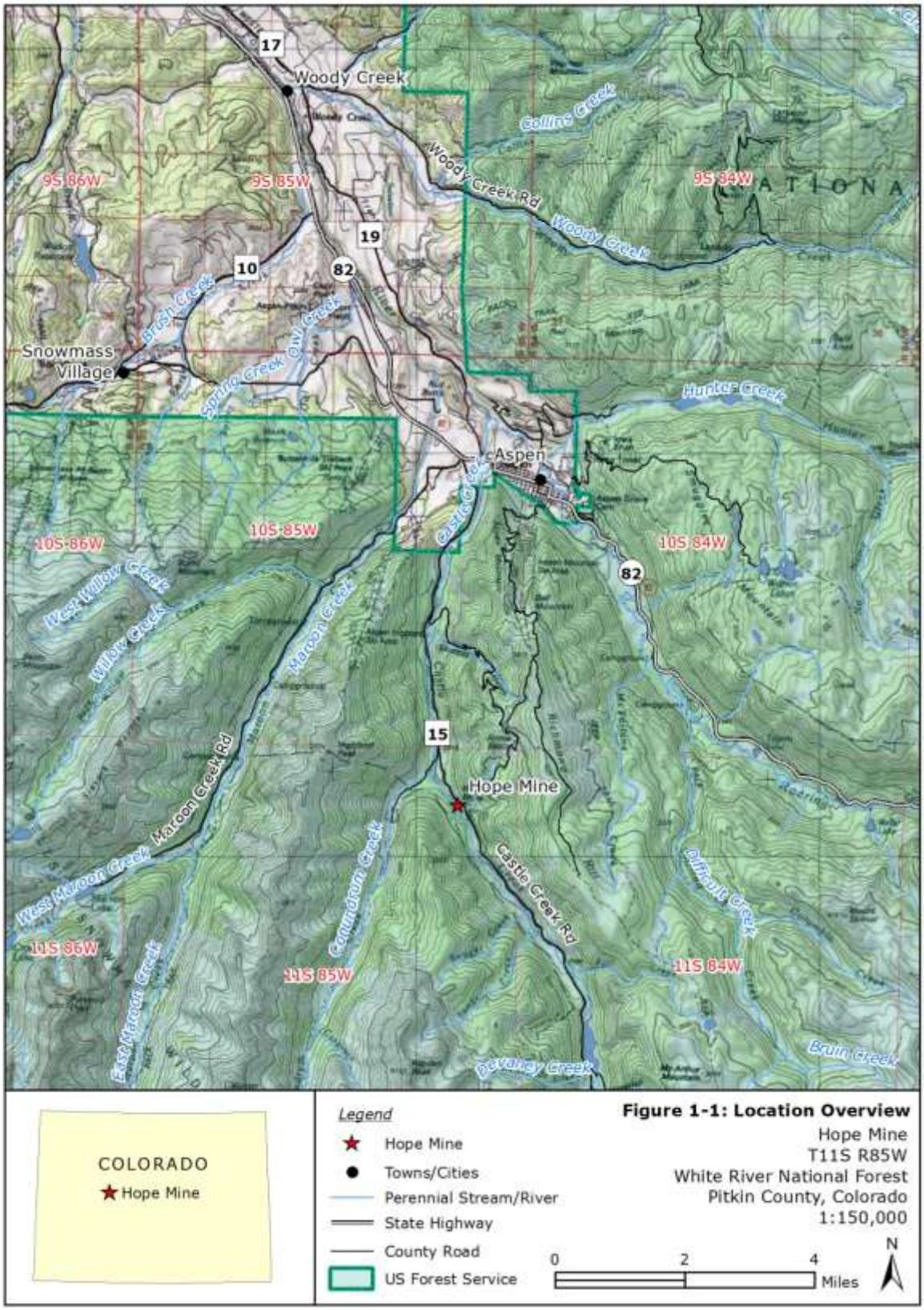


Figure 1-2. Topographic Map Location

SECTION 2 SITE CHARACTERIZATION

This section summarizes available data on the physical and chemical characteristics of the site and surrounding areas to provide background engineering information for analyzing removal alternatives.

2.1 ENVIRONMENTAL SETTING

2.1.1 Geologic Setting

The Colorado Mineral Belt is a result of the Laramide Orogeny of the early Tertiary period (approximately 75-50 million years ago). During this time igneous bodies intruded Precambrian metamorphics and hydrothermal solutions activated by the molten activity of the uplift and containing rich concentrations of dissolved metals (including precious metals such as gold and silver) were deposited with the intrusions in cracks and fissures from block faulting of the period (Henderson, 1926).

The ores in the Aspen area are primarily silver ores containing small amounts of other metals, with the exception of lead. The deposition of the metallic minerals has taken place along faults, such as the Castle Creek fault. The Hope Mine is located within the Richmond Hill Mining District on the southwest slope of Richmond Hill just below Annie Basin. The Castle Creek fault lies parallel to Richmond Hill (CMC, 2010).

2.1.2 Topographic and Ecologic Setting

The Site is located at an approximate elevation of 8,700 feet above sea level on the southwest facing slope of Richmond Hill. The Site area is considered a montane ecosystem with mixed forest and riparian areas. Most precipitation in the Site area is attributable to snow fall which has an annual mean of 140.0 inches. Afternoon thunderstorms during the summer months are common (TLI, 2011).

Summer time temperatures in the Site area range from 68 to 85°F in the day, dropping to 50°F and below at night. Day time winter temperatures range from 20 to 40°F and drop to 30°F and below at night (TLI, 2011).

The riparian areas along Castle Creek and the adjacent Maroon Creek support four significant plan communities dominated by blue willow, narrowleaf cottonwood, or blue spruce (CMC, 2010).

Threatened or endangered species that may be found within the Site area include the bonytail chub, Colorado pikeminnow, greenback cutthroat trout, humpback chub, razorback sucker, Uncompahgre fritillary butterfly, yellow-billed cuckoo, Mexican spotted owl, Canada lynx, and Ute ladies'-tresses orchid (CMC, 2010).

2.1.3 Site Watersheds and Drainages

The Site is located on the east bank of Castle Creek, which flows into the Roaring Fork River approximately six and a half miles to the north. Castle Creek experiences seasonal flow regimes with lower flow during the winter months, and higher flow rates during the snow melt of late spring and early summer. Monthly mean flows in January and February range between 8 and 9 cubic feet per second (cfs); from April to June, monthly mean flow rates range from 90 to 211 cfs (TLI, 2011).

2.2 PREVIOUS SITE INVESTIGATIONS AND REMOVALS

2.2.1 Preliminary Assessment and Site Inspection Report

In September, 2010, A Preliminary Assessment (PA) and Site Inspection (SI), as per the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) requirements, were completed for the Hope Mine Site (the Site) in Pitkin County, Colorado by CMC (Appendix B). A field sampling event was performed to assess the contaminant nature of the mine site. This consisted of water sample

collection for dissolved and total recoverable metals, and general water chemistry in addition to in situ water quality and discharge measurements. Water samples were collected at the mine adit (HMA); from Castle Creek upstream from the waste piles (CCUS); from Castle Creek downstream from the waste piles (CCUD), and at the spring located at the bottom edge of the northern waste pile (HMS). Aliquots were provided unfiltered for total recoverable metals, and filtered for dissolved metals. Surface water and spring sample results are provided in Table 2-1below.

Mine waste (soil and rock) samples were collected from both the north waste pile and the south waste piles. Thirty discrete samples were collected from the upper 15 centimeters of the soil stratum at random locations at the top of the north waste pile and a similar effort was conducted at the south waste pile. A background sample was also collected and analyzed. Sample locations did not include the steepest section of the pile due to safety concerns. Discrete samples were composited and sieved at CMC Timberline Campus and a 500 gram sample of material from the No. 10 sieve was analyzed by Timberline Analytical Laboratory, part of the CMC. This composite sieved sample was analyzed by TAL X-Ray Fluorescence (XRF) for total metal concentrations and by Inductively-Coupled Plasma-Optical Emissions Spectroscopy (ICP-OES) for leachate results. Composite sample results for the Hope Mine North Dump (HMND), Hope Mine South Dump (HMSD) and Hope Mine Background (HB) are provided in Table 2-2 below.

2.3 Nature and Extent of Contamination

Surface water sample results from the PASI are provided in Table 2-1. Sample results in Castle Creek were very similar both upstream and downstream of the waste piles for dissolved and total recoverable metals, indicating trace concentrations of iron, manganese and zinc. At the Hope Mine adit (HMA), dissolved concentrations of aluminum (59 μg/L) and manganese (28 μg/L) were slightly higher than the stream concentrations, while at the Hope Mine Spring (HMS) they were slightly lower. The largest variation was observed in the total recoverable metals at HMA and HMS, with total aluminum from the spring (HMS) at 809 μg/L, total iron at 3390 μg/L, and lead was detected at 38 μg/L.

Table 2-1. Surface Water Sampling Results (CMC, 2010)

Site ID	MDL μg/L	Al	As	Ba	Cd	Se	Ag	Zn	Fe	Mn	Pb
		40	3.5	0.5	1.0	4.1	0.4	2.9	7.7	0.9	4.3
CCUS-Diss		ND	ND	ND	ND	ND	ND	ND	16	2	ND
CCDS-Diss		ND	ND	ND	ND	ND	ND	ND	ND	2	ND
HMA-Diss		59	ND	ND	ND	ND	ND	3	14	28	ND
HMS-Diss		ND	ND	ND	ND	ND	ND	ND	ND	3	ND
CCUS-Trec		ND	ND	ND	ND	ND	ND	ND	30	3	ND
CCDS-Trec		ND	ND	ND	ND	ND	ND	5	31	3	ND
HMA-Trec		170	ND	ND	ND	ND	ND	5	88	22	ND
HMS-Trec		809	3	ND	ND	ND	ND	11	3390	43	38

Notes:
CCUS – Sample collected upstream of the Mine Waste Piles from Castle Creek.
CCDS – Sample collected downstream of the Mine Waste Piles from Castle Creek.
HMA – Sample collected from the water flowing directly out of the collapsed Hope Mine adit.
HMS – Sample collected from the water flowing directly out of the toe of the North Waste Pile (spring)
MDL – Method Detection Limit.
μg/L – Micrograms per liter.
Diss – Dissolved metals from filtered samples.

Trec – Total recoverable metals from unfiltered samples.
ND – Analyte not detected above the MDL.

Surface soil results from the PASI are provided in Table 2-2. All metals were detected at significantly higher concentrations in the surface soil mine waste piles than in the background sample. The sample from the north pile contained slightly higher concentrations of zinc, titanium, manganese, iron, and nickel. The sample from the south pile contained higher concentrations of arsenic, silver, barium, chromium, copper, mercury, lead and strontium.

Table 2-2. Waste Pile Soil Sampling Results (CMC, 2010)

Composite Sample Name	Composited Soil Analytical Result (mg/kg)												
	As	Ag	Ba	Cr	Cu	Hg	Pb	Zn	Ti	Mn	Fe	Ni	Sr
HMND	45	106	4532	176	96	11	1158	415	4687	1254	56867	114	342
HMSD	60	134	8818	189	103	18	2263	357	3973	963	34785	81	616
HMB	7	47	600	ND	32	12	30	72	277	854	31473	67	139

Source: CMC, 2010
Notes:

-- Not Available
PASI - Preliminary Assessment and Site Inspection Report (CMC, 2010)
BCL - Below Concentration Levels
HMND - Hope Mine North Dump (Tailings Pile 200)
HMSD - Hope Mine South Dump (Tailings Pile 201)
HMB - Hope Mine Background
mg/kg - Milligram per kilogram

Table 2-3. Waste Pile Leachate Analysis Results (CMC, 2010)

Composite Sample Name	Composited Soil Leachate Result (µg/L)									
	As 3.5 MDL	Al 40 MDL	Pb 4.3 MDL	Cd 1 MDL	Ba 0.5 MDL	Cu 3.3 MDL	Cr 2.6 MDL	Se 4.1 MDL	Ag 0.4 MDL	Zn 2.9 MDL
HMND	ND	155	ND	ND	14	6	ND	ND	0.5	ND
HMSD	ND	116	ND	ND	10	4	ND	ND	ND	ND
HMB	ND	1500	ND	ND	--	ND	ND	ND	ND	4

Source: CMC, 2010
Notes:

-- - Not Available
PASI - Preliminary Assessment and Site Inspection Report (CMC), 2010)
MDL - Method Detection Limit
HMND - Hope Mine North Dump (North Waste Pile)
HMSD - Hope Mine South Dump (Tailings Pile 201)
HMB - Hope Mine Background
µg/L - Micrograms per liter

Leachate results from composite surface soil samples are provided in Table 2-3. Leachate results provide a more accurate value to compare to groundwater standards than ideal soil screening levels, which are based on partitioning calculations. This data can be used to estimate the potential for metals from the waste piles to dissolve and be transported in infiltrating rainwater and migrate to springs or groundwater. Aluminum, barium, copper and silver were detected in the leachate samples from the waste piles.

Aluminum was also detected in the background leachate sample at approximately 10 times the waste pile values. Zinc was detected only in the background leachate sample.

2.4 PASI Screening Action Levels

The PASI did not conduct a detailed risk assessment but compared site concentrations to risk-based screening levels. The screening thresholds used for soil were:

- EPA Preliminary Remediation Goals (PRGs, now called Regional Screening Levels [RSLs]). Those values were updated to the most recent values (EPA, November 2012) for this report. These values are based on the residential exposure scenario, non-carcinogenic endpoint Table 2-4 presents results of samples collected during the PASI to RSLs.
- U.S. EPA Soil Screening Level (SSL) based on potential impact of leachate migrating to groundwater. These values were also updated to the most recent values (EPA, November 2012) for this report. These values assume leachate will impact the groundwater to elevate groundwater concentrations to Maximum Contaminant Level (MCL) defined by the Safe Drinking Water Act. While these values are provided, they are less accurate then the results of the leachate analysis. Table 2-4 presents results of samples collected during the PASI compared to human health SSLs.
- Bureau of Land Management Criteria for Metals at BLM Mining Sites (BLM, 2004) developed human health and ecological Risk Management Criteria (RMC), below which no negative impacts are expected. The human health criteria follow formula developed for EPA PRGs with BLM specific exposure scenarios, including Campers, and ATV Driver. These include the carcinogenic effects of the metals, though very short exposure durations are to be expected for campers at the Hope Mine Site. RMCs were not updated for this report, but are based on 2004 toxicity values for the metals measured. Table 2-4 presents results of samples collected during the PASI compared to human health RMCs and Table 2-5 presents results of samples collected during the PASI compared to ecological RMCs.
- EPA Ecological Soil Screening Level (Eco-SSL) were developed by the Superfund program and updated in 2005. Guidance for their use in ecological risk assessment is also available as *Guidance for Developing Ecological Soil Screening Levels (ECO-SSLs)*, February 2005. Currently, Interim Eco-SSL documents are available online for 17 metals and four organic compounds, which provide Eco-SSL values in soil for plants, soil invertebrates, avian wildlife and mammalian wildlife (http://www.epa.gov/ecotox/ecossl/). Table 2-5 presents results of samples collected during the PASI compared to Eco-SSLs.
- The U.S. Department of Energy trough the Oak Ridge National Laboratory developed toxicity concentrations for earth worms, micro-organisms and plants (phyto-toxicity), presented in *Toxicological Benchmarks for Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision* (Efroymson, et. al., 1997). Table 2-5 presents results of samples collected during the PASI compared to ecological receptor toxicity screening benchmarks in soil.

Table 2-4. Comparison of PASI Results to Human Health Soil Screening Benchmarks (CMC, 2010)

Analyte	Analysis Results (mg/kg)			EPA Regulatory and Human Health Benchmarks SSL (mg/kg)	EPA Regional Screening Level (RSL) Residential Soil; Non-Cancer (mg/kg)				BLM Risk Management Criteria (mg/kg)		
	HMND	HMSD	HMB	MCL	Ingestion	Dermal	Inhalation	Total	Resident	Camper	ATV Driver
As	45	60	7	0.29	24	280	21000	22	1	20	300
Ag	106	134	47	--	3900	--	--	3900	35	700	9600
Ba	4532	8818	600	82	16000	--	--	15000	--	--	--
Cr	176	189	ND	180000	--	--	--	--	--	--	--
Cu	96	103	32	46	31000	--	--	31000	250	5000	70000
Hg	11	18	12	0.1	--	--	--	--	2	40	550
Pb	1158	2263	30	14	--	--	--	--	400	1000	1000
Zn	415	357	72	--	23000	--	--	23000	2000	40000	550000
Ti	4687	3973	277	--	--	--	--	--	--	--	--
Mn	1254	963	854	--	1900	--	71000	1800	960	19000	250000
Fe	56867	34785	31473	--	55000	--	--	55000	--	--	--
Ni	114	81	67	--	3900	--	71000	3700	135	2700	38000
Sr	342	616	139	--	47000	--	--	47000	--	--	--

Source: CMC, 2010

Notes:

-- Not Available
PASI - Preliminary Assessment and Site Inspection Report (CMC, 2010)
BCL - Below Concentration Levels
HMND - Hope Mine North Dump (Tailings Pile 200)
HMSD - Hope Mine South Dump (Tailings Pile 201)
HMB - Hope Mine Background
MCGL - Maximum Contaminant Level Goal
MCL - Maximum Contaminant Level
SSL - USEPA Soil Screening Level, for potential impact to groundwater (November, 2012)
RSL - USEPA residential soil Regional screening Level for direct exposure, non-cancer endpoint (November, 2012)

Table 2-5. Comparison of PASI Results to Ecological Soil Screening Benchmarks (CMC, 2010)

Analyte	PASI Analysis Results (mg/kg)			EPA Ecological Soil Screening Level (Eco-SSL)				Oak Ridge National Laboratory			US BLM Wildlife Risk Management Criteria					
	HMND	HMSD	HMB	Plants	Soil Invertebrates	Avian Wildlife	Mammalian Wildlife	Earthworm toxicity	Micro-organism Toxicity	Phyto-toxicity	Deer Mouse	Cottontail	Bighorn Sheep	Mule Deer	Elk	Robin
As	45	60	7	18	--	43	46	60	100	10	230	438	387	200	328	4
Ag	106	134	47	560	--	4.2	14	--	50	2	--	--	--	--	--	--
Ba	4532	8818	600	--	330	--	2000	--	--	--	--	--	--	--	--	--
Cr	176	189	ND	--	--	(Cr-III)	(Cr-III, IV)	--	--	--	--	--	--	--	--	--
Cu	96	103	32	70	80	28	49	50	100	100	640	358	64	102	131	7
Hg	11	18	12	--	--	--	--	--	--	--	2	15	6	9	11	1
Pb	1158	2263	30	120	1700	11	56	500	900	50	142	172	152	106	127	6
Zn	415	357	72	160	120	46	79	200	100	50	419	373	369	222	275	43
Ti	4687	3973	277	--	--	--	--	--	--	--	--	--	--	--	--	--
Mn	1254	963	854	220	450	4300	4000	--	100	500	--	--	--	--	--	--
Fe	56867	34785	31473	--	--	--	--	--	--	--	--	--	--	--	--	--
Ni	114	81	67	38	280	210	130	--	--	--	--	--	--	--	--	--
Sr	342	616	139	--	--	--	--	--	--	--	--	--	--	--	--	--

Source (CMC, 2010)

Notes:

-- Not Available
PASI - Preliminary Assessment and Site Inspection Report (CMC, 2010)
BCL - Below Concentration Levels
HMND - Hope Mine North Dump (Tailings Pile 200)
HMSD - Hope Mine South Dump (Tailings Pile 201)
HMB - Hope Mine Background
MCGL - Maximum Contaminant Level Goal
MCL - Maximum Contaminant Level

2.5 SCREENING HAZARD ASSESSMENT

2.5.1 PASI Human Health Soil Screening Assessment

Table 2-4 presents a comparison of human health soil screening levels to PASI results. Arsenic, silver, copper, mercury, lead, manganese and iron exceeded one or more of the screening levels presented in Table 2-4. This indicates soil should not be available for direct contact to human receptors under the Residential, Camper, or ATV Driver exposure scenarios.

2.5.2 PASI Ecological Soil Screening Assessment

Table 2-5 presents a comparison of ecological soil screening benchmarks to PASI results. Arsenic, silver, barium, copper, mercury, lead, zinc, manganese, and nickel exceeded one or more of the screening levels presented in Table 2-5.

It should be noted that this is a screening hazard evaluation and not meant to determine actual risk but does provide an estimate of potential concerns.

2.5.3 Slope Stability Evaluation and Hazard Assessment

The focus of this EE/CA and the associated Non-Time Critical Removal Action (NTCRA) is the potential for the North Waste Pile to become unstable and slide into Castle Creek, which is a drinking water source for the City of Aspen, Colorado approximately 6 miles downstream of the North Waste Pile. Currently the waste pile is directly overhanging Castle Creek, with the toe susceptible to erosion during seasonal high water associated with annual spring snow melt.

The focus of the EE/CA field investigation was to determine slope stability through the collection of geotechnical data and survey data to map the topography of the North Waste Pile to determine slope and estimate volume of the waste material in the North Waste.

2.6 DATA GAP FIELD INVESTIGATION

Based upon a review of previous studies, as summarized in Sections 2.2, 2.3, and 2.5, additional soil data was required for an accurate EE/CA analysis. Data needs identified in a review of the Preliminary Site Assessment Report and the PRP report included additional geotechnical soil samples required to conduct slope stability analysis of the Hope Mine waste pile, and to accurately calculate the volume of material that will need to be addressed in the EE/CA. TEC worked with a drilling and geotechnical subcontractor to conduct a geotechnical evaluation at the Hope Mine. Directional hollow stem auger (HSA) borings was advanced to a maximum of 45 feet below ground surface (ft bgs) to determine the depth to native soil beneath the Hope Mine north waste pile. Depth of mine waste was needed for final design in order to estimate total volume of mine waste, and to conduct slope stability analyses.

The data gap field investigation portion of the EE/CA was completed on October 4, 2012. Under the supervision of a Cardno TEC geologist, Hepworth-Pawlak Geotechnical Inc. (HP Geotech) performed a subsurface exploration and tested soil samples collected from the subject site as described below and in Exploratory Drilling and Laboratory Testing report in Appendix C.

2.6.1 Soil Sampling Using Hollow Stem Auger Techniques

To characterize the mine waste pile at the Site for slope stability analysis, HP Geotech used a CME-55 drill rig to advance three 3.75-inch inside diameter (ID), 7.125-inch outside diameter (OD) HSA soil borings through the mine waste pile, terminating at the natural soils interface, with total depths ranging between 26 ft bgs to 45 ft bgs.

Drive samples and disturbed bulk samples were taken from the boreholes at generally the prescribed intervals of 2 to 5 feet to achieve a more or less continuous subsurface profile to 25 feet except for Boring 3 that was sampled on wider spaced intervals and deeper below the mine waste into the natural soils to a

total depth of 45 feet bgs. The sample core was evaluated by the Cardno TEC geologist visually and logged for lithologic purposes. Graphical logs of the boreholes are presented in Appendix C.

Soil geotechnical samples were collected from the soil borings for classification purposes. The samples taken from the borings were retained by HP Geotech. Samples were analyzed for particle size distribution, classification, in-place density, compaction characteristics, and shear strength tests.

Table 2-6. Summary of Exploratory Boring Logs

Boring	Depth (ft)	Thickness (ft)	USCS	Disturbed Bulk Sample	Thickness (ft)
B1	**0-3**	3.0	Fill	NA	
	3-26	23.0	Mine Waste	3'-10'	7.0
	AVG	*13.0*			
B2	**0-1**	1.0	Fill	NA	
	3-26	25.0	Mine Waste	3'-10'	7.0
	AVG	*13.0*			
B3	**0-1**	1.0	Fill	NA	
	1-39	38.0	Mine Waste	1'-5'	4.0
	39-44	5.0	CL	NA	
	44-45	1.0	GM	NA	
	AVG	*11.3*			
AVERAGE		**12.1**			

1. Exploratory borings were drilled on October 4, 2012 with 4-inch ID continuous flight hollow stem auger.
2. Locations of exploratory boring were provided by Cardno TEC.
3. Elevations of exploratory borings were not measured and the logs of exploratory borings are drawing to depth.
4. The exploratory boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between materials shown on the exploratory boring logs represent the approximate boundaries between material types and transitions may be gradual.
6. No free water was encountered in the borings at the time of frilling. Fluctuation in water level may occur with time.

2.6.2 Sampling Locations Survey

During sampling activities, topographic surveying by Inter-Mountain Engineering established horizontal and vertical coordinates of soil borings as well as coordinates of important site features. These were used to develop a site-specific topographic map of the mine waste rock piles in support of estimating the volume of waste rock material at the Site (Appendix D). The topographic survey included sufficient data points to ascertain the general shape and volume of the waste rock pile. The survey was not referenced to benchmarks with known elevations or horizontal coordinates. The survey included the vertical and horizontal locations of the three soil boring locations on top of the waste rock pile.

The survey determined relative horizontal coordinates to minimum accuracy of 0.1 feet and elevation to minimum accuracy of 0.083 feet (1 inch). An XYZ-coordinate system using northings, eastings, and elevations was used to identify locations. While the coordinate system is based on State Plane coordinates, its accuracy compared to the State Plane coordinate system has not been validated or verified.

2.6.3 Data Gap Field Investigation Results

The samples collected from the soil borings at the North Waste Pile were retained by HP Geotech. Laboratory testing was performed on selected samples in general accordance with the purchase order and the results are summarized in Table 2-7 and Table 2-8, and Appendix C. A map of mine features as identified in the Data Gap Field Investigation is presented in Figure 2-1. An interpolated surface of the mine waste piles and the interpolated surface of the natural soil beneath the mine waste is shown in Figure 2-2. A cross-section of the mine waste, two of the soil borings and the potentially unstable slope above Castle Creek is shown in Figure 2-3. This cross-section shows the slope for which slope stability calculations were calculated. Interpolated surfaces of North Waste Pile and the native soil underneath are presented in Figure 2-4.

Mine Waste Geotechnical Results

The three soil borings drilled in the North Waste Pile contained soil consisting of four layers as observed by the TEC Geologist. No groundwater was encountered in the three soil borings.

- Fill: capping mixture of sand and silt with charcoal, loose, slightly moist, and gray,
- Mine Waste: silty clayey sandy gravel with cobbles, loose to medium dense, slightly moist to moist, mixed browns,
- Clay (CL): sandy, silty, slightly gravelly, stiff, moist, brown, low plasticity (B3 only), and
- Gravel (GM): with cobbles, sandy, silty, dense, moist, brown (B3 only).

The soil samples retained and analyzed by HP Geotech in B1 and B3 were analyzed for particle size distribution, classification, in-place density, compaction characteristics, and shear strength tests, as shown in Table 2-7 and Table 2-8. The percent of soil passing through a No. 4 sieve is 52±9%, and the percent of soil passing through a No. 200 sieve is 31±14%. Therefore, approximately 48% of the soil by weight is greater than 0.187 inches in diameter.

Table 2-7. Summary of Geotechnical Results

Location					Rock Corrected		Uncorrected		Gradation				Atterberg Limits		
Boring	Depth (ft)	USCS	Natural Moisture Content (%)	Natural Dry Density (pcf)	Maximum Dry Density (pcf)	Optimum Moisture (%)	Maximum Dry Density (pcf)	Optimum Moisture (%)	Gravel (%)	Sand (%)	Percent Passing No. 4 Sieve	Percent Passing No. 200 Sieve	Plastic Limit (%)	Liquid Limit (%)	Plastic Index (%)
B1	3-10	GC			135.5	7.2	129.2	9	41	25	59	34	15	25	10
	17.5		9.7	114					27	48		25			
	20		11.0*	121.6*											
B3	1-5	GC	8.9*	122.8*	141.4	5.2	129.8	8.2	55	30	45	15	17	25	8
	40		22.4									48		32	9

* Average value of 3 tests specimens for each direct shear test prior to loading and wetting for test. B1 @ 20' is insitu and B3 @ 1.5' is remolded

The Atterberg limits of the mine waste in B1 and B3 has a liquid limit of 27±4%, a plastic limit of 16±1.4%, and a plasticity index of 9.0±1.0%, resulting in a low plasticity clay, according to the plasticity chart for the classification of fine soils.

The Proctor Test analysis was analyzed on the gravels, sands, and fines for each composite sample representing the fines in each test pit. The Proctor Test analysis results were then corrected for the oversize materials included in the composite samples. The average maximum dry density for the mine waste in North Waste Pile is 138.5±4.2 pounds per cubic foot (pcf), at an optimal moisture content of

6.2±1.4%. The average maximum dry density, corrected to include the cobbles, gravels, sands, and fines is 129.5±0.4 pcf at an optimal moisture content of 8.6±0.6%

The two samples collected from soil boring B1 for direct shear tests resulted in the cohesion and friction angle parameters as presented in Table 2-8. The peak and ultimate stresses were measured under an induced normal stress of 1,000 pounds per square foot (psf), 3,000 psf, and 5,000 psf. With these results HP Geotech calculated the cohesion and friction angles representative of the mine waste (Appendix C). These direct shear parameters were used by Cardno TEC to conduct slope stability calculations.

Table 2-8. Summary of Direct Shear Results

Location					Normal vs. Peak Shear		Normal vs. Ultimate Shear	
Boring	Depth (ft)	Normal Stress (psf)	Peak Stress (psf)	Ultimate Stress (psf)	Cohesion (psf)	Friction Angle (degrees)	Cohesion (psf)	Friction Angle (degrees)
B1	3-10	5000	4070	4043	281.0	37.3	197.8	37.8
		3000	2622	2576				
		1000	1018	945				
	20	4987	5837	5538	174.2	48.8	170.8	46.9
		3015	3692	3301				
		1005	1287	1287				

Slope Stability Analysis

The potential for the impact of COCs on human health or the environment would significantly increase if the steep slope of the Hope Mine North Waste Pile would fall into Castle Creek below, thus introducing mine waste leachate into the creek. There is concern by the USFS that a significant storm event would result in a landslide of mine waste into Castle Creek. The stability of the mine waste slope was calculated by Cardno TEC to estimate the risk of slope failure. In addition to calculating the slope stability of the North Waste Pile, Cardno TEC also calculated the slope stability for a soil repository placed immediately south and east of the North Waste Pile on the natural slope as measured by the topographic survey (3.3:1).

The slope stability analysis was based upon the shear strength parameters of peak shear cohesion and peak shear friction angle (Table 2-8), and does not assume the presence of a groundwater source in the mine waste. The slope stability calculations were conducted using the Fellenius solution to the method of slices (Craig, 2004). The soil within an assumed slope failure plane was divided by vertical planes into a series of slices that were 1-ft wide by 1-ft thick, extending from the slope surface to the failure plane. The plane of failure was assumed to be semi-circular, originating from the toe of the slope, across the mine waste and natural soil interface, and ending at or near the top of the slope (Figure 2-4). As shown in Table 2-9, the factor of safety (FS) was computed for an assumed slope failure plane as the ratio of the sum of stabilizing forces in all slices to the sum of all destabilizing forces in all slices. If the FS is less than 1, it means that the slope is in imminent danger of failure. For an FS value between 1 and 2, the slope ranges from likely failure to possible failure if stressed with either excessive load on the top of the slope, saturation of the soil within the slope, or undercutting of the toe of the slope by Castle Creek. An FS with a value of 2 or greater indicates a slope that is generally considered safe. The failure plane for the slope was adjusted by trial and error to determine the most likely failure plane with the lowest FS value.

Table 2-9. Summary of Slope Stability Calculations

Slope Stability Input (Units)	Tailings Pile 200	On-Site Repository with 2:1 Side-Slope	On-Site Repository with 1.5:1 Side-Slope
Tailings / Repository Pile Geometry			
Pile Width (ft)	200	150	150
Pile Volume (cy)	12,771	12,771	12,771
Pile Height (ft)	55	58	49
Base Slope	N/A*	3.3:1	3.3:1
Surface Slope	N/A*	2:1	1.5:1
Slope Failure Geometry			
Radius (ft)	56	110	70
Centroid Easting (ft)	2,619,904	2,619,936	2,619,923
Centroid Elevation (ft MSL)	8720	8786	8740
Width of Slices (ft)	1	1	1
Total Number of Slices	55	90	68
Measured Soil Parameters (Table 2-2 and 2-3)			
Dry Density (pcf)	121.6	121.6	121.6
Peak Shear Friction Angle (°)	37.3	37.3	37.3
Peak Shear Cohesion (psf)	281	281	281
Slope Failure Calculations			
Total Weight of Slope Failure per foot width (lb/ft)	103,360	109,805	96,915
Length of Failure Plane (ft)	82.1	104.3	85.5
Factor of Safety	**1.42**	**2.24**	**1.80**

Notes:

Factor of Safety:	**0-1.0**	**Imminent Danger of Failure**
	1.0-1.5	**Likely Failure**
	1.5-2.0	**Possible Failure**
	>2.0	**Unlikely Failure**

* - Slope Geometry Determined by Survey (Figure 2-5)
ft - feet
cy - cubic yards
ft MSL - feet above mean sea level
pcf - poinds per cubic foot
psf - pounds per square foot
lb - pounds

As shown in Table 2-9, the slope of North Waste Pile has a FS of 1.4, indicating that it is not in imminent danger of failure, but may do so in the event of a significant storm event, or with significant equipment loading on the head of the slope, or with continued erosion of the toe of the slope by high water conditions in Castle Creek. A hypothetical soil repository placed on the 3.3:1 natural slope to the south of North Waste Pile would result in a FS of 1.8 if graded to a 1.5:1 slope, or a FS of 2.2 if graded to a 2:1 slope.

A hypothetical onsite repository of the mine waste would require a 2:1 side slope. With the existing side slope of approximately 3.3:1 between the North Waste Pile and the South Waste Pile, a repository 150 feet wide would require approximately 0.7 acres of land for the repository, and would result in a repository that would be approximately 60 feet high from toe to head.

Mine Waste Volume

The volume of the mine waste within North Waste Pile was estimated by two methods in order to estimate the volume of material to be excavated, hauled, and consolidated in repositories in the

conceptual removal action alternatives in Section 5.3. Method 1, the volume of the mine material was calculated by Inter-Mountain Engineering based upon the topographic survey, assuming the base of the excavation to be located along a linear slope from the head of the mine waste pile to the base of the mine waste pile. Based upon this method, the estimated volume of mine waste in North Waste Pile is 10,350 cubic yards (CY) (Appendix D).

The volume was also calculated by Cardno TEC, assuming the base of the mine waste to be located at the depths indicated by the soil borings. Linear regression was used to interpolate the base of the mine waste between the edges of the mine waste pile and the soil boring locations. The volume of soil calculated between the two surfaces in Figure 2-2. Based upon this method, the estimated volume of mine waste in North Waste Pile is 12,770 CY. Based upon upgradient drainage topography, it is estimated that the total mine waste-rock volume to me managed/mitigated is approximately 15% to 20% greater than the 10,350 CY to 12,770 CY range; i.e. the total waste pile volume is estimated to be 11,900 to 15,300 CY. The upper range of this volume (15,300 CY) is used for evaluating the cost of Alternatives 3 and 4 (Sections 5.3.3 and 5.3.4).

If a removal action removed the mine waste in the North Waste Pile that is in danger of slope failure, the slope should be cut back to a 2:1 slope according to the slope stability analysis, and the toe of the mine waste approximately 10 feet in elevation above Castle Creek to prevent undercutting due to significant flooding events. Approximately 8,000 CY of mine waste would need to be excavated from the North Waste Pile to produce the 2:1 slope with a toe 10 feet above Castle Creek. This volume (8,000 CY) is used to estimate the costs of Alternative 2 in Section 5.3.2.

Figure 2-1. Site Features Map

Figure 2-2. Hope Mine Waste Pile Surface Profile

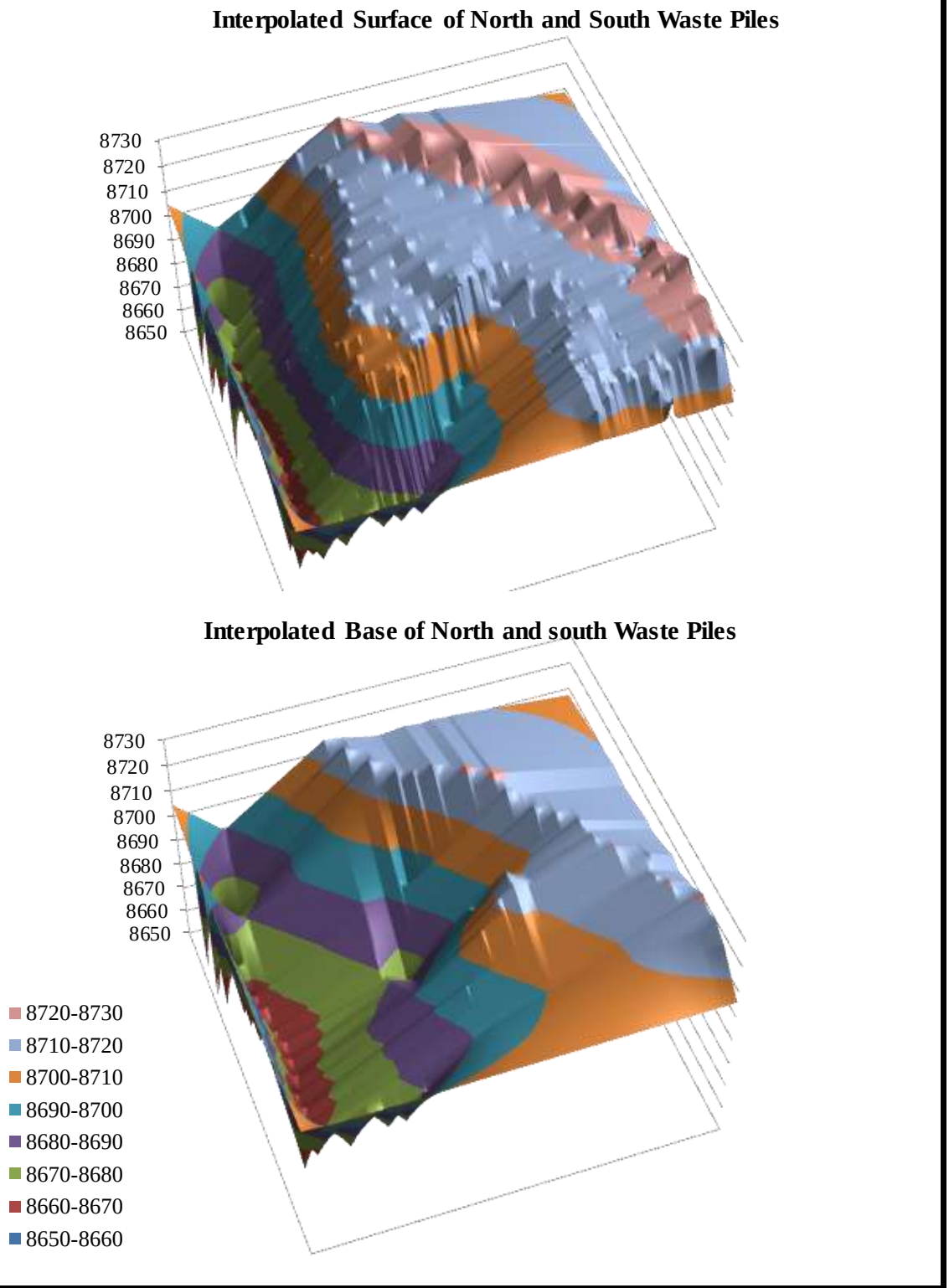


Figure 2-2

Interpolated Surface - Mine Waste Piles

Hope Mine
White River National Forest
Pitkin County, CO

Figure 2-3. Cross-Section – North Waste Pile: Hope Mine

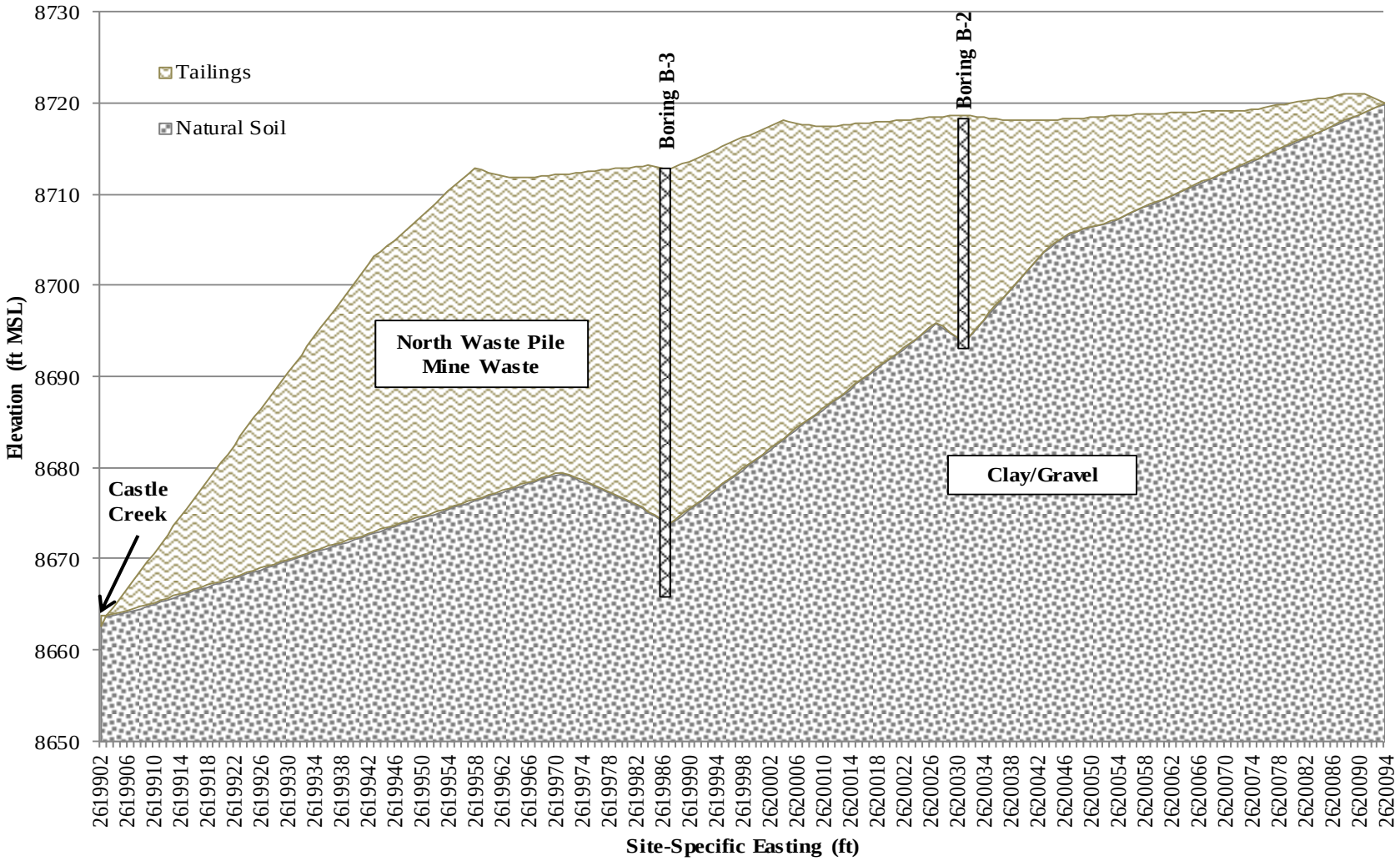
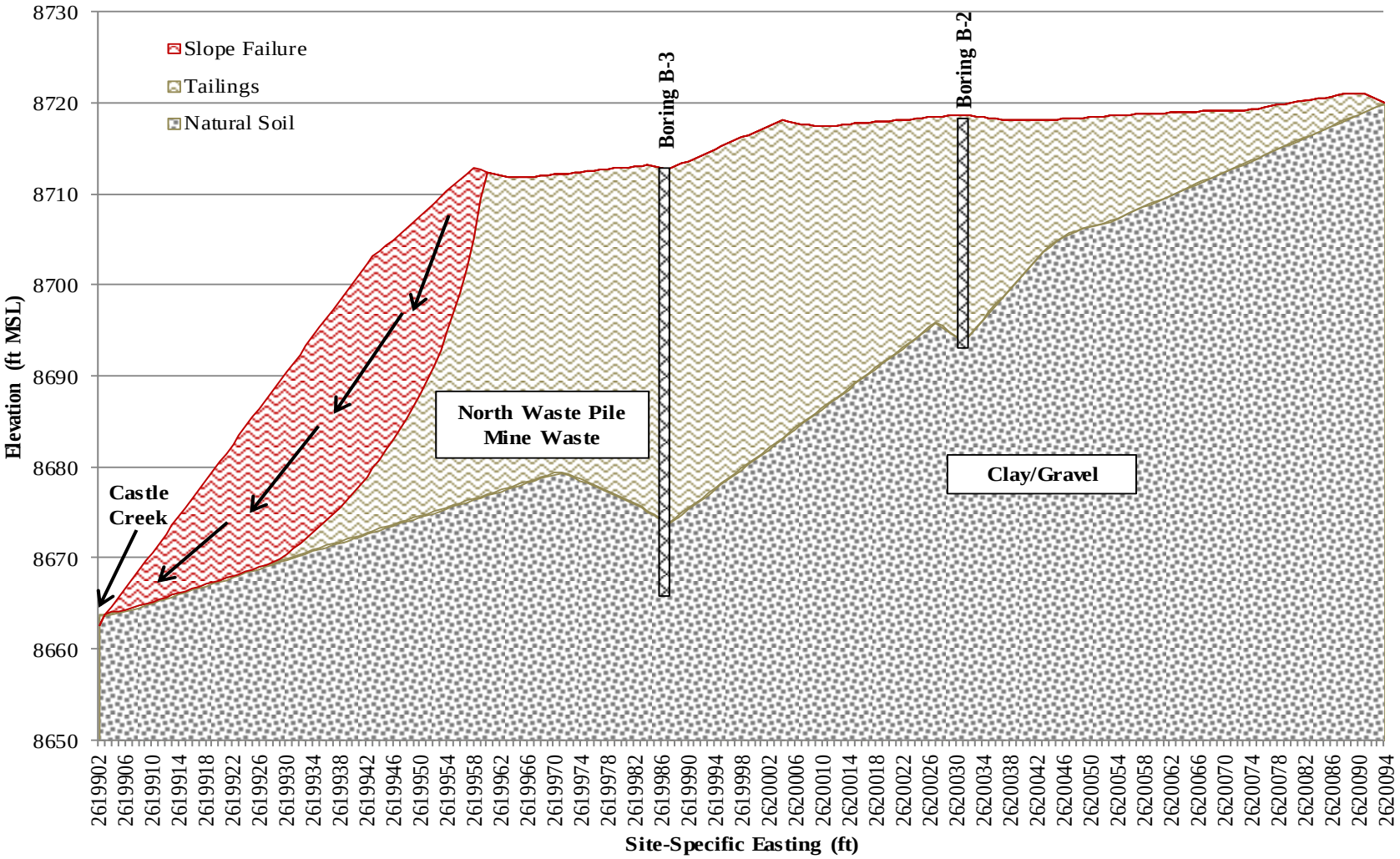


Figure 2-3

Cross Section - North Waste Pile
Hope Mine
White River National Forest
Pitkin County, CO

Figure 2-4. Slope Stability Cross-Section



Cardno TEC

Figure 2-4
Slope Failure Section - North Waste Pile
Hope Mine
White River National Forest
Pitkin County, CO

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SECTION 3 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

The purpose of this EE/CA is to develop and analyze removal action alternatives in accordance with CERCLA and to recommend a removal action alternative that is protective of human health and the environment and compliant with Applicable or Relevant and Appropriate Requirements (ARARs). The removal action alternative will be selected in an Action Memorandum, which is to be prepared by the lead federal agency (USFS). The removal action goal and RAOs for the Hope Mine Site are in compliance with these criteria and are detailed in the following subsections. The goals for the site may be altered following the submittal of this EE/CA, if additional information becomes available from stakeholders or other interested parties that requires reevaluation of the RAOs. As such, the final removal action goal and RAOs will reflect these alterations and refinements, if any, and will be defined in the Action Memorandum.

