DRAFT

COVER MATERIALS CHARACTERIZATION WORK PLAN

YERINGTON MINE SITE

June 25, 2010

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LIST OF ACRONYMS AND ABREVIATIONS

Anaconda	Anaconda Company
ABA	Acid-Base Accounting
ARC	Atlantic Richfield Company
ASTM	American Society of Testing and Materials
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
CSM	Conceptual Site Model
DQO	Data Quality Objective
DRI	Desert Research Institute
DSR	Data Summary Report
EPA	U.S. Environmental Protection Agency
ESI	Environmental Standards Inc.
ET	Evapotranspiration
FMS	Fluid Management System
FSAP	Field Sampling and Analysis Plan
GPS	Global Positioning System
HASP	Health and Safety Plan
HLP	Heap Leach Pad
LCS	Laboratory Control Sample
LEP	Lined Evaporation Pond
MWMP	Meteoric Water Mobility Procedure
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAG	Net Acid Generation
NAPT	North American Proficiency Testing Program
NDEP	Nevada Division of Environmental Protection
NPK	Nitrogen, Phosphorus, and Potassium
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PEL	Permissible Exposure Level
PLS	Pregnant Leach Solution
PPE	Personal Protective Equipment
QAPP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/ Feasibility Study
QA/QC	Quality Assurance/Quality Control
RPM	Remedial Project Manager
RSL	Regional Screening Level
SAR	Sodium Absorption Ratio
Site	Yerington Mine Site
SLERA	Screening-Level Ecological Risk Assessment
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leach Procedure
SWCC	Soil Water Characteristic Curve
SX/EW	Solvent Extraction/ Electro-Winning
TENORM	Technologically Enhanced Naturally-Occurring Radioactive Materials
TSEA	Task Safety and Environmental Assessment
UEP	Unlined Evaporation Pond
USA	Underground Service Alert
USCS	United Soil Classification System
VLT	Vat Leach Tails
WRA	Waste Rock Area
WRCC	Western Regional Climate Center
XRF	X-ray Fluorescence
°C	degrees Centigrade
°F	degrees Fahrenheit
amsl	above mean sea level
bgs	below ground surface
CY	cubic yards
g/l	grams per liter
gpm	gallons per minute
lbs/ft^2	pounds per square foot
lbs/ft^3	pounds per cubic foot
mg/kg	milligrams per kilogram
mm	millimeters
pCi/g	picocuries per gram

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SECTION 1.0
INTRODUCTION

Atlantic Richfield Company (ARC) has prepared this Draft Cover Materials Characterization Work Plan (Work Plan) for the Yerington Mine Site (Site) pursuant to the March 18, 2010 e-mail correspondence from the U.S. Environmental Protection Agency - Region 9 (EPA) to ARC entitled "Anaconda Evaporation Ponds Removal Actions". The removal action and Work Plan is required under the Administrative Order on Consent and attached Scope of Work[1] dated April 21, 2009. The characterization data resulting from the implementation of this Work Plan will also provide data in support of the remedial investigations and feasibility studies for several operable units (OUs) at the Site, pursuant to the *Administrative Order for Remedial Investigation and Feasibility Study* (RI/FS; EPA Docket No. 9-2007-0005).

1.1 Work Plan Purpose and Objectives

The objective of this Work Plan is to collect preliminary characterization data (i.e., geochemical and geotechnical/hydraulic properties) from potential on- and off-Site cover materials to evaluate their suitability for use in planned removal actions and final remedies for the OUs located on the Site. Results of the field sampling and analytical activities described in this Work Plan, and similar data from previous and ongoing Site investigations, will be summarized in a Data Summary Report (DSR), which can be used to make decisions regarding interim covers for the Lined Evaporation Pond (LEP) and Unlined Evaporation Pond (UEP). The DSR will also provide the framework for additional cover material investigations described in Section 1.3 (phased RI/FS process) and in Section 3.0 (volunteer re-vegetation conceptual site model element). ARC anticipates that additional cover materials characterization data will be needed to confirm the preliminary data presented in the DSR and to support construction-related quality assurance/quality control (QA/QC) criteria for the LEP and UEP interim covers.

[1] Administrative Order on Consent and Settlement Agreement for Past Response Costs Anaconda Copper Mine, Yerington Nevada; U.S. EPA Region IX; CERCLA Docket No. 09-2009-0010.

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1.2 Site Location and Description

The Site encompasses approximately 3,600 acres of land located about one-half mile west and northwest of the City of Yerington in Lyon County, Nevada (Figure 1-1). The Paiute Tribe Indian Reservation is located approximately 2.5 miles north of the Site and the Paiute Colony is located adjacent to the City of Yerington (Figure 1-1). For the purposes of the RI/FS, EPA has divided the Site into eight OUs (Figure 1-2). As indicated below, four of the on-Site OUs contain potential cover materials:

- Site-wide Groundwater (OU-1);
- Pit Lake (OU-2);
- Process Areas (OU-3);
- Evaporation Ponds and Sulfide Tailings (OU-4) – contains potential cover materials;
- Waste Rock Areas (WRAs; OU-5) – contains potential cover materials;
- Oxide Tailings (OU-6) – contains potential cover materials;
- Wabuska Drain (OU-7); and
- Arimetco Facilities (OU-8) – contains potential cover materials.

1.3 Phased Remedial Investigations

As noted above in Section 1.1, the characterization data to be collected and compiled during the implementation of this Work Plan will support decisions regarding the selection of interim covers to be placed on the LEP and the UEP during an upcoming removal action. Implementation of the *Revised VLT Characterization Work Plan Using X-Ray Fluorescence, Yerington Mine Site* (XRF Work Plan) dated November 13, 2009, which was approved by EPA in the March 18, 2010 correspondence, will provide new characterization data for vat leach tailings (VLT) materials (i.e., oxide tailings). These data will support both the short-term response activities and the RI/FS for OU-6. In order to achieve resource efficiency for this Work Plan and the OU-6 remedial investigation, ARC collected 10 samples for geochemical characterization during the implementation of the XRF Work Plan.

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Characterization data resulting from the implementation of future remedial investigation work plans of Site OUs that contain potential cover materials will supplement the framework developed from the implementation of this Work Plan. The remedial investigation for the five Arimetco Heap Leach Pads (HLPs; part of OU-8) on the Site has been completed (CH2M Hill, 2008), and only limited additional characterization work is planned for OU-8 as part of this Work Plan. The characterization data collected for the Waste Rock Areas and Oxide Tailings Area (OU-5 and -6, respectively) as part of this Work Plan will provide preliminary data that can assist in focusing the remedial investigations for these OUs (i.e., implementation of this Work Plan supports phased RI/FS activities). A future RI/FS characterization activity specifically associated with this Work Plan is a survey of plant species observed on stripped alluvial overburden within OU-5 and in native alluvial materials located west of the Site.

The framework resulting from the implementation of this Work Plan will address, to varying degrees, the physical and chemical characteristics of the material types identified in on- and off-Site potential cover material borrow sources (e.g., disturbed and undisturbed alluvial soils and spent ore materials). The characterization activities described in the Field Sampling and Analysis Plan (FSAP) will provide the basis for: 1) selecting the interim cover materials to be used for the LEP and the UEP; and 2) developing the specific cover material data quality objective (DQO) in future remedial investigations for select OUs. The volumetric mass balance, and the physical and chemical properties of on- and off-Site cover materials, will eventually be integrated into final re-grading and cover designs for Site OUs, including the optimal layering of these materials.

1.4 Project Management Team

The project management team for this Work Plan consists of EPA's Remedial Project Managers (RPMs) and advising technical staff, and ARC's Project Manager and technical staff. The Yerington Technical Work Group includes representatives of the U.S. Bureau of Land Management (BLM), Nevada Division of Environmental Protection (NDEP) and the Yerington Paiute Indian Tribe support the project management team by reviewing work plans and related documents. Key project personnel for this Work Plan are listed in Table 1-1.