3.1 DETERMINATION OF REMOVAL SCOPE

The overall goal of a potential removal action at the Hope Mine Site is to minimize the risk that COCs pose to human health and/or the environment. The removal action scope considers a cleanup, and/or containment level protective of human health and the environment based on the Site's current and anticipated future land use.

3.2 REMOVAL ACTION OBJECTIVES

EPA's *Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA* provides for the development of removal action objectives to form the basis for evaluating alternatives (EPA, 1993). According to the guidance, "…removal action objectives generally consist of medium-specific goals for protecting human health and the environment. The objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited. Removal action objectives should identify, for example, the contaminants of concern and exposure route(s) and receptor(s)."

To achieve the overall goals of the removal action, the following preliminary RAOs were developed to reduce the risks to human and ecological receptors at the site:

- Reduce the physical hazards at the North Waste Pile by minimizing slope stability hazards, and
- Reduce exposure of humans and wildlife to chemicals of concern in waste material and soil to acceptable levels.

These objectives will be achieved through slope stabilization and the attainment of the risk-based goals. The removal action in this EE/CA considers a cleanup and containment level protective of human health and the environment based on the nonresidential and limited recreational use of the site, as well as the habitat use for ecological receptors. The waste material in the Northern Waste Pile present the greatest risk due to the unstable conditions of the lope directly overhanging Castle Creek in combination with elevated concentrations of metal COCs in the waste material. While similar concentrations of COCs exist in the South Waste Pile, it does not directly overhang Castle Creek, nor is in danger of erosion at the toe by Castle Creek. Therefore, the scope of the removal action will focus on the stabilization by removal of the mine waste rock and mine waste at North Waste Pile.

3.3 CLEANUP ACTION LEVELS

Based on results of the risk evaluations, the COCs in waste material, soil, and sediment pose a potential risk to both human and ecological receptors. Regulatory standards and risk-based screening levels, along with site use considerations, were used to develop the cleanup action levels. The cleanup action levels

determined most appropriate for the site were based on reducing risks to acceptable levels for human and ecological receptors that could potentially use the site.

While regulatory standards and risk-based concentrations must be considered in the development of cleanup levels, EPA guidance and policy do not recommend that cleanup levels be established at levels less than background, even if the background level exceeds an ARAR or risk-based concentration. Where a regulatory standard or risk-based concentration is greater than the background concentration, the standard or risk-based concentration is used as the cleanup level.

The cleanup action levels were developed based on using a combination of background concentrations, EPA RSLs, BLM median wildlife RMCs, and Eco-SSLs as defined in Section 2.4 of this document. Because no critical habitat or sensitive species is present at the site, the median RMC is considered appropriate and suggested for use as criteria suitable for protecting groups of species, communities, or ecosystems. The cleanup action levels to achieve the RAOs are presented in Table 3-1. By achieving the RAOs, the removal action goals will be met and the potential risks to human health and the environment will be reduced or eliminated.

While individual ecological receptors (i.e., songbirds) may still be at risk to some of the lower COC concentrations remaining at the site, populations are unlikely to be significantly impacted by elevated COC concentrations remaining at the site because:

- The home range for most receptors is significantly larger than the site and it is improbable that entire populations of receptors reside strictly within the site boundaries.
- Contaminated areas on the site offer lower habitat quality compared to the adjoining habitat and it is unlikely that a receptor would regularly use habitat within the contaminated areas.

Given these conditions, the relatively low risk ratios, the risk to individual ecological receptors is considered low and would not cause adverse population effects to wildlife of the area.

3.1 DETERMINATION OF REMOVAL SCHEDULE

The USFS has determined that a NTCRA is appropriate at the site. The NTCRA could begin within 3 months following approval of this EE/CA. Based on past experience with implementation of removal action technologies similar to those proposed in this EE/CA and the volume of material to be removed, it is estimated that any removal action undertaken can be completed within 2 weeks.

Table 3-1. Chemical Remedial Action Objectives

Analyte	EPA Regulatory and Human Health Benchmarks SSL (mg/kg)	EPA Regional Screening Level (RSL) Residential Soil; Non-Cancer (mg/kg)	BLM Risk Management Criteria (Camper) (mg/kg)	EPA Ecological Soil Screening Level (Eco-SSL)				Oak Ridge National Laboratory			US BLM Wildlife Risk Management Criteria						Hope Mine Background (mg/kg)	Mean Reported Soil Metal Background Concentrations (Colorado)* (mg/kg)	RAO
				Plants	Soil Invertebrates	Avian Wildlife	Mammalian Wildlife	Earthworm toxicity	Micro-organism Toxicity	Phyto-toxicity	Deer Mouse	Cotton tail	Bighorn Sheep	Mule Deer	Elk	Robin			
As	0.29	22	20	18	--	43	46	60	100	10	230	438	387	200	328	4	7	6.7	**7**
Ag	--	3900	700	560	--	4.2	14	--	50	2	--	--	--	--	--	--	47	--	**47**
Ba	82	15000	--	--	330	--	2000	--	--	--	--	--	--	--	--	--	600	662	**662**
Cr	180000	--	--	--	--	(Cr-III)	(Cr-III, IV)	--	--	--	--	--	--	--	--	--	ND	41.7	**180000**
Cu	46	31000	5000	70	80	28	49	50	100	100	640	358	64	102	131	7	32	21	**32**
Hg	0.1	--	40	--	--	--	--	--	--	--	2	15	6	9	11	1	12	--	**12**
Pb	14	--	1000	120	1700	11	56	500	900	50	142	172	152	106	127	6	30	31	**31**
Zn	--	23000	40000	160	120	46	79	200	100	50	419	373	369	222	275	43	72	87	**87**
Ti	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	277	--	**277**
Mn	--	1800	19000	220	450	4300	4000	--	100	500	--	--	--	--	--	--	854	343	**854**
Fe	--	55000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31473	23048	**55000**
Ni	--	3700	2700	38	280	210	130	--	--	--	--	--	--	--	--	--	67	13	**67**
Sr	--	47000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	139	--	**47000**

Notes:

-- Not Available
PASI - Preliminary Assessment and Site Inspection Report (CMC, 2010)
HMND - Hope Mine North Dump (Tailings Pile 200)
SSL - USEPA Soil Screening Level, for potential impact to groundwater (Nove
RSL - USEPA residential soil Regional screening Level for direct exposure, noı
RAO - Remedial Action Objective - Maximum of: (1) Mean Reported Soil Metal Background for Colorado, (2) measured background for Hope
* Source: EPA, 2005

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SECTION 4 APPLICABLE OR RELAVANT AND APPROPRIATE REQUIREMENTS

Section 300.415(i) of the NCP provides that removal actions must attain ARARs to the extent practical, considering the exigencies of the situation.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the law or regulation directly address the circumstances at the site. An applicable federal requirement is considered an ARAR. An applicable state requirement is an ARAR only if it is more stringent than federal ARARs.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup criteria or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed removal action and are well suited to the conditions of the site. A requirement must be determined to be both relevant and appropriate to be considered an ARAR.

To qualify as a state ARAR under CERCLA and the NCP, a state requirement must be a promulgated law, substantive, consistently applied, and more stringent than a federal requirement. Provisions of generally relevant federal and state statutes and regulations that were determined to be procedural or nonenvironmental, including permit requirements, are not considered to be ARARs. Nonpromulgated advisories or guidance issued by federal or state governments are not legally binding and do not have the status of ARARs. However, such requirements may be useful and are “to be considered” for guiding decisions regarding cleanup levels or methods when regulatory standards are not available.

The EPA has developed the following three categories of ARARs to assist in the identification of site requirements: (1) chemical-specific, (2) location-specific, (3) and action-specific. EPA guidance recognizes that some requirements do not fall neatly into this classification; however, the following definitions provide a general guideline for each of these categories:

- Chemical-Specific ARARs are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numeric values (i.e., cleanup levels). These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment.
- Location-Specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. Location-specific ARARs relate to the geographical or physical position of the site (e.g., presence of wetlands, sensitive species, floodplains, etc.).
- Action-Specific ARARs are activity-based requirements or limitations on actions taken with respect to hazardous substances.

The Federal and State ARARs that are presented in this document are considered to be preliminary. Other Federal and State advisories, criteria, or guidance may, as appropriate, be considered in formulating the removal action. Table 4-1 through Table 4-3 summarize the preliminary potential ARARs for this project.

Table 4-1. Chemical-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
Federal				
Clean Water Act Federal Water Quality Criteria	Establishes AWQC as water quality standards.	40 CFR Part 131 Quality Criteria for Water, 1986, pursuant to 33 USC, Chapter 26, § 1313–1314	Relevant and Appropriate	AWQC are nonenforcable guidance developed by EPA and used to establish water quality standards. Generally, AWQC are considered potentially relevant and appropriate for surface water considered a potential drinking water source in the absence of promulgated MCLs. However, if the surface water's designated beneficial use includes protection of aquatic life, the AWQC may be more stringent than the MCL.
Risk Management Criteria for Metals at BLM Mining Sites	Provides nonregulatory screening criteria for the protection of ecological receptors.	http://www.epa.gov/ecotox/ecossl	To be considered	The eco-SSLs are generic; they are calculated without site-specific information. They are used for site "screening" and as initial cleanup goals if applicable.
Risk Management Criteria for Metals at BLM Mining Sites	Provides nonregulatory risk management criteria for human health and wildlife, which provide numerical action levels for metals in environmental media. Criteria are derived using EPA-acceptable levels of	Ford, K.L, 2004, Risk Management Criteria for Metals at BLM Mining Sites (Technical note 390) and BLM, 1998, Interim Revision of Wildlife Management Criteria	To be considered	BLM risk management criteria for metals at mining sites used to evaluate the potential risk posed by metals; criteria have been developed for human (camper, ATV driver, and worker), livestock, and wildlife receptors.

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
	risk and standard exposure assumptions.			
EPA Risk Screening Levels (RSLs)	Provides nonregulatory screening criteria for the protection of ecological and human health receptors.	http://www.epa.gov/region9/superfund/prg/	To be considered	The RSLs are generic; they are calculated without site-specific information. They are used for site "screening" and as initial cleanup goals if applicable.
RCRA Subtitle C	Excludes from hazardous waste classification solid waste from the extraction, beneficiation, and processing of ores and minerals	40 CFR §261.4(b)(7), RCRA § 3001(a)(3)(A)(ii) (Bevill Amendment), and 42 USC § 6921(a)(3)(A)(ii)	Applicable	On-site encapsulation of mine waste will not be regulated under hazardous waste disposal and landfill regulations. Mine waste piles at the site are from the extraction of minerals, therefore do not warrant regulation as hazardous waste and are not subject to RCRA Subtitle C regulation.
State				
Colorado Air Pollution Prevention and Control Act	Applicants for construction permits are required to evaluate whether the proposed source will exceed air quality standards.	5 CCR 1001-14	Applicable	Construction activities associated with the remedial action at the Hope Mine Site would be limited to generation of fugitive dust emissions. If necessary, compliance will be met with air quality requirements by adhering to a fugitive emission dust control plan prepared in accordance with Regulation

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
				No. 1
Proposed Soil Remediation Objectives Policy Document	Proposes guidance in establishing soil cleanup standards.	CDPHE HMWMD, December 31, 1997	To be considered	On-site encapsulation of contaminate soil will meet soil cleanup standards.
Provisional Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers	Guidance for assessing impacts to aquatic life and habitat conditions caused by human induced erosion and deposit of materials in aquatic systems.	Colorado Water Quality Control Commission Policy 98-1, June 1998	To be considered	Area of contamination is adjacent a stream. If erosion and deposition of contaminated soil into the stream is an outcome of the remedial action this guidance will be applicable.

Table 4-2. Location-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
Federal				
Endangered Species Act	Provides protection for threatened and endangered species and their habitats.	16 USC § 1536(a),(h)(1)(B)	Relevant	Threatened and endangered species are listed for Pitkin County. If threated or endangered species are encountered during the remedial activities at the Hope Mine Site, then requirements of this act would be applicable.
Migratory Bird Treaty Act	Protects almost all species of native migratory birds in the US from unregulated “take".	16 USC § 703	Relevant	If migratory birds are encountered during the remedial activities at the Hope Mine Site, then requirements of this act would be applicable.
Wilderness Act	Limits activities within areas designated as wilderness areas or National Wildlife Refuge Systems.	16 USC 1311; 16 USC 668; 50 CFR 53; 50 CFR 27	Relevant	If there are areas within the Hope Mine Site boundary that are designated as wilderness areas or National Wildlife Refuge Systems, then requirements of this act would be applicable.
National Historic Preservation Act	Establishes a program for the preservation of historic federal properties within the US.	16 USC § 470-470x-6 36 CFR 800 40 CFR § 6.301(b)	Relevant	If structures within the Hope Mine Site boundary are classified as being of historic importance according to available records and/or the site is on the National Register of Historic Places, then requirements of this act would be applicable.
National Historic Preservation Act	Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction	16 USC §§ 470	Applicable	Applicable if remediation activities occur in areas previously undisturbed where there is a potential to affect archaeological or historical data.

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
	project or a federally licensed activity or program.			
Archaeological Resources Protection Act	Prohibits unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources located on public lands unless such action is conducted pursuant to a permit.	16 USC § 470aa-470mm (Public Law No. 96-95)	Applicable	Applicable if it is determined that archaeological resources are potentially present in area of excavation.
State				
Colorado Historical, Prehistorical, and Archaeological Resources Act	Concerns historical, prehistorical, and archaeological resources; applies only to areas owned by the State or its political subdivisions.	CRS § § 24-80-401 to 410 1301 to 1305	Relevant and Appropriate	May be relevant and appropriate if the remedial action impacts an archaeological site.
Colorado Register of Historic Places	Authorizes the State Historical Society to nominate properties for inclusion on the State Register of Historical Places.	CRS § § 24-80.1-101 to 108	Relevant	Applicable if remedial action activities impact an area listed on the register.
Nongame, Endangered or Threatened Species Act	Standards for regulation of nongame wildlife and threatened and endangered species.	CRS § § 33-2-101 to 108	To be considered	Threatened and endangered species are listed for Pitkin County. If threatened or endangered species are encountered during the remedial activities at the Hope Mine Site, then requirements of this act would be applicable.

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
Colorado Species of Special Concern and Species of Undetermined Status	Protects species listed on the Colorado Division of Wildlife generated list.	Colorado Division of Wildlife Administrative Directive E-1, 1985, modified	Potentially Applicable	Species of concern and species of undetermined status are listed for Pitkin County. If species on this list are encountered during the remedial activities at the Hope Mine Site, then requirements of this act would be applicable.
Colorado Natural Areas	Protects listed plant species of special concern.	Colorado Revised Statutes, Title 33 Article 33, § 104	To be considered	Although not protected by State statute, coordination with Division of Parks and Outdoor Recreation is recommended if the remedial action impacts plant species on the list.

Table 4-3. Action-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
Federal				
Clean Water Act	Construction that disturbs at least 1 acre must use best management practices to control storm water discharges.	Clean Water Act §402 40 CFR § 122.44(k)(2) and (4)	Applicable	Applicable since remedial activities will disturb more than 1 acre of land.
Corrective Action Management Units and Temporary Units Regulations	These regulations allow for the designation and creation of a CAMU for the on-site consolidation of contaminated soil and debris.	40 CFR 264 Subpart S, and 40 CFR Part 264.552(c)	Relevant and Appropriate	These rules may apply if an on-site encapsulated soil cell is constructed to contain excavated mine waste piles, and mining equipment.
RCRA Subtitle C	Specifies hazardous waste identification, management, and disposal requirements	42 USC § 6901, 40 CFR Parts 260 to 279	Potentially Applicable	Planned remedial actions do include off-site disposal of waste. However, if mine waste and/or soil is disposed of off-site and is considered hazardous waste, the requirements of this subtitle are applicable.
RCRA Subtitle D	Establishes guidelines for the management of nonhazardous solid waste.	Establishes guidelines for the management of nonhazardous solid waste.	Potentially Applicable	Planned remedial actions do include off-site disposal of waste. However, if mine waste and/or soil is disposed of off-site and is considered non-hazardous waste, the requirements of this subtitle are applicable.
State				
Colorado Air Pollution Prevention and Control Act	Regulation No. 1 provisions concerning fugitive emissions for roadways, construction activities, storage and	5 CCR 1001-3; § III.D.1.a,b,c,d. § III.D.2.a,b,c,e,f,g,h.	Applicable	Construction activities associated with the remedial action at the Hope Mine Site would be limited to generation of fugitive dust emissions. If necessary, compliance will be met with air quality requirements by

Standard, Requirement, Criteria, or Limitation	Description	Citation	Applicable or Relevant and Appropriate	Comments
	stockpiling activities, haul roads, haul trucks, and waste rock ponds are applicable.	Regulation No. 1		adhering to a fugitive emission dust control plan prepared in accordance with Regulation No. 1
Colorado Water Quality Control Act, Storm Water Discharge Regulations	Establishes requirements for storm water discharges (except portions relating to site-wide surface and groundwater).	5 CCR 1002-2	Applicable	Substantive requirements for storm water discharges associated with construction activities are applicable. A Storm Water Management Plan will be prepared, if required.
Colorado Mined Land Reclamation Act	Regulates all aspects of land use for mining, including the location of mining operations and related reclamation activities and other environmental and socio-economic impacts.	CRS 34-32-101 to 125; Rule 3 of Mineral Rules and Regulations	Relevant and Appropriate	Substantive requirements of portions of Rule 3 regarding Reclamation Measure, Water - General Requirements, Wildlife, and Revegetation are potentially relevant and appropriate.
Colorado Hazardous Waste Regulations	Regulates the handling and disposal of hazardous waste.	6 CCR 1007-3, Part 264	To be considered	Mine waste present at the site is not considered hazardous waste, thus RCRA provision related to the handling of mine waste are not applicable. However, if during the remedial action the mine waste is designated hazardous waste, then this regulation applies.
Regulations on the Collection of Aquatic Life	Requirements governing the collection of aquatic life sample for scientific purposes.	2 CCR 406-8, Ch. 13, Article III, § 1316	Relevant and Appropriate	Area of contamination is adjacent a creek containing aquatic life. However, the remedial action within the Hope Mine Site will not include biological monitoring.

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SECTION 5 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section documents the process of identifying and screening removal technologies that are potentially applicable to the Hope Mine site. Potentially applicable technologies are identified based on available site characterization data and known physical site conditions. Technologies identified are then either retained for further consideration or screened out, based on an evaluation of their ability to effectively address site concerns. The technologies that are retained for further consideration in the EE/CA are then assembled into removal action alternatives to address the site-specific RAOs.

5.1 IDENTIFICATION AND SCREENING OF REMOVAL ACTION TECHNOLOGIES

In accordance with EE/CA guidance, technologies and associated process options having the highest potential for success at the Hope Mine site were identified for preliminary screening evaluation. The screening determination identifies whether the given process option will be retained for further consideration in assembling candidate removal action alternatives. A discussion of the rationale used to retain or eliminate technologies and process options is provided in this section.

5.1.1 No Action

Evaluation of the no action scenario is required by the National Contingency Plan (NCP), 40 CFR § 300,430(e)(6). The no action scenario represents a baseline condition against which other removal actions are compared.

5.1.2 Site Fencing

Physical access restrictions prevent access for recreational users, future miners, or other site visitors to impacted areas of the site using fencing, signage, and routine security inspections. Physical access restrictions are retained for further consideration because they are a reliable method of controlling direct human contact with physical and chemical site hazards.

5.1.3 Deed Restrictions

Deed restrictions may include modifying conditions of the current property and mine claim deeds to limit certain types of land uses to supplement the protectiveness of other actions taken as part of an overall site remedy. Such restrictions typically continue into the future or "run with the land." Deed restrictions remain in effect with property transfers to new owners. Future building restrictions in certain portions of the site, such as for an information kiosk, may be an appropriate type of deed restriction when combined with other site control measures. Deed restrictions would be subject to approval between the USFS and PRPs.

Proprietary land use or deed restriction agreements may be required between the USFS, PRPs, and/or EPA related to title considerations for land used in a removal action. Agreements would specify restrictions on future earthwork or construction of dwellings on or near the site. These restrictions would be enforced by the USFS, and would remain in force unless removed by a court order. Legal access restrictions are retained for further consideration because they are potentially applicable if impacted materials remain onsite as part of the removal action.

5.1.4 Grading

Grading is used to alter the ground surface contour of an area such that surface water runoff is directed along desired routes. Site plans are developed to establish an overall grading design to optimize surface water conveyance around and away from impacted areas of the site, or in strategic locations across the

site. Grading is considered potentially applicable to restore excavated areas and to limit infiltration rates into areas where mine waste and impacted soil remain onsite, and is retained for further consideration.

5.1.5 Diversion

Diversion may include construction or modification of features such as ditches, channels, and berms used to direct or divert surface water flow downslope, away from mine waste or impacted soils. Diversion is considered applicable to reduce erosion to areas where mine waste and impacted soil remain onsite, but would not mitigate slope stability concerns at the Hope Mine, and is eliminated from further consideration.

5.1.6 Surface Water Collection

Surface water storage in a surface impoundment or reservoir in a desired location is used to equalize surface water runoff from a site. This technique is implemented in conjunction with diversion structures (e.g., ditches or channels). The surface water collection process option is eliminated from further consideration since surface water runoff from the site can be adequately conveyed without equalization.

5.1.7 Revegetation

Replacing vegetation following disturbance of the ground surface will mitigate soil erosion and surface water infiltration and runoff. Roots from cover plants hold the soil in place, preventing wind and water erosion. Revegetation can also reduce infiltration of water into surface materials through interception of water by plant root systems and transpiration mechanisms. Revegetation is typically performed in conjunction with placement of clean fill and soil covers. For this site, revegetation includes topsoil replacement and planting native ground cover. Establishing vegetation can also be effective in enhancing the stability and permanence of cover systems. Revegetation is retained for further consideration.

5.1.8 Monitored Natural Attenuation

Natural attenuation processes are commonly used for remediation of contaminated sites. A variety of natural processes occur without human intervention at all sites at varying rates and degrees of effectiveness to attenuate (i.e., decrease) the mass, toxicity, mobility, volume, or concentrations of organic and inorganic contaminants in soil, groundwater, and surface water systems. The EPA uses the term "monitored natural attenuation" (MNA) when referring to the reliance on natural attenuation processes, within the context of a carefully controlled and monitored site cleanup approach, to achieve site-specific remedial objectives within a time frame that is reasonable compared to other more active methods. MNA requires more complex and costly site characterization prior to implementation, long-term monitoring, and potential of continued migration, and/or cross-media transfer of contaminants. Metals do not degrade over time and natural attenuation of the intertidal mine waste has not occurred to date and it is not expected that it will occur in the future. As such, MNA has been eliminated from further consideration.

5.1.9 HDPE Liner and Cover

High-density polyethylene (HDPE) is used as a liner material and a cover for stockpiled mine waste and impacted materials. Placement of HDPE liner and cover would prevent direct exposure of the materials to the environment or receptors, and significantly reduce the potential for leaching of the constituents of concern. HDPE liners and covers are retained for further consideration.

5.1.10 Soil and Waste Rock Cover

Onsite waste rock can be used to prevent direct contact with mine waste and impacted materials to human and ecological receptors, reduce erosion, and provide a media for revegetation. Soil materials at the site

are limited in quantity, and any soil to be used as cover material would have to be imported from an offsite borrow source. Soil and waste rock covers are retained for further consideration.

5.1.11 Clay Cover

A clay cover consists of low permeability clay layers approximately 6 to 12 inches thick. Clay covers are commonly specified instead of soil covers to further minimize surface water infiltration. Clay covers are typically used in landfill cover designs where strict control of leaching COCs into the subsurface environment is desired. Due to the lack of local material sources and remoteness of the site, and since adequate infiltration control could be achieved by other means, clay covers are not retained for further consideration.

5.1.12 Clean Fill

Clean fill material is used to perform grading activities and to place in excavated areas. A source for fill materials such as borrow material (soil) would have to be identified and transported to the site from an offsite borrow source; waste rock, however, is available onsite and can be crushed as needed. Thus, this option is retained for further consideration.

5.1.13 Excavation

Excavation techniques employ the physical removal of impacted materials to eliminate future receptor exposure. Excavation technologies typically involve conventional earthmoving construction equipment. Equipment such as backhoes and dozers would be satisfactory for excavating and moving mine waste. Mine waste and impacted soil beneath the mill site itself would be excavated by hand to preserve the structural integrity of the remaining historic mill features. Excavation techniques used at the site may require dust control measures in disturbed areas to prevent particulate inhalation. Dust control typically involves using water sprays to suppress particulate suspension.

Excavation would be required under scenarios which involve removal of mine waste from the high water zone. Excavated materials may be required to remove miscellaneous debris such as timber and logs in various portions of the mine waste. Excavation is retained for further consideration.

5.1.14 Transportation

Transportation technologies typically involve the use of conventional materials handling equipment, such as excavators, to transport excavated materials either onsite or offsite. As with excavation activities, transportation activities would include dust control measures to prevent particulate suspension around the site when equipment is in use. Transportation is retained since it is necessary to move excavated materials for most removal options.

5.1.15 Consolidation, Onsite Stockpile

An onsite repository would be constructed to consolidate the materials in one location for long-term care. Repositories are typically capped with an engineered low-permeability cover system, and may also be revegetated. Consolidation in an onsite repository allows for maintaining mine waste and impacted materials in a controlled environment. An appropriate cover can minimize or eliminate exposure pathways to potential human and ecological receptors. Consolidation in an onsite repository is retained for further consideration.

5.1.16 Capping In-Place

Capping in-place involves the use of covers described above on top of contaminated materials, without transporting and consolidating materials in a controlled stockpile first. Capping in-place typically works best under the following conditions:

- Contaminant sources have been sufficiently abated to prevent recontamination of the cap;

- Contaminants are of moderate to low toxicity and mobility;
- Costs and/or environmental effects are very high; and
- Site conditions do not necessitate removal of contaminated material.

Conceptually a surface cap would consist of a geotextile layer over the impacted areas followed by a sand isolation layer, a gravel erosion control layer, and then an organic soil habitat layer to support vegetation. Capping in-place would not include placement of an underlying impermeable liner, and as such, would not be completely effective in meeting RAOs involving migration-to-groundwater/surface water pathways and slope-stability. In addition capping in-place would not increase the stability to slope of the North Waste Pile and would likely have a destabilizing effect. Thus, this alternative is not retained for further consideration.

5.1.17 Permitted Offsite Disposal

Offsite disposal involves transporting and placing material in an engineered containment facility located outside of the site boundaries. Advantages of using existing offsite disposal facilities include removing mine waste and impacted materials from the site for permanent disposal for long-term protection of human health and the environment. Offsite disposal is retained for further consideration.

5.1.18 Stabilization

Stabilization techniques commonly use Portland cement as the primary stabilization agent, and can be conducted as either an in-situ or ex-situ process. For ex-situ stabilization, the work would involve excavation, crushing or processing of impacted materials, and adding a stabilization agent, such as Portland cement and potentially other pozzolanic materials, to reduce or eliminate the mobility of metal constituents through chemical and physical binding into a stable mass. This option may be combined with a cover option to further reduce potential exposure pathways.

Cement-based stabilization involves mixing the materials with an appropriate ratio of cement, pozzolan, and water. The composition of the mixture determines set time, cure time, and material properties for placing the treated waste. Binder addition would increase waste volumes to be handled and disposed, typically ranging from 10 to 30 percent depending on the chemical nature of the waste materials. The ratio of cement and need for pozzolans to effectively treat waste materials is determined through predesign laboratory treatability testing.

Most metals are amenable to cement-based stabilization, which tend to form insoluble hydroxides in the basic pH ranges commonly found in cement. The required proportions for the mine waste at the Hope Mine site would be based on treatability testing results. This technology is viable, and is retained for further consideration. However, stabilized materials are subject to weathering, so a soil cover would still be required and stabilization would increase the volume of materials requiring disposal.

5.1.19 Metals Recovery

Metals recovery from mine waste materials may be achieved using various reprocessing techniques including pyrometallurgical and hydrometallurgical processes. Pyrometallurgical processes expose materials to elevated temperatures under controlled conditions to recover pure metals or metal oxides. Hydrometallurgical processes involve the dissolution of target metal species in the solid materials into a solution using pH control, followed by their precipitation as elemental or other commercially acceptable chemical forms. Both pyrometallurgical and hydrometallurgical processes are commercially available, and well understood. However, metals recovery from site waste materials is not retained for further consideration because metals concentrations in the waste pile are below concentrations necessary for cost-effective use of the technology.

5.1.20 Biochar

Biochar is a carbon negative, charcoal based, soil amendment that can be designed to help reclaim and improve marginal soils by increasing soil water holding capacity and enhancing fertility, while also generating high-value renewable energy co-products during its production. If deployed correctly, the Biochar process is carbon negative: it removes net carbon from the atmosphere. When a green plant grows, it takes carbon dioxide (CO) out of the air to build biomass. All of the carbon in the plant came from CO_2 taken out of the air, and returns to the air when the plant dies and decomposes. When the biomass is instead pyrolyzed—heated in the absence of oxygen—it produces charcoal, which is called Biochar when it is buried in the ground. Over 40% of the total carbon from the waste biomass is retained in Biochar and sequestered in the soil for thousands of years, effectively removing that carbon from the atmosphere.

A "top soil" may be created on top of mine waste repositories by applying a 3-inch layer of compost and Biochar to the surface of the repository cap with a conveyer belt and hydroseeding with a mixture of native grasses. In past applications of Biochar by the USFS at Hope Mine, geotextile material was stapled to the ground surface to help hold the Biochar amendment in place; several waddles/retention logs were also installed.

This technology is retained for use at the Hope Mine site. However, the costs of this technology are not included in the analysis of Alternatives in Section 5.3. Biochar is retained for optional use as a soil amendment for enhanced vegetation and erosion control. An estimate of the cost to apply the Biochar over the area of the repository is $80,000 based on the cost of the previous Biochar amendment activity at the Hope Mine.

5.2 EVALUATION CRITERIA

Each of the potential removal action alternatives is evaluated against a prescribed set of criteria based on EPA guidance. The potential removal action alternatives will be evaluated based on:

- Effectiveness
  - Protectiveness of human health and the environment, including workers during implementation
  - Short and long-term effectiveness
  - Reduction of toxicity, mobility, or volume (through treatment) of contaminants
  - Ability to achieve the removal objectives
- Implementability
  - Technical feasibility
  - Availability of required services, materials, and equipment
  - Administrative feasibility
  - Maintenance and monitoring requirements
  - Construction feasibility
- Cost (budget costs for comparative analysis)
  - Capital cost (direct and indirect capital costs)
  - Post-removal site control or operation costs
  - Present value cost, if needed

5.2.1 Effectiveness

This criterion addresses the ability of an alternative to maintain protection of human health and the environment and the magnitude of residual risk remaining at the Site after the removal objectives have been met (long-term effectiveness). The criterion addresses the EPA preference for selection of remedies that permanently and significantly reduce the toxicity, mobility, and/or volume of impacted materials through treatment.

The criterion also addresses the ability of an alternative to comply with all ARARs and its short-term effectiveness. The short-term effectiveness criterion addresses the effects of the alternative during implementation before removal objectives have been met. Alternatives should also be evaluated with respect to their effects on human health and the environment following implementation. The following factors will be addressed as appropriate for each alternative:

- Protection of the Community – addresses any risk to the affected community that results from implementation of the proposed action, whether from air quality impacts, fugitive dusts, transportation of hazardous materials, or other sources.
- Protection of Workers – assesses any threats to site workers and the effectiveness and reliability of protective measures that would be taken.
- Environmental Impacts – evaluates the potential adverse environmental impacts from the implementation of each alternative. The factor also assesses the reliability of mitigation measures in preventing or reducing the potential impacts.

5.2.2 Implementability

This criterion evaluates the technical and administrative feasibility (i.e., the ease or difficulty) of implementation of each alternative. It also considers the availability of services and materials required for implementation and State and community acceptance of the alternative. The following factors will be addressed when evaluating the ability of alternatives to satisfy this criterion:

- Technical difficulties, site constraints, and any uncertainties associated with the implementation of an alternative.
- The reliability of each alternative and the likelihood that technical problems associated with implementation of the alternative would lead to schedule delays.
- The ease of undertaking additional actions to replace or augment the original alternative and the ability to monitor the effectiveness of the remedy.
- Activities needed to coordinate with regulatory agencies to implement an alternative. The ability and time required to obtain necessary approvals and permits from other agencies for any off-site actions, as required.
- Availability of services and materials, necessary equipment, and qualified professionals.

5.2.3 Cost

This criterion evaluates the estimated cost of each alternative. These costs include direct capital costs (i.e., costs to perform the alternative), indirect capital costs such as design expenses, permit fees (if appropriate), and annual post removal site control (PRSC) costs including monitoring and operation and maintenance (O&M) costs. The long term monitoring and operating costs include 30-year present value costs, which represent the dollar amount needed to be set aside at the initial point in time (base year) to assure that funds will be available in the future to pay for PRSC and O&M costs.

The costs presented are based on certain assumptions applicable to each removal action alternative and are only for comparative analysis so if all things are equal, a decision can be based on the cost factor alone. The removal action alternatives presented in the EE/CA are at a conceptual design stage only and do not provide specific design details to allow development of a "true" cost estimate. The costs presented here are budget costs (consisting of labor and materials) and may be somewhat higher or lower than actual costs to account for some uncertainties such as future cost fluctuations and final design details.

5.3 IDENTIFICATION AND ANALYSIS OF SELECTED REMOVAL ACTION ALTERNATIVES

The potential removal action alternatives for the Hope Mine Site were evaluated using the evaluation criteria described in Section 5.1. A general description of the conceptual design of each alternative and discussion of the pros and cons are presented in the following subsections. Final design specifications and features of the actual remedy may differ from the conceptual design described herein.

Based on the analysis of the nature and extent of contamination presented in Section 2.0 and on the RAOs developed in Section 3.0, this section identifies and assesses a limited number of alternatives that are either appropriate for meeting RAOs, or are provided for comparative analysis purposes. The alternatives identified and analyzed in the following subsections are considered well established remedies because they have been selected in the past at similar sites and/or for similar contaminants. Remedial options and technologies were screened and assembled into the following four removal action alternatives identified and evaluated in this section:

- Alternative 1 - No Action
- Alternative 2 – Partial Excavation, Consolidation in Onsite Repository, Stabilization and Capping
- Alternative 3 – Total Excavation, Relocation to Onsite Repository, Stabilization and Capping
- Alternative 4 – Excavation and Disposal Off-Site

Physical hazards present at the site, such as those associated with the underground mine workings and glory holes, do not constitute a release of hazardous substances at the site and are outside the scope of this EE/CA report.

Two on-site locations were evaluated for the construction of a consolidation repository and a newly constructed on-site repository located within the mine site property boundary (Figure 5-1). The two locations were judged to be potentially suitable sites for use as a mine waste-rock repository based upon the results of the geology, ecologic and engineering reconnaissance, the site investigation and the available geotechnical laboratory test results. No fatal flaws or conditions that would adversely affect a mine waste-rock repository at these locations were observed. As discussed in the operational history of the Hope Mine Site; a significantly small amount mined material milling occurred during Hope Mine Site operations. Therefore, the remedial actions to be considered will be the management of mined waste rock with minimal environmental impacts once managed in such a manner as to lessen the potential for mined waste-rock constituents released into the environment via surface and ground water flows to Castle Creek drainages.

For each of the "Action" alternatives; a storm water management system would be constructed to collect storm water run-on to the repository site(s), contain, divert, and release run-on waters down-stream of the waste-rock repository. Storm water run-off water from the capped or un-capped stabilized mine waste-rock repository (consolidated or re-located) would be collected and contained on-site by means of collection channels and retention ponds without release to the Castle Creek drainage. Both the run-on and run-off channels would be lined with geo-textile and sized rip-rap. Crest and constructed areas may be revegetated with soils amended with a vegetation amendment. Retention basins would be lined with rip-

rap and provided with a re-enforced concrete over-flow structure to release the flow from 500-year storm events captured from the capped repository run-off collection system.

5.3.1 Alternative 1 – No Action

Evaluation of the no action scenario is required by the National Contingency Plan (NCP), 40 CFR § 300.430(e)(6). This alternative is retained throughout the process and represents a baseline condition against which other removal actions are compared. The No Action Alternative consists of allowing the site to remain in its present condition, with no measures taken to reduce or monitor contaminant concentrations; therefore, mine waste slope stability concerns will not be addressed and no short-term or long-term risk reduction would be achieved. This alternative would not meet the RAOs identified for the removal action.

Effectiveness

The No Action alternative would not mitigate the slope stability concerns of the mine waste pile or reduce potential human or ecological exposure to COCs (arsenic, barium, chromium, copper, lead, manganese, nickel, and zinc). . As such, the potentially unstable mine waste pile would remain in place and would continue to pose potential unacceptable risks to humans and wildlife. In addition, no action would be taken to reduce or eliminate the erosion of waste materials to soil and sediment, and the waste material could impact downstream sediment. This alternative would not reduce or eliminate the risk to humans and wildlife. As a result, the effectiveness of Alternative 1 is low.

Implementability

No action would be required to implement Alternative 1; therefore, this alternative would be readily implementable and administratively feasible. No federal agency authorization would be required to implement this alternative. No services or materials would be needed for the implementation of this alternative. As a result, the implementability of Alternative 1 is high. However, regulatory and community acceptance of this alternative is assumed to be low, because physical and chemical risks would still remain at the site.

Cost

No costs are associated with Alternative 1, other than nominal long-term administrative costs; therefore, the cost rating for Alternative 1 is high.

5.3.2 Alternative 2 – Partial Excavation, Consolidation in Onsite Repository, Stabilization and Capping

Alternative 2 includes excavating site soils in the vicinity of the North Waste Pile, and the removal and relocation of material from the mine waste pile to a designated on-site impoundment area. The extent of site materials to be removed during this alternative is shown in Figure 5-1. A total of 8,000 CY of mine waste was estimated to require removal, based on the slope stability requirements of a 2:1 side-slope, and the need to remove mine waste to 10 feet above Castle Creek to minimize direct erosion (Section 2.6.3). Assuming a bulk density of 1.95 tons/CY, approximately 16,000 tons of material would require removal.

In Alternative 2, the on-site consolidation site repository will be located uphill of the existing Northern Waste Pile and the adjoining Southern Waste Pile to the south shown in Figure 5-1. The plan view of the consolidation repository would be approximately 75 feet (west to east) and 300 feet (north to south) with an average depth of 12-feet on a slope of 2:1. The on-site repository would be placed no less than 10 feet in elevation above Castle Creek to prevent degradation or slope stability issues due to creek flooding. The consolidation area would allow for the removal and relocation of approximately 8,000 CY of mined waste-rock from the flood plain of Castle Creek, to be consolidated on the upper portion of the north and south mine waste-rock piles. The area would be cleared of trees, brush, and other miscellaneous debris,

and prepared for material placement.Heavy equipment/machinery would be necessary to efficiently implement this alternative. To construct the repository, excavate and transfer impacted materials, as well as construct runon-runoff control structures as necessary, equipment requirements would include, but not be limited to, a bulldozer, front end loader, and excavator. Silt fencing may need to be installed along the edge of Castle Creek during earthmoving work.

The excavation work in all areas would be performed using conventional excavation and material handling equipment, and the mine waste and impacted soil would be segregated from non-impacted debris, such as logs and miscellaneous timbers. Material segregation would be accomplished using visual observations to direct the horizontal and vertical extent of the excavation work.

The underlying base of the on-site consolidation repository would not have a bottom liner-system. The relocated mine waste-rock would be placed on top of, and adjacent to the existing upper mine waste rock pile materials after it has undergone stabilization through mixing with a Type II/IV cement in the following manner. Prior to placement of the mine waste-rock into the constructed repository relief, the mine waste rock materials would be combined with Type II/IV cement at a ratio of 5% to 10% cement to stabilize the waste rock and to encapsulate any free inorganic sediment that would have the potential to migrate if ground water infiltrated the repository. Mined waste-rock would be placed and compacted within the repository in lifts not exceeding12-inches.

In accordance with NESHAP compliance procedures outlined in 40 CFR 61 Subpart M §61.151(a), the on-site consolidation repository would be covered with a cap system comprised of a top screened (minus 1”) protective soil/rock layer of 1-foot, on which a composite geo-textile/geo-net/geo-textile blanket would be placed. Using on-site excavated materials; a 3-foot earthen cap would be placed and compacted over the geo-fabric/geo-net/geo-fabric layer. A vegetation amendment will be added to the top six inches (6”) of the 3-foot cover cap, or according to manufacturers’ specifications, to promote site repository revegetation with the specified seed mixes.

The stabilization and earthen cap would be designed to accomplish the following objectives:

- Prevent exposure by dermal contact, inhalation, or incidental ingestion of mine waste and impacted soils;
- Prevent access from burrowing animals;
- Provide stability against slope failure and resist erosion; and
- Limit infiltration and migration of water through the materials.

The excavated areas would be regraded as necessary and shaped to ensure positive drainage. Native grass seed would be placed in regraded areas to initiate the revegetation process to the extent practicable.

The estimated time to construct storm water run-on and run-off controls, consolidate the mine waste-rock dump and its closure and site revegetation is 3.5 to 4.0 months (Appendix E).

The institutional controls would include deed restrictions and signage at the mill site. Physical access restrictions such as fencing around the footprint of the repository to prevent activities that could compromise the soil cover, such as damage from ATVs or backhoes, may also be implemented. Land use restrictions would be implemented at the repository to prevent activities that could compromise the soil cover. Prohibited activities would include: excavation, spreading, or disturbance of surface and subsurface soils and would be specified in deed restrictions at the Hope Mine site. Periodic monitoring and maintenance would be required indefinitely to verify that the cover remains intact and performs as intended.

Effectiveness

Alternative 2 would be effective because the mine waste threatening Castle Creek would be moved, stabilized, and capped thus reducing the risk to humans and wildlife from contaminated materials and physical hazards. Excavating and consolidating the excavated mine waste rock and capping would have long-term effectiveness providing long-term inspection and maintenance of the cap is performed. Capping the consolidated materials with clean material provides the necessary barrier for receptors and eliminates the possibility of physical contact so that human receptors and wildlife that come upon the Site will not be exposed to the waste source material. Burrowing animals have the potential to compromise the cover by bringing capped waste source material back to the surface with their burrowing activities; however, because the cap will consist of 3 feet of earthen cover, the potential for burrowing will be reduced.

However, long-term period O&M would be required to ensure the long-term integrity of the cap and that it is not compromised by natural erosion or human activities. It is expected that chemical-specific ARARs would be met over the long-term. The RAOs would be met under Alternative 2.

This alternative meets both short-term and long-term effectiveness. As a result, the effectiveness of Alternative 2 is moderately high.

Implementability

This alternative is readily implementable using existing construction technologies. Excavation and consolidation of the mine waste material can be implemented with locally available, standard earth moving equipment and local contractors once equipment is mobilized to the Site. Encapsulation of contaminated materials is a proven technology that has been used extensively for mine waste treatment.

Because mine waste is exempt from RCRA waste disposal criteria while it is located within a former mining area [40 CFR §261.4(b)(7)], on-site encapsulation of mine waste would not be regulated under hazardous waste disposal and landfill regulations. However, other federal or state requirements regarding appropriate siting, construction, and long-term inspection and maintenance may apply.

The proposed location for the on-site repository immediately uphill of the North Waste Pile and South Waste Pile would be easily implementable because it is relatively open, and covers an area of approximately 0.5 acres in the center of the site. The final decision regarding the location for the repository would be made during the design phase of the project.

Regulatory and community acceptance of this alternative is assumed to be high, given the overall benefits of restoring the area to its natural condition and improving recreational areas at the site. As a result, the implementability of Alternative 2 is high.

Cost

As shown in Table 5-2 and Table 6-1, the estimated capital cost for implementing this alternative is $1,956,950, with a present value cost, including annual LUC and O&M annual costs, totaling between $1,526,640 and $3,271,372. These costs were estimated with a similar level of available data and detail as the “Screening of Alternatives” phase of a Feasibility Study, with an expected accuracy range of -30 to +50 percent (EPA, 2000).The detailed cost estimate is included in Appendix E.

5.3.3 Alternative 3 – Total Excavation, Relocation to Onsite Repository, Stabilization and Capping

Alternative 3 includes excavating all mine waste in the vicinity of the North Waste Pile, and relocation of material from the mine waste pile to a designated on-site impoundment area shown in Figure 5-1. . A total of 15,300 CY of mine waste are estimated to require the complete removal of the mine waste from

the North Waste Pile location (Section 2.6.3). Assuming a bulk density of 1.95 tons/CY, approximately 30,000 tons of material would require removal.

The potential on-site relocation repository location chosen for Alternative 3 was determined using site topographical information (Figure 1-2 and Figure 5-1). This location is approximately 1,000 feet south and east of the Hope Mine adit entrance. The potential site is approximately 2,000 feet parallel to Castle Creek and approximately 1,000 feet wide. The on-site repository for the relocation of the entire mine waste-rock dump would have approximate plan view dimensions of 350 feet north to south and 100 ft west to east. The average repository depth would be approximately 10 feet sloped downhill, west to east, at a maximum 2:1 slope ratio. The average slope of the potential site is approximately 10% down slope to Castle Creek. The potential site has sufficient footprint and existing drainage terrain with additional drainage excavation. The repository would be constructed within the hillside and above the identified flood-plain, which is suitable for the required repository, capping and drainage systems. Site access would be achievable from Castle Creek Road located to the west of the site.

Heavy equipment/machinery would be necessary to efficiently implement this alternative. To construct the repository, excavate and transfer impacted materials, as well as construct runon-runoff control structures, equipment requirements would include, but not be limited to, a bulldozer, front end loader, and excavator. Silt fencing would be installed along the edge of Castle Creek during earthmoving work. The excavation work in all areas would be performed using conventional excavation and material handling equipment, and the mine waste and impacted soil would be segregated from non-impacted debris, such as logs and miscellaneous timbers. Material segregation would be accomplished using visual observations to direct the horizontal and vertical extent of the excavation work.

In accordance with NESHAP compliance procedures outlined in 40 CFR 61 Subpart M §61.151(a), the on-site repository would be covered with a cap system comprised of material excavated from the surface soil of the repository. It would include a repository drainage system constructed on its perimeter, including: a one foot thick layer of minus ¾-inch under drainage rock wrapped in geo-textile wrapped, with perforated drainage pipe embedded within this repository perimeter toe drainage collection system. The drainage layer would be encapsulated within geo-textile fabric for collection efficiency and filtration of fine sediment materials collected with groundwater and surface water entering the system along the outside slopes of the constructed repository walls. The repository floor would be constructed with a sloped downhill gradient of 3%. The floor of the repository would be compacted and smooth steel-drum rolled. Prior to placement of the mine waste-rock into the constructed repository relief, the mine waste rock materials would be combined with Type II/IV cement at a ratio of 5% to 10% to stabilize the waste rock and to encapsulate any free inorganic sediment that has the potential for migration should ground water infiltrate the repository. Mined waste-rock would be placed and compacted within the repository in lifts not exceeding 12-inches. The underlying repository perimeter drainage collection system would be tied into the repository walls which would be covered with a geo-textile/geo-net/geo-textile collection blanket to promote intercepted drainage away from the place repository materials. Following the placement of cement –stabilized mine waste-rock into the repository, the repository would be covered with a top liner system comprised of a top screened (minus 1”) protective soil/rock layer one foot thick. This soil/rock layer would be covered with a composite geo-textile/geo-net/geo-textile blanket. Using material previously excavated from the on-site repository, a 3-foot thick earthen cap would be placed and compacted over the geo-fabric/geo-net/geo-fabric layer. A vegetation amendment will be added to the top six inches (6”) of the 3-foot cover cap, or according to manufacturers’ specifications, to promote site repository revegetation with the specified seed mixes.

A liner and cap would be designed to accomplish the following objectives:

- Prevent exposure by dermal contact, inhalation, or incidental ingestion of mine waste and impacted soils;
- Prevent access from burrowing animals;
- Provide stability against slope failure and resist erosion; and
- Limit infiltration and migration of water through the materials.

The excavated areas would be regraded and shaped to ensure positive drainage. Native grass seed would be placed in regraded areas to initiate the revegetation process to the extent practicable. Additionally, all excavated areas would receive a clean soil cover, seeding and a biodegradable erosion control fabric to allow for vegetative growth.

The estimated time to construct storm water run-on and run-off controls, relocate the existing mine waste-rock dump to the newly constructed on-site repository, and its closure and site revegetation is 4 to 4.25 months (Appendix E).

The institutional controls would include deed restrictions and signage at the mill site. Physical access restrictions such as fencing around the footprint of the repository to prevent activities that could compromise the soil cover, such as damage from ATVs or backhoes, may also be implemented. Land use restrictions would be implemented at the repository to prevent activities that could compromise the soil cover. Prohibited activities would include: excavation, spreading, or disturbance of surface and subsurface soils and would be specified in deed restrictions at the Hope Mine site. Periodic monitoring and maintenance would be required indefinitely to verify that the cover remains intact and performs as intended.

Effectiveness

Alternative 3 would be effective because the mine waste threatening Castle Creek would be removed and encapsulated, thus reducing the risk to humans and wildlife from contaminated materials and physical hazards. Excavating, relocating and stabilizing the entire North Waste Pile mine waste rock and capping would have long-term effectiveness if long-term inspection and maintenance of the cap is performed. Capping the consolidated materials with clean material provides the necessary barrier for receptors and minimizes the possibility of physical contact so that human receptors and wildlife that come upon the Site will not be exposed to the waste source material. Burrowing animals have the potential to compromise the cover by bringing capped waste source material back to the surface with their burrowing activities; however, because the cap will consist of 3 feet of earthen cover, the potential for exposure to mine waste rock through burrowing will be reduced.

However, long-term periodic monitoring and maintenance would be required to ensure the long-term integrity of the cap against natural erosion or human/animal activities. It is expected that chemical-specific ARARs would be met over the long-term. The RAOs would be met under Alternative 4.

This alternative meets both short-term and long-term effectiveness. As a result, the effectiveness of Alternative 4 is moderately high.

Implementability

This alternative is readily implementable using existing construction technologies. Excavation and consolidation of the mine waste material can be implemented with locally available, standard earth moving equipment and local contractors once equipment is mobilized to the Site. Stabilization and encapsulation of contaminated materials into onsite repositories is a proven technology that has been used extensively for mine waste treatment.

Because mine waste is exempt from RCRA waste disposal criteria while it is located within a former mining area [40 CFR §261.4(b)(7)], on-site encapsulation of mine waste would not be regulated under hazardous waste disposal and landfill regulations. However, other federal or state requirements regarding appropriate siting, construction, and long-term inspection and maintenance would apply.

The proposed location for the on-site repository, approximately 1,000 feet to the south of the Hope Mine site, would be easily implementable because it is relatively open, with a gentle slope adequate for accommodating the 0.8 acre repository footprint. The final decision regarding the location for the repository would be made during the design phase of the project.

Regulatory and community acceptance of this alternative is assumed to be high, given the overall benefits of restoring the area to its natural condition and improving recreational areas at the site. As a result, the implementability of Alternative 3 is high.

Cost

As shown in Table 5-2 and Table 6-1, the estimated capital cost for implementing this alternative is $2,322,520, with a present value cost, including annual LUC and O&M annual costs, totaling between $1,782,539 and $3,819,727. These costs were estimated with a similar level of available data and detail as the "Screening of Alternatives" phase of a Feasibility Study, with an expected accuracy range of -30 to +50 percent (EPA, 2000).The detailed cost estimate is included in Appendix E.

5.3.4 Alternative 4 – Excavation and Disposal Off-Site

Alternative 4 includes all actions associated with Alternative 3 with the additional of off-site disposal of the excavated material currently on site at North Waste Pile. As with Alternative 3, a total of 15,300 CY of mine waste are estimated to require removal based on field measurements. Assuming a bulk density of 1.95 tons/CY, approximately 30,000 tons of material would require removal and hauling for offsite disposal.

The removal action would begin by identifying a suitable offsite repository as designated by the USFS. The costs prepared for this EE/CA assume that a suitable repository can be located within 0.5 to 50 miles of Hope Mine. To accommodate the wastes deposited with a side slope of 2:1 and a thickness of 20 feet on relatively flat ground, the repository would require a square footprint of approximately 0.5 acres (22,500 square feet). The area would be cleared of trees, brush, and other miscellaneous debris, and prepared for material placement. The offsite repository would require the same construction requirements as the onsite repository of Alternative 2, including the soil cap. The need for underlying drainage, liners, and the stabilization of mine waste would be dependent on the site conditions of the off-site repository, and would be determined during final engineering design of the offsite repository.

Heavy equipment/machinery would be necessary to efficiently implement this alternative. To construct the repository, excavate and transfer impacted materials, as well as construct runon-runoff control structures as necessary, equipment requirements would include, but not be limited to, a bulldozer, front end loader, and excavator. Silt fencing would be installed along the edge of Castle Creek during earthmoving work.

A majority of the excavation work would be performed using a conventional excavator and front-end loader, and the mine waste would be segregated from non-impacted debris such as logs and miscellaneous timbers. Approximately 1,700 20-foot shipping containers would be required to transport this volume of material from the Hope Mine site to the offsite repository location. The shipping containers would be filled with a maximum of 18-tons of mine waste each, and covered. The containers would be designed to transport the excavated mine waste without the need for secondary containment in drams or other smaller containment vessels. Various trucks, depending on the volume and disposal facility location, would be

used to transport primary source materials and debris off site. To the extent practicable, excavated areas would be regraded to match preexisting natural contours and surroundings.

The excavated areas would be regraded as necessary and shaped to ensure positive drainage. Native grass seed would be placed in regraded areas to initiate the revegetation process to the extent practicable. Additionally, all excavated areas would receive a clean soil cover, seeding and a biodegradable erosion control fabric to allow for vegetative growth.

The institutional controls would include deed restrictions and signage at the offsite repository site. Physical access restrictions such as fencing around the footprint of the repository to prevent activities that could compromise the soil cover, such as damage from ATVs or backhoes, may also be implemented. Land use restrictions would be implemented at the repository to prevent activities that could compromise the soil cover. Prohibited activities would include: excavation, spreading, or disturbance of surface and subsurface soils and would be specified in deed restrictions at the offsite repository site. Periodic monitoring and maintenance would be required indefinitely to verify that the cover remains intact and performs as intended.

Effectiveness

Alternative 4 would be effective because the mine waste would be removed from the site, thus eliminating the risk to humans and wildlife from physical hazards and from contaminated materials. Excavating and consolidating the excavated mine waste rock offsite and capping would have long-term effectiveness providing long-term inspection and maintenance of the cap is performed. Capping the consolidated materials with clean material provides the necessary barrier for receptors and eliminates the possibility of physical contact so that human receptors and wildlife that come upon the repository would not be exposed to the waste source material. Burrowing animals have the potential to compromise the cover by bringing capped waste source material back to the surface with their burrowing activities; however, because the cap would consist of 3 feet of earthen cover, the potential for exposure to mine waste rock through burrowing would be reduced.

However, long-term period O&M would be required to ensure the long-term integrity of the cap and that it is not compromised by natural erosion or human activities. It is expected that chemical-specific ARARs would be met over the long-term. The RAOs would be met under Alternative 4. Regrading and restoration, including erosion controls and vegetation, would be performed so that areas disturbed during removal action activities would be restored to preexisting conditions.

This alternative meets both short- and long-term effectiveness, and it is expected that chemical-specific ARARs would be met over the long-term. Additionally, Alternative 4 complies with the stated objectives in accordance with the USFS Statement of Work and would meet the RAOs. As a result, the effectiveness of Alternative 4 is moderately high.

Implementability

Alternative 4 is readily implementable using existing construction technologies. The site access road may require nominal reconditioning, if any, to allow equipment to be transported to the site and also allow for off-site disposal. This alternative is implementable if a class II landfill or a deposit location within a reasonable distance (i.e., approximately 130 miles) of the site will accept the material.

Excavation of the waste source area materials can be implemented with standard earth moving equipment available locally. Qualified local contractors can be used to perform all scopes of work including excavation, grading, and site restoration. If cover soil material for capping the excavated areas is not readily available locally to the Site, this material would be trucked in from the nearest vendor site (Aspen, CO).

Regulatory acceptance of this alternative is assumed to be high, given the overall benefits of restoring the site to its natural condition, improving recreational areas at the site, and reducing risks to recreational users. However, the community acceptance of this alternative is low to moderate, due to the large number of trucks that would pass through during the soil hauling. As a result, the implementability of Alternative 4 is moderate.

Cost

As shown in Table 5-2 and Table 6-1, the estimated capital cost for implementing this alternative is $3,334,070 with a present value cost, including annual LUC and O&M annual costs, totaling between $2,490,624 and $5,337,052. These costs were estimated with a similar level of available data and detail as the "Screening of Alternatives" phase of a Feasibility Study, with an expected accuracy range of -30 to +50 percent (EPA, 2000).The detailed cost estimate is included in Appendix E.

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Table 5-1. Screening of Technologies and Process Options

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	O&M	Pros	Cons	Retained?
No Action									
No Action	No Action	Leave site as is	None	None	None	None	Do not deed to do anything	Does not achieve the RAOs	Yes, as required under the CERCLA guidance
Institutional Controls									
Access Restrictions	Site Fencing	Security fences around perimeter of site	Medium	High	Low	Medium - Subject to Vandalis m	Simple and Inexpensive	Does not protect ecological receptors, recreational visitors, or Forest Service staff; unsightly; subject to vandalism	No
	Deed Restrictions	Modifying conditions of the current property and mine claim deeds to limit certain types of land uses	Low	High	Low	Low	Simple and Inexpensive	Does not protect ecological receptors, recreational visitors, or Forest Service staff	No
Containment									
Erosion Control	Grading	Alter the ground surface contour of an area such that surface water runoff is directed along desired routes	Medium	Medium	Medium	Low	Provides for diversion of Storm Water Run-On, thereby minimizing Mine Waste contact with surface water run-off.	Does not prevent total diversion of storm water contact with mine waste. Site subject to significant flood event contact and release of mine waste material.	No
	Diversion	Construction or modification of features such as ditches, channels, and berms used to direct or divert surface water flow down slope, away from	High	Medium	Medium	Low	Provides for diversion of Storm Water Run-On, thereby minimizing	Does not prevent total diversion of storm water contact with mine waste. Site subject to significant flood event contact and	No

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	O&M	Pros	Cons	Retained?
		mine waste or impacted soils					Mine Waste contact with surface water run-off.	release of mine waste material.	
	Surface Water Collection	Surface water storage in a surface impoundment or reservoir in a desired location is used to equalize surface water runoff from a site	Medium	High	High	Medium	Provides for diversion of Storm Water Run-On, thereby minimizing Mine Waste contact with surface water run-off.	Does not prevent total diversion of storm water contact with mine waste. Site subject to significant flood event contact and release of mine waste material. Requires periodic Pond Sediment removal and disposal.	No
	Revegetation	Replacing vegetation following disturbance of the ground surface will mitigate soil erosion and surface water infiltration and runoff	High	High	Low	Low	Provides for evaporative cover protection, which minimizes storm water and snow melt infiltration.	Requires periodic removal of weeds, scrub and tree growth.	No
Capping	HDPE Liner and Cover	High-density polyethylene is used as a liner material and a cover for stockpiled mine waste and impacted materials	Medium	Medium	High	Low	Eliminates direct exposure and erosion	Requires cap system that minimizes vegetation growth which may damage liner system.	Yes
	Soil and Waste Rock Cover	Onsite waste rock can be used to prevent direct contact with mine waste and impacted materials to human and ecological receptors, reduce erosion, and provide a media for revegetation	Medium	High	Medium	Medium	Eliminates direct exposure and erosion	Requires periodic maintenance to remove scrub and tree growth that has the potential to penetrate cap system.	Yes
	Clay Cover	A clay cover consists of low permeability clay layers approximately 6 to 12 inches thick	Medium	Medium	High	Medium	Eliminates direct exposure and erosion	Requires vegetated cover system to protect clay cap system from desiccation physical	Yes

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	O&M	Pros	Cons	Retained?
								damage.	
	Clean Fill	Clean fill material is used to perform grading activities and to place in excavated areas	Medium	Medium	Medium	Medium	Eliminates direct exposure and erosion	Periodic inspection to ensure revegetation process is complete.	Yes
	Capping In-Place	Capping in-place involves the use of covers described above on top of contaminated materials, without transporting and consolidating materials in a controlled stockpile first	Medium	High	Medium	Medium	Eliminates direct exposure and erosion	Slope stability needs to be addressed. Lack of surface foot print area may constrain consolidation.	Yes
On-Site Repository	Consolidation, Onsite Stockpile	An onsite repository would be constructed to consolidate the materials in one location for long-term care	High	High	Medium	Medium - Long-term cap	Eliminates direct exposure and erosion	Waste remains onsite; potential for exposure if cap fails or constructed slope unstable.	Yes
Removal									
Off-Site Disposal	Excavation	Excavation techniques employ the physical removal of impacted materials to eliminate future receptor exposure	High	High	Medium	None	Eliminates direct exposure and erosion	Requires excavated soils surface to be amended with soil stabilizers and top soil for revegetation.	Yes
	Transportation	Transportation technologies typically involve the use of conventional materials handling equipment, such as excavators, to transport excavated materials either onsite or offsite	High	High	High	None	Eliminates direct exposure and erosion	Risk of highway spills. Risk to community acceptance.	Yes
	Permitted Offsite Disposal	Offsite disposal involves transporting and placing material in an engineered containment facility located outside of the site boundaries	High	High	High	None	Eliminates direct exposure and erosion	Risk of highway spills. Risk to community acceptance.	Yes
Treatment									

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	O&M	Pros	Cons	Retained?
Stabilization	Stabilization	Most metals are amenable to lime/cement-based stabilization, which tend to form insoluble hydroxides in the basic pH ranges commonly found in lime/cement	Low - Does not eliminate slope stability risk	Medium	Medium	Medium	Eliminates direct exposure and erosion	Does not address slope stability. Stabilized soil may be subject to chemical weathering in groundwater, or without adequate earthen cap.	Yes
Recovery	Metals Recovery	Metals recovery from mine waste materials may be achieved using various reprocessing techniques including pyrometallurgical and hydrometallurgical processes	Low - Does not eliminate slope stability risk	Low - Requires power source, water source	High	High	Eliminates direct exposure and erosion	Expensive, and requires large amounts of water, a potential power source, and maintenance. Does not address slope stability.	No
MNA	Monitored Natural Attenuation	Natural attenuation processes are commonly used for remediation of contaminated sites	Low - Does not eliminate slope stability risk	High	Low	High	Low Cost	Not effective at achieving RAOs. Does not address slope stability.	No

Table 5-2. Capital Costs of Remedial Alternatives

	Remedy Design	Mobilization & De-Mobilization	SHEAP	On-Site Consoldiation Repository	On-Site Relocation Repository	Off-Site Transport & Disposal - 50 Mile Radius	Stormwater Controls All Alternatives	TOTAL CAPITAL COST
Total Labor Costs	$ 33,600.00	$ 21,775.00	$ 5,425.00	$ 374,440.00	$ 438,260.00	$ 254,530.00	$ 58,690.00	N/A
Total Other Direct Costs	$ 10,446.41	$ 14,974.15	$ 4,776.49	$ 1,089,649.66	$ 1,343,703.35	$ 2,407,045.32	$ 87,934.12	N/A
Total Task/Project Cost	$ 44,046.41	$ 36,749.15	$ 10,201.49	$ 1,464,089.66	$ 1,781,963.35	$ 2,661,575.32	$ 146,624.12	N/A
Total With Contingency	$ 50,653.37	$ 42,261.53	$ 11,731.71	$ 1,683,703.11	$ 2,049,257.85	$ 3,060,811.62	$ 168,617.74	N/A
Estimated Value, Rounded:	*$ 50,650.00*	*$ 42,260.00*	*$ 11,730.00*	*$ 1,683,690.00*	*$ 2,049,260.00*	*$ 3,060,810.00*	*$ 168,620.00*	*N/A*
Alternative 1: No Action	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$ -
Alternative 2: Excavation, Consolidation in Onsite Repository, and Stabilization	$ 50,650.00	$ 42,260.00	$ 11,730.00	$ 1,683,690.00	N/A	N/A	$ 168,620.00	$ 1,956,950.00
Alternative 3: Excavation, Relocation to Onsite Repository, and Capping	$ 50,650.00	$ 42,260.00	$ 11,730.00	N/A	$ 2,049,260.00	N/A	$ 168,620.00	$ 2,322,520.00
Alternative 4: Excavation and Disposal Off-Site	$ 50,650.00	$ 42,260.00	$ 11,730.00	N/A	N/A	$ 3,060,810.00	$ 168,620.00	$ 3,334,070.00

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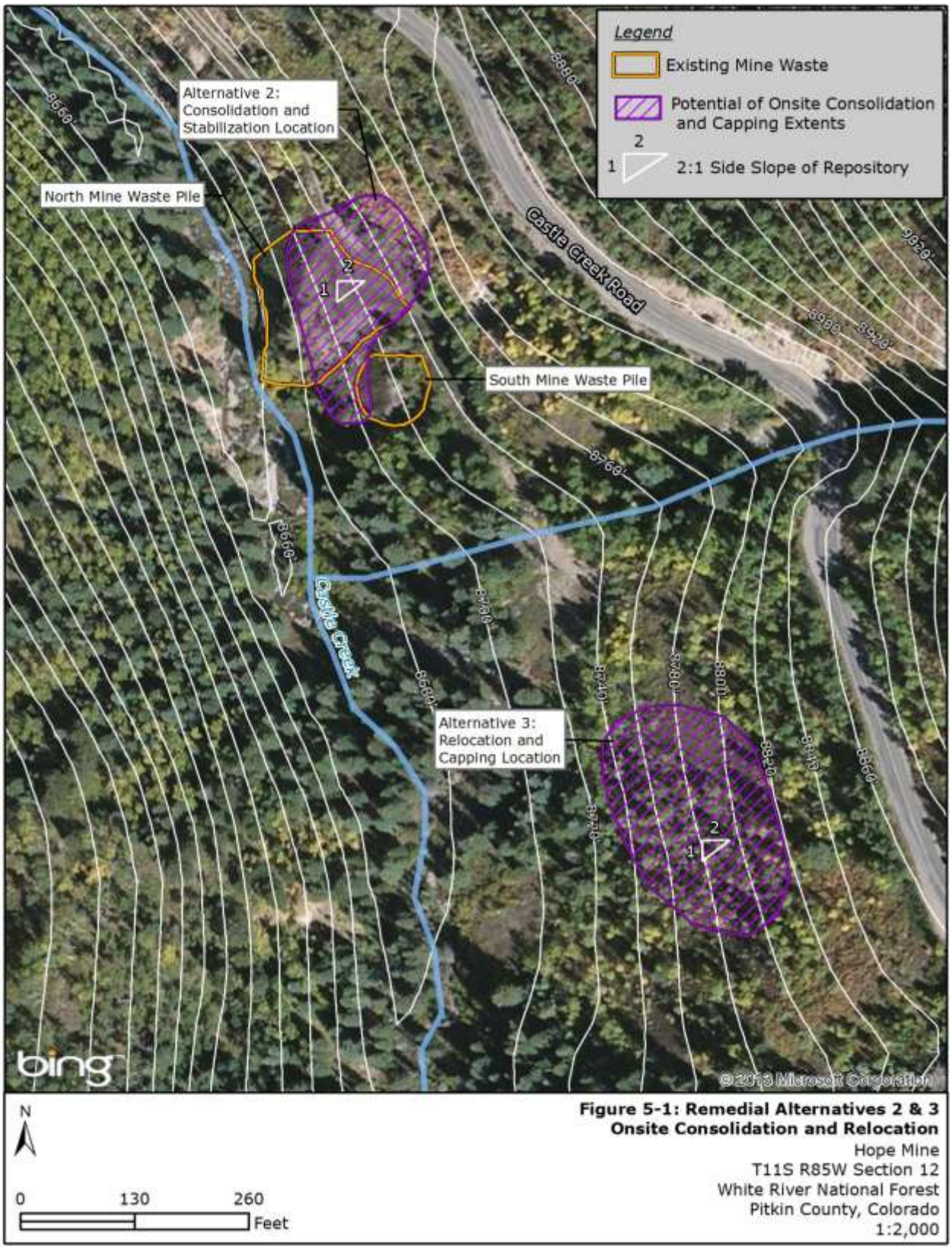
Figure 5-1. Remedial Alternatives 2 and 3 - Onsite Consolidation and Relocation



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SECTION 6 COMPARATIVE ANALYSIS OF REMOVAL ACTION OBJECTIVES

Comparisons are based on the three evaluation criteria discussed earlier and are summarized in the following sections.

6.1 EFFECTIVENESS

A summary of the effectiveness comparison of the each of the alternatives is presented in Table 6-1. The No Action alternative will not reduce the potential for slope failure, exposure of site visitors to COCs, or provide a reduction in the toxicity, mobility, or volume of contaminants as site conditions will remain as they are now. Estimated risk from slope failure and exposure of COCs to potential receptors will not be decreased in the long-term.

The main risk to human receptors at the Site is from slope stability, which could pose a physical hazard, and may release metals to Castle Creek. Additional risk to human receptors is from the chemical toxicity of arsenic, iron, mercury, and lead in the soil of the mine waste. In the event of slope failure, the North Waste Pile has the potential to release arsenic, mercury, iron, and lead into Castle Creek at concentrations that may be harmful to ecological receptors. Each of the "Action" alternatives provides an increase in slope stability through excavation of the mine waste pile. Engineering controls (i.e., dust control, proper PPE) will be required for all alternatives to ensure protectiveness of short-term exposure of workers during implementation.

Alternative 2, Alternative 3 and Alternative 4 provide physical barriers (fencing and vegetative cap) that will reduce the risk of exposure to metal-contaminated waste piles and reduces the mobility of the contaminants due to wind and surface erosion. Long-term effectiveness will also depend on inspection and maintenance of the repository cap to ensure its integrity. If long-term monitoring of the on-site and offsite repositories indicates leaching of contaminants, the addition of an impermeable liner to the cap will reduce the mobility of contaminants by preventing percolation of water through the material thus further reducing the leaching potential.

The optional application of Biochar as the vegetation amendment for each "Action" alternative would increase the effectiveness of each alternative. The enhanced biomass of Biochar would enhance vegetative growth on the caps of Alternatives 2 through 4, which would reduce wind and water erosion of the caps.

6.2 IMPLEMENTABILITY

Mine waste abatement and disposal can be completed by competent, local contractors. Alternatives 2, 3, and 4 will require readily available heavy equipment and qualified personnel for implementation.

All "Action" alternatives will require the development and implementation of a long-term maintenance program to ensure institutional controls remain effective. Alternatives 2 and 3 will also require long-term maintenance of the on-site repository including inspection of the integrity of the vegetative caps and periodic repair and replacement of cap materials.

Community acceptance of any of the alternatives is unknown. It is possible that community acceptance would be low for the mobilization of 1,700 truckloads of mine waste between Hope Mine and an offsite repository. None of the alternatives would preserve the historical aspect of the Site, if one is perceived by the community. Because some mine waste with elevated concentrations of heavy metals would remain on-site, engineering and administrative controls (i.e., personnel access limitations, personnel hazard awareness training/briefings) for long-term for future maintenance operations will be required for Alternative 2 and Alternative 3. Alternative 4 would also require engineering and administrative controls

if the offsite repository is located in uncontrolled areas, but would not be required if it is located in a controlled landfill. A summary of the Implementability comparison is shown in Table 6-1.

Construction schedule is also presented in Appendix E. The high altitude location of the Hope Mine results in a relative short construction season, typically four to five months between June and October. Major construction activities to be completed during this time include repository site preparation and mine waste-rock pile dewatering, mine adit water discharge, loading, slope stability, hauling and placing mine waste-rock in the repository, and repository cover construction. Preliminary schedule estimates indicate there would only be minor differences in the time to complete these work activities at the two potential on-site locations. However, there appears to be little float time to accommodate unanticipated site conditions, weather delays, etc. The short construction season should be considered during the design of the repository to minimize the use of items that require long lead times, ant the use of suitable construction materials that allow rapid installation (i.e. geosynthetic clay liner systems, etc.) should be considered.

The implementability criteria included in this EE/CA were developed to compare and contrast the geological, geotechnical, engineering and environmental issues at the Hope Mine and is not intended to be fully inclusive of all the issues associated with construction of a mine waste repository at the Hope Mine Site. These criteria could be modified based on input from USFS and other stakeholders, if any, to include additional items, and could also be incorporated into a rating matrix to aid in the selection of a repository site for additional design and construction as a mine waste repository.

6.3 COST

Table 6-1 presents the capital costs of each alternative, plus an estimate of the anticipated annual costs for maintaining the LUCs and the O&M for each alternative, estimated to be approximately $10,000 per year for 30 years, based on similar O&M/LUC costs for similar scopes of work (Weston, 2012). The total present value of each alternative is shown, totaling the present value of the annual costs and the capital cost, assuming an inflation rate of 2%. These costs were estimated with a similar level of available data and detail as the "Screening of Alternatives" phase of a Feasibility Study, with an expected accuracy range of -30 to +50 percent (EPA, 2000). The detailed cost estimate is included in Appendix E. All "Action" alternatives include costs for remedy design, mobilization and demobilization, health and safety, stormwater controls, and the annual costs for LUC monitoring and O&M.

As shown in Table 6-1, the estimated costs for implementing Alternative 2 are approximately 15% less than those of Alternative 3, and approximately 40% less than those of Alternative 4. Alternative 2 would cost approximately $2,180,915 with a present value cost ranging between $1,526,640 and $3,271,372. Alternative 3 would cost approximately $2,546,485 with a present value cost ranging between $1,782,539 and $3,819,727. Alternative 4 would cost approximately $3,558,035 with a present value cost ranging between $2,490,624 and $5,337,052.

The use of Biochar as a topsoil amendment is optional for each alternative. The cost of applying Biochar is not included for each alternative is not included in the above cost analysis. Past applications of Biochar at the Hope Mine site have cost approximately $80,000 (USFS, 2013). Therefore it is estimated that the additional application of Biochar at the site would cost approximately $80,000 in addition to the costs listed above for each alternative.

Note that the assumptions used in the ideas, concepts and pricing in this EE/CA and in Appendix E are based on limited engineering and design and are representative of current information and site conditions. A more detailed conceptual capital construction cost estimate could be developed for a mine waste-rock repository at one or both of the potentially suitable on-site locations after a conceptual design has been completed. In addition to capital costs, other project costs would need to be considered and included in

the more detailed engineering and design criterion. These costs consist of engineering, design, construction management, legal, permits, inflation, operations and maintenance, etc.

Table 6-1. Comparative Analysis of Removal Action Alternatives

Evaluation Criteria	Alternative 1	Alternative 2: Excavation, Consolidation in Onsite Repository, and Stabilization	Alternative 3: Excavation, Relocation to Onsite Repository, and Capping	Alternative 4: Excavation and Disposal Off-Site
Effectiveness	**Qualitative Ranking**			
Protection of Human Health and Environment	Low	High	High	High
Compliance with ARARs	Low	High	High	High
Long-Term Effectiveness	Low	High	High	High
Short-Term Effectiveness	Low	High	High	High
Achieve RAOs	Low	High	High	High
Reduction of Toxicity, Mobility, and Volume Through Treatment	Low	Medium	Medium	Medium
Implementability	**Qualitative Ranking**			
Technnical Feasibility	High	High	High	High
Administrative Feasibilty	High	High	High	High
Availability of Services of Materials	N/A	High	High	High
Community and Regulatory Agency Acceptance	Low	High	High	Medium
Cost	**Removal Action Cost**			
Estimated Total Capital Cost of Alternative	$0	$1,956,950	$2,322,520	$3,334,070
Estimated Annual Cost (LUCs and O&M)	$0	$10,000	$10,000	$10,000
Period of Analysis (Years)	30	30	30	30
Estimated Total Present Value Cost of Alternative	$0	$2,180,915	$2,546,485	$3,558,035
EE/CA Range (-30% to +50%)	$0 - $0	$1,526,640 - $3,271,372	$1,782,539 - $3,819,727	$2,490,624 - $5,337,052

Notes:
ARARs = Applicable or Relevant and Appropriate Requirements
EE/CA = Engineering Evaluation/Cost Analysis
N/A = Not Applicable
O&M = Operation and Maintenance
RAOs = Remedial Action Objectives

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SECTION 7 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Based on the alternatives evaluation using EE/CA guidance, and from the comparative analysis of the removal action alternatives, Alternative 2, which involves consolidation in an onsite repository and stabilization, and capping is recommended for the Hope Mine site. This alternative meets the threshold criteria of human health and environmental protection and compliance with ARARs, and has less capital costs than Alternative 3 or Alternative 4.

The following are the primary features of Alternative 2 that result in its selection as the preferred alternative:

- Alternative 2 is the least costly alternative that is expected to meet the RAOs within the removal action areas.
- Alternative 2 would provide excellent short and long-term effectiveness.
- Despite the technical challenges of the site, Alternative 2 would be implementable using standard construction equipment and methods.

The following steps would be required to implement Alternative 2:

- Perform a detailed site survey to confirm the proposed repository location is suitable, or to identify alternative locations.
- Further investigate possible sources of sand and organic cover materials.
- Select a staging area for equipment.
- Thoroughly evaluate alternative conceptual cap designs.
- Prepare design drawings and specifications for the selected cap design.
- Address deed restrictions, land use agreements. Jurisdictional Determination, and Section 404 permitting issues.
- Complete a detailed cost estimate.
- Conduct a site visit for prospective contractors.
- Contract for construction.

The use of Biochar as a topsoil amendment is optional for the selected alternative. The optional application of Biochar on the earthen cap of the onsite consolidation and stabilization would enhance vegetative growth, which would reduce wind and water erosion of the cap. Past applications of Biochar at the Hope Mine site have cost approximately $80,000 (USFS, 2013). Therefore it is estimated that the additional application of Biochar at the site would cost approximately $80,000 in addition to the costs listed in this EE/CA.

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SECTION 8 REFERENCES

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Appendix A

USFS-AMLI Field Data Form – Hope Mine

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USFS-AMLI FIELD DATA FORM

WS DE

LOCATION AND IDENTIFICATION

(1) **ID#:** 02- 08- 15 - 01 - 341 / 4331 - 1
rgn st fst rd xutm yutm area#

(2) **Sitename:** HOPE MINE

(3) **Other name/reference:**

2 (4) **Highest priority Environmental Degradation occurring in this area:**
1=extreme; 2=significant; 3=potentially significant; 4=slight; 5=none

3 (5) **Highest priority Mine Hazard noted in this area:**
E=emergency; 1=extreme danger; 2=dangerous; 3=potentially dangerous; 5=no significant hazard

M (6) **Commodity:** C=coal; U=uranium; M=metals; I=industrial material.
(Metal or Indust. material type: SILVER)

(7) **Quad name and date:** HAYDEN PEAK 1987

(8) **County:** PITKIN

(9) **2° map:** LEADVILLE

(10) **Water Cataloguing Unit #:** 14010004

(11) **Mining district/coal field:** ASPEN

(12) **Land survey location:** - NW - NW sec 12 ,T 11S ,R 85W

(13) **Receiving stream:** CASTLE flowing into ROARING FORK
nearest named stream next named

(14) **Elevation (ft):** 8700

2 (15) **General Slope:** 1=0-10°; 2=11-35°; 3=greater than 35°

M (16) **Regional terrain:** R=rolling or flat; F=foothills; T=mesa; H=hogback; M=mountains; S=steep/narrow canyon

G (17) **Type of access:** N=no trail; T=trail; J=jeep road; G=gravel road; M=paved road; P=private/restricted road

G (18) **Quality of access for construction vehicles:** G=good; M=moderate; P=poor; X=very poor

(19) **Nearest town on map:** ASPEN

7 (20) **Road distance from nearest town** (#.# miles)

(21) **Nearest road** (name and/or #): CASTLE CREEK ROAD
FR=forest rd; CR=county rd; SH=state highway; I=interstate

Distance to following types of public uses (#.# miles):

0.2 (22) Road
0.1 (23) Dwelling (year-round)
- (24) Campground/picnic area
- (25) Marked trail
- (26) Other public use (explain)

ENVIRONMENTAL INFORMATION

D (27) **Vegetation density adjacent to site:** D=dense; M=moderate; S=sparse; B=barren

ASGP (28) **Vegetation type adjacent to site:** B=barren; W=weeds; G=grass; R=riparian S=sagebrush/oakbrush/brush; J=juniper/piñon; A=aspen; P=pine/spruce/fir; T=tundra

N (29) **Evidence of intentional reclamation:** Y=yes; N=no (if yes, use comments)

Y (30) **Size of disturbed area in acres**

N (31) **Potential historical structures in area:** Y=yes; N=no (if yes, use comments)

N (32) **Positive evidence of BATS:** G=guano; I=insect remains; B=bat sighting; O=other(use comments); N=no (use comments to expand on any positive evidence;"No" only indicates absence of positive evidence, **not** absence of bats)

6/15/97 (33) **Recorded by/date:** John NEUBERT

ADITS, SHAFTS, AND OPENINGS

Feature Nos.		100	101	102	103	104	105	106	107	108	109	110	111
Type of Feature		A											
Opening Size (ft)	H	100											
	W	50											
Depth (ft)		12											
Condition		P											
Drainage		W											
Access Deterents		N											
Deterent Condition		—											
Ratings	Env. Deg.	3											
	Hazard	5											
Photo	Roll No.	NEV3											
	Frame No.	16,17											
Comments?		Y											

DUMPS, TAILINGS, AND SPOIL BANKS

Feature No.		200	201	202	203	204	205	206	207	208
Type of Feature		D	D							
Plan view Dimension (ft.)	L	100	100							
	W	90	50							
Volume (yds)		3000	2500							
Steepest Slope Angle (dgr)		43	34							
Steepest Slope Length (ft)		50	50							
Size of Materials		FSGL	FSGL							
Cementation		M	M							
Vegetation Type		SG	SG							
Vegetation Density		M	M							
Drainage		SP	W							
Stability		U	S							
Water Erosion	of Feature	RGS	G,R,S							
	Storm Runoff	C	N							
Wind Erosion		N	N							
Radiation Count		—	—							
Access Deterents		N	N							
Deterent Condition		—	—							
Ratings	Env. Deg.	2	4							
	Hazard	3	5							
Photo	Roll No.	NEV3 →								
	Frame No.	20,21,22	18,19							
Comments?		Y	Y							
Soil Sample No.										

DRAINAGE/WATER SAMPLES

Item Nos.	300	301	302	303	304	305
Adit/Shaft/Dump No./Other=0 (If other location, describe in comments)	100	200	200	201	201	100
pH (standard units)	7.27	7.24	8.25	8.12	8.46	7.16
Conductivity (uS)	1552	1665	254	1526	2660	1474
Flow (gpm)	150	15	15000	80	15000	60
Method of Flow Measure	E	E	E	E	E	W
Date Flow/Sample (m/d/y)	6/15 97	6/15 97	6/15 97	6/15 97	6/15 97	9/16/ 97
Location of Sample/Flow	A	B	RD	B	RD	A
Evidence of Toxicity in Site Drainage	P	N	N	P	N	P
Evidence of Toxicity in Receiving Stream	N	N	—	N	—	N
Distance from Stream (ft)	200	3	0	50	0	200
Comments?	Y	Y	Y	Y	Y	Y
Lab Water Sample No.						341/ 4331-1, 305

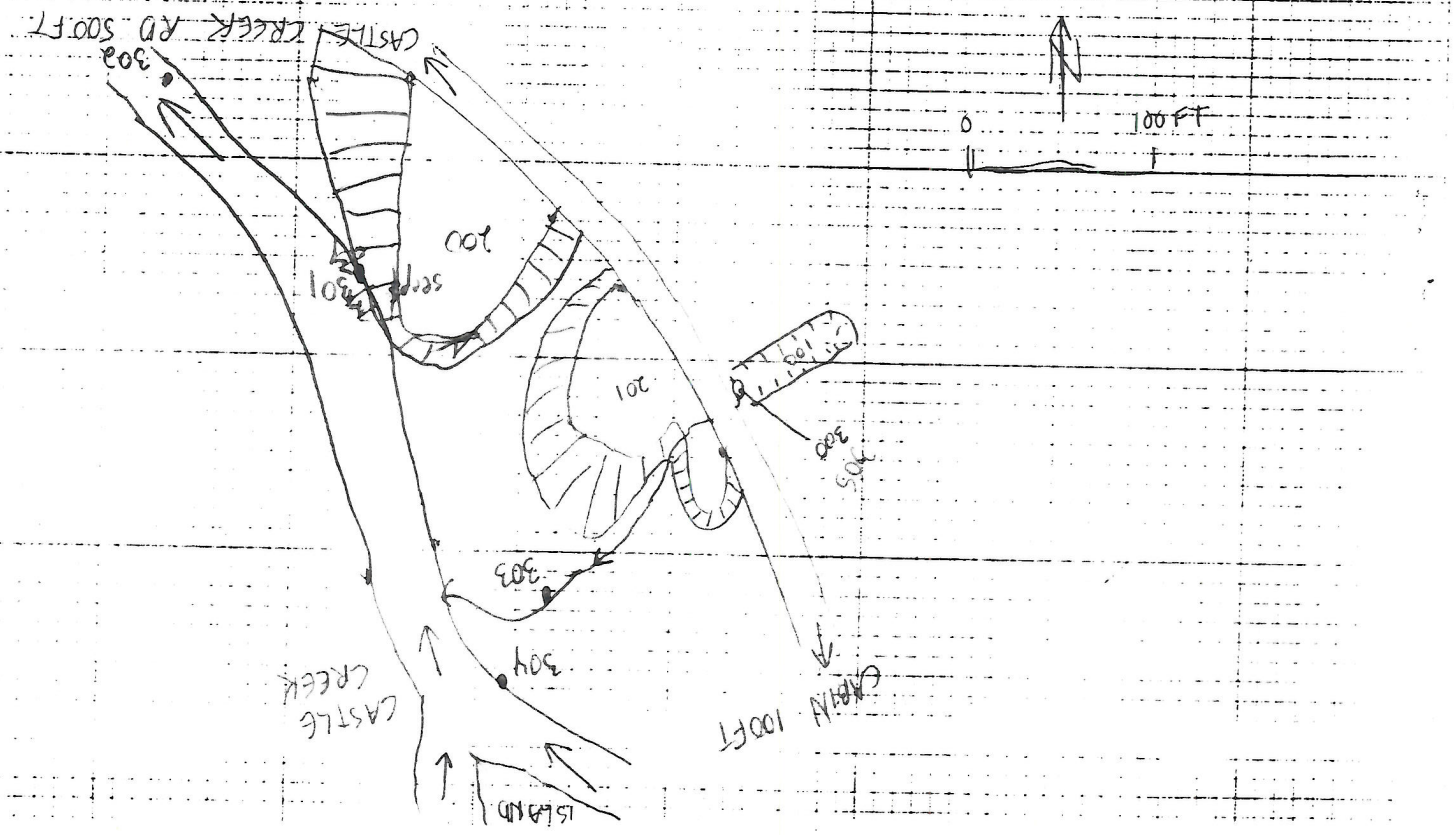
GPS READINGS

Ftr. No.	Location
200	Lat. 39° 07' 05.1" Long. 106° 50' 24.1"
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.

DIAGRAM OF PROBLEM AREA. (Locate all adits, shafts, dumps, prospects, etc. on topo map.)

Check off upon completion: ___ north arrow; ___ scale bar or general size noted; ___ direction to nearest trail/road/town noted; ___ significant mine features numbered

Adit shaft prospect hole building dump or tailings collapsed adit and shaft fence



•81. Local person interviewed _____
Name Address

•82. Name and address of person desiring a copy of this form: _____

•83. Describe the minimum work needed to mitigate any public health, safety, welfare, or environmental problems observed at the site. Note specific reclamation activities along with an estimated cost and time period to implement each activity described. Code costs as: 1= less $10,000; 2= $10,000 to $100,000; 3= $100,000 to $500,000; 4= more than $500,000. Code estimated time to complete the activity as: 1= less than 1 month; 2= 1 to 12 months; 3= 1 to 3 years; 4= over 3 years

Cost	Time	Recommended reclamation activity

•84. Comments relating to geology, health, safety, welfare, environmental, or restoration problems of a certain feature. All comments must be keyed to mine feature # or drainage/water sample item #.