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Table 1-1. Key Project Personnel

Personnel	Project Role	Company
EPA & Sub-Consultants		
Nadia Hollan	RPM	EPA Region 9
Tom Dunkelman	On-Scene Coordinator	EPA Region 9
Dave Seter	RPM	EPA Region 9
	Technical Support	TetraTech
	Technical Support	CH2M Hill
Bill Albright	Technical Support	Desert Research Institute
Atlantic Richfield and Sub-Consultants		
Jack Oman	Project Manager	ARC
John Batchelder	Geology, Health and Safety	EnviroSolve
Jim Chatham	Geochemistry	ARC
Chuck Zimmerman	Project Manager	Brown and Caldwell
Guy Graening	Task Manager	Brown and Caldwell
Linda Henry	Human Health Risk Assessment	Brown and Caldwell
Matt Arno	Radiological Issues	Foxfire Scientific
Derek Edge	Ecological Risk Assessment	Arcadis
Penny Bassett	Site Health and Safety	Brown and Caldwell

EPA's RPMs for the Site are Ms. Nadia Hollan and Mr. Dave Seter. Mr. Tom Dunkelman is the EPA On-Scene Coordinator. Technical support to the EPA is provided by EPA's subcontractors (CH2M Hill and Tetra Tech), and by Dr. Bill Albright of the Desert Research Institute (DRI). ARC's Project Manager is Mr. Jack Oman, who is assisted by Mr. John Batchelder and Dr. Jim Chatham. Brown and Caldwell is ARC's primary contractor for the Site. Mr. Chuck Zimmerman is Brown and Caldwell's project manager, with technical support provided by Dr. Linda Henry, Guy Graening, Greg Davis and Brad Hart. Dr. Matthew Arno (Foxfire Scientific, Inc) provides technical support for radiological issues, and Mr. Derek Edge (Arcadis) supports ecological risk assessment and related activities. Ms. Penny Bassett of Brown and Caldwell is the Site health and safety officer.

1.5 Project Schedule

A preliminary project schedule for this Work Plan is summarized below, and an integrated schedule for the evaporation ponds removal action is shown on Figure 1-3.

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- Draft Work Plan Submittal - June 25, 2010.
- Final Work Plan Approval - August 16, 2010.
- Field Sampling and Analysis Activities - August 16 through December 31, 2010.
- Data Compilation and Reporting - December 1, 2010 through March 21, 2011 (the preliminary submittal date for the DSR).

The above schedule will allow for the placement of the selected interim covers on the LEP and UEP during the 2011 construction season, as indicated by the following suggested milestones:

- EPA review, follow-up discussions and selection of cover materials for placement on the LEP and UEP - March and April 2011.
- Revised Implementation Plan - June 1, 2011.
- Contractor Procurement - April through June 15, 2011.
- Construction - June 15 to December 15, 2011.

1.6 Document Organization

This remainder of this Work Plan includes the following contents:

- Section 2.0 summarizes relevant background information including a description of potential cover material source areas and results from previous investigations;
- Section 3.0 presents a generalized Conceptual Site Model (CSM) for cover materials;
- Section 4.0 identifies data gaps and presents the DQOs for the characterization activities;
- Section 5.0 provides the details of the FSAP for the characterization activities;
- Section 6.0 describes QA/QC elements of the FSAP;
- Section 7.0 describes data management activities;
- Section 8.0 presents the health and safety elements associated with the FSAP; and
- Section 9.0 presents the references cited in this Work Plan.

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SECTION 2.0
BACKGROUND INFORMATION

This section of the Work Plan provides background information for the Site, including its physical setting and operational history. Available information for potential cover materials are summarized and, as appropriate, have been used to: 1) develop the conceptual model for cover materials presented in Section 3.0; 2) identify the data gaps and develop the DQOs presented in Section 4.0; and 3) design the FSAP described in Section 5.0 including the rationale for specific locations for potential cover materials characterization. Based on Site observations, including a Site visit with EPA and Dr. Bill Albright of DRI, and knowledge of historic mining and ore beneficiation activities at the Site, ARC has identified four potential on-Site sources of cover materials. In addition, two potential off-Site cover material types have been identified. These materials are listed below and the areas where they are located are depicted on Figure 1-2.

On-Site

- WRAs composed of alluvium and weakly mineralized or non-mineralized bedrock materials) located north and south of the open pit;
- Oxide tailings (also known as VLT) located northwest of the Process Areas and south of the Unlined Evaporation Ponds;
- Spent ore materials within the Arimetco HLPs; and
- Sulfide tailings located east and northeast of the Process Areas.

Off-Site

- Native, undisturbed alluvium associated with BLM and former Arimetco land located west of the Site.
- Outcrops of bedrock associated with BLM and former Arimetco land located around the margins of the Site.

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2.1 Physical Setting

The physical setting of the Site is within the Basin-and-Range physiographic province, which is part of the Great Basin sagebrush-steppe ecosystem. The Site is located in Mason Valley within the Walker River watershed. Agriculture is the principal economic activity in Mason Valley, typically hay and grain farming, onion production and some beef and dairy cattle ranches. The Walker River flows northerly and northeasterly between the Site and the City of Yerington (the river is within a quarter-mile of the southern portion of the Site).

The Site is located in a high desert environment characterized by an arid climate. Monthly average temperatures range from 33.3° F in December to 73.7° F in July. Annual average rainfall for the town of Yerington is only 5.3 inches per year, with lowest rainfall occurring between July and September (WRCC, 2007). Wind speed and direction at the Site are variable as a result of natural conditions and variable topographic features created by surface mining operations. Air quality and meteorological data collected since 2002 indicate that the dominant wind directions are to the north and the northeast (Brown and Caldwell, 2009a). Mining and ore beneficiation activities at the Site have resulted in modifications to the natural, pre-mining topography including a large open pit (occupied by a pit lake), waste rock and leached ore piles, and evaporation and tailings ponds.

The Site is located on the west side of Mason Valley and the Walker River (Figure 1-1). Mason Valley is a structural basin surrounded by uplifted mountain ranges within the Basin and Range physiographic province of west-central Nevada. Mason Valley is bordered by the Singatse Range to the west, the Desert Mountains to the north, and the Wassuk Range to the east. Specifically, the Site is located on the eastern flank of the Singatse Range along the distal edge of an alluvial fan between the Singatse Range and the flood plain of the Walker River. The alluvial fan ranges in elevation from 4,800 feet above mean sea level (amsl) to 4,380 feet amsl. The Site occupies the portion of the fan between 4,350 to 4,630 feet amsl.

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2.1.1 Geology

The Singatse Range is primarily composed of granitic and volcanic rocks, with minor outcrops of metamorphic rocks. The Singatse Range has been subject to metals mineralization, as evidenced by the large copper porphyry ore deposit at the Yerington Mine and other nearby mines. Proffett and Dilles (1984) published a geologic map of the Yerington Mining District that describes these features. Seitz et. al. (1982) described the geologic setting of the area around the Site based on existing information and subsurface information obtained through the drilling of test wells north of the site by the U.S. Geological Survey in 1978. Alluvial fan deposits along the west margin of the valley underlie the Process Areas and stream- and lake-deposited materials on the valley floor underlie the tailings and evaporation ponds (Seitz et. al., 1982).

As part of the Yerington Mining District, the Site is located within a large area characterized by surface expressions of base and precious metals mineralization and associated hydrothermal alteration, of bedrock outcrops of granitic and volcanic rocks (Proffett and Dilles, 1984). The Yerington ore deposit is a disseminated porphyry copper deposit associated with a quartz-monzonite porphyry and surrounding granodiorite (U.S. Bureau of Mines, 1958). The primary ore minerals are chrysocolla, a copper-alumina silicate, and chalcopyrite, a copper sulfide mineral. Other metals commonly associated with porphyry copper deposits (e.g., arsenic, molybdenum, uranium, zinc) often occur in a larger alteration halo around the ore body, which is the case at the Site. The mineralogical characteristics of the ore resulted in the occurrence of technologically enhanced naturally-occurring radioactive materials (TENORM) at the Site.