Ftr.# CAVED ADIT WITH ASSOCIATED SUBSIDENCE FEATURE, ABUNDANT DISCHARGE
300 - TEST OF DISCHARGE. BLACK PRECIPITATE (OR ALGAE?) COVERS ALL THE ROCKS GIVING THE WATER A MURKY APPEARANCE, BUT IT IS ACTUALLY PRETTY CLEAR. EFFLUENT SPLITS, WITH ABOUT 75% GOING UNDER THE ROAD. THE 25% GOES TO AN INOPERABLE VALVE & GATE, AND DISAPPEARS.
200 - NORTHERN DUMP. MOSTLY BLACK SHALE, SOME LIMONITIC ALTERED PORPHYRY & SOME LIMESTONE. THIS WAS PROBABLY A CROSSCUT ADIT/HAULAGEWAY. THE OUTSLOPE OF THIS DUMP IS SEVERELY OVERSTEEPENED BECAUSE THE TOE HAS BEEN ERODED BY CASTLE CREEK. ALSO, SEEPS TOTALLY ABOUT 50 GPM ARE EMANATING FROM THE DUMP ABOUT 6 FT ABOVE CREEK LEVEL. THESE SEEPS PROBABLY ARE THE RESULT OF THE MISSING WATER AT TEST SITE 300. THIS DUMP COULD BE VERY UNSTABLE. IT IS ON A STEEP SLOPE, IT HAS OVERSTEEPENED OUTSLOPES. AND WATER RUNS THROUGH IT. IT IS COMPOSED OF SHALE, WHICH HAS LITTLE INTERNAL STRENGTH. TOXIC METALS APPEAR TO BE SPARSE ON THE DUMP, BUT FAILURE OF THE DUMP WOULD RESULT IN A HUGE TEMPORARY SEDIMENT LOAD IN CASTLE CREEK. WATER FROM THE ADIT SHOULD BE DIVERTED EITHER TO THE MAIN DRAINAGE WAY, OR TO A NEW ONE, AWAY FROM BOTH DUMPS. THE HOLE ON THE NORTH SIDE OF THE DISCHARGE POINT SHOULD BE SEALED AS A PRELIMINARY, AND PROBABLY MOST IMPORTANT REMEDIATION MEASURE
201. SIMILAR MATERIAL AS 200. ADIT DISCHARGE RUNS ACROSS PART OF IT BUT DOES NOT SEEM TO AFFECT EITHER THE DISCHARGE OR THE DUMP.
301. FROM THE LARGEST OF SEVERAL SEEPS FROM 200, ABOUT 4 FT ABOVE CASTLE CREEK. 302 - FROM CASTLE CREEK DOWNSTREAM OF 200 & 201.
303. FROM ADIT DISCHARGE BELOW DUMP 201. 304 - FROM CASTLE CREEK ABOVE THE DISCHARGE CONFLUENCE, AND ABOVE 200 & 201.
305 - WATER SAMPLE AT 300, WATER AT GATE SUPPLIES HIGHLAND RANCH, ACCORDING TO CARETAKER AT HOPE MINE

-if more comments use back of page →

General Comment (on whole inventory area or group of mine features): _____

-if more comments use back of page →

OFFICE/LITERATURE INFORMATION

•41. Owner of surface _____
•42. Last known operator _____
•43. Estimated production _____
•44. Dates of production _____
•45. Literature not cited in comments _____
•46. Citation of any historical register listing _____

CODES FOR TABULAR INFORMATION

ALL TABLES: If appropriate code is not listed, use: N = none or no; N/A = not applicable; UNK = unknown; O = other, explain in #84

ADITS, SHAFTS, & OPENINGS

- Type of feature: A = adit; S = vertical shaft; I = incline shaft; P = prospect hole; ST = stope; G = glory hole; SU = subsidence feature; PT = open pit; O = other, explain in #84.
- Condition: I = intact; P = partially collapsed or filled; F = filled or collapsed; N = feature searched for but not found (mine symbol on map)
- Drainage: N = no water draining; W = water draining; S = standing water only (note at what depth below grade)
- Access deterents: N = none; S = sign; F = fence; C = sealed or capped; D = open door or hatch; L = locked door or hatch; G = open grill; O = other, explain in #84.
- Deterent condition: P = prevents access; D = discourages access; I = ineffective
- Ratings: Hazard: E = emergency; 1 = extreme danger; 2 = dangerous; 3 = potential danger; 5 = no significant hazard
  Env. Deg.: 1 = extreme; 2 = significant; 3 = potentially significant; 4 = slight; 5 = none
- Comments?: Y = yes; N = no

DUMPS, TAILINGS, AND SPOIL AREAS

- Type of feature: D = mine dump; T = mill tailings; W = coal waste bank; S = overburden or development spoil pile; DS = dredge spoil; HD = placer or hydraulic deposit; H = highwall; P = processing site
- Size of materials: F = fine; S = sand; G = gravel; L = cobbles; B = boulders
- Cementation: W = well cemented; M = moderately cemented; U = uncemented
- Vegetation Type: G = mixed grass; S = sagebrush/oakbrush/brush; J = juniper/piñon; A = aspen; P = pine/spruce/fir; T = tundra; R = riparian; F = tilled crops; B = barren/no vegetation; W = weeds
- Vegetation Density: D = dense; M = moderate; S = sparse; B = barren
- Drainage: N = no water draining; W = water draining across surface; S = standing water only; SP = water seeping from side of feature
- Stability: U = unstable; P = potentially unstable; S = stable
- Water erosion: of Feature: N = none; R = rills; G = gullies; S = sheet wash
  Storm Runoff: C = in contact with normal stream; S = near stream or gully, but only eroded during storm or flood; N = no storm/flood runoff erosion
- Wind erosion: N = none; D = dunes; B = blowouts; A = airborne dust
- Radiation Count: N = none taken; record value of reading if taken
- Access deterents: N = none; S = sign; F = fence; O = other, explain in #84
- Ratings: Hazard: E = emergency; 1 = extreme danger; 2 = dangerous; 3 = potential danger; 5 = no significant hazard
  Env. Deg.: 1 = extreme; 2 = significant; 3 = potentially significant; 4 = slight; 5 = none
- Comments?: Y = yes; N = no

DRAINAGE/WATER SAMPLES

- Adit/Shaft/Dump No./Other: Indicate Feature No. associated with water information; 0 = other, explain in comments
- Flow (cfs): record seeps as 0.01 cfs (Rule of Thumb: a cfs= one full-blast garden hose)
- Method of flow measure: E = estimate; T = bobber/stopwatch/x-section; W = weir; D = catchment; F = flow meter
- Location of sample and flow: A = immediately adjacent to adit/shaft; B = below dump/tailings; C = immediately above confluence with receiving stream; SW = standing water in/on feature; RU = receiving stream upstream of feature; RD = receiving stream dowmstream of feature;
- Evidence of toxicity: N = none; A = absence of benthic organisms; W = opaque water; P = yellow or red precipitate; S = suspended solids; D = salt deposits
- Comments?: Y = yes; N = no

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Appendix B

Preliminary Assessment and Site Inspection Report – Hope Mine

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PRELIMINARY ASSESSMENT and SITE INSPECTION REPORT

Final

The Hope Mine: Pitkin County, CO
White River National Forest

May 13, 2010

Prepared For: **USFS, White River National Forest**
Olivia Garcia: Abandoned Mine Land Coordinator

Prepared By: Kato Dee, Dirk Monroe, Melissa Wolfe, Caitlin Borbely
Colorado Mountain College, Natural Resource Management

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List of Acronyms

Ag	Silver
AMD	Acid Mine Drainage
ARD	Acid Rock Drainage
AML	Abandoned Mined Lands
As	Arsenic
ATV	All-Terrain Vehicle
AWQC	Ambient Water Quality Criteria
Ba	Barium
BLM	Bureau of Land Management
^{o}C	Degrees Celsius
$CaCO_3$	Calcium Carbonate
CCDS	Castle Creek Downstream
CCUS	Castle Creek Upstream
Cd	Cadmium
CDPHE	Colorado Department of Public Health and the Environment
CDRMS	Colorado Department of Reclamation and Mining Safety
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CGS	Colorado Geological Survey
cm	Centimeter
CMC NRM	Colorado Mountain College, Natural Resource Management department
CNHP	Colorado Natural Heritage Program
Cr	Chromium
CSM	Colorado School of Mines
Cu	Copper
Eco-SSL	Ecological Soil Screening Level
EPA	Environmental Protection Agency
ESL	Ecological Screening Level
Fe	Iron
HAZWOPER	Hazardous Waste Operations and Emergency Response Standard: 40 hour Health and Safety Training (Occupational Safety and Health Administration)
Hg	Mercury
HMA	Hope Mine Adit
HMB	Hope Mine Background (soil sample)
HMND	Hope Mine North Dump
HMS	Hope Mine Spring
HMSD	Hope Mine South Dump
HQ	Hazard Quotient
kg	Kilogram
L	Liter
MCL	Maximum Concentration Level
MCLG	Maximum Concentration Level Goal
MDL	Minimum Detection Limit
mg	Milligram
mg/kg	Milligrams per kilogram
mg/L	Milligrams per Liter
Mn	Manganese
Ni	Nickel
NIST	National Institute of Standards and Technology
PA	Preliminary Assessment
Pb	Lead
pH	Potential Hydrogen (acid/base units)
ppb	Part per Billion (ug/L)
ppm	Part per Million (mg/L or mg/kg)
QAPP	Quality Assurance Project plan
QA/QC	Quality Assurance/Quality Control
SI	Site Investigation
RSL	Regional Screening Levels
Sb	Antimony
Se	Selenium

List of Acronyms

SOW	Scope of Work
Sr	Strontium
SRM	Standard Reference Materials
SSL	Soil Screening Level
TAL	Timberline Analytical Laboratory
Ti	Titanium
TMDL	Total Maximum Daily Load
ug	Micrograms
ug/L	Micrograms per Liter
uS	Micro Siemens (conductivity units)
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WRNF	White River National Forest
XRF	X-Ray Fluorescence Spectrometer
Zn	Zinc

EXECUTIVE SUMMARY

A Preliminary Assessment (PA) and Site Inspection (SI), as per the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) requirements, were completed for the Hope Mine Site (the Site) in Pitkin County, Colorado. This effort was completed as noted in the Scope of Work (SOW) and the cooperative agreement between the US Forest Service and Colorado Mountain College Natural Resource Management Department (CMC NRM), and performed in accordance with CERCLA guidance methodologies.

The site history assessment indicated that there have been multiple owners, leasers, and managers to keep the mine active. The mining activity associated with the Site was focused on underground hard-rock exploration and extraction of silver-bearing and lead-bearing ore. The mine site and associated claim holdings were owned and leased by the Hope Mining, Milling, and Leasing Co, from 1916 to 1953. The mining claims were relinquished in 1956 after a mineral validity examination by the Forest Service.

At the time of this site reconnaissance, the mine site was gated, locked, and had limited access. The Site is comprised of a collapsed discharging adit and one primary mine waste dump. Two structures are located on the Site; one abandoned resident structure and a storage building. The mine adit drainage is redirected to subsurface flow by a valve gate. The discharge of the Hope Mine adit is redirected downstream by means of a water conduit system and released into Castle Creek between mile marker 6 -7 (FR 102-Castle Creek Road). Springs and seeps were identified at the lower segments of the mine waste pile and discharge directly into Castle Creek.

A field sampling event was performed to assess the contaminant nature of the mine site. This consisted of water sample collection for dissolved and total recoverable metals, and general water chemistry in addition to in situ water quality and discharge measurements. Water samples were collected at the mine adit, on Castle Creek (up-gradient and down-gradient of the mine site), and at the spring located at the bottom edge of the mine waste pile. Mine waste samples were collected from the south and north dump and analyzed for metal solids and leachate metals content.

A records research effort was completed in order to compile historic documents of the Site. This information revealed the chronology of site activity, and a brief history of the Site's setting. Reviews of these findings are presented in section 2.0.

The results of the sampling effort were used to compare measured metal concentrations to available literature-derived toxicity thresholds protective of human health and the environment. If a measured concentration was found to occur above any applicable threshold, a potential impact could be inferred. Results of the contaminant evaluation are presented by sample type as follows;

Groundwater Pathway and Targets

Upon site visit no groundwater was collected or analyzed, thus water analysis of the spring discharge may be considered the best representative of groundwater within the mine workings. The leachate analysis represents another potential impact of mine waste contaminates into the immediate groundwater system, but is an overestimation of groundwater impacts due to the highly concentrated nature of the leachate procedure and would likely produce a higher metal leachate than normally produced through precipitation infiltrating the mine waste pile.

The leachate samples processed from the mine waste composite and background (HMB) samples detected several analytes with aluminum concentrations having a potential impact on human health and the environment. The remaining analytes detected did not exceed any toxicity threshold criteria. The high concentration level of aluminum (1.5 mg/L) found within the HMB leachate sample is from unknown sources (i.e. naturally occurring or anthropogenic sources). The results for the composite leachate analysis can be found in section 4.1.

Human Health Hazard Assessment

- Dissolved water chemistry from Hope Mine Spring does not indicate a risk to human health and does not exceed drinking water criteria. The Hope Mine Spring does have total recoverable metal values that may be of potential concern.

- Chemistry of the leachate samples identified aluminum as exceeding the secondary drinking water standards (EPA, 2009). The measured concentrations of the remaining analytes did not exceed any criteria for drinking water or groundwater.

- There are several domestic well locations within a 4 mile radius and down-gradient of the Site. The town of Aspen, located six miles to the north, has residential development throughout the Castle Creek drainage area. No information was attained as to the water quality of these domestic wells.

Ecological Receptor Hazard Assessment for Aquatic Life

- Results from the Hope Mine Spring indicate the aquatic life-health could potentially be affected for Total Recoverable (Trec) iron and aluminum if water were released to a surface water body that provided aquatic habitat.

- Several analytes were detected in the leachate analysis with only aluminum as a potential risk for aquatic life-health (USEPA, 1988), but the Trec aluminum concentrations levels do not exceed the standards set by the CDPHE aquatic life parameters (CDPHE, 2007).

Surface Water Pathway and Targets

Surface water was collected and analyzed from four sites within the investigation area (sample locations can be found in Figure 1) for dissolved and total recoverable metals. Dissolved metals concentrations were used as a determination for risk assessment to human health and the environment unless otherwise stated. Results of the analysis from the water samples collected, and water quality parameters measured are found in Section 4.2.

Human Health Hazard Assessment

Castle Creek-CCUS and CCDS

- Metals detected from the Castle Creek Downstream (CCDS) and Upstream (CCUS) sample locations include calcium, iron, manganese, magnesium, and zinc. Concentrations for all metals did not exceed any risk assessment criteria for human health.

- Results from this analysis indicated the analyte concentrations are below a level of concern to human health if the surface water at the stream sites were relied upon as a drinking water source.

Hope Mine Adit-HMA

- Analysis of the water samples collected at the Hope Mine adit (HMA) detected aluminum, calcium, iron, magnesium, manganese, and zinc. Concentrations levels for all analytes did not exceed any risk assessment criteria for human health.

- Results of this analysis indicate that human health would not be affected if the surface water at the adit site were relied upon as a drinking water source, but the analyte concentrations at the site may vary during seasonal conditions.

Hope Mine Spring-HMS

- Analytes detected from the Hope Mine spring (HMS) include aluminum (Trec), calcium, copper (Trec), iron (Trec), lead (Trec), magnesium, manganese, zinc (Trec), and arsenic (Trec).

- Results indicate a potential risk to human health if the surface water at the HMS site were relied upon as a drinking water source. From the single site visit it is unknown if this source would ever be used as a drinking water source.

Ecological Receptor Hazard Assessment for Aquatic Life and Wildlife

Castle Creek-CCUS and CCDS

- Concentration levels detected for the analytes on Castle Creek did not exceed any risk assessment criteria (CDPHE, USEPA, BLM).

- Results indicate that aquatic life-health and ingestion by wildlife would not be affected within this stream segment.

Hope Mine Adit-HMA

- Aluminum concentration levels at the HMA have the potential to pose risks to aquatic life-health (USEPA, 1988), but the aluminum (Trec) concentrations levels do not exceed the standards set by the CDPHE aquatic life parameters (CDPHE, 2007).

Hope Mine Spring-HMS

- Iron (Trec) and aluminum (Trec) concentration levels exceed the CDPHE aquatic life parameters (CDPHE, 2007).

- Results indicate aquatic life-health could potentially be impacted. The water source includes discharge from a spring and seep, which flows for a distance of less than fifteen feet before entering Castle Creek. Dilution likely occurs after the discharge enters into

Castle Creek as determined by the chemical analysis completed down gradient at sample site CCDS.

Soil Pathways and Targets

Results of the solid mine waste sample analysis by X-Ray Fluorescence Spectrometer (XRF) yielded detectable concentrations of arsenic, silver, barium, chromium, copper, iron, lead, manganese, mercury, nickel, rubidium, strontium , tin, and titanium. The results for the XRF analysis can be found in Section 4.3. Leachate analysis was performed in order to determine the impact of soil-water interactions around the mine waste of the Hope Mine. Results of leachate analysis indicate a soil paste pH of 6.91 (HMND), 6.87 (HMSD), conductivity of 1694 µS/cm (HMND), 1674 µS/cm (HMSD), and acidity of 11.1 mg/L $CaCO_3$ (HMND), 24.8 mg/L $CaCO_3$. The soil leachate results indicate soil properties that do not produce high acidic conditions which reduce mobilization and availability of potentially harmful constituents at the site.

A background soil sample (HMB) was collected at the Hope Mine site at an undisturbed area as a comparison of naturally occurring soil material to the mine waste tailings. The analytical results from the XRF, for the background soil sample, exceeded BLM Resident Management Criteria (BLM, 2004) for detected Arsenic, Mercury, and Silver. Arsenic levels exceeded the EPA Soil Screening Level (SSL-MCL), and Mercury exceeded the EPA SSL (EPA, 2002) and Regional Screening Levels-Residential (SRL) standard for dermal (EPA, 2009). Leachate analysis results showed a soil paste pH of 6.67, conductivity of 101 µS/cm, and acidity of < 10 mg/L $CaCO_3$. Results of the HMB soil sample can be found in sections 4.1 and 4.3.

Ecological Receptor Hazard Assessment for Wildlife, Terrestrial Plants and Invertebrates for the HMB soil sample analysis by XRF results exceeded Eco-SSL standards for Silver, Barium, Copper, Mercury, Lead, Zinc, Manganese, and Nickel (EPA, 2010). Detected metals for Arsenic, Copper, Lead, and Zinc exceeded BLM Wildlife Risk Management Criteria for small avian/Robin (BLM, 2004). Results are located in section 4.3.

Human Health Hazard Assessment

- For the detected metals, the measured concentrations of arsenic, iron, and mercury exceeded the EPA Regulatory and Human Benchmarks used for Soil Screening Level Development (EPA, 2002). Arsenic exceeded the carcinogenic target risk for ingestion and dermal contact (EPA, 2009). Iron exceeded the non-cancer hazard for ingestion. Mercury exceeded the total non-cancer hazard (EPA, 2009). Arsenic, silver, lead, mercury, and manganese occurred above BLM risk management criteria (BLM, 2004) for residents while arsenic exceeded BLM risk management criteria for resident, camper, and worker. Lead exceeded all BLM risk management criteria for human exposure.

- Results indicate a potential risk to human health if there were resident type exposure conditions. Exposure pathways would likely occur through human ingestion of mine waste material at the site by recreational use or prolonged time within the area.

Ecological Receptor Hazard Assessment for Wildlife, Terrestrial Plants and Invertebrates

- Detected concentration levels of arsenic, barium, chromium, copper, lead, manganese, nickel, and zinc levels were above the protective ecological receptor levels by the EPA Ecological Soil Screening Levels (EPA, 2010). Lead, zinc, copper, and arsenic concentration levels were above the BLM wildlife risk management criteria (BLM, 2004).

Detected Metals	SSL Receptors for Elevated Concentration Levels
Arsenic	plants, avian, and mammalian
Barium	soil invertebrates and mammalian
Chromium	avian and mammalian
Copper	plants, avian, invertebrates, and mammalian
Lead	plants, avian, invertebrates, and mammalian
Manganese	plants and invertebrates
Nickel	plants
Zinc	plants, avian, invertebrates, and mammalian

- Lead exceeded all BLM wildlife risk criteria levels with mercury and zinc on average exceeding all BLM wildlife risk criteria except for sheep and cattle. Copper would exceed standards for sheep, mule deer, big-horn sheep, and small avian. Arsenic exceeded standards for small avian (BLM, 2004).

- All SSL receptor levels are very dependent on site specific conditions, speciation, solubility, geochemical behavior, moisture, species tolerance, and other factors that should always be considered.

- Results indicate a potential and adverse risk to wildlife receptors if continuous exposure conditions were to occur. The Site is set in a forested area with year round water sources and abundant vegetation-forage located at and throughout the surrounding area.

- Results of the hazard assessment indicate that current conditions are suitable for short-term human and ecological receptor exposure conditions. Both surface water, groundwater (as extrapolated from leachate results) and the mine waste solids are of potential concern. Seasonal fluctuations at the Site could create a higher potential of contaminate releases not identified during the site investigation. In addition, the groundwater pathway was not definably understood and requires further investigation. Soil and water pH and buffering conditions are favorable for the Site area to reduce the impacts of typical acid mine drainage.

- Aquatic life could be impacted by the Hope Mine. The leachate analysis indicated a potential impact if the leachate were to reach surface water areas. The assumption that mine waste leachate represents potential impacts on surface water and groundwater qualities are likely an overestimation of the actual conditions on site. Erosional releases of mine waste sediment accumulating within the stream bed or rapid slump of the mine waste pile is of concern.

Air Pathways and Targets

Air particulates were not sampled as part of the PA/SI for the Site.

Human Health Hazard Assessment

- No determination could be made for air particulate pathways and targets. If exposure pathways did occur it would do so through human ingestion of mine waste material mobilized from the Site through recreational disturbance, adverse weather conditions, or prolonged occupation at the mine waste site.

Ecological Receptor Hazard Assessment for Wildlife

- A hazard for wildlife through airborne particulate ingestion would exist in the case that mine waste particulates are mobilized by human activity or adverse weather conditions. It may also occur if wildlife proceeds to disturb the mine waste.

In summary, given the nature and extent of source areas, and the hazards posed by these source areas, it does appear that the Hope Mine may pose potential risks to ecological and human receptors within the immediate area, particularly by soil exposure and to a lesser extent due to elevated levels of aluminum (Trec) discharging into Castle Creek from HMS. The extent of seasonal fluctuations for possible increased contamination levels for contaminated groundwater discharging into Castle Creek has not been investigated. Further sampling may aid in evaluating if groundwater influenced by water interacting with the mine waste, as indicated by leachate results, is also an area of concern. The potential hazards associated with mine waste release(s), due to mass wasting directly into Castle Creek, is also a primary concern.

1.0 Introduction

This Preliminary Assessment and Site Inspection (PA/SI) were performed for the United States Department of Agriculture: Forest Service (USFS) under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as described in Executive Order 12580 and 7 CFR 2.60(a)(42). The purpose of this PA/SI is to determine if a release of hazardous substances have posed a threat to human health or the environment from the Hope Mine site. Work was completed in accordance with the National Contingency Plan (40 CFR 300) and pursuant to the United States Environmental Protection Agency (EPA) "*Guidance for Performing Preliminary Assessments under CERCLA*" (EPA, 1991).

This document provides a description of the methods and findings for the steps taken to complete the PA/SI for the Hope Mine site within the White River National Forest (WRNF) in Pitkin County, Colorado. The work was completed by Colorado Mountain College Natural Resource Management Department (CMC NRM) for Olivia Garcia/USFS WRNF/Abandoned Mined Lands (AML) coordinator. The methods used to complete the effort followed those described within the standard guidance for completing a sampling effort in addition to a site reconnaissance and records review. This document provides a description of all methods and findings, and attaches all relevant information relied upon for the conclusions drawn within this document.

The Hope Mine site is not listed on the EPA Federal Facilities Compliance Docket, and does not have a CERCLIS identification number (EPA, 2010). Research did not identify the Castle Creek tributary on the CDPHE 303(d) impaired water list. The Site is adjacent to Castle Creek a tributary to the Roaring Fork (HUC 14010004). The potential impact the Site has to both human health and the environment warrants the PA/SI to determine the potential impacts to human health and the environment.

1.1 Scope of Work

In September of 2008, CMC NRM and the US Forest Service entered into a cooperative agreement for the completion of a PA/SI for the Hope mine site located on NF lands managed by the Aspen-Sopris Ranger District in Pitkin County in the WRNF. This site was determined to be potentially impacting human health and the environment associated with USFS lands. This document presents the methods and findings of the PA/SI completed for the Hope Mine site; as per the cooperative agreement and the Scope of Work (SOW), which was previously reviewed and approved by the USFS. Within the SOW, the outline of methods to be completed, the time-line, and roles and responsibilities were all identified. The SOW, in its entirety is provided as **Appendix A**, with the pertinent components summarized within this Introduction.

There are three components addressed within this document; 1) a site history description, 2) the PA, and 3) the SI. The general scope of work for each are described as follows:

- The **Site History** documents the mining history, chronology of events and any environmental impacts resulting from actions taken place at the Site. This entire effort was completed by the review of available literature from a variety of sources. Information from mining records (i.e. Colorado State Archives, property ownership, Pitkin County, city and county agencies, and web-based search).

- The **Preliminary Assessment and Site Inspection** documents the waste characterization, as well as the contaminate pathways for human health and the environment associated with the Site. Typically, if sufficient information is available from existing studies, then this effort is a simple literature review exercise. However, if insufficient information exists which characterizes the waste; a field effort is needed in order to obtain samples to identify the waste contaminant characteristics. A planned site reconnaissance and site investigation were completed on August 17, 2009 in order to characterize source areas of contamination which included the mine waste pile, collapsed adit, and adjacent stream channel. The results of the sample analysis were compared to thresholds protective of human health and the environment as part of the SI evaluation process. There are numerous sources of these values that can provide an indication or magnitude of 'risk' associated with the Site. Sources used include Federal (EPA, BLM, and FWS) and State (CDPHE) criterion.

1.2 Purpose and Objectives

The purpose of this assessment was to complete investigative studies in order to be able to complete a site history, a PA, and a SI of the Hope Mine in accordance with the EPA, 1991 guidance. In order to accomplish this goal, several approaches were taken including;

a) A site reconnaissance to build the scope of work for the sampling effort, and gain an understanding of site characteristics.
b) Characterization of flowing surface waters, mine waste piles, and surface water potential leachate contamination from surface runoff.
c) A records review to reconstruct the history, ownership, activities, etc. associated with the site, and
d) Documentation of all efforts which are provided within this report.

1.3 Roles and Responsibilities

CMC NRM was responsible for coordination of the site reconnaissance, completion of the sampling effort, records review as well as the data interpretation and documentation presented herein. The Field Technicians, Field Managers, and Project Management staff within CMC NRM were responsible for the sampling event, while Cathy Patti, the NRM Contract Administrator was responsible for all accounting requirements. Kato Dee and Dirk Monroe were responsible for field team oversight, while Melissa Wolfe and Caitlin Borbely also helped with final documentation, presentations, and communication with USFS and the public.

1.4 Time-line and Milestones

The Site reconnaissance and sampling efforts were completed in the summer of 2009, while the documentation was completed in May 2010. A DRAFT was provided for review and approval to the USFS in May 2010. A Final Report will be provided to the USFS by June 2010.

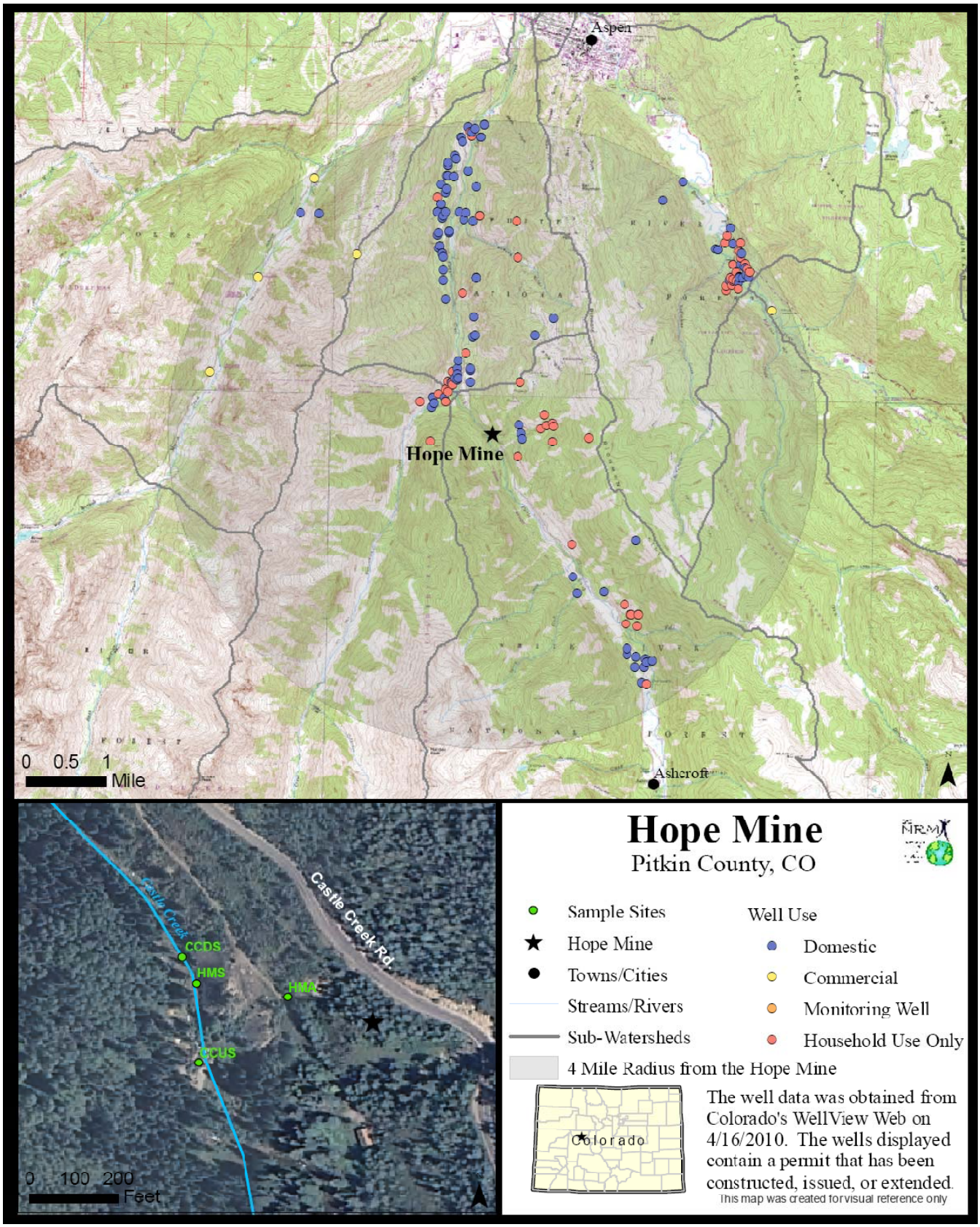

Figure 1: Site location map for the Hope Mine. Sample locations with well locations in a four mile radius.

2.0 Site History and Setting

Available literature and internet database records were relied upon to describe the setting features and a synopsis of the history associated with the mining heritage of the Site. The methods for the records research completed for this effort are described in Section 3.0. This section presents the location, ownership, historical overview, site features of waste characteristics and environmental setting.

2.1 Location

The Hope Mine is located approximately six miles south of Aspen, CO from Highway 82, on FR 102 (Castle Creek Road) within the WRNF. The Site is located adjacent to the east of Castle Creek on the west aspect of Richmond Hill, below Annie Basin (**Figure 1: Site Location**). The site is found on the USGS quadrangle map (Hayden Peak, 1987) within T 115N, R 85W, Section 12, 6th P.M. The Site is located at an elevation of ~8,700 feet.

2.2 Land Ownership

Historical research shows the Hope Mine claim had previous owners, leasers and adjoining claim activity. Dated records of Bureau of Mines claim inspection reports and records obtained from Aspen-Sopris Ranger District helped to identify the historic ownership and chronology of activity (described in subsection 2.3 below).

The following information below was obtained through records from the Aspen-Soporis Ranger District, Land Specialist, Jim Kirschvink.

> The Hope Mine site is currently managed by the USFS WRNF. The mining claims where relinquished by Mr. Garth Williams after a mineral validity examination by the Forest Service in 1956. Mr. Williams purchased the buildings and associated mine claims in 1953 and in 1957 Mr. Williams was issued a residence special permit. Dr. Donald King became the next owner in 1965. During ownership by both Mr. Williams and Dr. King a series of Special Use Authorization (residence, recreation residence, isolated cabin, and temporary) permits were issued between 1957 through 2003 until an Environmental Assessment decision in 1987 issued a 371 Cabin Permit with a non-renewable tenure to Dr. King (pursuant to WRNF Supplement #21 to 2721.23). Negotiations and discussions were held between Dr. King and the USFS regarding possible land exchange and or the donation of the building on site which extended his temporary use permits. On October 15, 2003, the last temporary use permit expired and Dr. King was responsible for removing all improvements under the terms and conditions set by the USFS WRNF.

2.3 Historical Overview

The following information below describing the historical overview and chronology of the Hope Mine was compiled from the Bureau of Mines Inspection and Annual Reports from 1916 to 1940.

The Hope Mine was also called the Hope Tunnel and was located in the Richmond Hill Mining District. The earliest records found for the Site were from 1916. Records from the Colorado State Bureau of Mines Inspection Reports revealed the Hope Mining, Milling, and Leasing Co. (Hope M, M, & L Co.) owned and operated the mine and associated claims and leased the property occasionally. Other patented mine claims associated with the Hope M, M, & L Co. were the Little Annie group, Climax group, Slide group, and the Hurrah group. Unpatented claims were the Hope 1, 2, 3, 4 and mill site.

The mine was drifted into what was called the Annie Contact; between shale and porphyry units with the shale overlying the porphyry. Records state that the drift was 6,000 feet by 1916 with 1,252 feet driven in that year and no ore produced. The Site had a power house, cook house, and bunkhouse. I n August of 1919, the drift cut through the little Annie Contact into the Richmond Contact at 7,000 feet. During this time the drift encountered a large amount of water thought to be coming from the Little Annie workings. The inspector estimated the amount of water at five hundred gallons per minute. During this time the drift was identified as cutting through the Maroon formation about 2,400 feet, Weber grits and shale 1,300 feet, Gypsum 300 feet, then into 400 feet of shale and limestone into the quartz porphyry. This contact was followed north to an ore deposit. The ore vein was encountered at 8,000 feet with an average of 101 ounces per ton of silver (polybasite and native) with some lead value.

A new bunkhouse, a two story boarding house, and a number of small buildings were constructed and completed in 1921. One hundred fifty eight and a half tons of ore was sold with an average of seventy ounces of silver. In 1922, an electric driven air compressor was on site to furnish ventilation and drilling. Previously seven cars of ore were shipped but lost. Ore was taken to Aspen by wagon and shipped by rail to the Arkansas Valley plant in Leadville, CO for processing. In 1923, the mine was leased to two individuals who were unnamed. Seven tons of ore were sold containing an average of ninety five ounces of silver with eight percent lead during the lease to the unnamed individuals. A new board of directors was elected for the Hope M, M, & L Co. in 1923.

A considerable amount of repairs and timbering were completed in 1924 with no ore production documented. In 1925, a phone was installed on the property and the mine purchased a storage battery motor capable of hauling four one ton cars per trip. At this time there was nine thousand feet of drifts, cross-cuts, and raises accessible throughout the mine. The mine started employing a larger number of men, up to fifteen, and ore production started to increase when an ore vein was discovered at 6500 feet from the portal. During the summer of 1926, ore production averaged one hundred fifty to two hundred tons per month with an average of forty to fifty ounces of silver per ton.

In 1927, the mine was leased to James Heatherly and Associates, and in 1928 it was leased to Jim Herron and Associates. During the Herron Lease the Hope M, M, & L Co. opened negotiations for the construction of a 50-ton mill at the site. Forty tons of silver ore were produced at forty ounces a ton during the Herron Lease. In March of 1929, the mine was under lease to the Cross Creek Mining and Milling Company. During this time the 50-ton concentration and floatation mill was near completion and was projected to start operation the 1st of April. On July 21, 1929 the new mill was operational and ran for about two hours before it caught fire and was destroyed.

The mine was leased to Michael Brand from 1930 to 1931 with little ore production. The last two men who leased the Hope Mine were William Herron and the Crosly Brothers. Little production was accomplished at the mine and the last mine inspection report was completed on June 14, 1940. Mr. Garth Williams purchased the property in 1953 (see Land Ownership 2.2).

2.4 Site Features and Waste Characteristics

The Hope Mine has limited access due to a locked and gated entrance with a private property sign stationed after the gate and prior to mine adit (see picture on title page). The Site is comprised of one collapsed, flowing mine adit located adjacent to the east of Castle Creek; Castle Creek then flows into the Roaring Fork to the north. The mine adit discharges on the surface for a very short distance before flowing subsurface through a valve gate which redirects the water through a water conduit down gradient and released back into Castle Creek between mile marker 6-7 on FR 102 (Castle Creek Road). During the site visit in 1997 (USFS), two sections comprising the mine waste dumps were identified, but the waste pile is actually one large mine waste dump divided by an erosional rill from occasional, flowing surface water when discharge flow at the area is larger than the diversion capacity through the valve gate. This site reconnaissance also separated the mine waste pile in two individual piles for chemical sampling efforts (north and south dumps) due to the area and nature of the mine waste pile. The north mine waste tailing is approximately 100 feet in length and 90 feet in width with an estimated volume of 3,000 cubic yards. The north mine waste tailing is approximately 100 feet in length and 50 feet in width with an estimated volume of 2,500 cubic yards. These measurements and calculations were documented during the USFS 1997 site reconnaissance. The top sections of the waste tailings have been graded and are primarily flat, with no real gradient. The west section of the tailings has a steep gradient just above and adjacent to Castle Creek; moreover the toe of the north waste pile is being undercut by Castle Creek (cut-bank). Due to the nature and situation of the steep natural hill slope, steep gradient of the mine waste slope being undercut, the Site has the potential to become unstable. If the mine waste tailings were to destabilize, large amounts of debris would directly enter into Castle Creek.

The waste tailings are indicative of most mine wastes with differing waste matrix sections throughout. The field reconnaissance conducted by the USFS in 1997 had observed reports of limonitic porphyry, black shale, and limestone. Observations at the Site identified seeps and springs (HMS) on the lower, central, west section of the north mine waste pile about five feet above Castle Creek. A wooden boxed structure was observed at the spring(s) location, at river level, which may indicate that the adit drainage was historically diverted through the mine waste by this wooden conduit and released directly into Castle Creek. The spring location was just down gradient of the wooden structure. Vegetation of trees, willows, shrubs, forbes, and grasses are establishing on the waste piles; however, some areas of the waste piles have little to no vegetation especially on the steep side slopes.

Approximately 100 ft. south of the adit is a two story building with an out building 75 ft. to the west. The residential building is a two story structure constructed of a concrete lower level and sawn lumber second floor. The building is 16 ft. wide by 40 ft. in length with a gross area of 1,280 square ft. The out-building is a very old lumber and wooden constructed storage area.

This site investigation determined there was no imminent danger presented at the portal of the mine adit except by naturally occurring rock or soil movement that may occur at the collapsed portal, which seemed relatively stable with little movement and moderate slope gradient. The sides of the waste piles are steep and located directly above Castle Creek. Structural stability and other dangers associated with the buildings on the Site may pose potential dangers to the public if they were to enter them.

2.5 Environmental Setting

The Hope Mine is on the South West slope of Richmond Hill adjacent to Castle Creek and is a montane ecosystem with mixed forest and riparian, at ~8,700 feet in elevation. The mean annual precipitation of Aspen, CO is 19.3 inches, and a mean annual temperature of 40.7˚. The mean annual precipitation is attributable to snow fall with an annual mean of 140.0 inches (WRCC, 2010). The summers have day time temperatures of 68-85˚ with mild night temperatures of 50˚ and below. Afternoon thunderstorms are common in the summer months, indicative of the Rocky Mountains. Winter temperatures are 20-40˚ during daytime and 30˚ degrees and below at night (City of Aspen and Pitkin County Home Website, 2010). Detailed climate summaries for Aspen, CO can be found at the following website: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?coaspe

Castle Creek experiences seasonal flow regimes with higher flow during the snow melt run-off in early summer and lower flows during the winter months. The stream flow information for Castle Creek was obtained for the years between 1969 and 1994. Flows are at the lowest during January and February with monthly mean discharges between eight and nine cubic feet per second (cfs). High monthly mean discharge occurs during June at 211 cfs.

Mean-Flows Streamflow Statistics (Monthly), USGS		
Statistic	**Flow** (ft^3/s)	**Prediction Error** (%)
January	8.37	25
February	8.92	24
March	21.6	19
April	118	21
May	211	21
June	90.3	56
July	34.7	61
August	21.7	32
September	49.3	11
October	18.6	19
November	13.3	21
December	9.69	21

Table 1. Monthly Mean Streamflow Statistics, USGS Station 09074800, Castle Creek Above Aspen, CO. This Information provided by the USGS, Colorado Water Science Center, Lakewood, CO.

Castle Creek and adjacent Maroon Creek have riparian areas supporting four significant plant communities dominated by blue willow (*salix drummondiana*), narrowleaf cottonwood (*Populus angustifolia*), or blue spruce (Spackman et al., 1999). A list of documented wildlife, plants, birds, amphibians, fish, and mammals identified in the Roaring Fork Watershed can be found in Appendix F.

The list provided below is a list of Threatened (T), Endangered (E), and Candidate Species (C) for Pitkin County, CO:

U.S.FWS Threatened and Endangered List; Pitkin, County, CO		
Bonytail chub*	*Gila elegans*	E
Canada lynx	*Lynx canadensis*	T
Colorado pikeminnow*	*Ptychocheilus lucius*	E
Greenback cutthroat trout#	*Oncorhynchus clarki stomias*	T
Humpback chub*	*Gila cypha*	E
Mexican spotted owl	*Strix occidentalis lucida*	T
Razorback sucker*	*Xyrauchen texanus*	E
Uncompahgre fritillary butterfly	*Boloria acrocnema*	E
Ute ladies'-tresses orchid	*Spiranthes diluvialis*	T
Yellow-billed cuckoo	*Coccyzus americanus*	C

* Water depletions in the Upper Colorado River and San Juan River Basins, may affect the species and/or critical habitat in downstream reaches in other states.
# Recent genetic tests identified cutthroat population as GB linage, therefore, consultation is an interim measure until genetic and taxonomic issues are resolved.

Table 2. Potential Threatened, Endangered, and Candidate Species List within the Site Proximity (USFWS, 2009).

2.6 Geologic Setting

The Colorado Mineral Belt is a result of the Laramide Orogeny of the early Tertiary period (approximately 75-50 million years ago). During this time igneous bodies intruded Precambrian metamorphics and hydrothermal solutions activated by the molten activity of the uplift and containing rich concentrations of dissolved metals (including precious metals such as gold and silver) were deposited with the intrusions in cracks and fissures from block faulting of the period (Henderson, 1926).

The following information is from: Geology of the Aspen Mining District, Colorado: with atlas. Department of the Interior Monograms. United States Geological Survey Volume XXXI. Washington Government Printing Office, 1898. Joshua Edward Spurr.

> *The ores of Aspen are essentially silver ores, and contain remarkably small amounts of other metals, with the exception of lead. Very considerable bodies of ore, notably the wonderfully rich bodies of polybasite and native silver found in the mines of Smuggler Mountain, are practically free even from lead. The ores*

> *of the district consist chiefly of lead and zinc sulphides, carrying silver, with a gangue of barite, quartz, and dolomite. On oxidation the sulphides change to sulphates, carbonates, and oxides. The deposition of the metallic minerals has taken place almost exclusively along the faults, but it is only in certain places that the fault zones lie come sufficiently mineralized to form valuable ore, for it is chiefly at the intersection of two or more faults that rich shoots are formed. The intimate association of the metallic sulphides with dolomite, quartz, and other gangue materials suggests a common origin for all that they were deposited by ascending hot waters.*

The Hope Mine is located within the Richmond Hill Mining District on the west aspect of Richmond Hill below the Annie Basin. Parallel to this geographic feature is the Castle Creek fault.

> *Subsequent to the deposition of the Laramie and the intrusion of these eruptive rocks, physical disturbance began. Among the first changes was the elevation of the Sawatch Range, so that the beds which lay round its flanks assumed a general dip away from the main uplift. At about the same time occurred some minor folding, which was apparently due to a lateral thrust exerted from the westward, and in the Aspen district was most pronounced in a narrow zone. Here an overthrown anticline was formed, which culminated in a great break, called the Castle Creek fault. Probably beginning at the same period, but continuing afterwards, was the development of a domelike uplift, which affected both granite and sedimentary rocks in a restricted region east of the Castle Creek fault, now occupied by Aspen Mountain and Tourtelotte Park.*

As mentioned in the Historical Overview (Section 2.3) from the Bureau of Mines Inspection Reports, the Hope Mine drift drove into what was known as the Annie contact and the Richmond contact. The Hope Mine also cut through the Maroon formation, Weber grits and shale, gypsum, shale, and limestone into quartz porphyry. Ore at the mine had averaged 40 to 101 ounces of silver per ton during periods of peak ore extraction.

3.0 Methods for the Investigative Studies

This section describes the methods used for the completion of this report. There were three components to the methods for this evaluation. The first was a site reconnaissance effort (Section 3.1) that was completed to obtain an overall understanding of the Site and to construct the design for the second component, the sampling effort (Section 3.2). The final component is comprised of a records review (Section 3.3), which took place concurrent with the site reconnaissance and the sampling effort. The methods for these three components are described in the following subsections, along with a description of the sample analysis methods used by the contracted laboratory.

The results of the investigative studies were used to determine the receptors potentially impacted by the Site, the pathways by which the receptors can be exposed, and the potential hazard to the receptors as a result of exposure (Section 4.0 Pathway and Environmental Hazard Assessment). As previously mentioned, the site reconnaissance also helped to identify the field team health and safety considerations and the sampling effort design component. The records review also helped to identify data gaps to be filled during the sampling effort. All components followed congruently in step with each other as the project progressed.

3.1 Site Reconnaissance

A site reconnaissance was completed by John Neubert /USFS (1997), Olivia Garcia/USFS and Dirk Monroe/CMC NRM on August 17, 2009. Available information obtained by the USFS (1997) was reviewed, and each feature associated with the site was visited. During the site visit, features of the site were photo-documented. A clear understanding of the impacted areas was determined. Results of the Site reconnaissance helped construct a SOW which identified the exact numbers and types of samples to be collected.

Upon the completion of the site reconnaissance, a site investigation was conducted in order to characterize the waste, site setting, and potential exposure conditions (8/17/09).

A determination was made on site to divide the mine waste pile into two separate segments for two composite sample collections of mine waste due to the size and area of the mine waste pile. A background sample was not collected during this event, but was later collected at the site by Olivia Garcia (USFS) on June 6, 2010. The background sample was collected as a grab sample approximately one hundred feet south of the residential structure in an undisturbed location at the site.

Surface water sampling was determined to be conducted at four sites:

- Up gradient of the mine waste piles on Castle Creek (CCUS) to collect a background sample
- Down gradient of the mine waste site to determine if any chemical loading was being introduced into Castle Creek (CCDS)
- Discharge at the Hope Mine adit (HMA)
- After further investigation, samples were collected at the site where seeps and springs were discovered at the bottom segment of the mine waste pile just above Castle Creek (HMS). Only one spring had enough discharge to properly measure and sample water.

As part of the surface water sampling protocol, general water quality and chemistry (pH, specific conductivity, temperature, total dissolved solids (TDS), oxygen reduction potential (ORP), acidity, alkalinity, hardness, dissolved oxygen (DO)) were measured in situ at each site. Discharge measurements were document along with water sample collection. During the discharge measurements on Castle Creek (CCUS) the equipment used malfunctioned and could not be repaired. A general area (cross section measurement) and timed method was performed for a general estimate of discharge. Discharge was not measured at the CCDS site.

The field sampling methods are described in the following Section 3.2.

3.2 Sampling and Analysis

In order to achieve the purpose discussed in Section 3.0, the following tasks were accomplished during the sampling effort:

1. General site characterization
2. Sampling of mine waste and background sample
3. Water sample collection tasks

The methods for these tasks are described in the following subsections with more detail provided in the SAP and QAPP (Appendix B). Upon completion of the field sampling effort, the samples obtained were process by CMC NRM staff and field technicians. Chemical analysis consisted of XRF for mine waste solids and ICP-OES for leachate and surface water samples in the Timberline Analytical Laboratory.

3.2.1 General Site Characterization

The entire property was traversed and characterized as per the Guidance for Performing Preliminary Assessments under CERCLA (EPA, 1991). Observations of the following features were surveyed using a GPS, photo-documented, and described within field notes. The following is a description of the observations conducted in order to characterize the Site during the site reconnaissance and the sampling effort.

- Waste occurrence and possible source, transport, and receptor mechanisms
- Impacted media from the waste
- Site features associated with the mining heritage (mine openings, waste piles, and volume of waste piles, etc.)
- Site features of environmental components

3.2.2 Sampling of Mine Waste

The Hope Mine site was comprised of one mine waste feature. This mine waste feature was sampled in order to characterize the potential impacts to human health and the environment. Mine waste was collected and analyzed for a standard suite of metals as per the Timberline Analytical Laboratory (TAL) in-house analysis methods. Mine waste samples were analyzed for total solids metals content by XRF, and leaching procedure extract analysis established by Smith and others (2000).

There were distinct protocols, identified in the SAP, found in Appendix B, for the collection and analysis of the mine waste samples. The initial identification of locations for sampling was chosen in order to fully characterize each mine feature. A regimen of overlying QA/QC measures were used for the sampling. The details of the sampling methodology (SAP) are provided in Appendix B. The following describes the general approaches for the collection of surface water and mine waste samples.

Mine Waste

The Hope Mine site consisted of one waste pile located on the west-facing slope of Richmond Hill adjacent to the east of Castle Creek. The waste pile site was divided into two separate areas: the Hope Mine North Dump (HMND) and Hope Mine South Dump (HMSD). These two areas were separated by an erosional rill. There is noticeable erosion and mass movement on the lower sections of the mine waste tailings. Castle Creek is undercutting a portion of the mine waste pile at the toe, and springs and seeps were identified at the toe of the mine waste pile. The HMND sampling was not a complete representative of the mine waste due to the hazard posed on the steep west slope of the waste pile. This area was inaccessible and was not sampled as part of the composite sample.

Samples of mine waste were collected randomly throughout the surface of the pile, following the methods described within Smith and others (2000) and Hageman and Briggs (2000). Thirty distinct aliquots of waste were gathered by hand, taken at a depth of fifteen centimeters, and made into a single composite sample in a 5 gallon bucket. The samples were later homogenized by hand mixing. The bucket was capped and transported back to the CMC Timberline Campus for sieving, paste pH, and conductivity analysis. A 500 g size 10 sieve sample was taken from the homogenized bucket of material from each site, and analyzed in the TAL by XRF and ICP-OES for leachate analysis. A second sieved sample was retained at CMC NRM lab and analyzed for paste analysis of pH and conductivity (following methods described by Hageman and Briggs, 2000). The TAL analyzed the mine waste samples by XRF, and leachate dissolved metals content as described in subsection 3.2.4.

3.2.3 Water Quality Characterization

The Hope Mine site had three surface water sites from which water samples were collected. Surface water sample collection was performed to characterize the potential impacts to human health and the environment. Water samples were analyzed for dissolved and total recoverable metals by ICP-OES in the TAL using an in house method.

Two samples were collected on Castle Creek (CCUS and CCDS) and samples were collected at the Hope Mine adit (HMA) and the Hope Mine Spring (HMS). A baseline sample for background conditions was collected at CCUS and sample collection was performed down gradient of CCUS and Hope Mine waste tailing area, at CCDS, to determine potential loading of contaminates from the site area into surface waters. The HMS is listed as surface a water site, but may be representative of groundwater in the Site area. It is unknown if the HMA and HMS are connected.

General Water Chemistry and Quality

General water chemistry analysis for alkilinity, hardness, acidity, and DO used Hach volumetric titration methods 8203, 8213, 8202, and 8215. Details to the Hach methods can be found in Appendix B. General water quality measurements for pH, temperature, conductivity, TDS, and ORP were conducted with a Myron Ultra Meter II.

3.2.4 Analysis Methods

Mine waste samples were submitted to the TAL which used in house methods for water analysis. All samples were preserved per the SAP (see Appendix B).

TAL conducted four types of environmental analysis:

1. Total soil solids for metals (XRF with three soil NIST SRMs)
2. Leachable metals from the solids (Smith et al., 2000 and Method 6010C for aqueous solutions)
3. Dissolved Metals (in house TAL Method)
4. Total Recoverable Metals (in house TAL Method)

CMC NRM staff and student field technicians completed the leachate tests and the subsequent leachate analysis of metals content in the TAL. The list of metals analyzed for was consistent for each of the four types of media analyzed. These include; Arsenic (As), Barium (Ba), Cadmium (Cd), Copper (Cu), Lead (Pb), Mercury (Hg), Selenium (Se), Silver (Ag), Zinc (Zn), Nickel (Ni), and Aluminum (Al). In addition to the previous analytes, the TAL in house methods analyses include twenty two other analytes.

Copies of the analytical results and laboratory QA/QC data are provided in Appendix C. The ICP-OES method detection limits fell within acceptable ranges for the quality of data needed for this evaluation, excluding arsenic. The method detection limit for arsenic is 3.5 µg/L, which is above the BLM groundwater health benchmarks. In order to accurately determine if arsenic is a threat to human and ecological receptors, analysis would need to be conducted at a laboratory with method detection limit of 1 µg/L. All other method detection limits fell below the screening thresholds used in the hazard assessment portion of this report (Section 4.0).

The analysis for the mine waste leachate chemistry involved the use of Hach SensIon pH meters for pH, temperature and conductivity. Total Acidity was measured using Hach volumetric digital titration techniques, which can achieve 1.00 ppm detection limits. The qualitative observations were subjective, but were completed in a consistent manner by the field personnel in order to assure a high QA/QC level.

3.3 Records Review

As previously described, existing records describing site features were obtained from available sources. The specific information researched included:

- Site location
- Property ownership
- Mining history
- Historical significance
- Operational history
- Waste characterization
- Environmental Setting
  - Threatened, Endangered, and Candidate Species evaluation
  - Site biological features

- Site geological features
- Hydrologic and topographic description

The sources of records reviewed were in the forms of literature (journals, mining survey entries, and agency field records) and/or electronic databases (i.e. Colorado Natural Heritage Program for the Threatened and Endangered Species evaluation). All records relied upon were referenced, and where possible, provided in complete form as an Appendix to this document (Appendix D). As per the PA guidance, there are standard databases from which to access waste characterization information (CERCLIS, RCRA, NPL).

A summary of the points of contact for the records reviewed are summarized below. The records obtainable from each of the following sources are also described.

Bureau of Land Management – Mined Land Inventories and Records
Carl Barna (Historian): (303) 239-3727
Andy Senti (Librarian/Historian): (303) 239-3717
Barbara Hite (AML Coordinator) (303) 239-3711

Colorado State Archives
1313 Sherman, Room 1B20
Denver, Colorado 80203
Phone: (303) 866-2354
www.colorado.gov/dpa/doit/archives/

> *Obtainable records include: Colorado Mine Inspector Reports summarizing production, owners, and activity at the Site; Colorado Bureau of Mines Annual Reports which list mines by county and give the owner/operator and products produced from a given mine.*

Colorado State Library – Denver Public Library
201 East Colfax Avenue, Room 309
Denver, CO 80203
www.cde.state.co.us/index_library.htm

Colorado School of Mines – Arthur Lakes Library
Mining Records and Archives: Bob Sorgentry (303)-273-3911
Mining Research Records: Lisa Dunn (303)-273-3911

State of Colorado, Bureau of Mines
Martha Poley (Archivist) (303) 866-3679
Richard Moorman (Colorado Inactive Mine Program) (303) 866-3651

State of Colorado, Division of Minerals and Geology
Richard Moorman (Colorado Inactive Mine Program) (303) 866-3651

United States Forest Service-White River National Forest
Olivia Garcia (USFS WRNF AML Coordinator) (970) 945-3220
James A. Kirschvink (Realty Specialist – Aspen Sopris Ranger District) (970) 945-3313

Documents obtained included the USFS AML Field Forms from the 1997 Hope Mine Site reconnaissance and USFS WRNF documents of Special Authorization Use Permits for the Williams and King Cabin (Aspen-Sopris Ranger District).

United States Geological Survey, Colorado Water Science Center
Denver Federal Center, Bldg 53, MS 415 , PO Box 25046
Lakewood, CO 80225 (303) 236-4882 ext. 290

Information included the Statistical Stream Flow Data for Castle Creek.

A variety of databases were accessed to identify hazardous and non-hazardous waste site inventory characteristics (as obtained from the CERCLIS, CORRACTS and RCRA web pages, all within the EPA home web page) and threatened and endangered species (USFWS) as well as wetlands inventory (NWI maps).

4.0 Pathway and Environmental Hazard Assessment

There are two components to this section; 1) an identification of pathways, and 2) a hazard assessment.

The identification of pathways was completed by using professional judgment when reviewing site conditions of waste source areas, possible transport mechanisms and possible receptors (both human and ecological) to exposure. The following subsections describe whether a possible fate and transport pathway between the waste source to receiving media (ground water, surface water and soil) is possible. It also describes the possible receptors (targets) exposed to the affected media, and the exposure pathways to these receptors. Observations of the area populations and environmental features were noted, in order to determine the possible exposure pathways that could occur.

The hazard assessment was completed by comparing the measured concentrations of contaminants (resulting from the sampling and analysis completed at the Site) to background concentrations and toxicity threshold concentrations protective of human health and ecological receptors. If the measured concentrations exceed these protective values, then an impact may be inferred. However, there are uncertainties associated with this method which may either over or under-estimate the impact. These uncertainties are described within each media pathway and target evaluation.

For the purposes of this evaluation, the hazard assessment relied upon available thresholds from various literature sources in order to determine potential impacts attributable to the Site. A description of each type of threshold, the source and the limits of their use is as follows;

EPA Drinking Water – Health Advisories (Tables 5 and 7)
Criteria protective of potable water supplies are regulated by the EPA and summarized within their health advisories for drinking water sources as either Maximum Concentration Level Goals (MCLGs) or Maximum Concentration Levels (MCLs) (EPA, 2009). The MCLs are promulgated criteria, where as the MCLGs are 'goals' for future consideration. Both values are protective of human consumption of water supplies assuming chronic exposure conditions and conservative assumptions (i.e. compromised individuals).

CDPHE Ambient Water Quality Criteria (AWQC) for the Protection of Aquatic Life – Cold Water Class 1 advisories and site-specific criteria (Table 6 and 7)
These criteria are set forth by the State of Colorado to protect the designated uses of the waters of the state (CDPHE, 2005a and b). The site-specific AWQC values set forth for this segment, as well as table value standard default criteria (where site specific values were absent) were used for the hazard assessment for aquatic life. Both site specific and default values are provided in the Tables. In the interest of being conservative, and assuming that the Hope Mine site surface water may recharge local groundwater, which in turn could recharge into the Castle Creek's surface water; the AWQC threshold comparison was completed for groundwater as well.

EPA and CDPHE Groundwater Standards (Table 6)
The EPA and CDPHE have established standards for groundwater potable supply use. These values are protective of human health (EPA, 2009; CDPHE, 2005c). The surface water and leachate results were compared to these values as a conservative method to determine groundwater impacts.

EPA Regional Soil Screening Thresholds (Table 10)
Available EPA Regional thresholds which are correlative to screening values that determine if a site is polluted, were obtained from EPA Region 3, 6 and 9 (EPA, 2009). These values are used only to determine if anthropogenic levels of contaminants are present in soils. These guidance values are not mandatory or a binding rule under CERCLA.

EPA Regulatory and Human Benchmarks for Soil Screening Levels (Table 10)
These thresholds were developed for Soil Screening Levels and are only guidance for human threshold levels (EPA, 2002).

Bureau of Land Management, Risk Management Criteria for Metals at BLM Mining Sites (Tables 5, 10, and 12)
The BLM has developed both human health and ecological threshold values for groundwater, surface water and soils (Ford, 1996). The values vary by receptor and exposure type. These values were useful for all pathways assessed and are therefore used for the groundwater, surface water and mine waste hazard assessment. These values do not represent cleanup criteria, but rather they are screening thresholds to determine if certain receptors and exposure settings would be a concern if exceeded.

EPA Soil Screening Toxicity Thresholds (Tables 11 and 12)
The EPA has developed a set of risk-based soil screening levels (Eco-SSLs) for many of the soil contaminants that are frequently of ecological concern for terrestrial plants and animals at hazardous waste sites (EPA, 2010). The screening values are used routinely to identify those contaminants of potential concern in soils requiring further evaluation in a risk assessment process. The values were derived separately for four groups of ecological receptors, plants soil invertebrates, birds and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. The Eco-SSLs are not designed to be used as cleanup levels. There are limits to the types of soils that these values can be applied. They apply to soils where the pH is greater than or equal to 4.0 and less than or equal to 8.5, and the organic matter content is less than or equal to 10%. The Oak Ridge National Laboratory toxicity thresholds are similar, yet derived from different toxicity studies (Efroymson et al., 1997a and b). They too, provide toxicity thresholds protective of terrestrial receptors that may be either directly or indirectly

exposed to soil related contamination. If an observed contaminant concentration is greater than these values, a possible effect to the receptor can be inferred. Other lines of evidence such as exposure rate etc., need to be incorporated before a conclusion regarding toxicity can be drawn. These values are for 'screening' purposes only, and not a true measure of site toxicity conditions.

Tables 3 and 4 provide a summary of data results developed from the waste leachate tests completed by CMC NRM. The results of these analyses may reflect a source of contaminates that could potentially impact groundwater or surface water runoff concentrations from the mine waste. As a conservative method, the results of these measures were compared to toxicity thresholds protective of human health drinking water supply use (MCL and MCLG values) (**Table 5**), as well as AWQC values protective of aquatic life (**Table 6**).

Table 7 provides a summary of the data results from the dissolved metals and total recoverable metals by ICP-OES at the TAL using an in house method. This analysis provides the characterization of surface water pathways at the Hope Mine site. **Table 8** provides the summary for the in situ, general water chemistry and quality taken during surface water sample collection. The results for the surface water sampling were not compared to toxicity thresholds to human and aquatic life. The HMS concentration values for aluminum (Trec) and iron (Trec) were the only constituents to exceed the CDPHE aquatic life parameters and have a potential risk to human health if the HMS site were used as a drinking source.

Table 9 provides a summary of the data results from the waste samples (solids) by XRF. Within **Table 10**, the waste sample results are compared to human health soil protection standards, and regional values that define the degree of contamination. Within **Table 11**, summary statistics of the data gathered from the Site sampling is provided, along side EPA Regional values for soils, USFWS comparable background levels, and toxicity thresholds from various sources that are protective of plants, invertebrates and wildlife (**Table 12)**. The results of the Site sample comparison to these thresholds provide a line of evidence for the soils pathway hazard assessment. Other lines of evidence include the proximity of targets in relation to the waste source, and the completion of exposure pathways. All of these lines of evidence are then folded together to determine if a hazard is present, and whether further action is warranted.

4.1 Groundwater Pathway and Targets

The waste associated with the site is in the form of mine waste rock piles that can indirectly impact the local groundwater aquifer. In conjunction with the mine waste, The HMA and HMS are listed as surface water sites, but may represent the conditions for groundwater characterization. The HMA may characterize groundwater quality within the mine workings and of the immediate area. Under certain conditions the HMS may representative any water quality impacts to groundwater by the mine waste leachate.

The area groundwater was not sampled; therefore the current conditions of these resources were extrapolated from the results of the mine waste sample leachate analysis. The results of analysis of the mine waste leachate would represent worst-case possible conditions for the area groundwater quality. The mine waste solids material can release metals to underlying groundwater through the processes of infiltration and leaching. Precipitation from snow and rainfall can trickle through the waste, and carry metals into solution if the conditions permit. It is assumed that leachate from the mine waste will flow into Castle Creek which is a likely source of aquifer recharge in the area. Results of the leachate tests are further examined within this subsection.

There are wildlife and aquatic receptors within the area. The Site has year-round water sources and vegetation-forage at the immediate site and adjacent area conducive to several species of biota. Aquatic life is limited to Castle Creek and wildlife receptors would be exposed if they ingested the surface water resource from Castle Creek, adit discharge, and spring discharge. Aquatic life would be exposed if the contaminated groundwater recharged a surface water body that was habitat to the organism. Aquatic life would then become exposed via direct contact, inhalation and ingestion.

There is a potential for human health targets within the immediate area of the Site that could potentially be exposed to groundwater as there are several groundwater wells within the Castle Creek drainage, which is highly populated. The nearest town is Aspen located approximately six miles to the north. The only case for human exposure at the Site would occur if surface water and ground water from the Site were ingested. The likely source of this pathway would be recreators visiting the area.

The accessibility or availability of metals depends on specific physical and geochemical binding mechanisms that vary among metals and soil types. Contaminants transported through soil interact with the surface of soil particulate material (adsorption), by penetration through the particulate surface where the contaminant becomes associated with the internal material (absorption or partitioning) and through specific contaminant reactions sometimes referred to as chemisorption. Also, metals in particular will associate with inorganic ligands and precipitate. The affinity of a metal to be associated with soil particulates, thus removed from solution, is generally referred to as sorption. Metals are generally considered to be bioavailable when they are released from interactions with the soil, thus released into the soil pore-water (EPA, 2000)

Metals show variable mechanisms of interaction in soils. Metals can exist in the pore-water as ionic species, as soluble complexes, or precipitate out of solution. Metals existing as cations (zinc, copper, cadmium, lead, aluminum, iron, nickel and silver) have an affinity to bind with soil particulates and organic matter which tends to be anionic, which then becomes less bioavailable. In contrast, certain metals (arsenic, selenium, antimony) typically stay in anionic form generally remain in pore-water solution and retain their bioavailability to organisms (EPA, 2000).

A general trend is often observed with the mobilization of metals from soil when acidic water sources percolate the medium. Acidic conditions provide the potential for soil bound metals to be leached into groundwater. This may not be the case for the Hope Mine site, given the water and soil pH is in a neutral range > 6.8 to < 8.4. However, results of the mine waste leachate tests indicate that minimal metals leach as a result of a rigorous analysis procedure. The range of detected metals from the sample used for leachate analysis is shown in **Table 3**. Leachate and paste chemistry is shown in **Table 4**. Comparison of measured concentrations to applicable groundwater thresholds for human health (**Table 5**), and ecological receptors (**Table 6**) is provided. Results are summarized as follows;

- The leachate samples processed from the mine waste composite samples yielded detectable concentrations of aluminum, arsenic, barium, beryllium, boron, calcium, copper, magnesium, phosphorus, potassium, silicon, silver, sodium, strontium, and sulfur with minor amounts of lithium, manganese, beryllium, molybdenum, silver, and vanadium. The remaining metals analyzed fell below

detection limits (cadmium, chromium, cobalt, iron, lead, nickel, and selenium). The leachate pH of the mine waste samples measured 7.33 (HMND) and 7.26 (HMSD) with conductivity measurements of 2194 μS/cm (HMND) and 1395 μS/cm (HMSD).

- The leachate samples processed from the mine waste composite and background (HMB) samples detected analytes with aluminum concentrations having a potential impact on human health and the environment. The remaining analytes detected did not exceed any toxicity threshold criteria. The high concentration level of aluminum (1.5 mg/L) found within the HMB leachate sample is from unknown sources (i.e. naturally occurring or anthropogenic sources).

- Upon site visit no groundwater was collected or analyzed, thus water analysis of the spring discharge may be considered the best representative of groundwater within the mine workings. The leacheate analysis represents another potential impact of mine waste contaminates into the immediate groundwater system, but is an overestimation of groundwater impacts due to the highly concentrated nature of the leachate procedure and would likely produce a higher metal leachate than normally produced through precipitation infiltrating the mine waste pile.

Human Health Hazard Assessment

- Dissolved water chemistry from HMS does not indicate a risk to human health and does not exceed drinking water criteria. The HMS does have total recoverable metal values that may be of potential concern (Table 7).

- Chemistry of the leachate samples identified aluminum as exceeding the secondary drinking water standards (EPA, 2009). The measured concentrations of the remaining analytes did not exceed any criteria for drinking water or groundwater.

- There are several domestic well locations within a 4 mile radius and down-gradient of the Site. The town of Aspen, located six miles to the north, has residential development throughout the Castle Creek drainage area. No information was attained as to the water quality of these domestic wells.

Ecological Receptor Hazard Assessment for Aquatic Life

- Results from the HMS indicate the aquatic life-health could potentially be affected for total recoverable iron and aluminum if water were released to a surface water body that provided aquatic habitat.

- Several analytes were detected in the leachate analysis with only aluminum as a potential risk for aquatic life-health (USEPA, 1988), but the aluminum (Total Recoverable Metals- Trec) concentrations levels do not exceed the standards set by the CDPHE aquatic life parameters (CDPHE, 2007).

Table 3. Mine Waste Leachate Metals Results (ug/L)[1]

Site ID		As	Al	Pb	Cd	Ba	Cu	Cr	Se	Ag	Zn
	MDL µg/L	3.5	40	4.3	1	0.5	3.3	2.6	4.1	0.4	2.9
Hope Mine North Dump HMND		ND	155	ND	ND	14	6	ND	ND	0.5	ND
Hope Mine South Dump HMSD		ND	116	ND	ND	10	4	ND	ND	ND	ND
Hope Mine Background HMB		ND	1500	ND	ND	NM	ND	ND	ND	ND	4

ND= Non-Detect with current ICP-OES method
[1]Leachate analysis by ICP-OES in the TAL using an in house method.
MDL – Method Detection Limit
NM – Not Measured.

Table 4. Mine Waste Leachate and Paste Chemistry

Site ID	Paste pH	Paste Conductivity (µS/cm)	Leachate pH	Leachate Conductivity (µS/cm)	Leachate TDS (ppm)	Leachate Acidity[1] (mg/L $CaCO_3$)
Hope Mine North Dump HMND	6.87	1694	7.33	2194	1616	11.1
Hope Mine South Dump HMSD	6.91	1674	7.26	1395	988	24.8
Hope Mine Background HMB	6.67	195	7.16	101	NA	< 10

1. Hach total acidity digital volumetric method
2. NA – Measurement was not taken

Table 5. Human Health Groundwater Protection Standards (µg/L)

Analyte	Leachate Summary µg/L			EPA Human Health Drinking Water Standards		EPA Groundwater Protection Limits	CDPHE Groundwater Use Standards			BLM Risk Management Criteria		
	HMND	HMSD	HMB	MCLG	MCL		Human Health Standards	Drinking Water Standards	Agricultural Standards	Resident	Camper	ATV Driver
As	ND	ND	ND	0	10	50	50	(1)	100	0.1	1	(1)
Pb	ND	ND	ND	0	15	50	50	(1)	100	15	15	(1)
Cd	ND	ND	ND	5	5	10	5	1000	10	0.2	2	(1)
Ba	14	10	NM	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cu	6	4	1	1300	1399	(1)	(1)	(1)	200	18	137	(1)
Hg	ND	ND	ND	2	2	2	2	(1)	10	0.1	1	(1)
Cr	ND	ND	ND	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Se	ND	ND	ND	50	50	10	50	(1)	20	2	18	(1)
Ag	0.5	ND	ND	(1)	(1)	50	50	(1)	(1)	2	18	(1)
Zn	ND	ND	4	(1)	(1)	(1)	(1)	5000	2000	142	1106	(1)
Al	155	116	1500	50	200	(1)	(1)	(1)	5000	(1)	(1)	(1)

ND – Non-detect with current ICP-OES method.
NM – Not Measured.
(1) Not Available

Table 6. Ecological Groundwater Protection Standards (µg/L)

Analyte	Leachate Summary µg/L			EPA AWQC		CDPHE AWQC	
	HMND	HMSD	HMB	Acute	Chronic	Acute	Chronic
As	ND	ND	1	340	150	340	150
Pb	ND	ND	3	82.3	0.32	65	2.5
Cd	ND	ND	ND	2.0	0.25	4.3	2.2
Ba	14	10	ND	(1)	(1)	(1)	(1)
Cu	6	4	1	13.5	9.4	13	9.0
Hg	ND	ND	ND	1.65	0.91	1.4	0.77
Cr	ND	ND	ND	(1)	(1)	(1)	(1)
Se	ND	ND	ND	(1)	5.0	18.4	4.6
Ag	0.5	ND	ND	4.0	(1)	2.0	0.32
Zn	ND	ND	4	122.7	121.7	117	118
Al	155	116	1500	(1)	750	(1)	750

ND – Non-detect with current ICP-OES method.
(1) Not Available

4.2 Surface Water Pathway and Targets

The Hope Mine site is located within the Roaring Fork watershed, in the Castle Creek tributary drainage system. The Site is approximately six and a half miles up gradient of the confluence between Castle Creek and the Roaring Fork. At the time of the site investigation, discharging surface flow was observed at the Hope Mine adit and the seeps and springs at the toe of the mine waste. There is evidence of additional surface flow across the mine waste that likely occurs during seasonal spring snow melt season and during precipitation events.

Water sample collection for dissolved and total recoverable metals, general water chemistry, and water quality along with discharge measurements was conducted at the site. Water samples were collected at the mine adit, on Castle Creek (up-gradient and down-gradient of the mine site), and at the spring located at the toe of the mine waste pile. Analytical results for surface water sampling and in situ water chemistry is found in **Tables 7 and 8**.

There are targets associated with the surface water pathway. Recreators could visit the Site and assume surface water to be of sufficient water quality for drinking purposes. In regards to ecological receptors, Castle Creek, the mine adit, and spring discharges; though the adit and spring discharges is very limited in size and depth, and does not contain an aquatic habitat sufficient for fish species, Castle Creek is certain to have aquatic and wildlife receptors. Regardless, the exposure pathway to certain aquatic and wildlife ecological receptors is complete. The exposure pathway to human receptors is also complete.

The routes by which aquatic receptors would be exposed include direct contact, ingestion and inhalation. Wildlife and human receptors could become exposed through direct contact and ingestion. Additional pathways for wildlife and humans receptors may include ingestion of contaminated vegetation that has accumulated surface water related to bioaccumulated contaminants.

Human Health Hazard Assessment

Castle Creek-CCUS and CCDS

- Metals detected from the Castle Creek Downstream (CCDS) and Upstream (CCUS) sample locations include calcium, iron, manganese, magnesium, and zinc. Concentrations for all metals did not exceed any risk assessment criteria for human health.

- Results from this analysis indicated the analyte concentrations are below a level of concern to human health if the surface water at the stream sites were relied upon as a drinking water source.

Hope Mine Adit-HMA

- Analysis of the water samples collected at the Hope Mine adit (HMA) detected aluminum, calcium, iron, magnesium, manganese, and zinc. Concentrations levels for all analytes did not exceed any risk assessment criteria for human health.

- Results of this analysis indicate that human health would not be affected if the surface water at the adit site were relied upon as a drinking water source, but the analyte concentrations at the site may vary during seasonal conditions.

Hope Mine Spring-HMS

- Analytes detected from the Hope Mine spring (HMS) include aluminum (Trec), calcium, copper (Trec), iron (Trec), lead (Trec), magnesium, manganese, zinc (Trec), and arsenic (Trec).

- Results indicate a potential risk to human health if the surface water at the HMS site were relied upon as a drinking water source. From the single site visit in August it is unknown if this source would ever be used as a drinking water source.

Ecological Receptor Hazard Assessment for Aquatic Life and Wildlife

Castle Creek-CCUS and CCDS

- Concentration levels detected for the analytes on Castle Creek did not exceed any risk assessment criteria. (CDPHE, USEPA, BLM).

- Results indicate that aquatic life-health and ingestion by wildlife would not be affected within this stream segment.

Hope Mine Adit-HMA

- Aluminum concentration levels at the HMA have the potential to pose risks to aquatic life-health (USEPA, 1988), but the aluminum (Trec) concentrations levels do not exceed the standards set by the CDPHE aquatic life parameters (CDPHE, 2007).

Hope Mine Spring-HMS

- Iron (Trec) and aluminum (Trec) concentration levels exceed the CDPHE aquatic life parameters (CDPHE, 2007).

- Results indicate aquatic life-health could potentially be impacted. The water source is a spring and seep discharge just above river level and flows for a distance of less than fifteen feet before entering the river. Dilution likely occurs after the discharge enters into Castle Creek as determined by the chemical analysis completed down gradient at sample site CCDS.

Table 7. Dissolved[1] and Total Recoverable[1] Analytes µg/L

Site ID		Al	As	Ba	Cd	Se	Ag	Zn	Fe	Mn	Pb
	MDL µg/L	40	3.5	0.5	1.0	4.1	0.4	2.9	7.7	0.9	4.3
CCUS-Diss		ND	ND	ND	ND	ND	ND	ND	16	2	ND
CCDS-Diss		ND	ND	ND	ND	ND	ND	ND	ND	2	ND
HMA-Diss		59	ND	ND	ND	ND	ND	3	14	28	ND
HMS-Diss		ND	ND	ND	ND	ND	ND	ND	ND	3	ND
CCUS-Trec		ND	ND	ND	ND	ND	ND	ND	30	3	ND
CCDS-Trec		ND	ND	ND	ND	ND	ND	5	31	3	ND
HMA-Trec		170	ND	ND	ND	ND	ND	5	88	22	ND
HMS-Trec		809	3	ND	ND	ND	ND	11	3390	43	38

[1]ICP-OES Analysis TAL Method.
Notes: Total Recoverable (Trec) Aluminum and Iron exceeded the CDPHE aquatic life parameters;
CDPHE aquatic life parameters-750 µg/L for Aluminum and 1,000 µg/L for Iron.
MDL – Method Detection Limit.

Table 8. General Water Chemistry and Quality

Site ID	DATE	Time	pH	Cond. µS/cm	TDS ppm	ORP mV	Temp ºC	Alk mg/L $CaCO_3$	Hardness mg/L $CaCO_3$	DO mg/L	Acidity mg/L $CaCO_3$	Discharge (cfs)
CCUS	8/17/10	11:50	8.33	383	258	160	8.5	75	218	7.64	65	62-65
CCDS	8/17/10	14:25	8.33	406	272	222	11.3	79.6	220	7.26	95	NM
HMA	8/17/10	10:45	7.19	1591	1120	229	8.8	123	925	3.06	152	0.42
HMS	8/17/10	13:30	7.27	1758	1229	306	10.7	258	1158	NM	216	0.010

NM – Not Monitored.
HMS discharge measured in liters per minute by volumetric measurements.
Notes: Area velocity flow meter malfunctioned at CCUS (could not repair). Discharge measured with general cross section area (measured) and averaged timed intervals.

4.3 Soil Pathways and Targets

The Site has one mine waste pile comprised of waste rock and ore materials. There appears to be a mix of rock types (i.e. limonitic altered porphyry, shale, and limestone) within the pile which was estimated to cover approximately one acre in surface area. The waste pile was divided into two separate sampling sites due to the size and nature of the waste pile. There were observable signs of erosion in and around each pile. The waste is above and adjacent to Castle Creek and the potential is very high for sediment discharge of mine waste directly into Castle Creek. The potential release(s) may happen over a period of time, with the accumulation of sediments and particulates of concern into the stream bed, or release(s) of large amounts of mine waste containing several constituents of concern into the stream channel at once, posing a potential risk to aquatic life-health and potential human risks (Castle Creek is an influent to water supplies downstream).

The mine waste represents a solids source of contamination for the Site. Often, mine waste can be inert and non-reactive thereby creating no hazard to the environment. Whereas other mines waste piles may have the chemical and physical nature (high sulfide mineral concentrations) to react with water to create acid rock drainage lowering the pH and mobilizing metals into solution. When metals are in ionic form, as in acid rock drainage, they are more readily available for human and environmental receptors. It was unknown as to the character of the piles, so samples of waste were collected and analyzed for both solids metal content and leachate metal content.

There are aquatic, wildlife and human targets associated with the Site. The Site occurs within a well forested region of the valley with year-round water sources, and has natural setting features that would attract wildlife activity. The waste pile had a well established plant community, but specific areas had little to no vegetation. As mentioned in the beginning of this section, aquatic life-health could have potential adverse affects from sediment releases from the mine waste directly into the aquatic ecosystem. Wildlife receptors could become exposed to the waste rock by direct contact, incidental ingestion, or indirectly through the ingestion of contaminated vegetation that has accumulated contaminants from the waste.

The Site has had past human residency, but there were no indications as to the Site being used for recreational use. The access to the Site is limited due to a locked entrance gate and private property sign located on site. Major trails or incoming access points to the Site were not observed.

The range of detected metals from the mine waste solids samples is shown in **Table 9**. Comparisons of measured concentrations to applicable soils thresholds for human health are provided in **Table 10**, while the thresholds protective of wildlife are provided in **Table 11**. Comparisons of measured concentrations to the BLM Wildlife Risk Management criteria are provided in **Table 12**. Results of the measured site concentrations as compared to these thresholds are summarized by receptor as follows;

Results of the solid mine waste sample analysis (XRF) yielded detectable concentrations of arsenic, silver, barium, chromium, copper, iron, lead, manganese, mercury, nickel, rubidium, strontium , tin, and titanium. The paste pH measured 6.87 (HMSD) and 6.91 (HMND), with conductivity measurements 1674 µS/cm (HMSD) and 1694 µS/cm (HMND). The leachate analysis indicate a pH of 6.91 (HMND), 6.87 (HMSD),

conductivity of 1694 µS/cm (HMND), 1674 µS/cm (HMSD), and acidity of 11.1 mg/L $CaCO_3$ (HMND), 24.8 mg/L $CaCO_3$.

A background soil sample (HMB) was collected at the Hope Mine site at an undisturbed area as a comparison of naturally occurring soil material to the mine waste tailings. The analytical results from the XRF, for the background soil sample, exceeded BLM Resident Management Criteria (BLM, 2004) for detected Arsenic, Mercury, and Silver. Arsenic levels exceeded the EPA Soil Screening Level (SSL-MCL), and Mercury exceeded the EPA SSL (EPA, 2002) and Regional Screening Levels-Residential (SRL) standard for dermal (EPA, 2009). Leachate analysis results showed a soil paste pH of 6.67, conductivity of 101 µS/cm, and acidity of < 10 mg/L $CaCO_3$.

Ecological Receptor Hazard Assessment for Wildlife, Terrestrial Plants and Invertebrates for the HMB soil sample analysis by XRF results exceeded Eco-SSL standards for Silver, Barium, Copper, Mercury, Lead, Zinc, Manganese, and Nickel (EPA, 2010). Detected metals for Arsenic, Copper, Lead, and Zinc exceeded BLM Wildlife Risk Management Criteria for small avian/Robin (BLM, 2004).

Human Health Hazard Assessment

- For the detected metals, the measured concentrations of arsenic, iron, and mercury exceeded the EPA Regulatory and Human Benchmarks for Soil Screening Level Development (EPA, 2002). Arsenic exceeded the carcinogenic target risk for ingestion and dermal contact (EPA, 2009). Iron exceeded the non-cancer hazard for ingestion. Mercury exceeded the total non-cancer hazard (EPA, 2009). Arsenic, silver, lead, mercury, and manganese occurred above BLM risk management criteria (BLM, 2004) for residents while arsenic exceeded BLM risk management criteria for resident, camper, and worker. Lead exceeded all BLM risk management criteria for human exposure.

- Results indicate a potential risk to human health if there were resident type exposure conditions. Exposure pathways would likely occur through human ingestion of mine waste material at the site by recreational use or prolonged time within the area.

Ecological Receptor Hazard Assessment for Wildlife, Terrestrial Plants and Invertebrates

- Detected concentration levels of arsenic, barium, chromium, copper, lead, manganese, nickel, and zinc levels were above the protective ecological receptor levels by the EPA Ecological Soil Screening Levels (EPA, 2010). Lead, zinc, copper, and arsenic concentration levels were above the BLM wildlife risk management criteria (BLM, 2004).

Detected Metals	SSL Receptors for Elevated Concentration Levels
Arsenic	plants, avian, and mammalian
Barium	soil invertebrates and mammalian
Chromium	avian and mammalian
Copper	plants, avian, invertebrates, and mammalian
Lead	plants, avian, invertebrates, and mammalian

Manganese	plants and invertebrates
Nickel	plants
Zinc	plants, avian, invertebrates, and mammalian

- Lead exceeded all BLM wildlife risk criteria levels with mercury and zinc on average exceeding all BLM wildlife risk criteria except for sheep and cattle. Copper would exceed standards for sheep, mule deer, big-horn sheep, and small avian. Arsenic exceeded standards for small avian (BLM, 2004).

- All SSL receptor levels are very dependent on site specific conditions, speciation, solubility, geochemical behavior, moisture, species tolerance, and other factors that should always be considered.

- Results indicate a potential and adverse risk to wildlife receptors if continuous exposure conditions were to occur. The Site is set in a forested area with year round water sources and abundant vegetation-forage located at and throughout the surrounding area.

- Results of the hazard assessment indicate that current conditions are suitable for short-term human and ecological receptor exposure conditions. Both surface water, groundwater (as extrapolated from HMS and leachate results) and the mine waste solids are of potential concern. Seasonal fluctuations at the Site could create a higher potential of contaminate releases not identified during the site investigation. In addition, the groundwater pathway was not definably understood and requires further investigation. Soil and water pH and buffering conditions are favorable for the Site area. The higher pH levels and buffering capacity decreases mobilization of metals and binds these metals diminishing the toxicity and the amount of metals which could potentially be bioavailable.

- Aquatic life could be impacted by the Hope Mine. The leachate analysis indicated a potential impact if the leachate were to reach surface water areas. The assumption that mine waste leachate represents potential impacts on surface water and groundwater qualities are an overestimation of the actual conditions at the Site. Erosional releases of mine waste sediment accumulating within the stream bed or rapid slump of the mine waste pile directly into Castle Creek has the potential for contaminated sediments to affect water quality and aquatic life and is a potential concern.

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Table 9. Mine Waste XRF[1] Analysis (mg/kg)

Site ID	As	Ag	Ba	Cr	Cu	Hg	Mn	Ni	Pb	Sr	Ti	Zn	Fe
Hope Mine North Dump HMND	45	106	4532	176	96	11	1254	114	1158	342	4687	415	56867
Hope Mine South Dump HMSD	60	134	8818	189	103	18	963	81	2263	616	3973	357	34785
Hope Mine Background HMB	7	47	600	ND	32	12	854	67	30	139	277	72	31473

Notes:

1. Innov-X α-4000 Environmental Analyzer XRF. Data measured in Soils mode at 120 second acquisition. Three Soil NIST SRMs used for verification.

Table 10. Human Health Soil Protection Standards (ppm)

Analyte	XRF[1] Analysis Results (mg/kg)			EPA Regulatory and Human Health Benchmarks SSL (ppm)		EPA Regional Screening Level (SRL) Residential Soil; Non-Cancer (ppm)				BLM Risk Management Criteria (ppm)		
	HMND	HMSD	HMB	MCGL	MCL	Ingestion	Dermal	Inhalation	Total	Resident	Camper	ATV Driver
As	45	60	7	(1)	.005	24	280	21000	22	1.0	20	300
Ag	106	134	47	(1)	(1)	3900	(1)	(1)	3900	35	700	9600
Ba	4532	8818	600	2	2	16000	BCL	BCL	15000	(1)	(1)	(1)
Cr	176	189	ND	0.1	0.1	2400	BCL	BCL	2300	(1)	(1)	(1)
Cu	96	103	32	(1)	(1)	31000	(1)	(1)	31000	250	5000	70000
Hg	11	18	12	0.002	0.002	13	10	(1)	56	2	40	550
Pb	1158	2263	30	(1)	(1)	(1)	(1)	(1)	(1)	400	1000	1000
Zn	415	357	72	(1)	(1)	24000	(1)	(1)	24000	2000	40000	550000
Ti	4687	3973	277	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Mn	1254	963	854	(1)	(1)	(1)	(1)	(1)	(1)	960	19000	250000
Fe	56867	34785	31473	(1)	(1)	55000	(1)	(1)	55000	(1)	(1)	(1)
Ni	114	81	67	(1)	(1)	BCL	BCL	BCL	BCL	135	2700	38000
Sr	342	616	139	(1)	(1)	47000	(1)	(1)	47000	(1)	(1)	(1)

(1) Not Available

Notes:

[1]Innov-X α-4000 Environmental Analyzer XRF. Data measured in Soils mode at 120 second acquisition. Three NIST soil SRMs used for verification.

BCL – Below Concentration Levels

Table 11. Ecological Soil Protection Standards (ppm)

Analyte	XRF[1] Analysis Results (mg/kg)			EPA Ecological Soil Screening Level (Eco-SSL)				Oak Ridge National Laboratory		
	HMND	HMSD	HMB	Plants	Soil Invertebrates	Avian Wildlife	Mammalian Wildlife	Earthworm Toxicity	Microorganism Toxicity	Phytotoxicity
As	45	60	7	18	(1)	43	46	60	100	10
Ag	106	134	47	560	(1)	4.2	14	(1)	50	2.0
Ba	4532	8818	600	(1)	330	(1)	2000	(1)	(1)	(1)
Cr	176	189	ND	(1)	(1)	(Cr-III)	(Cr-III, VI)	(1)	(1)	(1)
Cu	96	103	32	70	80	28	49	50	100	100
Hg	11	18	12	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Pb	1158	2263	30	120	1700	11	56	500	900	50
Zn	415	357	72	160	120	46	79	200	100	50
Ti	4687	3973	277	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Mn	1254	963	854	220	450	4300	4000	(1)	100	500
Fe	56867	34785	31473	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Ni	114	81	67	38	280	210	130	(1)	(1)	(1)
Sr	342	616	139	(1)	(1)	(1)	(1)	(1)	(1)	(1)

<LOD: Limit of Detection
(1) Not Available
Notes:

[1] Innov-X α-4000 Environmental Analyzer XRF. Data measured in Soils mode at 120 second acquisition. Three NIST soil SRMs used for verification.