The occurrence of an alteration halo in the local country rock around the Yerington copper ore body, in conjunction with the alteration haloes associated with the nearby Blue Stone, Bear and MacArthur copper deposits, has resulted in elevated metals concentrations in the bedrock and alluvial fan deposits underlying the Site, which is consistent with the results presented for the Yerington area in Shacklette and Boerngen (1984). More Site-specific chemical data for background soils, located immediately west of the Site, are presented in the *Background Soils Data Summary Report - Revision 1* (Brown and Caldwell, 2009b).

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2.1.2 Hydrogeology

The principal source of recharge into the alluvial aquifer and bedrock groundwater flow systems in the Yerington area of Mason Valley is from the Walker River (Huxel, 1969). The East and West Forks of the Walker Rivers originate in the Sierra Nevada and merge south of the Site. The Walker River then flows northward through Mason Valley to Walker Gap. From Walker Gap, the river turns eastward and then flows southeastward to Weber Reservoir, and ultimately to its terminus at Walker Lake.

Huxel (1969) estimated the following recharge components to the Mason Valley hydrographic basin: 1) 3 percent from precipitation that falls on the surrounding mountain ranges; 2) 97 percent from the river and associated agricultural diversions; and 3) less than 0.1 percent from direct precipitation on the valley floor. Along the southern margin of the Site, recharge to the alluvium from the adjacent Walker River occurs as a result of seepage from the river (visible seepage from the Walker River can be observed on the east highwall of the open pit).

As the Walker River flows northeast past the City of Yerington, the Groundhog Hills (a spur of the Singatse Range) may attenuate direct recharge from the Walker River to the alluvium underlying the northern half of the Site (recharge from the Campbell Ditch to the alluvial aquifer could also be attenuated by bedrock immediately east of the Groundhog Hills). Percolation from irrigated agricultural fields immediately north of the Site appears to be the dominant source of groundwater recharge in the northern area of the Site (Brown and Caldwell, 2009c).

During Anaconda and Arimetco operations, mine-related groundwater is conceptualized to have percolated to the alluvial aquifer beneath the Site and impacted groundwater quality. Although some degree of resistance to vertical flow exists within the alluvial aquifer, created by the depositional layering of sedimentary deposits and the local occurrence of low-permeability layers, downward vertical gradients have been observed along the northern margin of the Site as a result of recent adjacent agricultural practices as described in the *2009 Annual Groundwater Monitoring Report* (Brown and Caldwell, 2010).

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2.2 Historical Mining Operations

The following descriptions, similar to those presented in the *Draft Process Areas (OU-3) Remedial Investigation Work Plan* (Brown and Caldwell, 2007a), are based on research conducted by ARC at the Anaconda Mine archives located in Laramie, Wyoming (managed by the University of Wyoming) and the Site archives located near Yerington, Nevada (managed by the EPA).

2.2.1 Anaconda Operations

Mining

Anaconda mined the open pit from 1953 through 1978. Materials removed from the pit included: 1) oxide ore; 2) sulfide ore; 3) low-grade dump leach oxide ore; 4) low-grade sulfide ore; and 5) waste rock/overburden. Mining was conducted using electric- and diesel-powered shovels, bulldozers, scrapers, and 25-ton haul trucks (U.S. Bureau of Mines, 1958). By 1972, approximately 70,000 tons per day were mined, including 28,000 tons of oxide and sulfide ore, 28,000 tons of low-grade dump leach ore, and 14,000 tons of overburden/waste rock. The mineralogy of the copper ore mined and beneficiated by Anaconda resulted in the presence of TENORM at the Site.

The open pit was mined in 25-foot benches with an approximate 45 degree pit wall slope. Final dimensions of the mined pit were approximately 6,200 feet long, 2,500 feet wide and 800 feet deep. Groundwater was encountered at approximately 100 to 125 feet below ground surface, and deep wells were installed along the eastern perimeter of the pit to de-water the fractured bedrock as the depth of the pit increased. Water was pumped from each of these wells at rates up to 900 gallons per minute (gpm), and a total of up to 2,800 gpm was primarily used for mining and ore beneficiation operations and water for the Weed Heights housing community (U.S. Bureau of Mines, 1958; Skillings Mining Review, 1972).

Waste rock resulting from mining activities was placed in piles located both south and north of the open pit in three WRAs, as described below and shown in Figure 1-2: 1) the South WRA, which occupies the majority of disturbed lands south of the pit and is composed of alluvial

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overburden and bedrock that was below an economic cut-off for ore grade during Anaconda-era mining; 2) the W-3 WRA, which is located north of the pit and was partially mined by Arimetco for leaching on the Phase I, II, III, and IV-Slot HLPs; and 3) the S-32 WRA, which is also located north of the pit and generally consists of low-grade material stockpiled west of the Arimetco Phase I/II HLP. As described in an Anaconda Environmental Progress Report (Anaconda, 1978): "For many years, the State, County and individuals have been allowed to remove materials from these waste dumps….for many beneficial purposes".

Crushing and Grinding

Oxide and sulfide ores were crushed prior to beneficiation, which involved two steps for oxide ore and three steps for sulfide ore. All ores underwent coarse crushing in the Primary Crusher which was a 54-inch gyratory crusher that reduced the ore to 5 inches or less, at a rate of approximately 1,400 tons per hour and were stored in the oxide and sulfide Coarse Ore Storage. Coarse ores were transported to the Secondary Crusher by conveyor and reduced in size to 7/16-inch using standard and short-head cone crushers.

Oxide ores exited the Secondary Crusher through an underground conveyor to the Sample Tower where a sample was collected for assay and water was sprayed onto the crushed ore to agglomerate fine material as well as control dust (U.S. Bureau of Mines, 1958 and Anaconda, 1954). Sulfide ores underwent additional crushing at the Sulfide Ore Crushing and Stockpile area located at the northwest end of the Leach Vats. Fine grinding of the sulfide ore to a grain size between 20- and 200-mesh particle size was necessary to achieve flotation, and was accomplished using several rod and ball mills in sequence (Skillings Mining Review, 1972).

Leaching (Oxide Ore)

Oxide ores were loaded into the Leach Vats in a manner to prevent segregation and allow uninhibited circulation of leach solutions within the tank. Each tank had a capacity to hold approximately 12,000 dry tons of ore and 800,000 gallons of solution when filled to within 6 inches from the top. The vats typically operated on a 96-hour (4-day) or 120 hour (5-day)

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leaching cycle, with an additional 32- to 40-hour wash period, and 24 hours required to excavate and refill. The entire cycle required approximately 8 days, therefore eight leach vats were installed and used to maximize efficiency (U.S. Bureau of Mines, 1958).

A sulfuric acid leach solution was added to the oxide ores in the tanks at an initial concentration of 20 to 30 grams per liter (g/l) and circulated through the tanks for at least three hours until the acid content dropped to less than 2 g/l. The reinforced-concrete bottoms of the tanks were covered with timbers and cocoa matting as a filter to allow bottom drainage of solutions. Solutions were re-circulated and pumped at a rate of 2,000 gpm. Pregnant solutions were pumped to one of the two 286,000-gallon Solution Storage Tanks, and new solutions were transferred from the previous vat while acid was added to achieve the desired leaching strength of 40 to 60 g/l. This solution was re-circulated and then transferred to the next vat. This cycle continued for four or five leaching periods.

After leaching, the spent ore underwent three wash cycles at a rate of approximately 1.4 million gallons per day using recycled and fresh make-up water. Spent ore, known as oxide tailings or VLT was excavated from the Leach Vats by a clamshell digger mounted on a rolling overhead gantry crane which could position over any of the eight tanks. The digger would drop the leached ore into a hopper under which 25-ton end-dump trucks would drive, receive a load, and then haul the spent ore to the VLT pile (i.e., Oxide Tailings Area or OU-6 shown on Figure 1-2). The average time to excavate one tank was 16 hours at a rate of 40 truckloads per hour.

The VLT pile is primarily located on private land, and is composed of multiple benches and 'end-dump' mounds. Slopes up to 80 feet high exist on the north, west and southeast portions at or near the angle of repose. Access to the oxide tailings is via roads and ramps from the Phase IV-VLT Heap and from the north and south margins of the tailings area. As described by Anaconda (1978), VLT materials "also had wide usage in Mason Valley as a surfacing material for highway shoulders, County and private roads, driveways, yards, etc. because of its stable nature".

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After leaching, the oxide ore was beneficiated as follows:

Cementation/Precipitation (Oxide Ore)

Copper was recovered from the leach solution by precipitating (i.e., "cementing") the copper using scrap iron by means of the following chemical conversion: $CuSO_4 + Fe \rightarrow FeSO_4 + Cu$. The Precipitation Plant was divided into five separate banks or individual cells: 1) Primary, 2) Secondary, 3) Stripping/Settling, 4) Scavenger, and 5) Dump Leach. These banks of cells were operated in the following ways (Anaconda, 1954):

1. Primary Bank. 90,000 pounds of new scrap iron were loaded into each cell. Pregnant solution, with a concentration of approximately 15 to 25 g/l copper and 4-5 g/l sulfuric acid, was pumped through 4" lead pipes sunk into the concrete bottoms of the launder tanks and percolated upwards through the iron, overflowing to a weir box on the north east side at a rate of 700 to 900 gpm. The overflow solution discharged to the recirculation sump at the northwest end of the precipitation tanks where it was re-circulated back to the secondary bank. Re-circulation continued for four days, followed by the washing, removal and drying of the copper cement.
2. Secondary Bank. 90,000 pounds of new scrap iron was added to each cell. Solution discharged from the primary bank was re-circulated through the iron in the same manner as the primary bank. Solutions were re-circulated for five days at a pumping rate of 900 to 1,000 gpm, and then washed and excavated. Discharge solutions from the secondary bank were sent to the stripping/settling bank.
3. Stripping/Settling. This section was operated as pairs of tanks where the stripping tank contained iron and the settling tank did not. Solutions entering the stripping tank came solely from the secondary bank where additional copper was removed from the solutions prior to disposal. Solutions were re-circulated through these tanks for approximately 15 days. Final solutions from this area were sent to the Spent Solution Sump, and then ultimately returned to the Acid Plant for use as a slurry agent to wash the calcines from the acid plant to the evaporation ponds (Anaconda, 1954).
4. Scavenger. The purpose of the scavenger was to consume unused iron that was removed from the other precipitation banks after washing and separation in a trommel. Typically the residual iron was much finer and the precipitates form a dense mass. At some point, non-digestible residual material was removed from the system and discarded.
5. Dump Leach Primary and Secondary. Leach solution from the low-grade W-3 dump leach was kept entirely separate from the tank leach solutions so that the waste water could be reused. Dump leach precipitation operated similarly to the vat leach operation, and was initiated in 1965 (Mining Engineering, 1967). These solutions were re-circulated from the dump leach primary to the dump leach secondary through a separate dump leach recirculation sump.

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Following cementation, the ore was washed and conveyed to a trommel hopper where it was further washed and the unused scrap iron separated from the copper cement. The copper cement was then heated to achieve 12 percent moisture (Skillings Mining Review, 1972) prior to shipment. Copper cement product averaged 83 percent copper, which was hauled by trucks to the Wabuska rail spur and, eventually, to the Washoe Smelter in Anaconda, Montana for final smelting.

Concentrator (Sulfide Ore)

A froth flotation system was constructed in 1961 to beneficiate sulfide ores. Flotation and separation of sulfide ores was accomplished by: 1) mixing very finely ground ore (pulp) with water and a chemical (typically xanthate) to make the sulfide mineral hydrophobic; 2) sparging air and a surfactant chemical (typically pine oil) through the mixture to create a froth mixture; 3) allowing sulfide minerals in the pulp to float to the surface on air bubbles (froth mixture) in the aeration tank in the flotation circuit; and 4) skimming off the sulfide ores as a concentrate.

The concentrator separated and ground solids in a 75-foot diameter thickener to a fine pulp size of minus 325 mesh (<44 microns). The final concentrate was thickened in a 50-foot diameter thickener, dewatered using a vacuum filter, and dried in a 24-foot rotary dryer. The finished concentrate (28 percent copper) was hauled by trucks to the Wabuska rail spur and shipped to Anaconda, Montana for final smelting to a pure copper product. Operation of the concentrator required approximately 3,000 gpm of water, which was obtained from groundwater production wells and recycled water from decanting the sulfide tailings and other plant operations. Sulfide tailings were deposited as a slurry mixture of solids and water (Skillings Mining Review, 1972) in the Sulfide Tailings Area which is a portion of OU-4 shown in Figure 1-2.

Sulfuric Acid Production

Sulfuric acid was produced from raw sulfur ore shipped to the Site from the Leviathan Mine until 1971, when sulfur ore was purchased from other sources. The production of sulfuric acid from sulfur ore can be broken down into 5 steps: (1) crushing, (2) grinding, (3) roasting, (4) dust

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precipitation, and (5) contact acid plant. The final product was 93 percent sulfuric acid that was used in the tank leach and the dump leach of the oxide ore. A summary of acid production steps are provided below (Anaconda, 1954 and U.S. Bureau of Mines, 1958):

1. Crushing. Two stage crushing was completed using a jaw crusher and short-head crusher to reduce the sulfur ore to minus one inch.
2. Grinding. Rod mills were used to further reduce the ore to minus 10 mesh (<2 mm) for feed to the flousolids roaster.
3. Roasting. Fluosolid roasters were used to roast the sulfur ore, and drive SO2 gas from the ore, which would then be converted to sulfuric acid in the subsequent steps. The ore was bedded into an 18-foot wide by 25-foot high reactor lined with insulating and fire brick. The bed of material was maintained at five feet and fluidizing air heated by propane was circulated to heat the ore to a temperature of 1,100^{o}F to oxidize the sulfur. The burned ore or "calcines" were removed from the bottom of the reactor and disposed of in the evaporation ponds via the Calcine Ditch using spent solution pumped from cementation.
4. Dust Precipitation. Gases leaving the reactor contained 10 to 12 percent SO_2 which were cooled, and sent through the Peabody scrubber and Cottrell electrostatic precipitator to remove dust. Precipitates were collected at a rate of about 800 pounds per day and contained 30 to 40 percent selenium with silica. Water from the scrubber was recycled and used as wash water in the leaching vats (U.S. Bureau of Mines, 1958). Selenium precipitates were sold and shipped off-site several times per year.
5. Contact Acid Plant. The SO_2 gas entered the contact acid plant by going through a primary and secondary converter where the SO_2 was converted to SO_3. The SO_3 gas then went through a heat exchanger and the adsorption tower where it was contacted with 98 percent sulfuric acid resulting in a diluted 93 percent sulfuric acid product for use in the plant. Approximately 450 tons of 93 percent sulfuric acid was produced per day from 600 tons per day of raw sulfur ore.

No smelting or other ore processing activities were conducted at the Site by Anaconda.

2.2.2 Arimetco Operations

The Arimetco solvent extraction/electro-winning (SX/EW) facility (i.e., Plant Site), HLPs and ancillary facilities (e.g., pregnant leach solution [PLS] ponds) were constructed and operated between 1989 and 1998. Arimetco constructed the Plant Site on the south side of Burch Drive to beneficiate copper ore using conventional heap leaching and SX/EW technology.

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Heap leaching involves the application of an acidic solution to the top and sides of the HLP, resulting in the percolation and leaching of copper and other metals from the HLPs, which is collected on an HDPE-liner and perimeter solution collection ditches. SX/EW involves two steps: 1) extracting copper ions from low-grade leach solutions into a concentrated electrolyte; and 2) depositing pure copper onto cathodes using an electrolytic procedure. SX/EW technology involves leaching ores with an acidic solution resulting in a pregnant (i.e., copper-bearing) solution, which is then contacted with an organic solvent (i.e., extractant) in the SX step. The extracted copper is separated from the fluid phase leaving behind most of the impurities that were in the leach solution. Because the copper ion is exchanged for hydrogen ion, the aqueous phase is returned to its original acidity and recycled to the leaching step. The copper-bearing organic phase is then stripped of its copper by contacting it with a strongly acidified aqueous solution, which transfers the copper to an aqueous phase while the organic phase is reconstituted. The copper-bearing aqueous phase is advanced to the EW step, while the barren organic phase is returned to the extraction step of the process. In the EW step, the copper is electrochemically reduced in solution from copper sulfate to a solid phase on a metallic cathode.

Some or all of the Arimetco HLPs shown in Figure 1-2 (reproduced from CH2M Hill, 2008), and briefly described below, may contain potential cover materials. The Phase I and II HLPs are contiguous, and relevant information for these HLPs are combined. The Phase III South and III-4X Heaps contain similar materials and are adjacent to one and other. For these reasons, these two Heaps are also discussed together. The Phase IV-Slot and VLT Heaps are geographically and materially distinct, and are discussed separately.

Phase I/II HLPs

The Phase I/II HLPs were constructed in 1989 to leach low-grade oxide ore on private property. Leaching occurred from 1996 to early 1997 at rates from 400 to 500 gpm. A solution ditch was constructed in the northeast corner of the HLPs, with 11 leak detection points around the HLPs. The Phase I HLP covers approximately six acres. The Phase II HLP, which was extended to the west and north of the Phase I HLP, covers an additional eight acres. A variable 2- to 10-foot-thick layer of VLT was placed on a single 40-mil (0.04-inch-thick) HDPE liner. Leach-grade ore

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material consisted of weakly mineralized quartz monzonite with some sulfides and oxide alteration on joint faces, and appears to be poorly graded (6-inch plus to silt-sized particles).

Phase III and III-4X HLPs

The approximate 46-acre Phase III South HLP was constructed on private property (40 acres) and public lands (6 acres) in 1990 and operated until 1992. The approximate 50-acre Phase III 4X HLP was constructed in 1992 and operated until 1995 on both private and public lands (approximate equal division). A single 40-mil HDPE liner was installed to recover drain-down solution. The perimeter ditch has a leak detection system over a 40-mil HDPE membrane.

The solution ditch surrounding Phase III South HLP drained to the Phase III Bathtub Pond or to the Mega Pond and the drain-down solution from the Phase III 4X HLP was collected in the southeastern corner and conveyed to the Mega Pond. Ditches were constructed with two HDPE liners with geonet for leak detection between the liners. The leached ore surface is visually identical to that in the Phase I/II Heaps. The material appears poorly graded, from 12-inch plus to silt-sized particles.

Phase IV-Slot HLP

The Phase IV Slot Heap was constructed in 1993 and operated until 1998 on private lands. Initially, it was constructed on a starter pad that had previously been excavated into the W-3 WRA and asphalt-lined area. The Slot Heap was expanded to the north by excavating further into the W-3 WRA and transporting this material a short distance to the Slot Heap. The Slot Heap features a 40-mil HDPE primary liner and a secondary liner of compacted naturally-occurring gray lean clay. A variable 2- to 10-foot thick 'blanket' of VLT material was placed on the liner surface to act as drain rock and to protect the liner from the more irregular and angular run-of-mine material to be leached. The Slot Heap material consists of run-of-mine low-grade quartz monzonite with little or no sulfide alteration on joint faces, with a grain size distribution from 12-inch plus rock to silt-sized particles.

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Phase IV-VLT HLP

The Phase IV-VLT HLP was constructed in 1995 and operated until 1998 on private land. The initial HLP was constructed, in 20-foot lifts on the southern portion of the inactive Finger Evaporation Ponds and alluvium north of the existing oxide tailings (OU-6), and was extended to the south by excavating into the oxide tailings and transporting the VLT material to the HLP. The VLT HLP includes a 40-mil HDPE primary liner and a secondary liner of compacted naturally-occurring gray lean clay, and the leach-grade material consists of VLT and run-of-mine and crushed ore from the MacArthur Pit. The spent ore appears homogeneous, poorly graded 0.5-inch-minus to sand- size.

2.3 Previous Investigation Results

Results of previous investigations from potential on- and off-Site cover material borrow sources are listed and briefly summarized below. The majority of available data results from the remedial investigation for the Arimetco HLPs (OU-8). Available characterization data for these potential cover material sources are provided in Appendix A.

WRAs

- Whole-rock analytical results from an Expanded Site Inspection conducted by EPA (2000) for the S-32 and W-3 WRAs. In addition, a portion of these materials have been re-leached by Arimetco and these materials types are present in the Phase I/II and Phase IV Slot HLPs. These HLPs have been characterized by CH2M Hill (2008).

Oxide Tailings

- VLT materials were characterized as part of NDEP's temporary capping of 'iron bleed' tailings in 2002. These data have been summarized in the *Anaconda Evaporation Ponds Removal Action Characterization Data Summary Report – Revision 1* (Brown and Caldwell 2009d). In addition, as indicated above in Section 1.3, additional VLT characterization data will result from implementation of the XRF Work Plan.
- Geotechnical data for VLT borrow source areas specific to the *Implementation Work Plan for the Anaconda Evaporation Pond Removal Action – Revision 1* (Brown and Caldwell 2009e).

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Arimetco HLPs

- As part of the OU-8 remedial investigation (RI), EPA characterized the five Arimetco HLPs described above in Section 2.1.2. Samples were collected in 2007 for analysis of physical, geochemical and geotechnical properties (CH2M Hill, 2008).
- Geotechnical data for the construction of the Phase IV-Slot Heap Leach Pad, including an evaluation of bulk slope stability, recommended constructed slope angles and benches, and soil strength properties.
- As part of the engineering design of the Phase IV-VLT HLP, samples of materials from the oxide and sulfide tailings were tested using the Meteoric Water Mobility Procedure (MWMP). The oxide tailings sample was also subjected to acid/base accounting.

Sulfide Tailings

- In support of the removal actions for transite pipe and the Anaconda evaporation ponds, samples of sulfide tailings were taken for analysis of geotechnical properties.

Alluvial Materials

- Background soil sampling was conducted in July 2007 of native alluvial materials located west of the Site (Brown and Caldwell, 2009b). The soil samples were analyzed for total metals and radiochemicals, and a statistical analysis was performed to establish background concentration limits for a portion of the Site that includes the Process Areas.

2.3.1 Waste Rock Areas

WRAs are located north and south of the open pit, and consist of three distinct topographic features. WRAs include two principal material types: 1) alluvial overburden removed to allow open-pit mining of waste and ore, which only occurs in the South WRA; and 2) variably altered and mineralized quartz monzonite bedrock, generally classified as either oxidized or sulfide-bearing. No data from the South WRA is available.

Existing data from the two WRAs located north of the pit are limited to references in design documents or evaluation records from the HLPs and information from the EPA. A portion of the W-3 WRA was leached by Anaconda and subsequently excavated and re-leached by Arimetco (the Arimetco excavation provides for a good view of the W-3 WRA materials). Arimetco performed a whole rock analysis and MWMP leach test of a sample from the W-3 WRA in 1992 (Appendix A-1) in support of the engineering design of Arimetco's Phase IV-Slot HLP.

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In 2000, EPA collected waste rock samples from the S-32 and W-3 WRAs as part of an initial Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation of the mine site. Sample T-11 was submitted as a duplicate of sample T-2 from the S-32 WRA, and sample T-4 was collected from the W-3 WRA. Whole-rock analytical results are provided in Appendix A-1.

2.3.2 Oxide Tailings

The approximate 500-acre Oxide Tailings Area (OU-6; Figure 1-2) contains spent oxide ore (VLT) that classifies as coarse-grained poorly graded sands with silts and gravels (half-inch size fractions with fine sand-, silt- and clay-size particles). VLT has been used at the Site by: 1) Anaconda and Arimetco (e.g., berm construction and cover for mine roads, berms between evaporation pond and tailings pond cells, dust covers for Process Areas soils and sulfide tailings, sub-grade materials for HLPs); and 2) NDEP and EPA for past removal actions (e.g., covers for finger ponds, exposures of 'iron bleed' tailings and portions of the Sulfide Tailings Area).

In 2009, VLT data were reported in the *Implementation Work Plan for the Anaconda Evaporation Pond Removal Action – Revision 1* (Brown and Caldwell 2009e). VLT bulk samples were collected at five-foot intervals in eleven approximate 20-foot deep trenches in the planned north and south borrow source areas, with an additional sample composited over the length of each trench. These samples were analyzed for size gradation, plasticity and moisture density analyses, and hydraulic parameter testing (e.g., porosity, and saturated and unsaturated conductivity values). The results are provided in Appendix A-2.

Although the data are not available for inclusion in this Work Plan, ARC collected VLT samples for whole rock chemical analyses in May 2010. These samples were collected in accordance with the XRF Work Plan dated November 13, 2009. The data will be provided in a DSR for the XRF Work Plan, and will also be included in the DSR associated with this Work Plan.

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2.3.3 Arimetco HLPs

The OU-8 remedial investigation performed by EPA included geochemical and geotechnical properties of the spent ore materials (CH2M Hill, 2008). Analytical results from this investigation are provided in Appendix A-3. In general, data show that pH values ranged from 2.66 to 7.89, and metal concentrations exceeded residential EPA Regional Screening Levels (RSLs) for arsenic, copper, and iron. Synthetic Precipitation Leach Procedure (SPLP) results indicated that aluminum, copper, iron, and manganese exceeded the primary or secondary maximum contaminant level for drinking water. Leachate characteristics of HLP materials were evaluated using the SPLP and the MWMP.

In general, the geotechnical data indicated that the HLP materials range from well-graded sand to well-graded gravel. The amount of fines varied, but typically did not exceed 15 percent. Moisture content for all samples ranged from 3.1 to 13.4 percent with an average of 7.1 percent. Wet density ranged from 104 to 154 pounds per cubic foot (lbs/ft^3) and dry density ranged from 97 to 141 lbs/ft^3. The specific gravity of the samples tested ranged from 2.64 to 2.81. The cohesion values for these samples varied much more than any other parameter at 109 to 3,084 pounds per square foot (lbs/ft^2). Data from the HLPs indicated that, in general, the low pH values would limit plant growth given that soils in arid regions are typically alkaline. Nitrogen values were also low, but this is typical of arid region soils. Low total chloride and sodium values indicate that salinity is not a major issue. HLP water-holding capacity is low, and is unlikely to support plant growth (CH2M Hill, 2008).

2.3.4 Sulfide Tailings

In 2009, ARC collected samples of sulfide tailings for geotechnical characterization in support of the removal actions for transite pipe and the Anaconda evaporation ponds. These data were reported in the *Transite Pipe Removal Action Work Plan* (Brown and Caldwell, 2009f) and the *Implementation Work Plan for the Anaconda Evaporation Pond Removal Action – Revision 1* (Brown and Caldwell 2009e), and are provided in Appendix A-4. Geotechnical samples were submitted to the laboratory for size gradations, plasticity indices, specific gravity and direct shear tests (Table 2-1).

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Table 2-1. Sulfide Tailings Testing Summary

Description	Standard Reference	Tests
Field Moisture/Density	ASTM D6938	12
Laboratory Moisture	ASTM D2216	15
Plasticity Index	ASTM D4318	15
Gradation	ASTM D422	15
Moisture Density Relationship	ASTM D1557	6
Soil Classification (USCS)	ASTM D2487	15
Specific Gravity	ASTM D5550	4
Direct Shear	ASTM D3080	4
Flexible Wall Hydraulic Conductivity	ASTM D5084	2

2.3.5 Alluvial Soils

ARC collected 148 soil samples from 74 locations within two reference sub-areas (37 in each sub-area) located west of the Site for the analysis of total metals and radiochemicals as presented in the *Background Soils Data Summary Report - Revision 1* (Brown and Caldwell, 2009b). Samples were collected from depths of 2 to 10 inches below ground surface (bgs) and from 2 to 3 feet bgs at each location. Per the Background Soils Work Plan dated August 2, 2006, as approved by EPA on September 26, 2006, samples from the upper six inches of soil were excluded because of the potential for impacts by wind-blown dust or anthropogenic sources.

Soils in the reference sub-areas are predominantly composed of sands and gravels. The most common soil type was determined to be a well-graded sand (SW), described in the field notes as a silty-sand with gravels and a range of particle sizes. This soil type is more common in sub-area A-1 and in the shallow interval. A poorly-graded sand (SP) was also identified in the reference areas, and is generally described as an uncompacted fine to coarse grained sand with minor gravel and even less silt. This soil type is more likely to occur in the shallow interval, and appears to result from recent weathering activities (e.g., ephemeral surface runoff conditions). Soils with coarser rock and gravel content (GW and GP) were more commonly found in sub-area A-2 and were also more common in the deep interval. Approximately two thirds of the deep soil samples in sub-area A-2 were described as gravels, sourced from nearby bedrock outcrops, and several sample locations encountered decomposed bedrock within the excavation.

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Occurrences of caliche, a white calcium carbonate mineral, were commonly observed in the excavated soils from both sub-areas at depths typically starting between one to three feet below the surface. Caliche occurrences were generally weak and dispersed throughout the pore space as a coating on medium to coarse particles within the soil and concentrated in plant roots. However, at several locations, distinct caliche horizons (typically less than six inches in thickness) were discontinuous and not strongly cemented. Background soils chemical data and statistically derived background concentration limits are provided in Appendix A-5.

2.4 Summary of Available Data

Available data for potential cover materials from on- and off-Site borrow sources are summarized in Table 2-2. The information presented in Table 2-2 provides the basis for: 1) the identification of data gaps and the DQOs described in Section 4.0 of this Work Plan; and 2) the FSAP presented in Section 5.0 of this Work Plan.

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Table 2-2. Summary of Cover Material Sources and Existing Analytical Data

Sampling and Analyses	Method	Off-Site Locations (west of site)		On-Site Locations									
		Native Alluvium	Bedrock	Oxide Tailings (VLT)	Sulfide Tailings[3]	W-3 Waste Rock Area	S-32 Waste Rock Area	South Waste Rock Area	Phase I/II HLP	Phase III South HLP	Phase III 4X HLP	Phase IV Slot HLP	Phase IV VLT HLP
Cover Material Source Area Information													
Bottom Area	n/a	n/a	n/a	345 acres	674 acres	85 acres	19 acres	389 acres	12 acres	45 acres	53 acres	75 acres	51 acres
Top Area	n/a	n/a	n/a	n/a [4]	680 acres	49 acres	8 acres	294 acres	3 acres	15 acres	22 acres	37 acres	29 acres
Maximum Height	n/a	n/a	n/a	189 feet	100 feet	234 feet	132 feet	314 feet	120 feet	168 feet	156 feet	145 feet	128 feet
Estimated Volume (cubic yards)	n/a	n/a	n/a	30,677,045 CY	15,966,349 CY	12,052,338 CY	1,464,355	60,000,000 CY[5]	981,719 CY	4,359,747 CY	5,203,844 CY	6,516,877 CY	5,462,447 CY
Geotechnical/Hydraulic Analyses													
Saturated hydraulic conductivity	ASTM D5084				**2**								
Gravimetric water content (soil moisture)	ASTM D2216			**13**	**15**				**9**	**18**	**11**	**12**	**17**
Dry bulk density	ASTM D2937/D6836			**18**					**3**	**5**	**2**	**4**	**3**
Calculated total porosity	ASTM D6836			**5**									
Moisture characteristics curve (5-7 points)	ASTM D6836			**5**									
Calculated unsaturated hydraulic conductivity	ASTM D6836			**5**									
Standard sieves (wash)	ASTM D422			**13**	**15**				**6**	**12**	**5**	**7**	**8**
Atterberg Limits: liquid limit, plastic limit, plasticity index	ASTM D4318			**13**	**15**								
Soil Classification for Engineering Purposes	ASTM D2487	**74**		**13**	**15**								
Specific Gravity	ASTM D854			**4**	**4**				**3**	**7**	**3**	**3**	**5**
Geochemical Analyses													
Total metals	EPA 6010B/6020	**74**		**6**[1]					**6**	**11**	**12**	**15**	**16**
Radiochemicals	EPA 903.0/904.0	**74**							**5**	**6**	**5**	**6**	**4**
MWMP	ASTM E2242			**6**[2]					**2**	**2**	**2**	**2**	**2**
Plant Growth Parameters													
pH	NAPT S-1.10								**6**	**4**	**3**	**2**	**3**
Calcium, Magnesium and Sodium	NAPT S-5.10								**6**	**4**	**3**	**2**	**3**
Sodium Absorption Ration (SAR)	NAPT S-1.60								**6**	**4**	**3**	**2**	**3**
Nitrogen, Phosphorus, and Potassium (NPK)	NAPT S-4.20 (Weak Bray) and S-4.10 (Olsen)								**6**	**4**	**3**	**2**	**3**

Notes: CY = cubic yards NAPT = North American Proficiency Testing Program n/a = information not available

[1] In addition to the six results from NDEP, plus two duplicates (Brown and Caldwell, 2009d; Appendix G), implementation of the VLT XRF Characterization Work Plan will result in an additional 48 results for a total of 52 analyses plus duplicates

[2] SPLP (not MWMP) testing was performed by NDEP on six samples, plus two duplicates (Brown and Caldwell, 2009d; Appendix G)

[3] Sulfide tailings may be used to increase fine-grained component of cover material profile)

[4] Top area not calculated due to irregular surface.

[5] The estimated volume for alluvial materials in the South Waste Rock Area, as described in this Work Plan, is consistent with the volume presented by Anaconda (1978). Volume estimates for bedrock materials in the South Waste Rock Area are not presented, but are assumed to be less than 5,000,000 CY.

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SECTION 3.0
CONCEPTUAL SITE MODEL

The conceptual site model (CSM) for potential cover materials for use at the Site includes their physical (i.e., hydraulic) and geochemical properties (e.g., potential to leach or attenuate chemicals), the ability of the covers to support volunteer vegetation and anticipated final cover conditions, and the mass balance of on- and off-Site cover materials. Covers for hydraulic control manage water by providing two essential elements: 1) water storage capacity in the unsaturated near-surface soil to prevent drainage during periods when precipitation exceeds soil evaporation or evapotranspiration (ET); and 2) sufficient removal of the stored water by soil evaporation or ET during periods of lesser precipitation and greater evaporative demand. Interim covers or final caps for the Site will be subject to the same four primary fluxes (i.e., precipitation, runoff, soil evaporation and/or ET, and percolation) associated with the movement of meteoric water through natural geologic materials. Guidance provided by EPA for cover systems (e-mail transmittal to ARC dated September 24, 2009) are provided in Appendix B and include: 1) *Cover System Design Guidance and Requirements Document* (Dwyer, et. al., 2007); and 2) *Evapotranspiration Landfill Cover Systems Fact Sheet* (EPA, 2003).

Covers can be designed to incorporate adequate storage capacity characteristics, soil evaporation and evapotranspiration properties, which can limit percolation to varying degrees to address site-specific requirements. Although such designs may achieve small to very small percolation rates, such rates will never achieve zero percolation. The soil water storage capacity depends on the unsaturated hydraulic properties of the cover soils, cover thickness, and the soil layering. Water removal generally is controlled by evaporation from the soil surface and transpiration by plants. The transpiration rate depends on a combination of factors including the composition of the plant community, the above-ground distribution of biomass (e.g., percent cover and leaf area), and the rooting depth and distribution. Under ideal circumstances, with sufficient plant root density, transpiration can remove soil water throughout the entire depth of the cover profile.

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Soil Characteristics

The relevant unsaturated soil properties are typically described by the soil water characteristic curve (SWCC), which relates volumetric water content to soil water suction (or the tension under which water is held by capillary forces). SWCC parameters define soil water storage and are key input to computer models used to predict performance and understand important mechanisms. Two water content values on the SWCC, *field capacity* and *wilting point*, provide a general description of the storage characteristics of a particular soil. Field capacity is the amount of water soil can hold against the force of gravity. Wilting point describes the water content corresponding to the suction at which transpiration ceases. For preliminary design purposes, the *available storage capacity* is calculated as the difference between these two values.

Vadose zone conceptual models also recognize the potential for preferential pathways and localized faster seepage rates. Preferential flow is defined as flow that occurs in a non-volume averaged fashion along localized, preferential pathways, by-passing a fraction of the porous space. Such flow may occur along root channels associated with volunteer vegetation, earthworm burrows, fissures and cracks. Heterogeneities may be created by the mixing of material types in covers/caps, depositional conditions during cover/cap construction and differential weathering processes. The heterogeneity of cover materials at different scales combined with non-uniform areal precipitation and run-off are primary causes of the phenomenon of multi-scale flow (e.g., slow matrix versus fast preferential) and heterogeneous cover conditions, as indicated below (Looney and Falta, 2000):

- The contrasts in permeability of covers/caps at different locations and depth in the system may be extreme, and very localized (e.g., on the scale of inches);
- The geometry of water flow depends strongly on the interconnection or connectivity of a preferential flow zone network, which makes the confirmation through field monitoring difficult, and very costly and time-consuming at best; and
- Point measurements, typically obtained from field monitoring, can not reveal complex processes that result from the interaction of features at many different scales.

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Despite the recognized importance of preferential flow, these processes are difficult to quantify and simulate. EPA's Alternative Cover Assessment Program investigated the effect of pedogenesis on soil hydraulic properties in engineered cover materials (Benson, et. al., 2007) and provided methods to estimate the magnitude of those changes. These methods may be useful for developing cover designs at one or more Site locations.

Numerical simulations of cover performance and unsaturated zone flux are often performed to support cover designs. Unsaturated flow models are based on Richards' Equation (Richards, 1931), and route water in the vadose zone according to the unsaturated hydraulic conductivity and the hydraulic gradient of the cover materials and soil profile. The unsaturated hydraulic conductivity is a function of the volumetric water content (θ) of the material (i.e., $K[\theta]$). The direction of the unsaturated flow is determined based on gravity and the matric suction or negative pore water pressure (ψ) value with moisture moving from less negative values (lower suction) to more negative values (higher suction). Input parameters required by these models include atmospheric inputs (e.g., precipitation and evaporation rates), the SWCC determinations described above and observed physical boundary conditions in the soil profile. Numerical models typically employ internal routines to solve for unsaturated hydraulic conductivity (e.g., van Genuchten, 1980).

The most common approach to determine soil hydraulic properties is to determine the saturated hydraulic conductivity and the SWCC through laboratory analysis of re-compacted samples. Methods for the SWCC are described in ASTM D 6836. Saturated hydraulic conductivity should be determined by rigid wall permeameter (ASTM D 5856 for fine-grained soils or ASTM D 2434 for coarse-grained soils) or flexible-wall permeameter (ASTM D 5084).

Final Cover Conditions

Conceptualization of future conditions associated with a final cover composed of alluvium over one or more of the OUs at the Site can address the potential progression from a newly placed alluvial soils cover to a more mature cover that includes a volunteer plant community. This conceptualization would, in general, be consistent with the EPA publication entitled *Ecological*

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Revitalization: Turning Contaminated Properties Into Community Assets (EPA, 2009). Although reference to this document in this section of the Work Plan does not suggest that partial or complete ecological restoration is a goal for the placement of cover materials on the Site, ARC recognizes that potential habitat may develop over time based on the volunteer growth of local native plant species. An additional element for final cover conditions is presented in a technical paper entitled *Postconstruction Changes in the Hydraulic Properties of Water Balance Cover Soils* (Benson, et. al., 2007).

As indicated above, ARC recognizes that volunteer growth of local native plant species vegetation can create conditions where potential habitat may develop in suitable cover materials. For the Site, the following two reference areas can be evaluated to benchmark this progression: 1) the materials located within the South WRA (approximate 40-year condition with volunteer vegetation); and 2) native alluvial fan materials located west of the Site (an established ecosystem in an arid high-desert environment). The South WRA exhibits volunteer plant growth in alluvial materials, with less plant growth associated with weakly mineralized waste rock.

As previously discussed in Section 1.3, additional investigations of potential cover materials will be performed during the remedial investigations of the spent ore, waste rock and alluvial materials investigated in this Work Plan. Subsequent investigations of the South WRA will include a plant survey, which would likely include the following soil and plant characteristics, respectively: 1) soil texture, structure, lithology and grain size, dry bulk density, chemical properties including pH, electrical conductivity (salinity), cation exchange capacity, sodicity (sodium adsorption ratio or exchangeable sodium percentage), macronutrients (N, P, K, Ca, Mg, S) and micronutients (Mn, Fe, Zn, Cu, Mo, Cl, B) and total organic carbon, and other trace elements or contaminants that may affect plant growth; and 2) established plant species and measures of plant abundance and diversity, and transpiration indices such as leaf area and root depth and distribution. Ecological aspects of a soil cover habitat on Site with volunteer plant growth will also be addressed for the South WRA in the RI-required screening level ecological risk assessment (SLERA), which will also address conditions on the alluvial fan adjacent to the Site as a benchmark.

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Materials Mass Balance

The volume of available cover materials on the Site is the final CSM element discussed in this Work Plan. As indicated above, in Section 1.1, the variability and volumes of on-Site material types will be critical components in the decision-making process for the placement of these materials in interim and final covers (i.e., the basis for optimal layering of these materials in the context of an overall Site cover materials mass balance). Table 2-2 provides material volume estimates for the on-Site potential cover materials.

No estimate is provided for off-Site alluvial materials given limited data on the vertical extent of the alluvial fan thickness west of the Site (permitting limitations on the use of off-Site materials located on BLM lands cannot be addressed at this time). Such permitting limitations may also affect the availability of undisturbed bedrock for use as a cover material at the Site, which would limit the usefulness of any volume estimate at the present time.

The volume estimates for these materials were developed using AutoCAD Civil 3D 2010 software, as described in Appendix C. The estimates provided in Table 2-2 are important to the development of any final comprehensive cover materials and re-grading plan for the Site, including the following elements: 1) the volume of potentially 'good quality' alluvial overburden materials present in the South WRA that can be used in a final cap design; 2) the volume of potentially 'poor quality' spent ore materials present in the WRAs, oxide tailings and Arimetco HLPs; and 3) excess volumes of materials present in topographically steep OUs (e.g., Arimetco HLPs adjacent to WRAs or oxide tailings) that would be available if these surface features were re-graded to a nominal 3:1 slope.

The approximate 60 million cubic yards of alluvium that was removed as overburden during the mining of the Yerington open pit and stored in the South WRA is anticipated to have similar properties as the undisturbed alluvial fan materials located west of the Site. Conceptually, these 'good quality' materials should be considered as a 'high value' borrow source with respect to their use in a final cap design.

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Approximately 40 million cubic yards of alluvium may be available from the South WRA, assuming an approximate 65 percent efficiency in separating alluvium from non- or weakly mineralized rock materials. This volume would equate to 12,000 acres for a 2-foot cover and 8,000 acres for a 3-foot cover. Appendix C presents the method used to calculate the volume of alluvial soils present in the South WRA. Depending on the need for more 'good quality' materials than the available or extractable volume of alluvium from the South WRA, additional alluvial materials may be borrowed from the undisturbed alluvial fan west of the Site. The final cap design may also require coarser materials to limit dust mitigation.

Figure 3-1 depicts conceptual configurations of interim covers and final caps that incorporate the use of: 1) excess waste rock and spent ore materials for Site re-grading requirements: 2) 'good quality' alluvial materials for the closure cap; and 3) a relatively thin layer of coarse materials, if needed, to eliminate or limit the generation of fugitive dust from the final cap. These conceptual configurations represent possible cover designs, and are not intended to suggest any final cap designs. Final cap designs would be developed during the RI/FS process for each OU that will require a cap and, in part, will be based on the information resulting from the implementation of this Work Plan.

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SECTION 4.0
DATA GAPS AND DATA QUALITY OBJECTIVES

Based on the information presented in Sections 2.0 and 3.0, ARC has identified the additional data required for this Work Plan, presented in larger, bold-face font in Table 4-1. The analytical parameters presented in Table 4-1 are divided into geotechnical and hydraulic and geochemical analyses and plant growth parameters. Filling of these data gaps will: 1) provide a preliminary assessment of the range of cover material properties needed to make short-term decisions about interim covers; 2) develop the basis for final cover designs for Site OUs resulting from the RI/FS; and 3) assist in developing the design for the plant species survey described in Section 3.0. ARC recognizes that additional characterization data may be needed to supplement the analytical data identified in Table 4-1 for specific applications of cover materials and to provide the basis for a QA/QC program during construction. Such additional information will be obtained during the remedial investigation for the waste rock areas, oxide tailings, and sulfide tailings and, if needed, additional investigations in the background soils reference areas.

DQOs developed for this Work Plan, summarized in Table 4-2, are intended to ensure that reliable data are acquired for decision making by the project management team described in Section 1.4. A systematic seven-step planning approach outlined in the EPA quality assurance document *Guidance on Systematic Planning Using the Data Quality Objective Process* (EPA, 2006) is used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity. The DQO process consists of the following seven iterative steps:

Step 1: State the Problem
Step 2: Identify Study Goals
Step 3: Identify Information Inputs
Step 4: Define the Boundaries of the Study
Step 5: Develop an Analytical Approach
Step 6: Specify Performance or Acceptance Criteria
Step 7: Develop the Plan for Obtaining the Data.

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Table 4-1. Cover Materials Analytical Parameters

Sampling and Analyses	Method	Off-Site Locations (west of site)		On-Site Locations									
		Native Alluvium	Bedrock	Oxide Tailings (VLT)	Sulfide Tailings	W-3 Waste Rock Area	S-32 Waste Rock Area	South Waste Rock Area[3]	Phase I/II HLP	Phase III South HLP	Phase III 4X HLP	Phase IV Slot HLP	Phase IV VLT HLP
Geotechnical/Hydraulic Analyses													
Saturated hydraulic conductivity	ASTM D5084	**2**	0	**2**	2	**2**	**2**	**5**	**1**	**1**	**1**	**1**	**1**
Gravimetric water content (soil moisture)	ASTM D2216	**2**	0	13	15	**2**	**2**	**5**	9	18	11	12	17
Dry bulk density	ASTM D2937/D6836	**2**	0	18	**2**	**2**	**2**	**5**	3	5	2	4	3
Calculated total porosity	ASTM D6836	**2**	0	5	**2**	**2**	**2**	**5**	**1**	**1**	**1**	**1**	**1**
Moisture characteristics curve (5-7 points)	ASTM D6836	**2**	0	5	**1**	**1**	**1**	**5**	**1**	**1**	**1**	**1**	**1**
Calculated unsaturated hydraulic conductivity	ASTM D6836	**2**	0	5	**1**	**1**	**1**	**5**	**1**	**1**	**1**	**1**	**1**
Standard sieves (wash)	ASTM D422	**2**	0	13	15	**2**	**2**	**5**	6	12	5	7	8
Atterberg Limits: liquid limit, plastic limit, plasticity index	ASTM D4318	**2**	0	13	15	**2**	**2**	**5**	**1**	**1**	**1**	**1**	**1**
Soil Classification for Engineering Purposes	ASTM D2487	74/**2**	0	13	15	**2**	**2**	**5**	**1**	**1**	**1**	**1**	**1**
Specific Gravity	ASTM D854	**2**	0	4	4	**2**	**2**	**5**	3	7	3	3	5
Geochemical Analyses													
Total metals	EPA 6010B/6020	74	0	**54[1]**	**2**	**2**	**2**	**8**	6	11	12	15	16
Radiochemicals	EPA 903.0/904.0	74	0	**10**	**2**	**2**	**2**	**8**	5	6	5	6	4
MWMP Leachate Analysis	ASTM E2242	**2**	0	**10[2]**	**2**	**2**	**2**	**8**	2	2	2	2	2
Plant Growth Parameters													
pH	NAPT S-1.10	**2**	0	**2**	**2**	**2**	**2**	**5**	6	4	3	2	3
Calcium, Magnesium and Sodium	NAPT S-5.10	**2