Table 12. Ecological Soil Protection Standards (ppm)

Analyte	XRF Analysis Results (mg/kg)			US BLM Wildlife Risk Management Criteria					
	HMND	HMSD	HMB	Deer Mouse	Cottontail	Bighorn Sheep	Mule Deer	Elk	Robin
As	45	60	7	230	438	387	200	328	4.0
Ag	106	134	47	(1)	(1)	(1)	(1)	(1)	(1)
Ba	4532	8818	600	(1)	(1)	(1)	(1)	(1)	(1)
Cr	176	189	ND	(1)	(1)	(1)	(1)	(1)	(1)
Cu	96	103	32	640	358	64	102	131	7.0
Hg	11	18	12	2	15	6	9	11	1
Pb	1158	2263	30	142	172	152	106	127	6.0
Zn	415	357	72	419	373	369	222	275	43
Ti	4687	3973	277	(1)	(1)	(1)	(1)	(1)	(1)
Mn	1254	963	854	(1)	(1)	(1)	(1)	(1)	(1)
Fe	56867	34785	31473	(1)	(1)	(1)	(1)	(1)	(1)
Ni	114	81	67	(1)	(1)	(1)	(1)	(1)	(1)
Sr	342	616	139	(1)	(1)	(1)	(1)	(1)	(1)

<LOD: Limit of Detection
(1) Not Available
Notes: Innov-X α-4000 Environmental Analyzer XRF. Data measured in Soils mode at 120 second acquisition. Three NIST soil SRMs used for verification.

4.4 Air Pathways and Targets

Air particulates were not sampled as part of the PA/SI for this site inspection. The site encompasses on mine waste pile comprised of waste rock and ore materials. There appears to be a mix of rock types within the piles which was estimated to cover approximately one acre in surface area. There were observable signs of erosion in and around each pile in the Site. The climate of the Site is considered semi-arid with strong wind currents that are likely controlled by topography. Air releases of contaminates from the mine waste piles may occur as a result of particulates that are mobilized and transported as dust from recreational activities that disturb the piles. During the site investigation, there was no visible evidence for substantial environmental degradation as a result of air release and dispersion of mine waste material.

Human Health Hazard Assessment

- No determination could be made for air particulate pathways and targets. If exposure pathways did occur it would do so through human ingestion of mine waste material mobilized from the Site through recreational disturbance, adverse weather conditions, or prolonged occupation at the mine waste site.

Ecological Receptor Hazard Assessment for Wildlife

- A hazard for wildlife through airborne particulate ingestion would exist in the case that mine waste particulates are mobilized by human activity or adverse weather conditions. It may also occur if wildlife proceeds to disturb the mine waste.

5.0 Summary and Discussion

Results of the hazard assessment indicate that current conditions may be suitable for short-term human and ecological receptor exposure conditions. Provided there is a direct hydrologic connection with the interaction between the groundwater (as extrapolated from leachate results and HMS results) and the mine waste solids are of potential concern. If recreators utilize groundwater as a source of drinking water there may be metals constituents of potential concern ingested from the Site. However, there is not a well located at the Site for this exposure pathway. Recreators may also be exposed to mine waste through incidental ingestion and inhalation. Results of the mine waste solids measured concentrations of several metals of concern above resident, worker, and camper protective thresholds. This pathway may also be complete and be of concern.

Several metals of concern were detected in the mine waste and exceeded BLM risk management criteria and SSL concentration levels for wildlife, avian and other terrestrial receptors. The mine waste is well established with vegetation which poses potential risks for wildlife and terrestrial biota receptors exposed to the Site. Plants have a high potential for the accumulation of contaminates by uptake and there is potential for ingestion by wildlife. Wildlife, however, require large forage ranges for their life cycle stages and the Hope Mine provides a portion of a typical wildlife receptor range (especially small mammals). The results of soil pH levels may minimize the impacts and mobility of contaminates, but the potential risks remains at the Site for receptors. This pathway may also be complete and be of concern.

Chemical results indicate the Hope Mine site did not have an impact on the water quality of Castle Creek at the time of the PA/SI, however; the Site has the potential to impact the stream channel and aquatic life-health and is a possible pathway for human health risks. Groundwater as represented by the HMS results, indicated that aluminum and iron concentrations would exceed CDPHE concentration levels for aquatic life parameters, but dilution from Castle Creek, as determined by CCDS results, display that the total influx from the HMS into Castle Creek is not having an impact to the water quality or to the aquatic life-health. Seasonal fluctuations (snow melt run-off and precipitation events) of leachate ground water into Castle Creek may increase contaminate concentrations at the HMS site and may increase the potential risk to aquatic life-health. One of the primary potential risks at the Site is the release of soil and sediment from the mine waste directly into Castle Creek.

In summary, given the nature and extent of source areas, and the possible significant hazards posed therein, it appears that the Hope Mine may be a potential issue to ecological receptors. However, further investigation of pathways to humans using the area for recreational purposes may be required to determine the true risk to recreators. Seasonal fluctuations effecting leachate groundwater to surface waters may also require further evaluation. The results of this PA/SI have identified soil as a pathway of concern to residence, recreators, and ecological receptors.

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Appendix C

Exploratory Drilling and Laboratory Testing Report, HP Geotech

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HP Geotech
HEPWORTH - PAWLAK GEOTECHNICAL

Hepworth-Pawlak Geotechnical, Inc.
5020 County Road 154
Glenwood Springs, Colorado 81601
Phone: 970-945-7988

Fax: 970 945 8454
email: hpgeo@hpgeotech.com

November 26, 2012

Cardno TEC, Inc.
Attn: Ned Turner
P.O. Box 5127
Charlottesville, Virginia 22905
Ned.turner@cardnotec.com

HP Geotech Job No.112 340A
Cardno TEC Purchase Order: 4282-27873

Subject: Exploratory Drilling and Laboratory Testing, Hope Mine, White River National Forest, Castle Creek Road, Pitkin County, Colorado

Mr. Turner:

As requested, Hepworth-Pawlak Geotechnical, Inc. (HP Geotech) performed subsurface exploration and tested soil samples taken from the subject site according to the scope of services described in Purchase Order: 4282-27873. The exploratory data obtained and the laboratory test results requested are presented in this report.

Exploratory Drilling: The exploratory borings were drilled with a CME-55 drill rig operated by Mr. Myron Schank and assistant Louis Eller of HP Geotech. The exploration was directed by Mr. Jeffrey Hart of Cardno Tec. Drive samples and disturbed bulk samples were taken from the boreholes at generally the prescribed intervals of 2½ to 5 feet to achieve a more or less continuous subsurface profile to 25 feet except for Boring 3 that was sampled on wider spaced intervals and deepened below the mine waste into the natural soils to a total depth of 45 feet. Graphical logs of the boreholes are presented on Figure 1 with an explanation of the symbols and terms presented on Figure 2.

The samples taken from the borings were retained by HP Geotech. Laboratory testing was performed on selected samples in general accordance with the purchase order and the results are presented on Figures 3 through 5, summarized in Table 1 and the Appendix: direct shear tests by Advanced Terra Testing.

Limitations: The exploration and testing have been conducted in accordance with generally accepted geotechnical engineering principles and practices in this area at this time. We make no warranty either express or implied. Our findings include interpolation

and extrapolation of the subsurface conditions identified by the samples taken from the exploratory borings and there could be variations in the subsurface conditions. This report has been prepared for the exclusive use by our client for design purposes. We are not responsible for technical interpretations by others of our information.

If you have any questions or need further assistance, please let us know.

Respectfully Submitted,

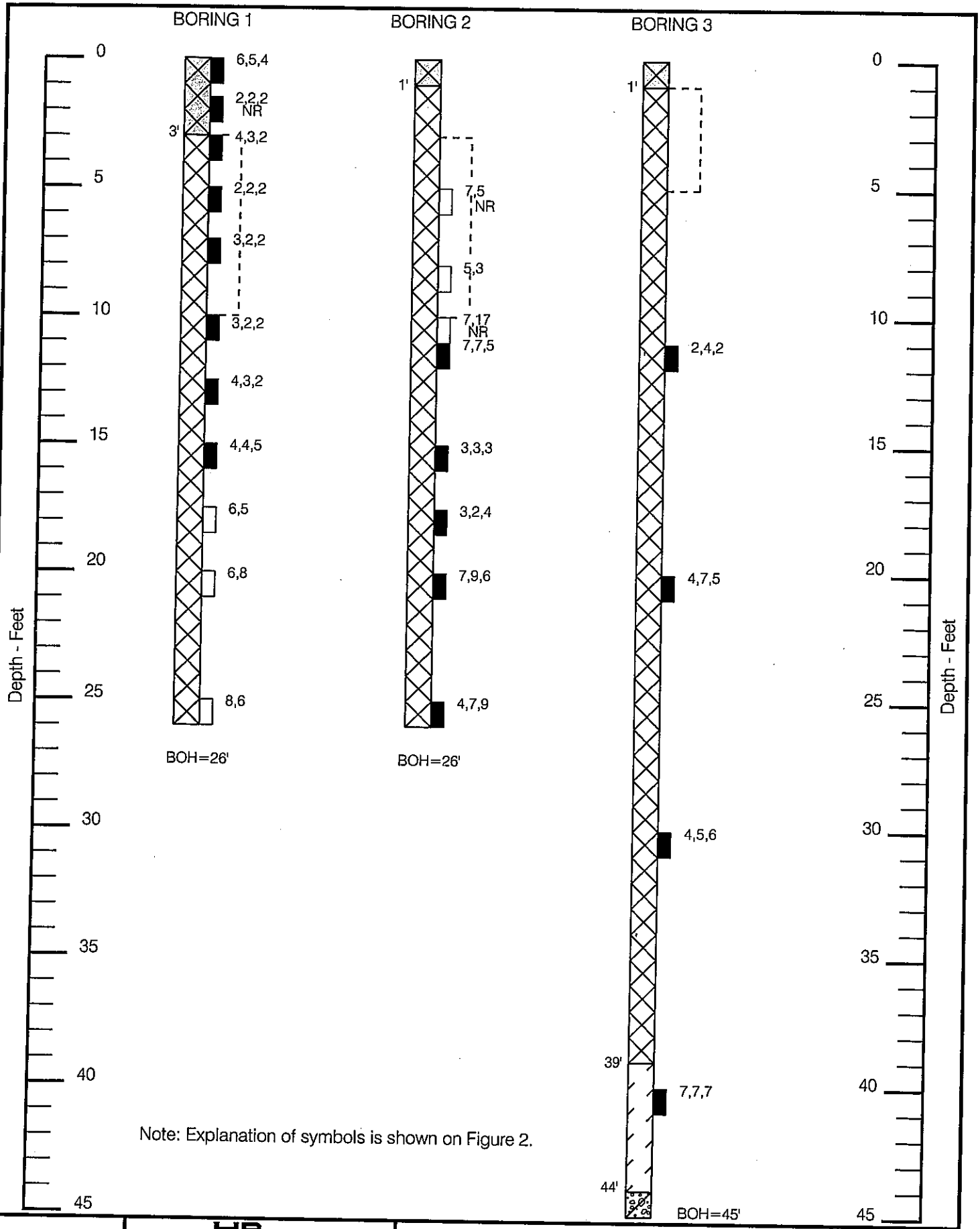
HEPWORTH - PAWLAK GEOTECHNICAL, INC.

Steven L. Pawlak, P.E.

SLP/ksw

Attachments: Figure 1 – Logs of Exploratory Borings
Figure 2 – Legend and Notes
Figures 3 and 4 – Laboratory Proctor Compaction Test Report
Figures 3A, 4A and 5 – Gradation Test Results
Table 1 – Summary of Laboratory Test Results
Appendix – Advanced Terra Testing Direct Shear Test Results

cc: Michelle Toney-Johnson (michelle.toney-johnson@cardnotec.com)



Note: Explanation of symbols is shown on Figure 2.

112 340A	HP Geotech HEPWORTH-PAWLAK GEOTECHNICAL	LOGS OF EXPLORATORY BORINGS	Figure 1

LEGEND:

FILL; capping mixture of sand and silt with charcoal, loose, slightly moist, gray.

MINE WASTE; silty clayey sandy gravel with cobbles, loose to medium dense, slightly moist to moist, mixed browns.

CLAY (CL); sandy, silty, slightly gravelly, stiff, moist, brown, low plasticity. (Boring 3 only)

GRAVEL (GM); with cobbles, sandy, silty, dense, moist, brown.(Boring 3 only)

Relatively undisturbed drive sample; 2-inch I.D. California liner sample.

Drive sample; standard penetration test (SPT), 1 3/8 inch I.D. split spoon sample, ASTM D-1586.

6,4,5 Drive sample blow count; indicates the number of blows of a 140 pound hammer falling 30 inches were required to drive the California or SPT sampler 6 inches.

Disturbed bulk sample.

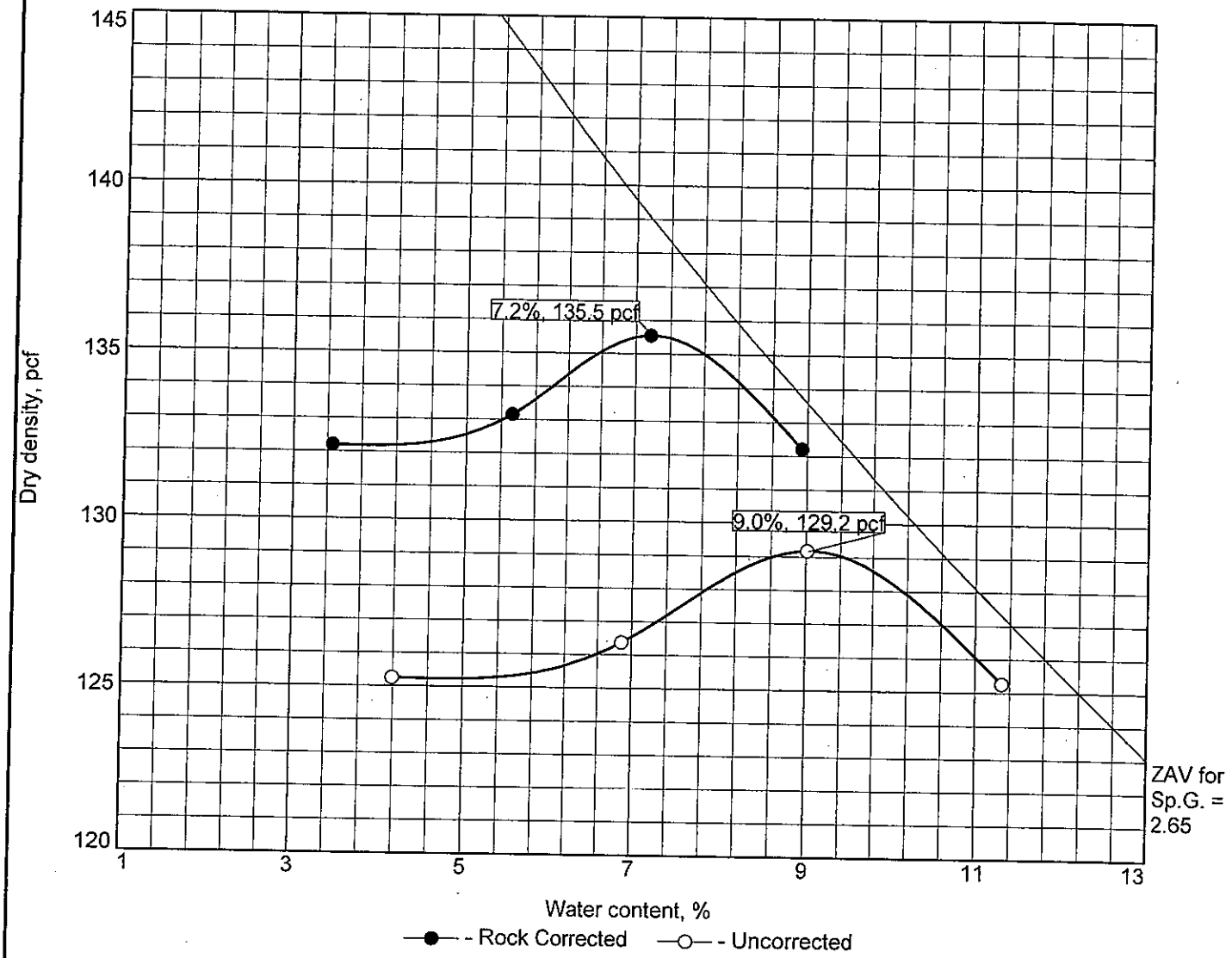
NR = No recovery of drive sample.

BOH = Bottom of hole.

NOTES:

1. Exploratory borings were drilled on October 4, 2012 with 4-inch ID continuous flight hollow stem auger.
2. Locations of exploratory borings were provided by Cardno Tec.
3. Elevations of exploratory borings were not measured and the logs of exploratory borings are drawn to depth.
4. The exploratory boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between materials shown on the exploratory boring logs represent the approximate boundaries between material types and transitions may be gradual.
6. No free water was encountered in the borings at the time of drilling. Fluctuation in water level may occur with time.

Laboratory Proctor Compaction Test Report



Test specification: ASTM D 698-07 Method B Standard
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
	GC	A-2-4(0)			25	10	23	34

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 135.5 pcf	129.2 pcf	Silty Clayey Sandy Gravel (Mine Waste)
Optimum moisture = 7.2 %	9.0 %	

Project No. 112340A **Client:** Cardno TEC, Inc.
Project: Hope Mine Waste Pile, Castle Creek Road, Pitkin County, Colorado

○ **Source of Sample:** Boring 1, 3' - 10'

Remarks:
See Figure 3A for Gradation Results

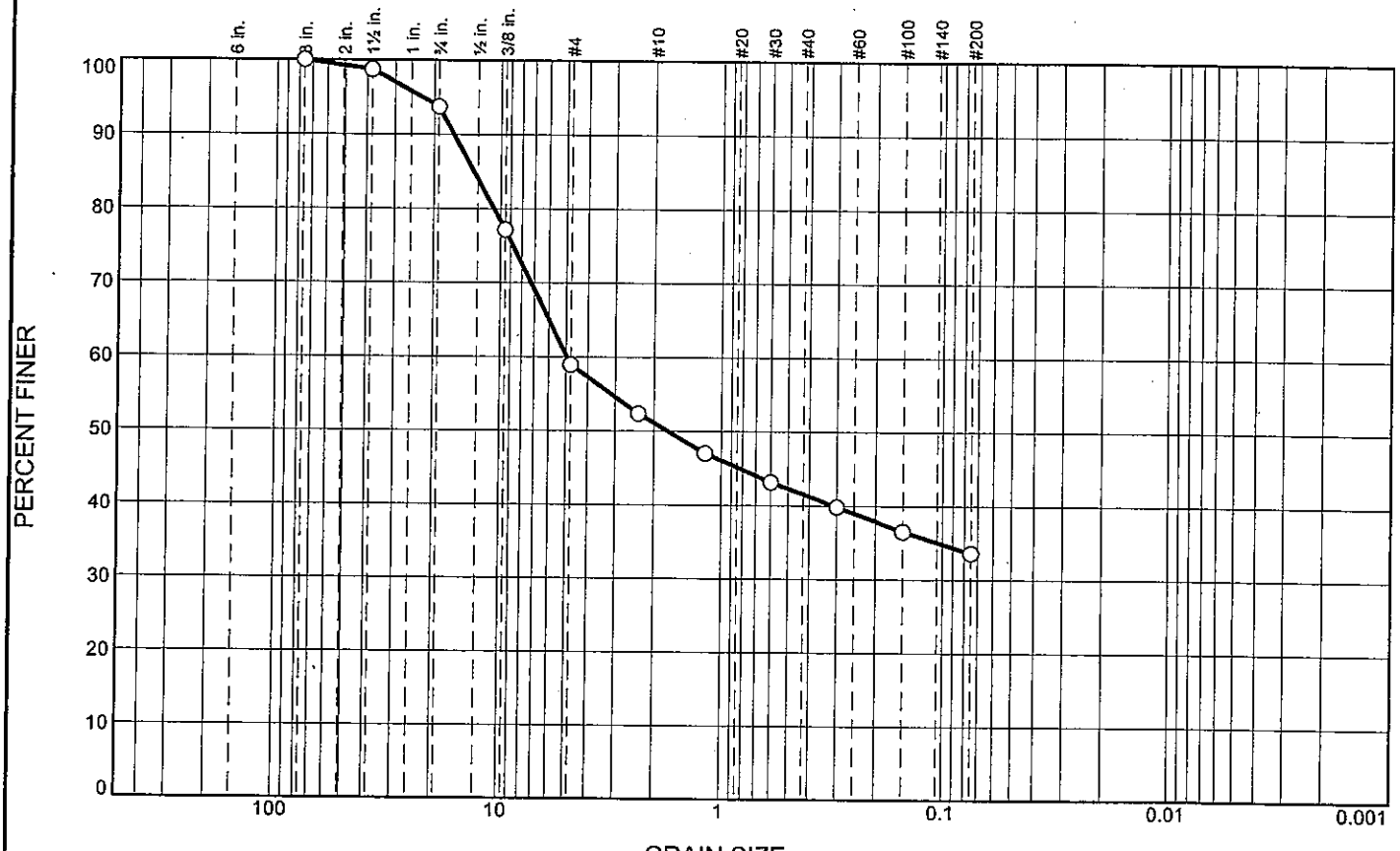
Hepworth-Pawlak Geotechnical, Inc.

Glenwood Springs, Colorado

Figure 3

Tested By: MY **Checked By:** JP

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	6	35	8	9	8	34	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100		
1.5	99		
.75	94		
.375	77		
#4	59		
#8	52		
#16	47		
#30	43		
#50	40		
#100	37		
#200	34		

* (no specification provided)

Material Description

Silty Clayey Sandy Gravel (Mine Waste)

Atterberg Limits

PL= 15 LL= 25 PI= 10

Coefficients

D_{90}= 16.2918 D_{85}= 13.2198 D_{60}= 4.9441
D_{50}= 1.7307 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= GC AASHTO= A-2-4(0)

Remarks

See Figure 3 for Standard Compaction Results

Source of Sample: Boring 1, 3' - 10'

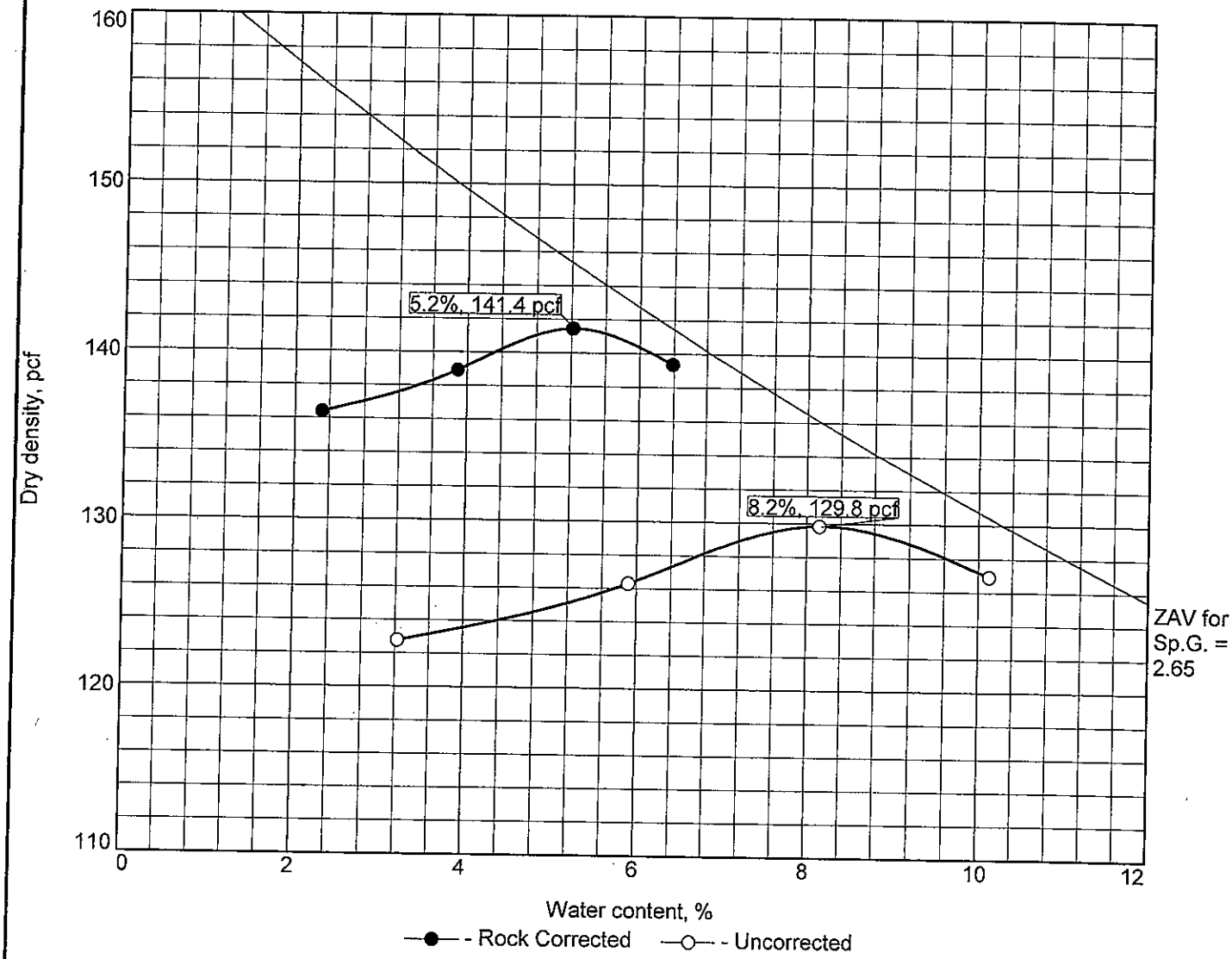
Date: 10-04-12

Hepworth-Pawlak Geotechnical, Inc.
Glenwood Springs, Colorado

Client: Cardno TEC, Inc.
Project: Hope Mine Waste Pile, Castle Creek Road, Pitkin County, Colorado
Project No: 112340A **Figure** 3A

Tested By: MY **Checked By:** JP

Laboratory Proctor Compaction Test Report



Test specification: ASTM D 698-07 Method B Standard
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
	GC	A-2-4(0)			25	8	41	15

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 141.4 pcf	129.8 pcf	Silty Clayey Sandy Gravel (Mine Waste)
Optimum moisture = 5.2 %	8.2 %	

Project No. 112340A **Client:** Cardno TEC, Inc.
Project: Hope Mine Waste Pile, Castle Creek Road, Pitkin County, Colorado

○ **Source of Sample:** Boring 3, 1' - 5'

Remarks:
See Figure 4A for Gradation Results

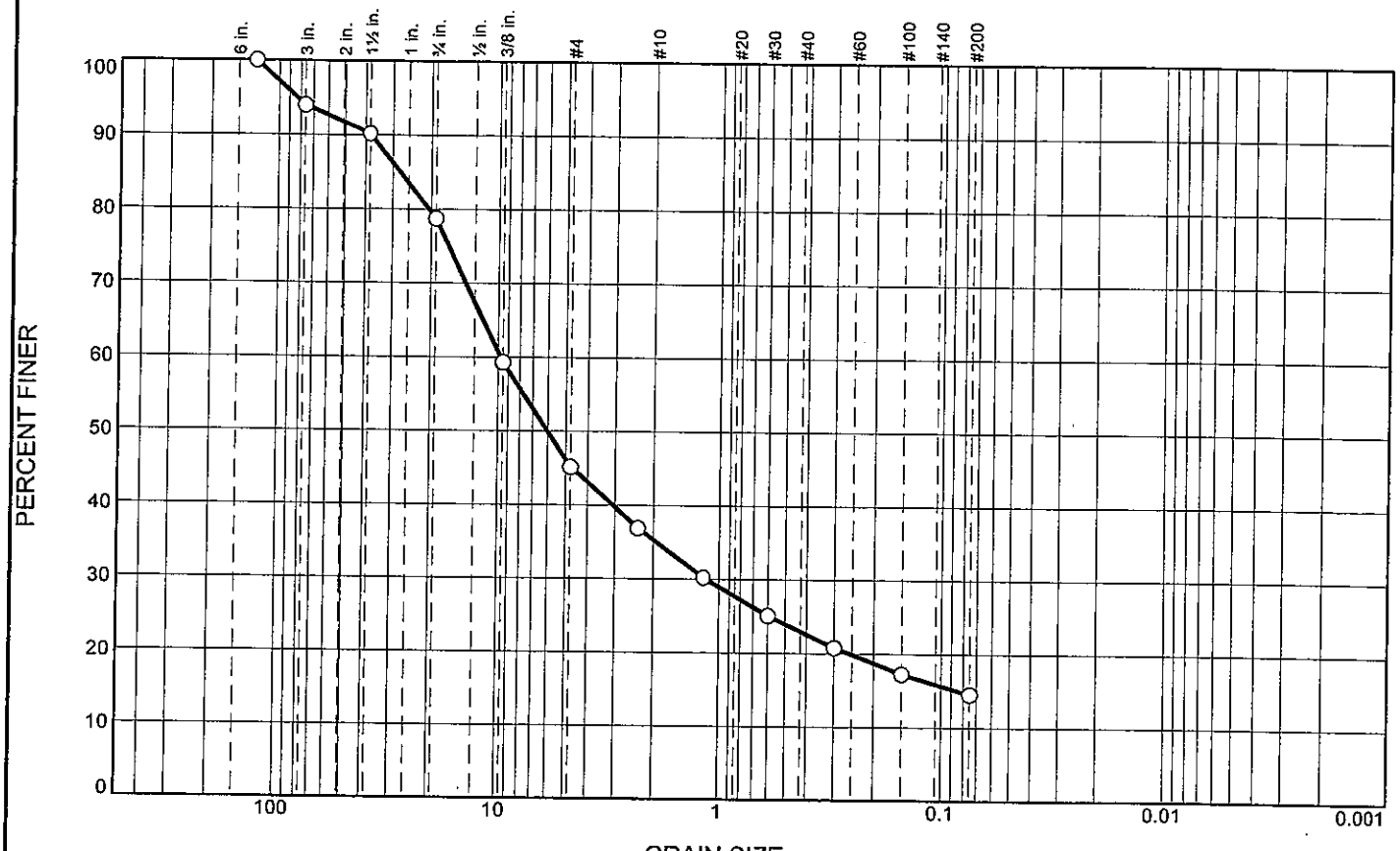
Hepworth-Pawlak Geotechnical, Inc.

Glenwood Springs, Colorado

Figure 4

Tested By: MY **Checked By:** JP

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
6	15	34	10	12	8	15	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5	100		
3	94		
1.5	90		
.75	79		
.375	59		
#4	45		
#8	37		
#16	30		
#30	25		
#50	21		
#100	17		
#200	15		

* (no specification provided)

Material Description

Silty Clayey Sandy Gravel (Mine Waste)

Atterberg Limits

PL= 17 LL= 25 PI= 8

Coefficients

D_{90}= 37.7047 D_{85}= 27.8351 D_{60}= 9.7647
D_{50}= 6.0287 D_{30}= 1.1449 D_{15}= 0.0842
D_{10}= C_u= C_c=

Classification

USCS= GC AASHTO= A-2-4(0)

Remarks

See Figure 4 for Standard Compaction Results

Source of Sample: Boring 3, 1' - 5'

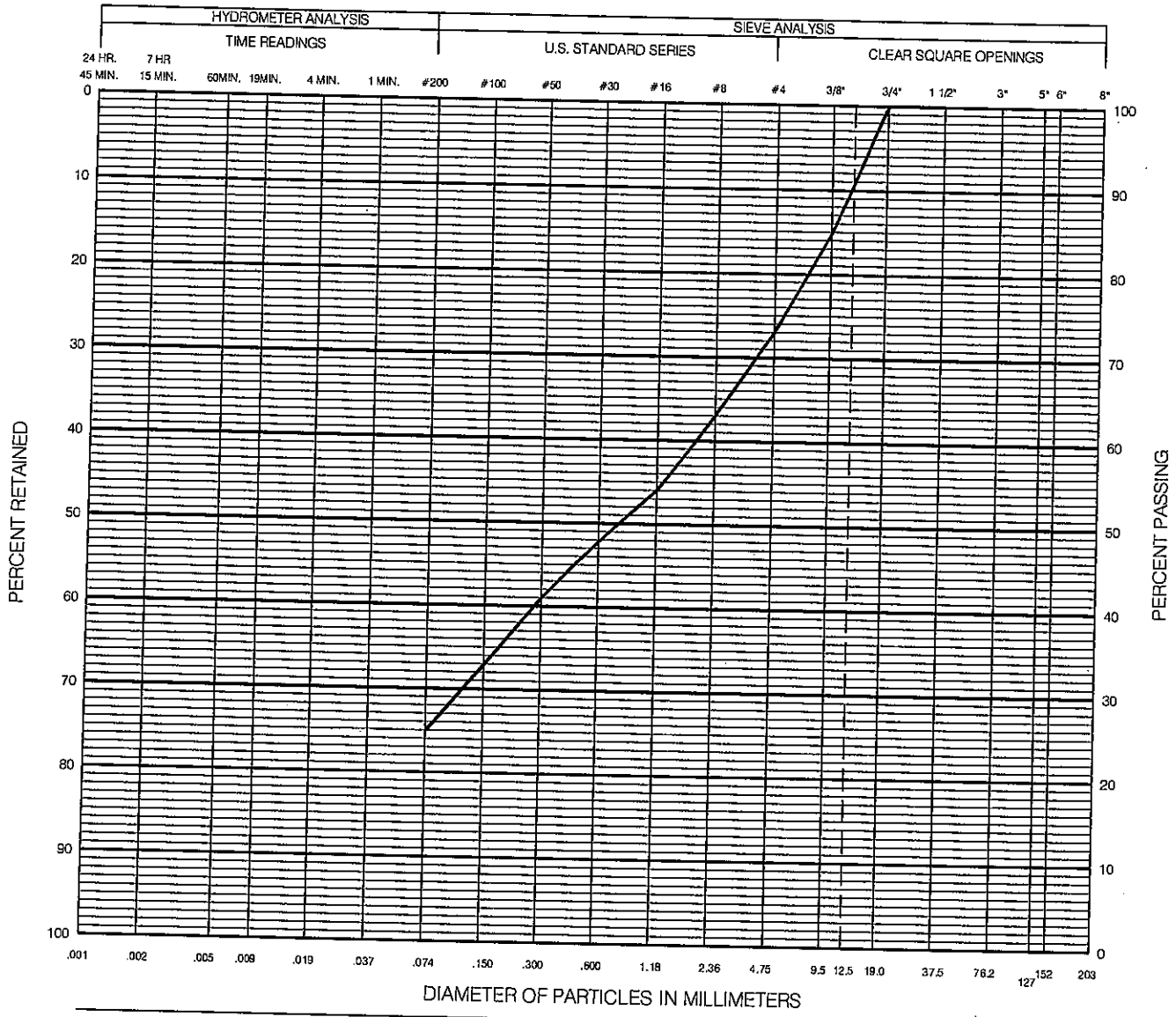
Date: 10-04-12

Hepworth-Pawlak Geotechnical, Inc.
Glenwood Springs, Colorado

Client: Cardno TEC, Inc.
Project: Hope Mine Waste Pile, Castle Creek Road, Pitkin County, Colorado

Project No: 112340A **Figure** 4A

Tested By: MY **Checked By:** JP



CLAY TO SILT	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

Gravel 27 %

Sand 48 %

Silt and Clay 25 %

Liquid Limit %

Plasticity Index %

Sample of: Silty Clayey Gravelly Sand (Mine Waste) From: Boring 1 at 17 1/2 Feet

112 340A	HP Geotech HEPWORTH-PAWLAK GEOTECHNICAL	GRADATION TEST RESULTS	FIGURE 5

HEPWORTH-PAWLAK GEOTECHNICAL, INC.
TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

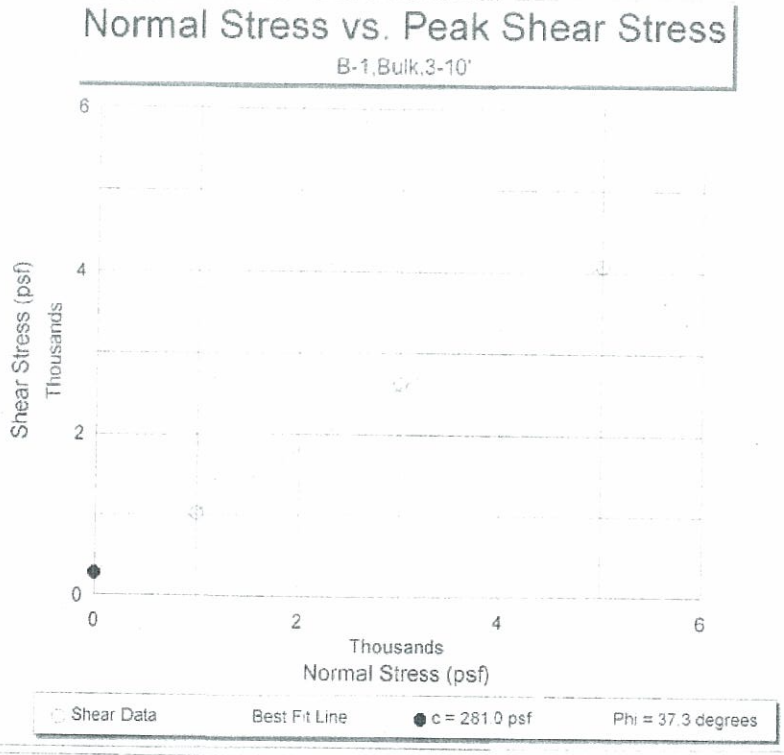
Job No. 112 340A

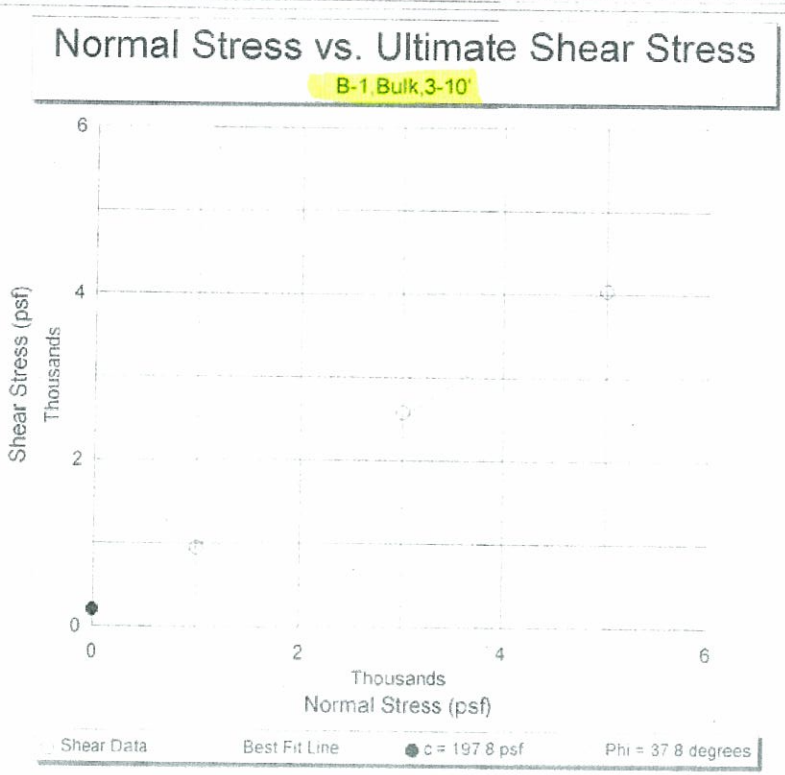
SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH	SOIL OR BEDROCK TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(PSF)	
1	3-10			41	25	34	25	10		Silty Clayey Sandy Gravel (Mine Waste)
	17.5	9.7	114	27	48	25				Silty Clayey Gravelly Sand (Mine Waste)
	20	11.0*	121.6*							Silty Clayey Sand with Gravel (Mine Waste)
3	1-5	8.9*	122.8*	55	30	15	25	8		Silty Clayey Sandy Gravel (Mine Waste)
	40	22.4				48	32	9		Very Sandy Silty Clay w/Gravel (Natural Soil)

* **Average value of 3 tests specimens for each direct shear test prior to loading and wetting for test. B-1 @ 20' is insitu and B-3 @ 1.5' is remolded.**

APPENDIX

Advanced Terra Testing
Direct Shear Test Results
ASTM D 3080


Normal Stress vs. Peak Shear Stress
B-1,Bulk,3-10'
Shear Stress (psf)
Thousands
0
2
4
6
Thousands
Normal Stress (psf)
Shear Data
Best Fit Line
c = 281.0 psf
Phi = 37.3 degrees


Normal Stress vs. Ultimate Shear Stress
B-1,Bulk,3-10'
Shear Stress (psf)
Thousands
0
2
4
6
Thousands
Normal Stress (psf)
Shear Data
Best Fit Line
c = 197.8 psf
Phi = 37.8 degrees

DIRECT SHEAR TEST DATA
ASTM D 3080

CLIENT HP Geotech

JOB NO. 2158-92

BORING NO.	B-1
DEPTH	3-10'.
SAMPLE NO.	Bulk
POINT	A
SOIL DESCR.	112340A
LOCATION	Hope Mine
NORMAL STRESS (psf)	5000

SAMPLED	
TEST STARTED	11/16/12 DPM
TEST FINISHED	11/16/12 DPM
CELL NUMBER	Dinosaur
SATURATED TEST	Yes
TEST TYPE	CD

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1123.3	1145.8
Wt. Wet Soil & Pan (g)	1154.5	1177.0
Wt. Dry Soil & Pan (g)	1061.6	1061.6
Wt. Lost Moisture (g)	92.8	115.4
Wt. of Pan Only (g)	31.2	31.2
Wt. of Dry Soil (g)	1030.5	1030.5
Moisture Content %	9.0	11.2
Wet Density (pcf)	133.7	141.2
Dry Density (pcf)	122.7	127.0

Init. Diameter (in)	4 x 4
Init. Area (sq in)	16.000
Init. Height (in)	2.000
Vol. Bef. Consol. (cu ft)	0.01852
Final Height (in)	1.932
Vol. After Consol. (cu ft)	0.01789

Test Set Up: Continuous Increasing Deflection Control
Shear Speed: 0.00410 in/min

Notes & Comments:

Data File Name: HEDSB1BA.WK4

Normal Stress:	5000 psf	34.72 psi
Peak Stress:	4070 psf	28.26 psi
Ultimate Stress:	4043 psf	28.08 psi

Data entry by: DAW Date: 11/20/2012
Data checked by: DPM Date: 11/21/12
FileName: HEDSB131

ADVANCED TERRA TESTING, INC. ATT

DIRECT SHEAR TEST DATA
ASTM D 3080

CLIENT HP Geotech

JOB NO. 2158-92

BORING NO.	B-1
DEPTH	3-10'
SAMPLE NO.	Bulk
POINT	B
SOIL DESCR.	112340A
LOCATION	Hope Mine
NORMAL STRESS (psf)	3000

SAMPLED	
TEST STARTED	11/14/12 DPM
TEST FINISHED	11/15/12 DPM
CELL NUMBER	Dinosaur
SATURATED TEST	Yes
TEST TYPE	CD

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1123.6	1149.2
Wt. Wet Soil & Pan (g)	1150.0	1175.6
Wt. Dry Soil & Pan (g)	1057.0	1057.0
Wt. Lost Moisture (g)	93.0	118.6
Wt. of Pan Only (g)	26.4	26.4
Wt. of Dry Soil (g)	1030.6	1030.6
Moisture Content %	9.0	11.5
Wet Density (pcf)	133.8	139.7
Dry Density (pcf)	122.7	125.3

Init. Diameter (in)	4 x 4
Init. Area (sq in)	16.000
Init. Height (in)	2.000
Vol. Bef. Consol. (cu ft)	0.01852
Final Height (in)	1.958
Vol. After Consol. (cu ft)	0.01813

Test Set Up: Continuous Increasing Deflection Control
Shear Speed: 0.00410 in/min

Notes & Comments:

Data File Name: HEDSB1BB.WK4

Normal Stress:	3000 psf	20.83 psi
Peak Stress:	2622 psf	18.21 psi
Ultimate Stress:	2576 psf	17.89 psi

Data entry by: DAW Date: 11/20/2012
Data checked by: ARM Date: 11/22/12
FileName: HEDSB131

ADVANCED TERRA TESTING, INC. ATT

DIRECT SHEAR TEST DATA
ASTM D 3080

CLIENT HP Geotech

JOB NO. 2158-92

BORING NO.	B-1	SAMPLED	
DEPTH	3-10'	TEST STARTED	11/13/12 DPM
SAMPLE NO.	Bulk	TEST FINISHED	11/14/12 DPM
POINT	C	CELL NUMBER	Dinosaur
SOIL DESCR.	112340A	SATURATED TEST	Yes
LOCATION	Hope Mine	TEST TYPE	CD
NORMAL STRESS (psf)	1000		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1122.5	1154.3
Wt. Wet Soil & Pan (g)	1152.0	1183.9
Wt. Dry Soil & Pan (g)	1061.6	1061.6
Wt. Lost Moisture (g)	90.4	122.2
Wt. of Pan Only (g)	29.5	29.5
Wt. of Dry Soil (g)	1032.1	1032.1
Moisture Content %	8.8	11.8
Wet Density (pcf)	133.6	139.0
Dry Density (pcf)	122.9	124.3

Init. Diameter (in)	4 x 4
Init. Area (sq in)	16.000
Init. Height (in)	2.000
Vol. Bef. Consol. (cu ft)	0.01852
Final Height (in)	1.977
Vol. After Consol. (cu ft)	0.01830

Test Set Up: Continuous Increasing Deflection Control
Shear Speed: 0.00410 in/min

Notes & Comments:

Data File Name: HEDSB1BC.WK4

Normal Stress:	1000 psf	6.94 psi
Peak Stress:	1018 psf	7.07 psi
Ultimate Stress:	945 psf	6.56 psi

Data entry by: DAW Date: 11/20/2012
Data checked by: DPM Date: 11/21/12
FileName: HEDSB131

ADVANCED TERRA TESTING, INC. ATT

DIRECT SHEAR TEST DATA
ASTM D3080

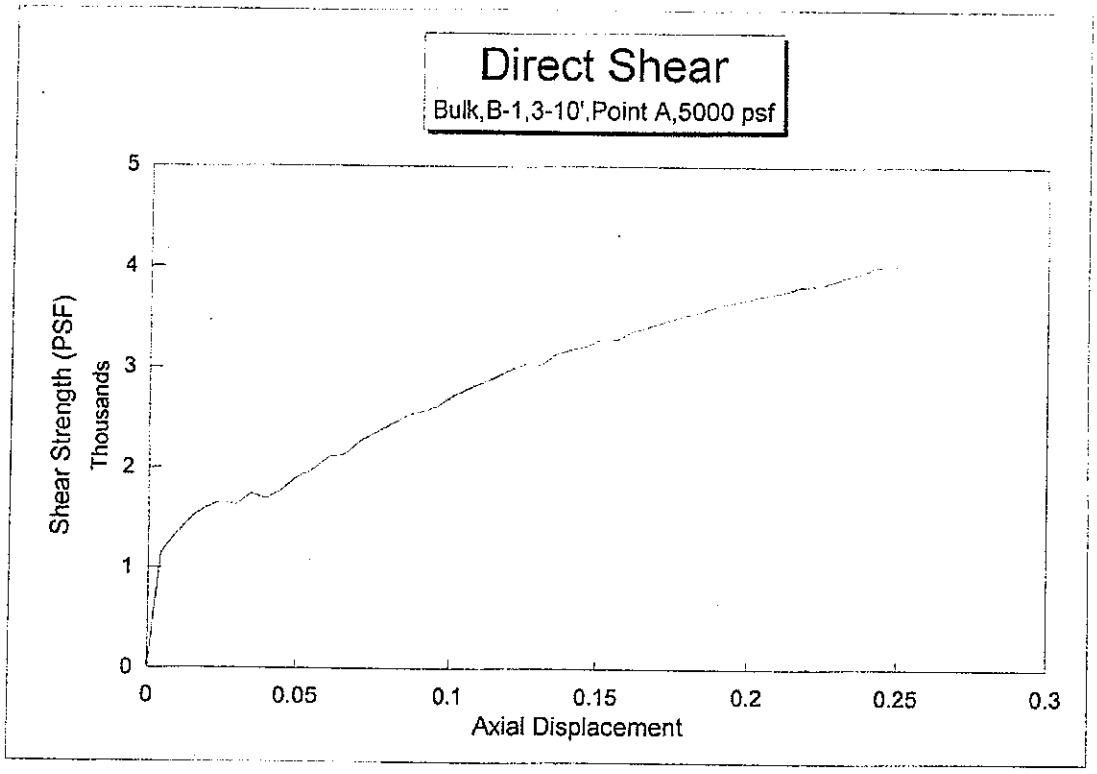
Client:	HP Geotechnical	Job Number:	2158-92
		Date Tested:	11/16/2012 DPM
Boring:	B-1		
Sample Number:	Bulk	Soil Description:	112340A
Depth:	3-10'	Point:	A
Location:	Hope Mine	Normal Load	5000 PSF
		Peak Strength	4070 PSF

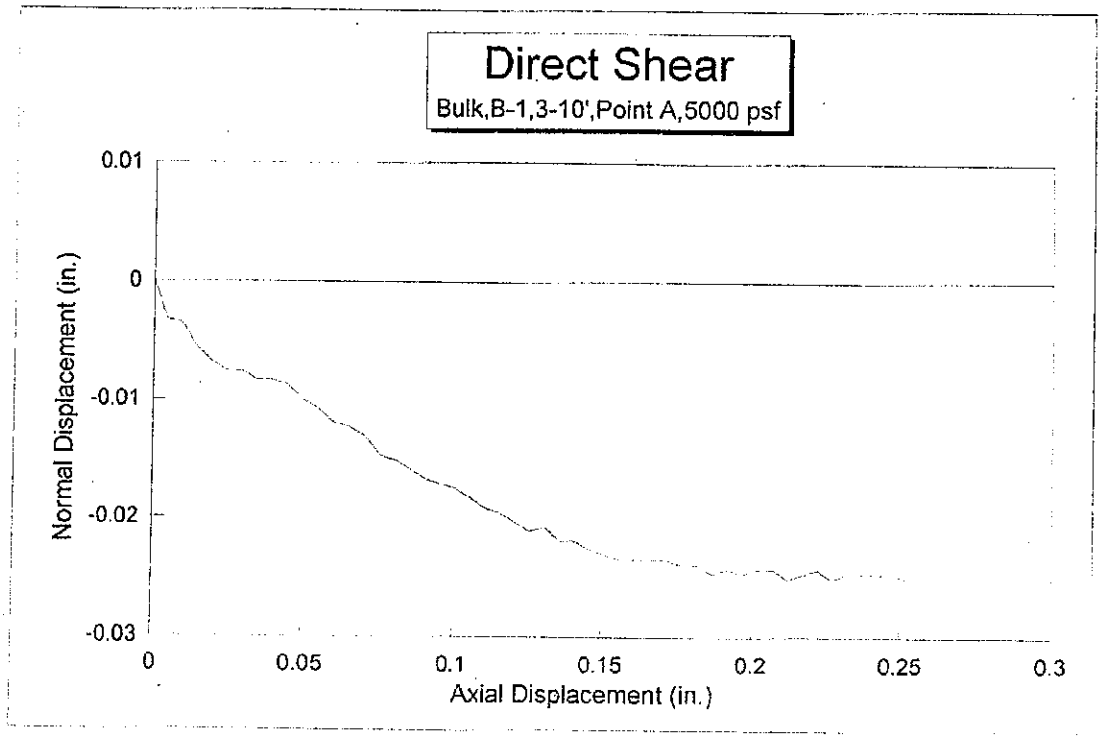
Shear Displacement (inches)	Shear Load (lbs.)	Shear Load (PSF)	Normal Displacement (inches)
0.0000	0.0	0	0.0000
0.0045	126.4	1138	-0.0032
0.0098	148.8	1339	-0.0036
0.0148	167.0	1503	-0.0056
0.0198	178.2	1604	-0.0068
0.0248	184.4	1660	-0.0076
0.0299	181.4	1633	-0.0076
0.0349	193.6	1742	-0.0084
0.0399	188.4	1696	-0.0084
0.0449	197.6	1778	-0.0088
0.0499	211.8	1906	-0.0100
0.0550	220.0	1980	-0.0108
0.0600	234.2	2108	-0.0120
0.0653	237.4	2137	-0.0124
0.0703	252.6	2273	-0.0131
0.0753	261.8	2356	-0.0148
0.0803	271.0	2439	-0.0152
0.0853	280.2	2522	-0.0160
0.0904	285.2	2567	-0.0167
0.0953	290.4	2614	-0.0171
0.1006	301.6	2714	-0.0175
0.1056	309.6	2786	-0.0183
0.1107	316.8	2851	-0.0192
0.1157	324.0	2916	-0.0196
0.1207	332.0	2988	-0.0203
0.1257	338.2	3044	-0.0211
0.1307	337.2	3035	-0.0207
0.1358	349.4	3145	-0.0219
0.1408	354.4	3190	-0.0219
0.1463	358.6	3227	-0.0227
0.1513	366.8	3301	-0.0231
0.1563	365.6	3290	-0.0236
0.1614	374.8	3373	-0.0236
0.1664	379.0	3411	-0.0236
0.1714	385.0	3465	-0.0236
0.1764	390.2	3512	-0.0239
0.1814	393.2	3539	-0.0239
0.1865	399.4	3595	-0.0247
0.1915	405.4	3649	-0.0243
0.1965	407.4	3667	-0.0247
0.2015	411.6	3704	-0.0243
0.2068	415.6	3740	-0.0243
0.2120	418.6	3767	-0.0251
0.2171	423.8	3814	-0.0247
0.2221	424.8	3823	-0.0243
0.2271	428.8	3859	-0.0251
0.2321	434.0	3906	-0.0247
0.2371	439.0	3951	-0.0247
0.2422	445.2	4007	-0.0247
0.2472	447.2	4025	-0.0247
0.2522	449.2	4043	-0.0251

Data entry by: DPM
Checked by: DAV
FileName: HEDSB1BC

Date: 11/19/2012
Date: 11/20/12

ATT


Direct Shear
Bulk,B-1,3-10',Point A,5000 psf
Shear Strength (PSF)
Thousands
5
4
3
2
1
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Axial Displacement


Direct Shear
Bulk,B-1,3-10',Point A,5000 psf
Normal Displacement (in.)
0.01
0
-0.01
-0.02
-0.03
0
0.05
0.1
0.15
0.2
0.25
0.3
Axial Displacement (in.)

DIRECT SHEAR TEST DATA
ASTM D3080

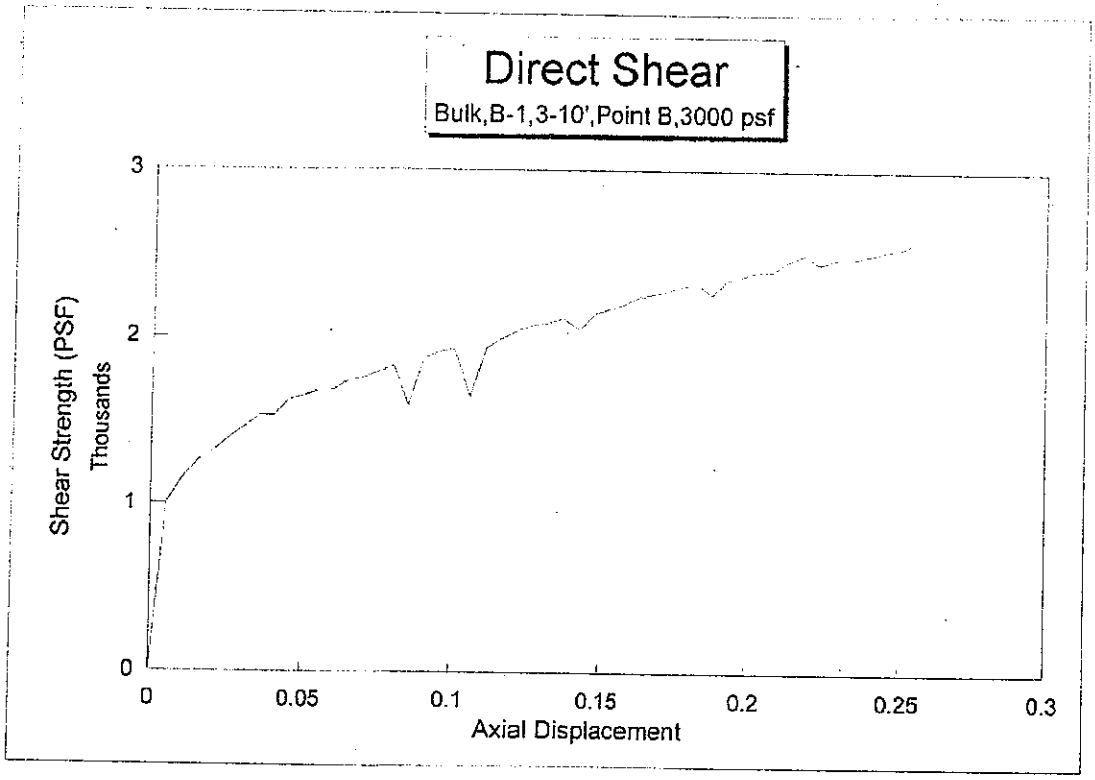
Client:	HP Geotechnical	Job Number:	2158-92
		Date Tested:	11/15/2012 DPM
Boring:	B-1		
Sample Number:	Bulk	Soil Description:	112340A
Depth:	3-10'	Point:	B
Location:	Hope Mine	Normal Load	3000 PSF
		Peak Strength	2622 PSF

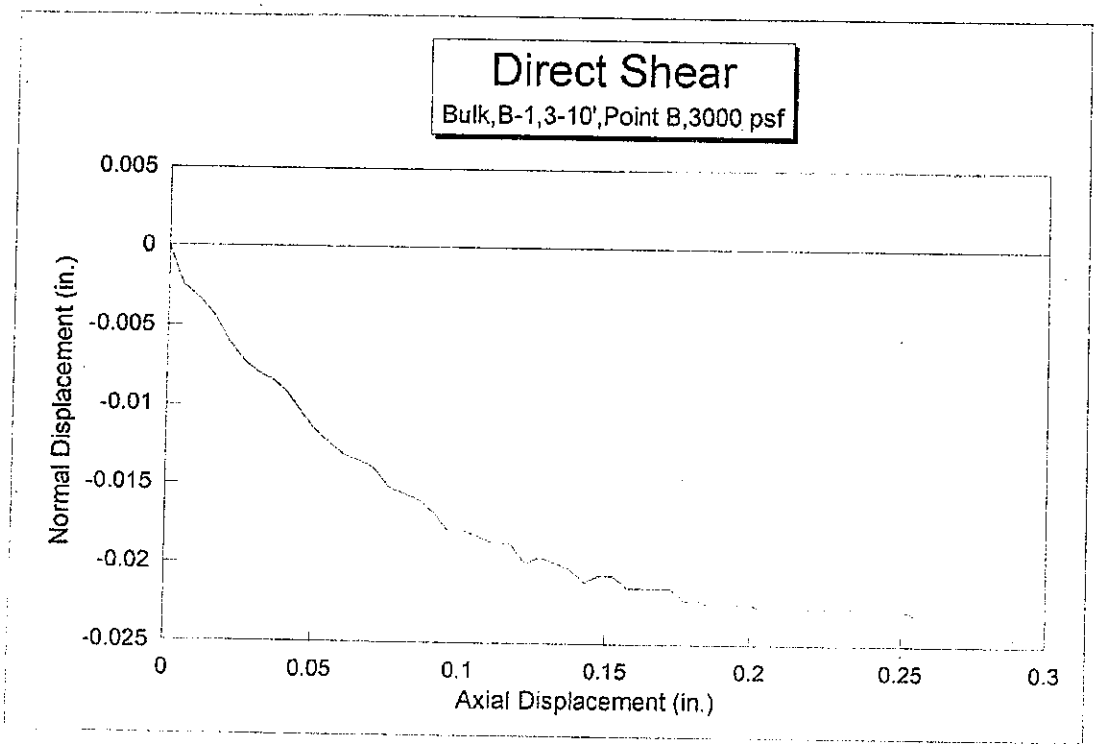
Shear Displacement (inches)	Shear Load (lbs.)	Shear Load (PSF)	Normal Displacement (inches)
0.0000	0.0	0	0.0000
0.0050	111.0	999	-0.0024
0.0101	128.4	1156	-0.0032
0.0153	139.6	1256	-0.0044
0.0203	146.6	1319	-0.0060
0.0253	155.8	1402	-0.0072
0.0304	163.0	1467	-0.0080
0.0354	170.2	1532	-0.0084
0.0404	170.2	1532	-0.0092
0.0454	180.4	1624	-0.0104
0.0504	183.4	1651	-0.0116
0.0555	186.4	1678	-0.0124
0.0605	187.4	1687	-0.0131
0.0658	193.6	1742	-0.0135
0.0707	195.6	1760	-0.0139
0.0758	199.6	1796	-0.0152
0.0808	203.8	1834	-0.0156
0.0858	177.2	1595	-0.0160
0.0908	208.8	1879	-0.0167
0.0958	213.0	1917	-0.0179
0.1009	215.0	1935	-0.0179
0.1064	183.4	1651	-0.0183
0.1117	216.0	1944	-0.0187
0.1167	222.0	1998	-0.0187
0.1217	227.2	2045	-0.0200
0.1269	231.2	2081	-0.0196
0.1320	232.2	2090	-0.0200
0.1370	235.4	2119	-0.0203
0.1423	228.2	2054	-0.0211
0.1473	238.4	2146	-0.0207
0.1523	241.4	2173	-0.0207
0.1573	244.4	2200	-0.0215
0.1623	249.6	2246	-0.0215
0.1674	251.6	2264	-0.0215
0.1724	253.6	2282	-0.0215
0.1774	256.8	2311	-0.0223
0.1827	258.8	2329	-0.0223
0.1877	251.6	2264	-0.0227
0.1927	260.8	2347	-0.0227
0.1977	263.8	2374	-0.0223
0.2027	266.8	2401	-0.0227
0.2078	266.8	2401	-0.0227
0.2130	274.0	2466	-0.0227
0.2181	278.0	2502	-0.0227
0.2233	272.0	2448	-0.0227
0.2286	275.0	2475	-0.0227
0.2341	276.0	2484	-0.0227
0.2391	278.0	2502	-0.0227
0.2441	280.2	2522	-0.0227
0.2492	282.2	2540	-0.0227
0.2542	286.2	2576	-0.0231

Data entry by: DPM
Checked by: DPM
FileName: HEDSB1BC

Date: 11/19/2012
Date: 11/20/12

ATT


Direct Shear
Bulk,B-1,3-10',Point B,3000 psf
Shear Strength (PSF)
Thousands
3
2
1
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Axial Displacement


Direct Shear
Bulk,B-1,3-10',Point B,3000 psf
Normal Displacement (in.)
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
0
0.05
0.1
0.15
0.2
0.25
0.3
Axial Displacement (in.)

DIRECT SHEAR TEST DATA
ASTM D3080

Client:	HP Geotechnical	Job Number:	2158-92
		Date Tested:	11/14/2012 DPM
Boring:	B-1		
Sample Number:	Bulk	Soil Description:	112340A
Depth:	3-10'	Point:	C
Location:	Hope Mine	Normal Load	1000 PSF
		Peak Strength	1018 PSF

Shear Displacement (inches)	Shear Load (lbs.)	Shear Load (PSF)	Normal Displacement (inches)
0.0000	0.0	0	0.0000
0.0050	30.6	275	-0.0004
0.0103	39.8	358	-0.0004
0.0153	45.8	412	-0.0012
0.0203	50.0	450	-0.0023
0.0253	56.0	504	-0.0031
0.0306	60.0	540	-0.0048
0.0356	62.2	560	-0.0044
0.0406	64.2	578	-0.0056
0.0457	66.2	596	-0.0067
0.0507	68.2	614	-0.0063
0.0557	70.2	632	-0.0075
0.0610	72.4	652	-0.0075
0.0660	73.4	661	-0.0083
0.0710	76.4	688	-0.0079
0.0760	78.4	706	-0.0088
0.0810	80.4	724	-0.0088
0.0860	81.4	733	-0.0095
0.0913	82.6	743	-0.0092
0.0963	84.6	761	-0.0095
0.1014	85.6	770	-0.0095
0.1064	86.6	779	-0.0095
0.1114	86.6	779	-0.0099
0.1164	89.6	806	-0.0099
0.1219	89.6	806	-0.0099
0.1269	88.6	797	-0.0099
0.1320	90.6	815	-0.0099
0.1370	91.6	824	-0.0095
0.1420	92.6	833	-0.0099
0.1470	92.6	833	-0.0103
0.1520	91.6	824	-0.0099
0.1581	92.6	833	-0.0103
0.1631	94.8	853	-0.0099
0.1681	90.6	815	-0.0103
0.1731	92.6	833	-0.0111
0.1781	94.8	853	-0.0111
0.1831	94.8	853	-0.0107
0.1882	89.6	806	-0.0111
0.1935	92.6	833	-0.0115
0.1987	93.8	844	-0.0119
0.2040	93.8	844	-0.0119
0.2090	99.8	898	-0.0115
0.2140	102.8	925	-0.0119
0.2190	99.8	898	-0.0119
0.2243	98.8	889	-0.0123
0.2293	105.0	945	-0.0123
0.2343	106.0	954	-0.0123
0.2394	106.0	954	-0.0123
0.2444	101.8	916	-0.0123
0.2494	105.0	945	-0.0127
0.2544	105.0	945	-0.0127

Data entry by: DPM
Checked by: DAW
FileName: HEDSB1BC

Date: 11/19/2012
Date: 11/20/12

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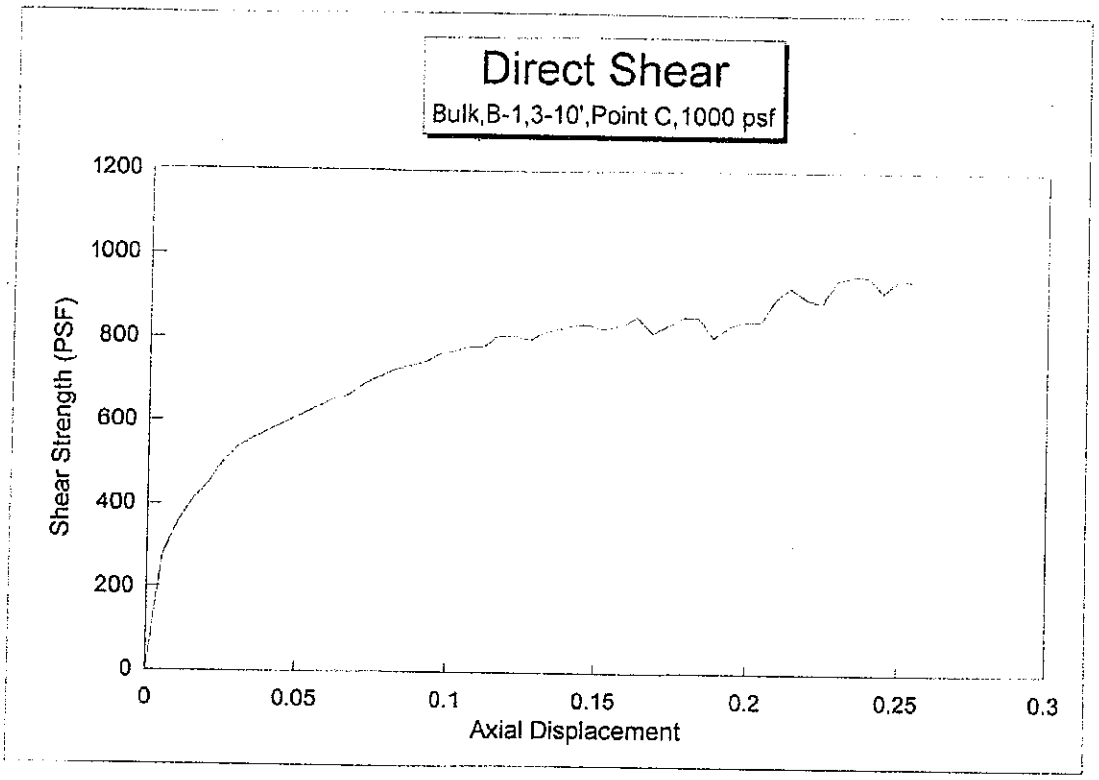
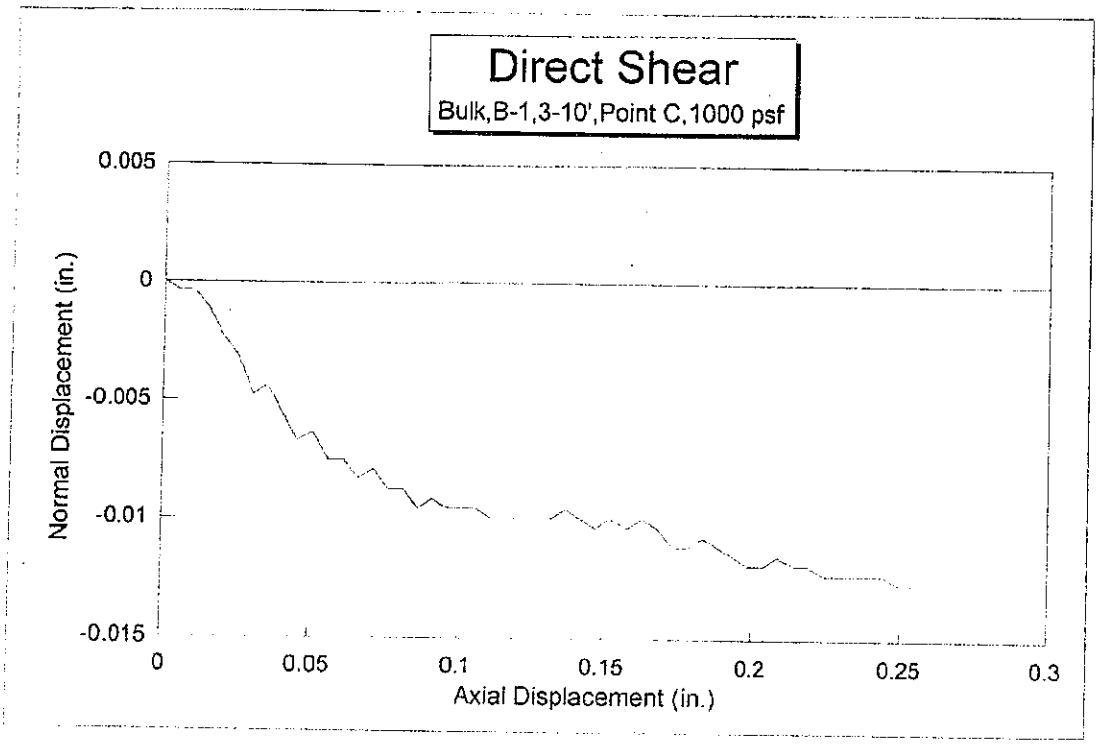

Direct Shear
Bulk,B-1,3-10',Point C,1000 psf
Shear Strength (PSF)
1200
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Axial Displacement


Direct Shear
Bulk,B-1,3-10',Point C,1000 psf
Normal Displacement (in.)
0.005
0
-0.005
-0.01
-0.015
0
0.05
0.1
0.15
0.2
0.25
0.3
Axial Displacement (in.)

Steve Pawlak

From: cheapoair@cheapoair.com
Sent: Saturday, November 24, 2012 4:54 PM
To: steve@hpgeotech.com
Subject: CheapOair.com - Pawlak/ Steven - Booking receipt - Booking # 14022894

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Click here to see your itinerary on mobile »

Customer Information

Traveler:	**Steven Lawrence Pawlak**	Email:	**slpawlak1@yahoo.com**	Phone:	**970-945-5957**
Booking #:	**14022894**	Booked on:	**Sat, Nov 24, 2012**		

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Trip Summary

Flight Summary

From:
Denver, CO , US **(DEN)**

To:
Newark Liberty, NJ , US **(EWR)**

Depart:
Thu, Dec 13, 2012
08:07 am - 01:59 pm (Nonstop)

Return:
Mon, Dec 17, 2012
09:01 am - 11:42 am (Nonstop)

Airline Confirmation:
United Airlines : B08Z2K

Select Seats

Traveler Name	Ticket Number	Meal Preference	Special Request
Pawlak, Steven Lawrence (Adult)	0167162590652 E-Ticket	Any meal	—

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Price Details (USD)

Flight Price Details

Traveler Type	Ticket Price	Tax & Fee Breakdown	Total
1 Adult/s	US$ 327.00	US$ 21.60	US$ 348.60
		Insurance Fee:	US$ 0.00
		Promo Discount:	- US$ 13.00
Charged on Credit Card - Visa - ****4294		**Subtotal:**	US$ 335.60
Total Booking Amount:			**US$ 348.60**
Total Discount (Savings):			**- US$ 13.00**
Total Cost:			**US$ 335.60**

Please Note:

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- Some airlines may charge baggage fees .

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- Name changes are not permitted. Prices do not include Baggage and Carry-On Fees or other fees charged directly by the airline.
- Fares are not guaranteed until ticketed. All changes are subject to availability, additional fees, airlines rules and regulations.
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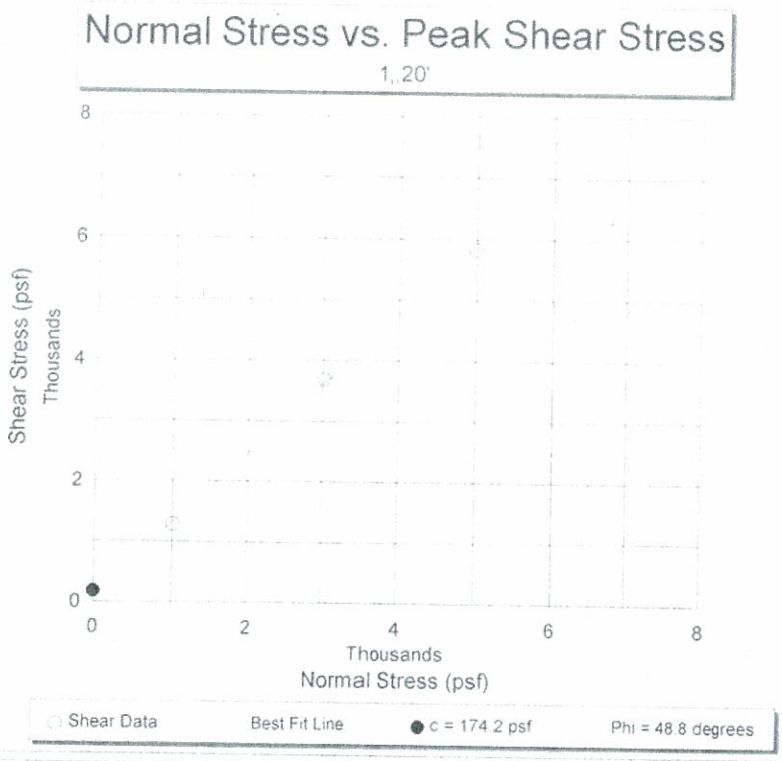
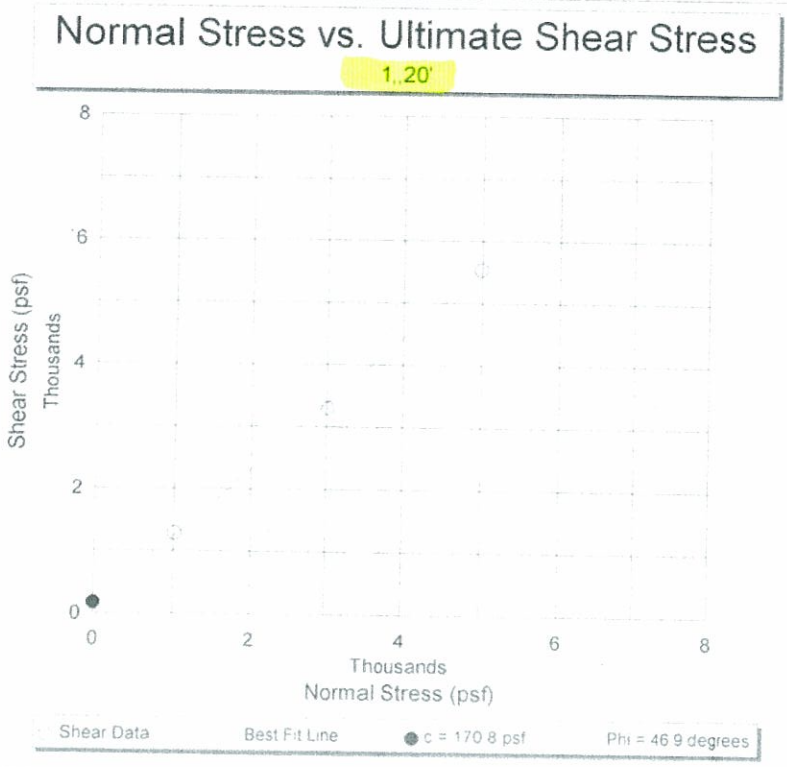

Normal Stress vs. Peak Shear Stress
1,.20'
Shear Stress (psf)
Thousands
0
2
4
6
8
Thousands
Normal Stress (psf)
Shear Data
Best Fit Line
c = 174.2 psf
Phi = 48.8 degrees


Normal Stress vs. Ultimate Shear Stress
1,.20'
Shear Stress (psf)
Thousands
0
2
4
6
8
Thousands
Normal Stress (psf)
Shear Data
Best Fit Line
c = 170.8 psf
Phi = 46.9 degrees

DIRECT SHEAR TEST DATA
ASTM D 3080

CLIENT HP Geotech

JOB NO. 2158-92

BORING NO.	1
DEPTH	20'
SAMPLE NO.	
POINT	A
SOIL DESCR.	112340A
LOCATION	Hope Mine
NORMAL STRESS (psf)	4987

SAMPLED	
TEST STARTED	10/31/12 DPM
TEST FINISHED	11/01/12 CAL
CELL NUMBER	Geomatic
SATURATED TEST	Yes
TEST TYPE	CD

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	105.4	108.1
Wt. Wet Soil & Pan (g)	113.9	116.6
Wt. Dry Soil & Pan (g)	103.4	103.4
Wt. Lost Moisture (g)	10.5	13.2
Wt. of Pan Only (g)	8.6	8.6
Wt. of Dry Soil (g)	94.9	94.9
Moisture Content %	11.1	13.9
Wet Density (pcf)	136.1	143.0
Dry Density (pcf)	122.5	125.5

Init. Diameter (in)	1.938
Init. Area (sq in)	2.950
Init. Height (in)	1.000
Vol. Bef. Consol. (cu ft)	0.00171
Final Height (in)	0.976
Vol. After Consol. (cu ft)	0.00167

Test Set Up: Continuous Increasing Deflection Control
Shear Speed: 0.00200 in/min

Notes & Comments:

Data File Name: HEDS120A.DAT

Normal Stress:	4987 psf	34.63 psi
Peak Stress:	5837 psf	40.53 psi
Ultimate Stress:	5538 psf	38.46 psi

NOTE: The sample contained gravel. Significant filling was required to achieve testable specimens.

Data entry by: DAW Date: 11/02/2012
Data checked by: DPM Date: 11/05/12
FileName: HEDS120H

ADVANCED TERRA TESTING, INC. ATT

DIRECT SHEAR TEST DATA
ASTM D 3080

CLIENT	HP Geotech	JOB NO.	2158-92
BORING NO.	1	SAMPLED	
DEPTH	20'	TEST STARTED	10/31/12 DPM
SAMPLE NO.		TEST FINISHED	11/01/12 DPM
POINT	B	CELL NUMBER	Geomatic
SOIL DESCR.	112340A	SATURATED TEST	Yes
LOCATION	Hope Mine	TEST TYPE	CD
NORMAL STRESS (psf)	3015		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	107.0	107.2
Wt. Wet Soil & Pan (g)	115.2	115.4
Wt. Dry Soil & Pan (g)	104.0	104.0
Wt. Lost Moisture (g)	11.2	11.5
Wt. of Pan Only (g)	8.2	8.2
Wt. of Dry Soil (g)	95.8	95.8
Moisture Content %	11.7	12.0
Wet Density (pcf)	138.2	140.9
Dry Density (pcf)	123.7	125.8

Init. Diameter (in)	1.938
Init. Area (sq in)	2.950
Init. Height (in)	1.000
Vol. Bef. Consol. (cu ft)	0.00171
Final Height (in)	0.983
Vol. After Consol. (cu ft)	0.00168

Test Set Up: Continuous Increasing Deflection Control
Shear Speed: 0.00200 in/min

Notes & Comments:

Data File Name: HEDS120B.DAT

Normal Stress:	3015 psf	20.94 psi
Peak Stress:	3692 psf	25.64 psi
Ultimate Stress:	3301 psf	22.92 psi

Data entry by: DAW Date: 11/02/2012
Data checked by: DRM Date: 11/05/12
FileName: HEDS120H

ADVANCED TERRA TESTING, INC. ATT

DIRECT SHEAR TEST DATA
ASTM D 3080

CLIENT	HP Geotech	JOB NO.	2158-92
BORING NO.	1	SAMPLED	
DEPTH	20'	TEST STARTED	10/31/12 DPM
SAMPLE NO.		TEST FINISHED	10/31/12 DPM
POINT	C	CELL NUMBER	Geomatic
SOIL DESCR.	112340A	SATURATED TEST	Yes
LOCATION	Hope Mine	TEST TYPE	CD
NORMAL STRESS (psf)	1005		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	101.3	105.7
Wt. Wet Soil & Pan (g)	107.8	112.2
Wt. Dry Soil & Pan (g)	98.3	98.3
Wt. Lost Moisture (g)	9.5	13.9
Wt. of Pan Only (g)	6.5	6.5
Wt. of Dry Soil (g)	91.8	91.8
Moisture Content %	10.3	15.1
Wet Density (pcf)	130.8	137.3
Dry Density (pcf)	118.6	119.3

Init. Diameter (in)	1.938
Init. Area (sq in)	2.950
Init. Height (in)	1.000
Vol. Bef. Consol. (cu-ft)	0.00171
Final Height (in)	0.994
Vol. After Consol. (cu ft)	0.00170

Test Set Up: Continuous Increasing Deflection Control
Shear Speed: 0.00200 in/min

Notes & Comments:

Data File Name: HEDS120C.DAT

Normal Stress:	1005 psf	6.98 psi
Peak Stress:	1287 psf	8.94 psi
Ultimate Stress:	1287 psf	8.94 psi

Data entry by: DAW Date: 11/02/2012
Data checked by: DPM Date: 11/05/12
FileName: HEDS120H

ADVANCED TERRA TESTING, INC. ATT

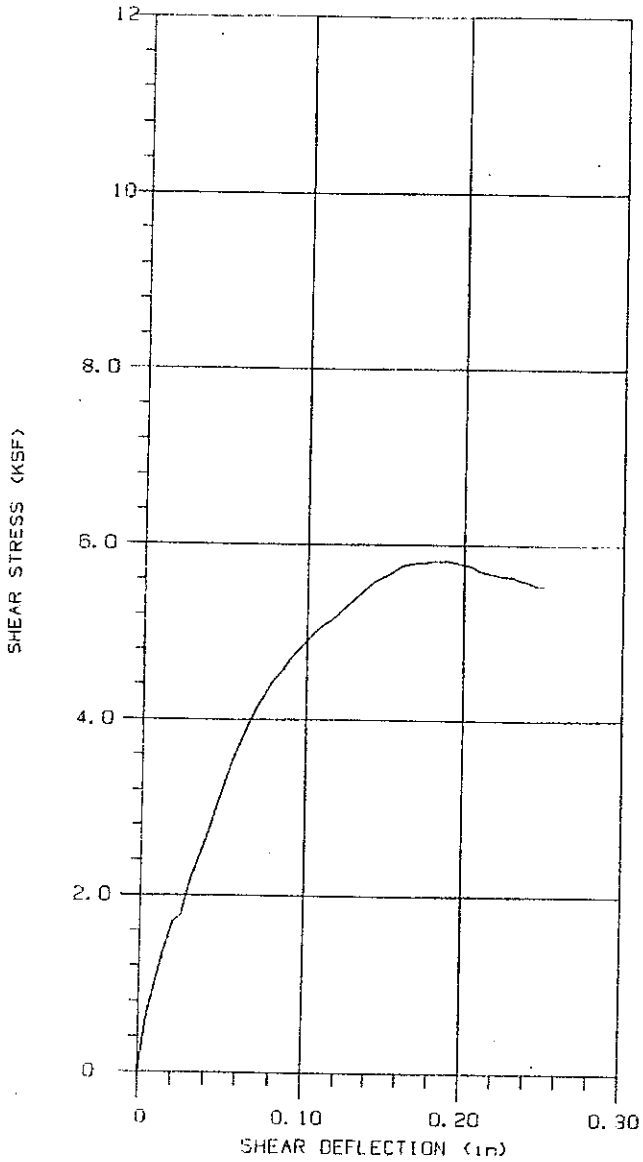
ADVANCED TERRA TESTING

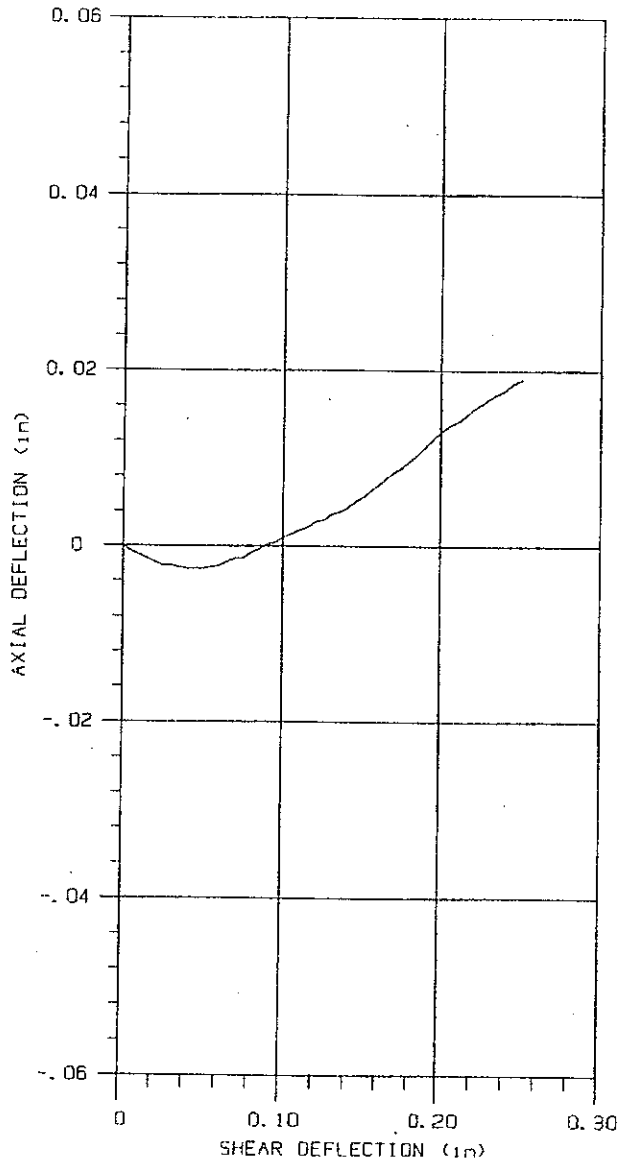
Direct Shear Test

Client..... HP Geotchnical
Location..... Hope Mine

Soil Type..... 112340A
Depth..... 20' (ft)
Confining Pressure.. 4987 (psf)
Shear Rate..... .0020 (in/min)
Date Tested..... 11-01-2012

Job Number..... 2158-92
Sample Number... Pt. A
Boring..... 1
File Name..... HEDS120A.DAT
Tested By..... CAL





Pass Number and Line Type....	1 ————	2 - - - - - -	3 — — —	4 — — — —
Maximum Shear Stress.....	5837	.0000	.0000	.0000
Shear Deflection @ Max Stress.	.1735	.0000	.0000	.0000

GEOMATIC Direct Shear Data

File Name.....HEDS120A.DAT
Client.....HP Geotchnical
Job Number....2158-92
Location.....Hope Mine
Date.....11-01-2012
Technician....CAL
Sample Diameter (in).....1.938
Confining Pressure (psf)..4987
Number of Passes.....1
Shear Distance (in).....0.25
Shear Rate (in/min).....0020
Soil Type.....112340A
Boring Number.....1
Sample Number.....Pt. A
Depth (ft).....20'

SHEAR DEFLECTION (in)	SHEAR STRESS (lb/sqFT)	AXIAL DEFLECTION (in)
0.005	634	-.0005
0.010	1026	-.0010
0.015	1380	-.0014
0.020	1697	-.0018
0.025	1790	-.0021
0.030	2144	-.0022
0.035	2406	-.0024
0.040	2667	-.0026
0.045	2965	-.0026
0.050	3245	-.0026
0.055	3506	-.0024
0.060	3711	-.0022
0.065	3953	-.0019
0.070	4158	-.0015
0.075	4308	-.0013
0.080	4457	-.0008
0.085	4569	-.0004
0.090	4699	0.0001
0.095	4792	0.0004
0.100	4904	0.0009
0.105	4998	0.0014
0.110	5072	0.0018
0.115	5147	0.0023
0.120	5221	0.0027
0.125	5296	0.0030
0.130	5389	0.0035
0.135	5464	0.0040
0.140	5538	0.0045
0.145	5594	0.0051
0.150	5650	0.0057
0.155	5706	0.0064
0.160	5762	0.0070
0.165	5781	0.0077
0.170	5799	0.0084
0.175	5799	0.0091

Continued next page.

Pass 1 Continued

SHEAR DEFLECTION (in)	SHEAR STRESS (lb/sqFT)	AXIAL DEFLECTION (in)
0.180	5818	0.0098
0.185	5818	0.0106
0.190	5818	0.0114
0.195	5799	0.0122
0.200	5781	0.0130
0.205	5762	0.0138
0.210	5706	0.0142
0.215	5688	0.0149
0.220	5669	0.0155
0.225	5632	0.0162
0.230	5632	0.0168
0.235	5594	0.0173
0.240	5576	0.0178
0.245	5538	0.0185
0.250	5538	0.0190

Pass 1 completed with max load = 5837 psf at deflection of .1735 in

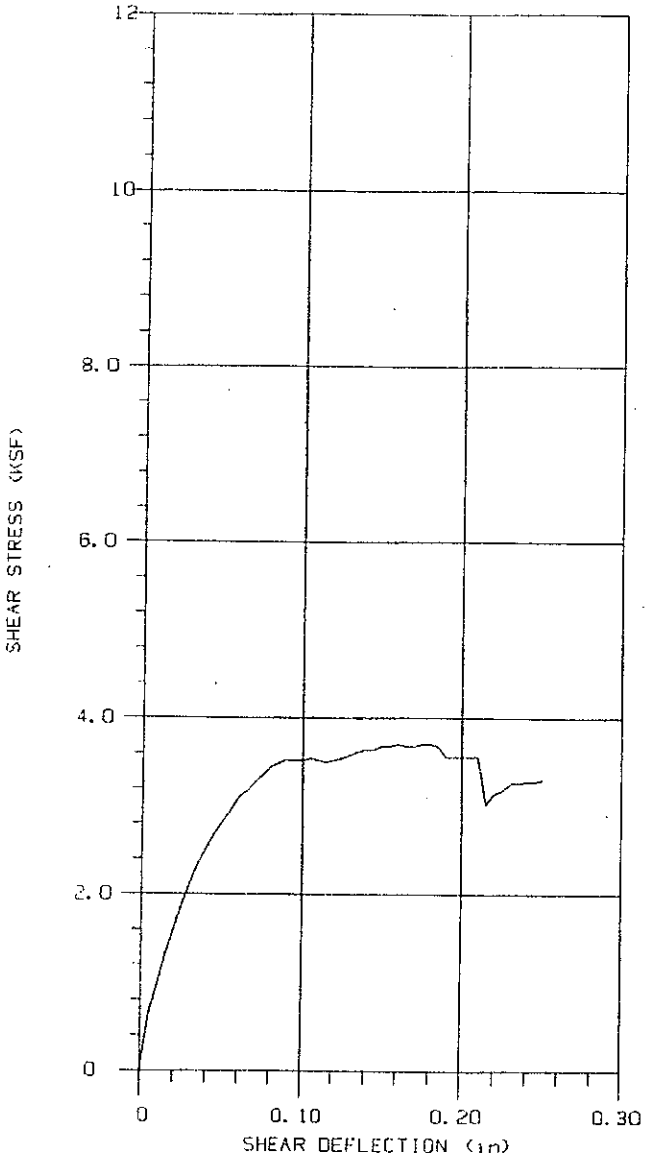
ADVANCED TERRA TESTING

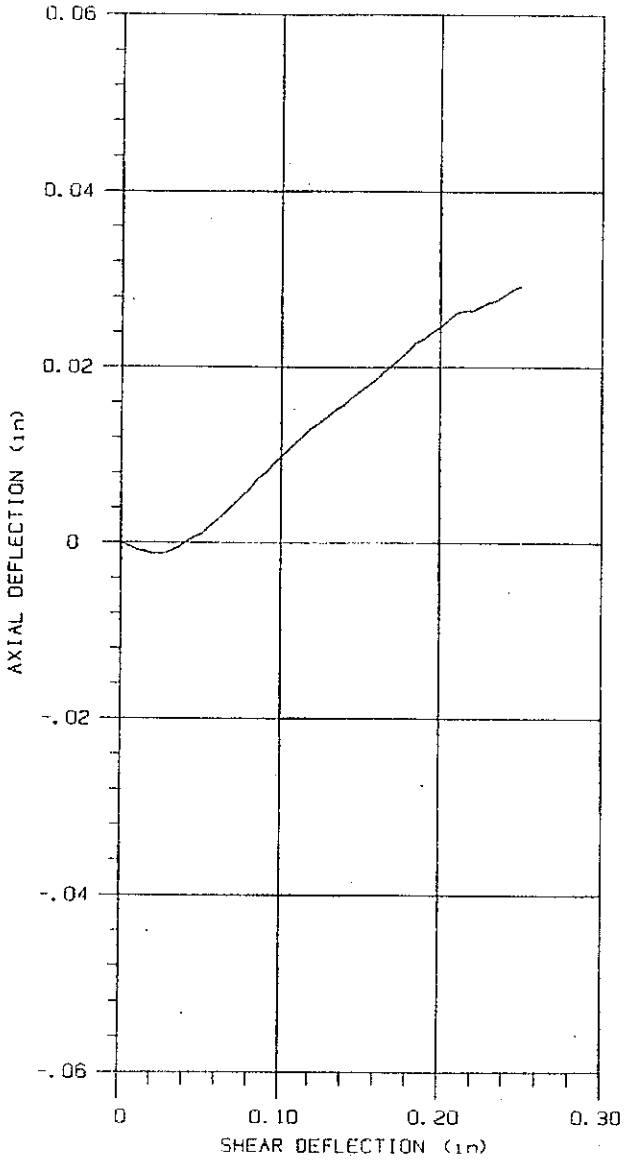
Direct Shear Test

Client..... HP Geotchnical
Location..... Hope Mine

Soil Type..... 112340A
Depth..... 20' (ft)
Confining Pressure.. 3015 (psf)
Shear Rate..... .0020 (in/min)
Date Tested..... 11-01-2012

Job Number..... 2158-92
Sample Number... Pt. B
Boring..... 1
File Name..... HEDS120B.DAT
Tested By..... DPM





Pass Number and Line Type....	1 ———	2 - - - - - -	3 —— - -	4 - - - - —
Maximum Shear Stress.....	3692	.0000	.0000	.0000
Shear Deflection @ Max Stress.	.1575	.0000	.0000	.0000

GEOMATIC Direct Shear Data

File Name.....HEDS120B.DAT
Client.....HP Geotchnical
Job Number....2158-92
Location.....Hope Mine
Date.....11-01-2012
Technician....DPM
Sample Diameter (in).....1.938
Confining Pressure (psf)..3015
Number of Passes.....1
Shear Distance (in).....0.25
Shear Rate (in/min).....0020
Soil Type.....112340A
Boring Number.....1
Sample Number.....Pt. B
Depth (ft).....20'

SHEAR DEFLECTION (in)	SHEAR STRESS (lb/sqFT)	AXIAL DEFLECTION (in)
0.005	615	-.0004
0.010	951	-.0008
0.015	1324	-.0011
0.020	1622	-.0012
0.025	1902	-.0012
0.030	2144	-.0009
0.035	2368	-.0006
0.040	2536	0.0000
0.045	2704	0.0005
0.050	2834	0.0011
0.055	2965	0.0018
0.060	3096	0.0026
0.065	3189	0.0034
0.070	3282	0.0043
0.075	3357	0.0052
0.080	3431	0.0061
0.085	3487	0.0071
0.090	3524	0.0080
0.095	3524	0.0089
0.100	3524	0.0098
0.105	3543	0.0107
0.110	3524	0.0114
0.115	3506	0.0123
0.120	3524	0.0130
0.125	3543	0.0137
0.130	3580	0.0144
0.135	3618	0.0151
0.140	3636	0.0157
0.145	3636	0.0164
0.150	3674	0.0171
0.155	3674	0.0179
0.160	3692	0.0187
0.165	3674	0.0195
0.170	3674	0.0203
0.175	3692	0.0211

Continued next page.

Pass 1 Continued

SHEAR DEFLECTION (in)	SHEAR STRESS (lb/sqFT)	AXIAL DEFLECTION (in)
0.180	3692	0.0219
0.185	3674	0.0227
0.190	3562	0.0233
0.195	3562	0.0239
0.200	3562	0.0246
0.205	3562	0.0254
0.210	3562	0.0262
0.215	3021	0.0265
0.220	3133	0.0265
0.225	3189	0.0269
0.230	3263	0.0274
0.235	3263	0.0277
0.240	3282	0.0282
0.245	3282	0.0288
0.250	3301	0.0292

Pass 1 completed with max load = 3692 psf at deflection of .1575 in

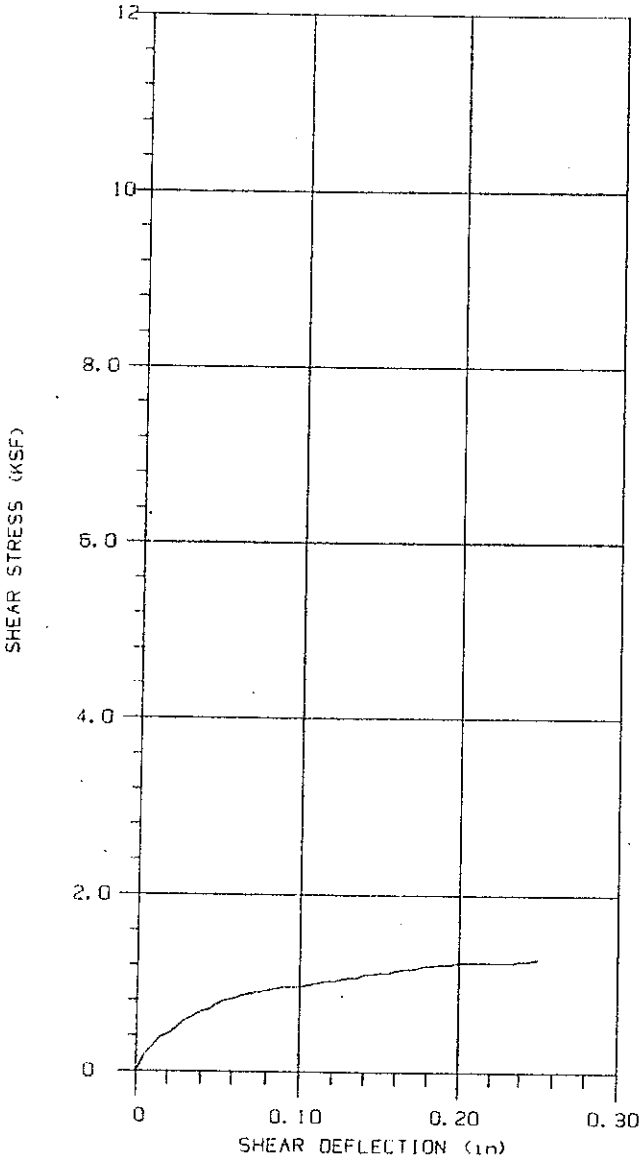
ADVANCED TERRA TESTING

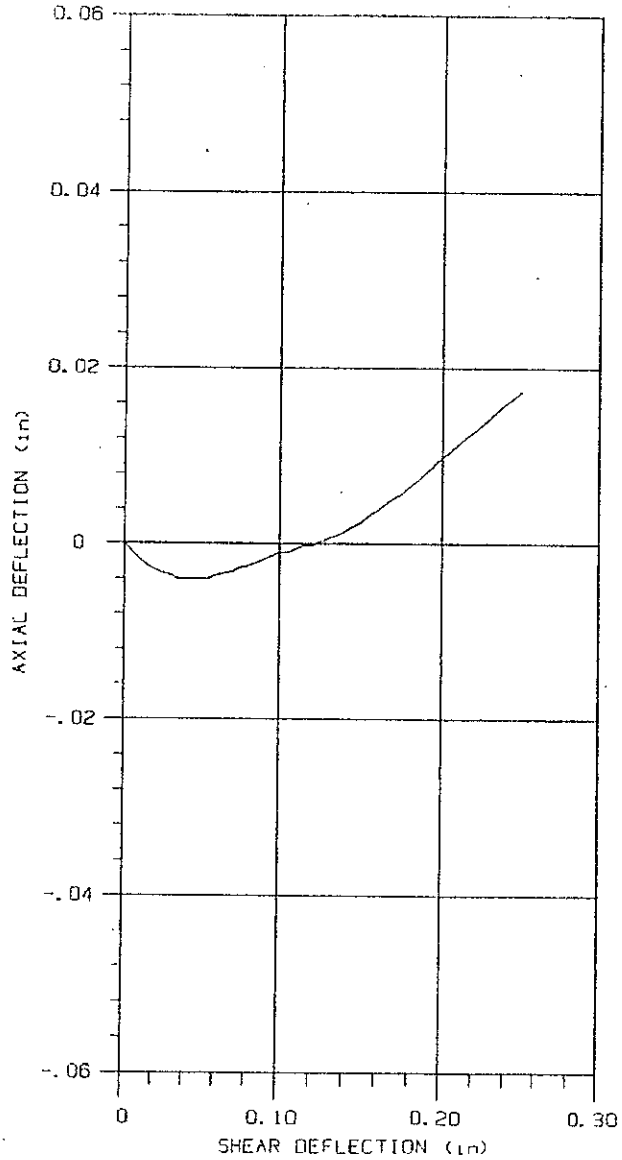
Direct Shear Test

Client..... HP Geotchnical
Location..... Hope Mine

Soil Type..... 112340A
Depth..... 20' (ft)
Confining Pressure.. 1005 (psf)
Shear Rate..... .0020 (in/min)
Date Tested..... 10-31-2012

Job Number..... 2158-92
Sample Number... Pt. C
Boring..... 1
File Name..... HEDS120C.DAT
Tested By..... DPM





Pass Number and Line Type....	1 ————	2 - - - - - -	3 —— —	4 — - - —
Maximum Shear Stress.....	1287	.0000	.0000	.0000
Shear Deflection @ Max Stress.	.2472	.0000	.0000	.0000

GEOMATIC Direct Shear Data

File Name.....HEDS120C.DAT
Client.....HP Geotchnical
Job Number....2158-92
Location.....Hope Mine
Date.....10-31-2012
Technician....DPM
Sample Diameter (in).....1.938
Confining Pressure (psf)..1005
Number of Passes.....1
Shear Distance (in).....0.25
Shear Rate (in/min).....0020
Soil Type.....112340A
Boring Number.....1
Sample Number.....Pt. C
Depth (ft).....20'

SHEAR DEFLECTION (in)	SHEAR STRESS (lb/sqFT)	AXIAL DEFLECTION (in)
0.005	186	-.0009
0.010	280	-.0018
0.015	373	-.0025
0.020	429	-.0030
0.025	485	-.0034
0.030	559	-.0037
0.035	615	-.0039
0.040	671	-.0040
0.045	709	-.0040
0.050	765	-.0040
0.055	802	-.0039
0.060	821	-.0037
0.065	858	-.0034
0.070	876	-.0032
0.075	895	-.0028
0.080	914	-.0025
0.085	932	-.0022
0.090	951	-.0018
0.095	970	-.0014
0.100	970	-.0010
0.105	988	-.0009
0.110	1007	-.0005
0.115	1026	-.0002
0.120	1026	-.0001
0.125	1044	0.0001
0.130	1063	0.0006
0.135	1063	0.0009
0.140	1100	0.0014
0.145	1100	0.0020
0.150	1119	0.0025
0.155	1119	0.0031
0.160	1138	0.0038
0.165	1156	0.0046
0.170	1156	0.0051
0.175	1175	0.0058

Continued next page.

Pass 1 Continued

SHEAR DEFLECTION (in)	SHEAR STRESS (lb/sqFT)	AXIAL DEFLECTION (in)
0.180	1193	0.0066
0.185	1193	0.0074
0.190	1212	0.0081
0.195	1212	0.0090
0.200	1231	0.0098
0.205	1231	0.0106
0.210	1231	0.0114
0.215	1231	0.0122
0.220	1249	0.0129
0.225	1249	0.0137
0.230	1249	0.0144
0.235	1249	0.0151
0.240	1268	0.0159
0.245	1268	0.0166
0.250	1287	0.0173

Pass 1 completed with max load = 1287 psf at deflection of .2472 in

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Appendix D

Topographic Survey, Inter-Mountain Engineering

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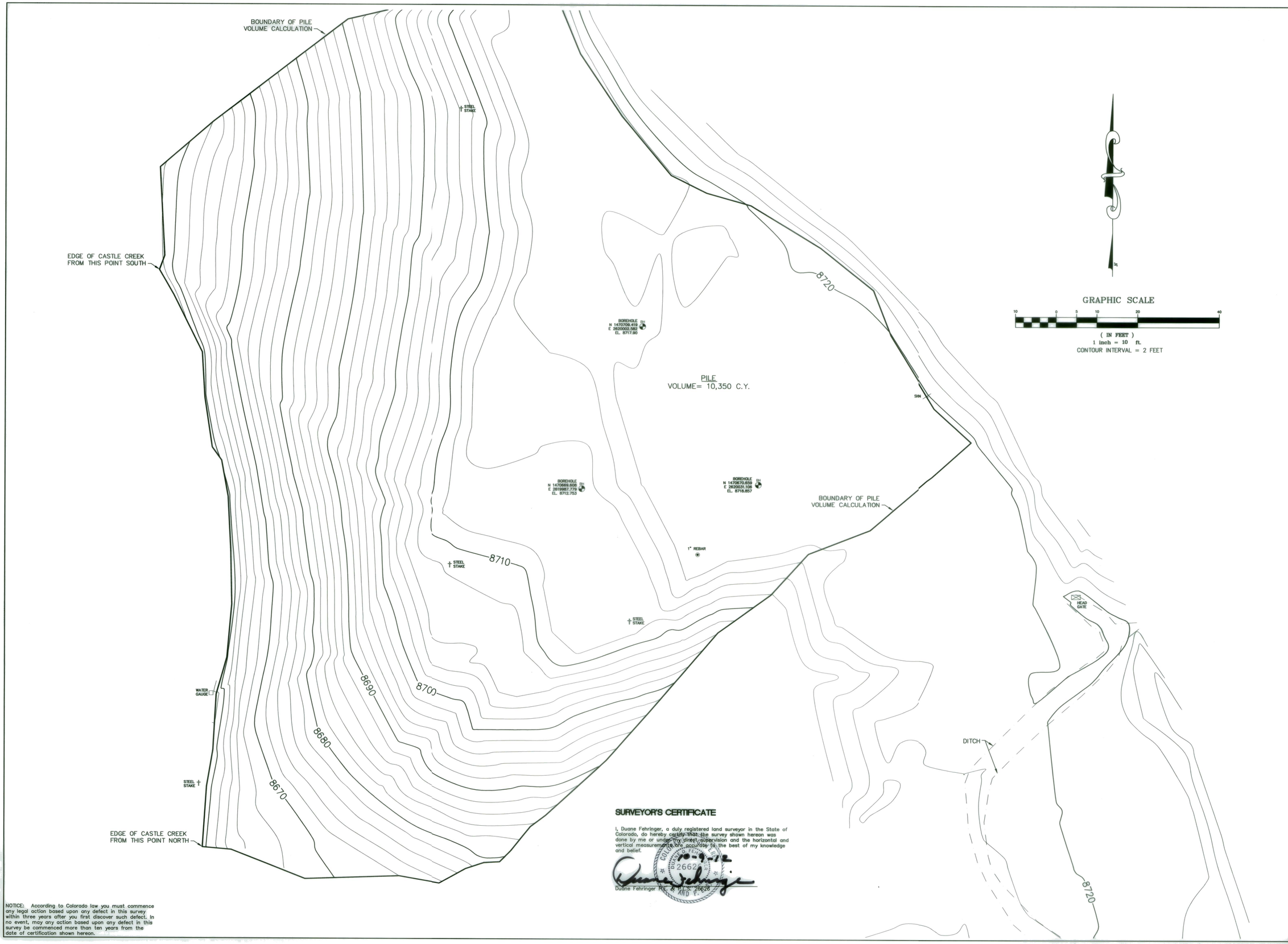

SURVEYOR'S CERTIFICATE

I, Duane Fehringer, a duly registered land surveyor in the State of Colorado, do hereby certify that the survey shown hereon was done by me or under my direct supervision and the horizontal and vertical measurements are accurate to the best of my knowledge and belief.

10-9-12

Duane Fehringer PE & PLS 28628

COLORADO DUANE D. FEHRINGER 28628 PLS

NOTICE: According to Colorado law you must commence any legal action based upon any defect in this survey within three years after you first discover such defect. In no event, may any action based upon any defect in this survey be commenced more than ten years from the date of certification shown hereon.

NO.	DATE	REVISION	BY

Inter-Mountain ENGINEERING
Civil Engineers & Surveyors
40801 US HWY 6&24, SUITE 203 BOX 979, AVON, CO 81620 PH: (970)949-5072
6551 S. REVERE PARKWAY, SUITE 106 CENTENNIAL, CO 80111 PH: (303)948-6220

CLIENT: CARDNO TEC

This document was prepared for the exclusive use of the Client specified hereon. The use of this document or the information contained herein by any other person or entity is prohibited. In the event that any other person or entity desires to use this document or the information contained herein for any purpose, they must first obtain the consent of Inter-Mountain Engineering. This document and any information contained herein is intended to be used within one year of the date hereof. Use after that period is not to be used.

TOPOGRAPHIC SURVEY

HOPE MINE
WHITE RIVER NATIONAL FOREST
PITKIN COUNTY, COLORADO

DESIGNED BY:	
DRAWN BY:	SPF
CHECKED BY:	DDF
DATE ISSUED:	10-8-12
PROJECT NO.	12-0051
SHEET NO.	1 OF 1

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Appendix E

Detailed Cost Estimates and Schedules, Frontier Environmental Services

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FRONTIER ENVIRONMENTAL SERVICES, INC. Project Worksheet

FES Project Number:
Proposal Number: 130107

Scheduled Start Date:
1-Jan-2013

Frontier Environmental Services
Project Name: Cardno-TEC: USFS Hope Mine

Scheduled Finish Date:
31-Dec-2013

	Project Labor Discription (Fully Burdened Project Work Day Hours:	Rate/hr: 10.00	Item 1 Remedy Design	Item 2 Mobilization & De-Mobilization	Item 3 SHEAP	Item 4 Off-Site Transport & Disposal - 50 Mile Radius	Item 5.1 On-Site Consoldiation Repository Waste-Rock Excavation/Movement	Item 5.2 On-Site Consoldiation Repository Cap System	Item 5.2 On-Site Consoldiation Repository Revegetation
A	Program Director	$125.00	24 $3,000.00	10 $1,250.00	2 $210.00	24 $3,000.00	12 $1,500.00	24 $3,000.00	5 $625.00
B	Project Manager	$105.00	32 $3,360.00	40 $4,200.00	5 $525.00	80 $8,400.00	200 $21,000.00	100 $10,500.00	10 $1,050.00
C	Engineer	$90.00	120 $10,800.00	10 $900.00	5 $450.00	24 $2,160.00	50 $4,500.00	50 $4,500.00	0 $0.00
D	Geologist/Geo-Tech	$90.00	40 $3,600.00	0 $0.00	2 $180.00	40 $3,600.00	40 $3,600.00	32 $2,880.00	0 $0.00
E	Auto CAD Designer	$65.00	56 $5,040.00	0 $0.00	5 $450.00	8 $720.00	8 $720.00	16 $1,440.00	0 $0.00
F	Site Remediation Manager	$90.00	24 $2,160.00	40 $3,600.00	5 $450.00	600 $54,000.00	400 $36,000.00	250 $22,500.00	20 $1,800.00
G	QA/QC Supervisor	$85.00	24 $2,040.00	0 $0.00	30 $2,550.00	200 $17,000.00	180 $15,300.00	100 $8,500.00	10 $850.00
H	Craft Supervisor/Foreperson	$80.00	0 $0.00	40 $3,200.00	2 $160.00	600 $48,000.00	400 $32,000.00	250 $20,000.00	20 $1,600.00
I	Equipment Operator, (D-B Wage Plus Overhead Burden):	$55.00	0 $0.00	80 $4,400.00	0 $0.00	900 $49,500.00	1200 $66,000.00	750 $41,250.00	20 $1,100.00
J	Skilled Labor: (D-B Wage Plus Overhead Burden):	$50.00	0 $0	80 $4,000	0 $0	1200 $60,000	800 $40,000	500 $25,000	40 $2,000
K	Welder: (D-B Wage Plus Overhead Burden):	$55.00	0 $0.00	0 $0.00	0 $0.00	50 $2,750.00	50 $2,750.00	0 $0.00	0 $0.00
L	Administrative:	$45.00	80 $3,600.00	5 $225.00	10 $450.00	120 $5,400.00	30 $1,350.00	20 $900.00	5 $225.00
	Total Hours		400	305	66	3846	3370	2092	130
	Total Labor Costs		$33,600.00	$21,775.00	$5,425.00	$254,530.00	$224,720.00	$140,470.00	$9,250.00

	FRONTIER ENVIRONMENTAL SERVICES, INC. I						
	FES Project Number: Proposal Number: 130107						
	Frontier Environmental Services Project Name: Cardno-TEC: USFS Hope Mine						
	Project Labor Discription (Fully Burdened Project Work Day Hours:	Rate/hr: 10.00	Item 6.1 On-Site Relocation Repository - 0.5 Mile Radius Excavation & Construction	Item 6.2 On-Site Relocation Repository - 0.5 Mile Radius Waste-Rock Relocation	Item 6.3 On-Site Relocation Repository - 0.5 Mile Radius Cap System Construction	Item 6.4 On-Site Relocation Repository Revegetation	Item 7 Stormwater Controls Run-On & Run-Off
A	Program Director	$125.00	24 $3,000.00	40 $5,000.00	50 $6,250.00	5 $625.00	8 $1,000.00
B	Project Manager	$105.00	80 $8,400.00	60 $6,300.00	50 $5,250.00	10 $1,050.00	16 $1,680.00
C	Engineer	$90.00	60 $5,400.00	80 $7,200.00	100 $9,000.00	0 $0.00	24 $2,160.00
D	Geologist/Geo-Tech	$90.00	80 $7,200.00	40 $3,600.00	80 $7,200.00	0 $0.00	16 $1,440.00
E	Auto CAD Designer	$65.00	16 $1,440.00	8 $720.00	20 $1,800.00	0 $0.00	8 $720.00
F	Site Remediation Manager	$90.00	250 $22,500.00	300 $27,000.00	200 $18,000.00	30 $2,700.00	40 $3,600.00
G	QA/QC Supervisor	$85.00	50 $4,250.00	50 $4,250.00	50 $4,250.00	10 $850.00	24 $2,040.00
H	Craft Supervisor/Foreperson	$80.00	250 $20,000.00	300 $24,000.00	200 $16,000.00	30 $2,400.00	150 $12,000.00
I	Equipment Operator, (D-B Wage Plus Overhead Burden):	$55.00	750 $41,250.00	900 $49,500.00	600 $33,000.00	30 $1,650.00	300 $16,500.00
J	Skilled Labor: (D-B Wage Plus Overhead Burden):	$50.00	500 $25,000	600 $30,000	400 $20,000	60 $3,000	300 $15,000
K	Welder: (D-B Wage Plus Overhead Burden):	$55.00	50 $2,750.00	20 $1,100.00	20 $1,100.00	0 $0.00	30 $1,650.00
L	Administrative:	$45.00	30 $1,350.00	40 $1,800.00	20 $900.00	5 $225.00	20 $900.00
	Total Hours		2140	2438	1790	180	936
	Total Labor Costs		$142,540.00	$160,470.00	$122,750.00	$12,500.00	$58,690.00

FRONTIER ENVIRONMENTAL SERVICES, INC. Project Worksheet

FES Project Number:
Proposal Number: 130107

Scheduled Start Date:
1-Jan-2013

Frontier Environmental Services
Project Name: Cardno-TEC: USFS Hope Mine

Scheduled Finish Date:
31-Dec-2013

	Project Labor Discription (Fully Burdened Project Work Day Hours:	Rate/hr: 10.00	Item 1 Remedy Design	Item 2 Mobilization & De-Mobilization	Item 3 SHEAP	Item 4 Off-Site Transport & Disposal - 50 Mile Radius	Item 5.1 On-Site Consoldiation Repository Waste-Rock Excavation/Movement	Item 5.2 On-Site Consoldiation Repository Cap System	Item 5.2 On-Site Consoldiation Repository Revegetation
::		Unit:	Job	Job	Job	Unit Rate (Ton):	Unit Rate (CY):	Unit Rate (SF)	Unit Rate (Acre)
	OTHER DIRECT COSTS	Quantity (CY or LF):	1	1	1	15,300	8,000	25,000	2.5
		Tons:				29,950	15,660		
		Density (dry):				145.00	145.00		
		Truck Loads:				1664			
		Turn-Around Time (hrs):				3.5			
		Trucks/Day:				20			
Row #		Total Days:				83			
1	Waste Disposal ($/Ton):	$45	$0.00	$300.00	$0.00	$1,347,739	$1,500.00	$2,500.00	$250.00
2	Engineering Consultant	$150	$2,750.00	$0.00	$500.00	$2,750.00	$3,200.00	$5,250.00	$0.00
3	Geo-Tech Materials ($/SF):	$2.35	$0.00	$0.00	$0.00	$0.00	$33,851	$58,750.00	$0.00
4	Transporter ($/hr):	$115	$0.00	$6,900.00	$0.00	$669,710	$0.00	$0.00	$0.00
5	Clay Cap Material ($/Ton, Delivered):	$25	$0.00	$0.00	$0.00	$0.00	$359,370	$0.00	$0.00
6	Cement Type II/IV ($/Ton Deliverd):	$75	$0.00	$0.00	$0.00	$0	$117,450	$0.00	$0.00
7	Re-Vegetation Materials ($/Acre):	$1,250	$0.00	$0.00	$0.00	$4,375.00	$0.00	$0.00	$3,125.00
8	Rip-Rap ($/Ton, Delivered):	$40.00	$0.00	$0.00	$0.00	$0.00	$66,842.82	$0.00	$0.00
9	Utilities (On-Site Electric Generator, 120/240vac) ($/hr.):	$24	$0.00	$250.00	$0.00	$11,455	$7,636	$0.00	$0.00
10	Office Supplies	0.50%	$168.00	$108.88	$271.25	$1,272.65	$1,123.60	$702.35	$46.25
11	Ref material/periodicals	0.01%	$3.36	$2.18	$81.38	$25.45	$22.47	$14.05	$0.93
12	Postage/Delivery/Ship	0.10%	$33.60	$21.78	$35.00	$254.53	$224.72	$140.47	$9.25
13	Field/Office Supplies	2.00%	$672.00	$435.50	$108.50	$5,090.60	$4,494.40	$2,809.40	$185.00
14	CSP - 18" Diameter ($/LF):	$18	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
15	Concrete ($/CY):	$155	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
16	Safety Supplies	$6.75	$50.00	$171.56	$0.00	$2,163.38	$1,895.63	$1,176.75	$73.13
17	Safety Equipment	$3.80	$100.00	$96.58	$0.00	$1,217.90	$1,067.17	$662.47	$41.17
18	Heavy Equipment (Fully Burdened)	1.60	$0.00	$0.00	$0.00	$130,893.51	$113,080.52	$100,568.18	$2,603.64
19	Minor Equip Purchase	2.00%	$672.00	$435.50	$0.00	$5,090.60	$4,494.40	$2,809.40	$185.00
20	Repairs & Maintenance	5.00%	$0.00	$30.00	$0.00	$6,994.68	$5,954.03	$5,028.41	$130.18
21	Printing & Reproduction	1.00%	$3,360.00	$217.75	$54.25	$2,545.30	$2,247.20	$1,404.70	$92.50
22	Miscellaneous	5.00%	$336.00	$1,088.75	$0.00	$12,726.50	$11,236.00	$7,023.50	$462.50
23	Insurance	3.25%	$1,386.45	$1,129.41	$321.11	$81,797.82	$32,717.78	$11,696.78	$581.10
24	Bonding	2.50%	$0.00	$868.77	$0.00	$62,921.40	$25,167.52	$8,997.52	$447.00
25	Fuel - Vehicle/Equipment	15.00%	$0.00	$0.00	$0.00	$19,634.03	$16,962.08	$15,085.23	$390.55
26	Site Truck/Vehicle ($/Day):	$160.00	$640.00	$640.00	$80.00	$9,600.00	$6,400.00	$4,000.00	$320.00
27	Site Office & Tool Trailer ($/Day):	$150.00	$0.00	$600.00	$75.00	$9,000.00	$6,000.00	$0.00	$0.00
28	Mileage	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
29	Meals ($/Day):	$25.00	$125.00	$762.50	$0.00	$8,995.00	$7,695.00	$5,230.00	$325.00
30	Hotels/Motels/Lodging ($/Day):	$30.00	$150.00	$915.00	$0.00	$10,794.00	$9,234.00	$6,276.00	$390.00
31	Training (HAZWOPER/MSHA):		$0.00	$0.00	$3,250.00	$0.00	$0.00	$0.00	$0.00

	FRONTIER ENVIRONMENTAL SERVICES, INC. I						
	FES Project Number: Proposal Number: 130107						
	Frontier Environmental Services Project Name: Cardno-TEC: USFS Hope Mine						
	Project Labor Discription (Fully Burdened Project Work Day Hours:	Rate/hr: 10.00	Item 6.1 On-Site Relocation Repository - 0.5 Mile Radius Excavation & Construction	Item 6.2 On-Site Relocation Repository - 0.5 Mile Radius Waste-Rock Relocation	Item 6.3 On-Site Relocation Repository - 0.5 Mile Radius Cap System Construction	Item 6.4 On-Site Relocation Repository Revegetation	Item 7 Stormwater Controls Run-On & Run-Off
::		Unit:	Unit Rate (CY):	Unit Rate (CY):	Unit Rate (SF)	Unit Rate (Acre)	Unit Rate (LF):
	OTHER DIRECT COSTS	Quantity (CY or LF):	16,000	15,300	35,000	3.5	975
		Tons:	31,320	29,950			
		Density (dry):	145.00	145.00			
		Truck Loads:					
		Turn-Around Time (hrs):					
		Trucks/Day:					
Row #		Total Days:					
1	Waste Disposal ($/Ton):	$45	$1,500.00	$1,250.00	$2,500.00	$250.00	$1,240.00
2	Engineering Consultant	$150	$3,200.00	$1,500.00	$0.00	$0.00	$1,500.00
3	Geo-Tech Materials ($/SF):	$2.35	$59,239	$20,680.00	$82,250.00	$0.00	$10,310.63
4	Transporter ($/hr):	$115	$0.00	$0.00	$0.00	$0.00	$0.00
5	Clay Cap Material ($/Ton, Delivered):	$25	$395,307	$0.00	$0.00	$0.00	$0.00
6	Cement Type II/IV ($/Ton Deliverd):	$75	$0	$224,623	$0.00	$0.00	$0.00
7	Re-Vegetation Materials ($/Acre):	$1,250	$0.00	$0.00	$0.00	$4,375.00	$1,875.00
8	Rip-Rap ($/Ton, Delivered):	$40.00	$0.00	$10,462.50	$0.00	$0.00	$10,462.50
9	Utilities (On-Site Electric Generator, 120/240vac) ($/hr.):	$24	$4,773	$5,727	$0.00	$0.00	$764
10	Office Supplies	0.50%	$712.70	$802.35	$613.75	$62.50	$293.45
11	Ref material/periodicals	0.01%	$14.25	$16.05	$12.28	$1.25	$5.87
12	Postage/Delivery/Ship	0.10%	$142.54	$160.47	$122.75	$12.50	$58.69
13	Field/Office Supplies	2.00%	$2,850.80	$3,209.40	$2,455.00	$250.00	$1,173.80
14	CSP - 18" Diameter ($/LF):	$18	$0.00	$0.00	$0.00	$0.00	$6,142.50
15	Concrete ($/CY):	$155	$0.00	$4,960.00	$0.00	$0.00	$4,960.00
16	Safety Supplies	$6.75	$1,203.75	$1,371.38	$1,006.88	$101.25	$526.50
17	Safety Equipment	$3.80	$677.67	$772.03	$566.83	$57.00	$296.40
18	Heavy Equipment (Fully Burdened)	1.60	$75,181.82	$103,683.12	$80,454.55	$3,905.45	$24,366.23
19	Minor Equip Purchase	2.00%	$2,850.80	$3,209.40	$2,455.00	$250.00	$1,173.80
20	Repairs & Maintenance	5.00%	$3,946.59	$5,409.16	$4,022.73	$195.27	$1,248.31
21	Printing & Reproduction	1.00%	$1,425.40	$1,604.70	$1,227.50	$125.00	$586.90
22	Miscellaneous	5.00%	$7,127.00	$8,023.50	$6,137.50	$625.00	$2,934.50
23	Insurance	3.25%	$23,803.71	$19,376.37	$10,779.86	$804.90	$4,506.18
24	Bonding	2.50%	$18,310.55	$14,904.90	$8,292.20	$619.15	$3,466.29
25	Fuel - Vehicle/Equipment	15.00%	$11,277.27	$15,552.47	$12,068.18	$585.82	$3,654.94
26	Site Truck/Vehicle ($/Day):	$160.00	$4,000.00	$4,800.00	$3,200.00	$480.00	$640.00
27	Site Office & Tool Trailer ($/Day):	$150.00	$3,750.00	$4,500.00	$0.00	$0.00	$600.00
28	Mileage	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
29	Meals ($/Day):	$25.00	$4,865.00	$6,095.00	$4,475.00	$450.00	$2,340.00
30	Hotels/Motels/Lodging ($/Day):	$30.00	$5,838.00	$7,314.00	$5,370.00	$540.00	$2,808.00
31	Training (HAZWOPER/MSHA):		$0.00	$0.00	$0.00	$0.00	$0.00

FRONTIER ENVIRONMENTAL SERVICES, INC. Project Worksheet

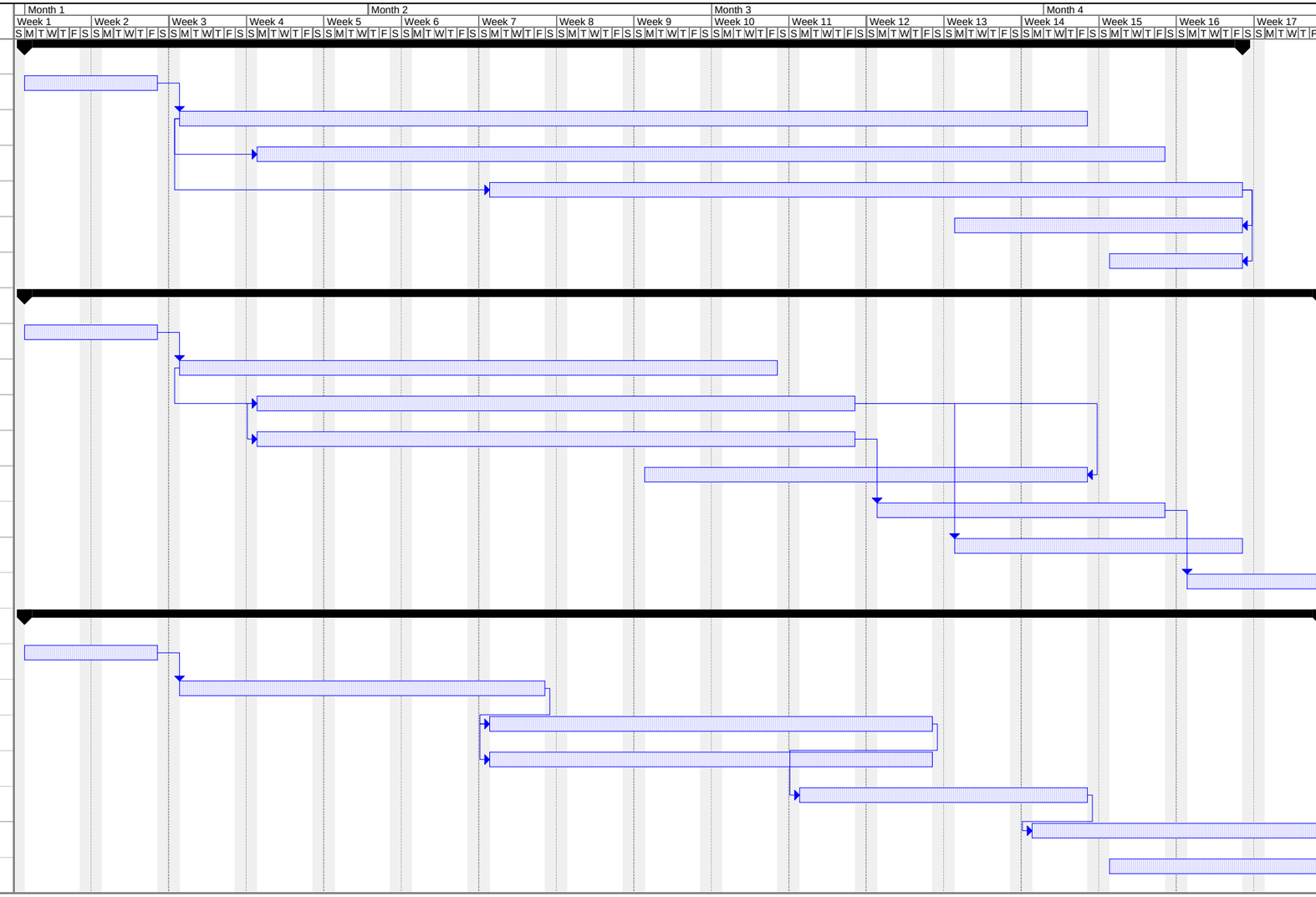
FES Project Number: Proposal Number: 130107	Scheduled Start Date: 1-Jan-2013
Frontier Environmental Services Project Name: Cardno-TEC: USFS Hope Mine	Scheduled Finish Date: 31-Dec-2013

Project Labor Discription (Fully Burdened Project Work Day Hours:	Rate/hr: 10.00	Item 1 Remedy Design	Item 2 Mobilization & De-Mobilization	Item 3 SHEAP	Item 4 Off-Site Transport & Disposal - 50 Mile Radius	Item 5.1 On-Site Consoldiation Repository Waste-Rock Excavation/Movement	Item 5.2 On-Site Consoldiation Repository Cap System	Item 5.2 On-Site Consoldiation Repository Revegetation
Total Other Direct Costs		$10,446.41	$14,974.15	$4,776.49	$2,407,045.32	$839,866.27	$240,125.20	$9,658.18
Total Task/Project Cost		$44,046.41	$36,749.15	$10,201.49	$2,661,575.32	$1,064,586.27	$380,595.20	$18,908.18
Total With Contingency		$50,653.37	$42,261.53	$11,731.71	$3,060,811.62	$1,224,274.21	$437,684.48	$21,744.41
Adjusted Bid Line Value, Rounded:		$50,650.00	$42,260.00	$11,730.00	$3,060,810.00	$1,224,270.00	$437,680.00	$21,740.00

	FRONTIER ENVIRONMENTAL SERVICES, INC. I						
	FES Project Number: Proposal Number: 130107						
	Frontier Environmental Services Project Name: Cardno-TEC: USFS Hope Mine						
	Project Labor Discription (Fully Burdened Project Work Day Hours:	Rate/hr: 10.00	Item 6.1 On-Site Relocation Repository - 0.5 Mile Radius Excavation & Construction	Item 6.2 On-Site Relocation Repository - 0.5 Mile Radius Waste-Rock Relocation	Item 6.3 On-Site Relocation Repository - 0.5 Mile Radius Cap System Construction	Item 6.4 On-Site Relocation Repository Revegetation	Item 7 Stormwater Controls Run-On & Run-Off
	Total Other Direct Costs		$631,996.08	$470,007.18	$228,009.99	$13,690.09	$87,934.12
	Total Task/Project Cost		$774,536.08	$630,477.18	$350,759.99	$26,190.09	$146,624.12
	Total With Contingency		$890,716.49	$725,048.76	$403,373.99	$30,118.61	$168,617.74
	Adjusted Bid Line Value, Rounded:		$890,720.00	$725,050.00	$403,370.00	$30,120.00	$168,620.00

USFS Hope Mine
Remediation/Reclamtion Schedule
EE/CA

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Project Duration: Off-Site Disposal**	**80 days**	**Mon 7/1/13**	**Fri 10/18/13**	
2	Install Storm Water Run-On Controls	2 wks	Mon 7/1/13	Fri 7/12/13	
3	Excavation	12 wks	Mon 7/15/13	Fri 10/4/13	2
4	Transportation	12 wks	Mon 7/22/13	Fri 10/11/13	3SS+1 wk
5	Site Reclamation Grading	10 wks	Mon 8/12/13	Fri 10/18/13	3SS+4 wks
6	Construct Storm Water Management Systems	4 wks	Mon 9/23/13	Fri 10/18/13	5FF
7	Site Revegetation	2 wks	Mon 10/7/13	Fri 10/18/13	5FF
8	**Project Duration: On-Site Consolidation Repository**	**85 days**	**Mon 7/1/13**	**Fri 10/25/13**	
9	Install Storm Water Run-On Controls	2 wks	Mon 7/1/13	Fri 7/12/13	
10	Excavation & Preparation of Consolidation Repository	8 wks	Mon 7/15/13	Fri 9/6/13	9
11	Excavate Mine Waste Rock & Relocate to Consolidation Location	8 wks	Mon 7/22/13	Fri 9/13/13	10SS+1 wk
12	Process Relocated Mine Waste Rock with Cement Stabilization	8 wks	Mon 7/22/13	Fri 9/13/13	11SS
13	Process Existing Mine Waste Rock with Cement Stabilization	6 wks	Mon 8/26/13	Fri 10/4/13	11FF+3 wks
14	Install Cap System	4 wks	Mon 9/16/13	Fri 10/11/13	12
15	Construct Storm Water Management Systems	4 wks	Mon 9/23/13	Fri 10/18/13	11FS+1 wk
16	Site Revegetation	2 wks	Mon 10/14/13	Fri 10/25/13	14
17	**Project Duration: On-Site Consolidation Repository**	**85 days**	**Mon 7/1/13**	**Fri 10/25/13**	
18	Install Storm Water Run-On Controls	2 wks	Mon 7/1/13	Fri 7/12/13	
19	Excavate On-Site Repository and Install Perimeter Drain System	5 wks	Mon 7/15/13	Fri 8/16/13	18
20	Excavate Mine Waste Rock and Relocate to Repository	6 wks	Mon 8/12/13	Fri 9/20/13	19FS-1 wk
21	Process Mine Waste Rock with Cement Stabilization & Place	6 wks	Mon 8/12/13	Fri 9/20/13	20SS
22	Install Cap System	4 wks	Mon 9/9/13	Fri 10/4/13	20FS-2 wks
23	Construct Storm Water Management Systems	4 wks	Mon 9/30/13	Fri 10/25/13	22FS-1 wk
24	Site Revegetation	3 wks	Mon 10/7/13	Fri 10/25/13	23FF



Project: ScheduleHope-Mine-EECA
Date: Mon 2/18/13

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline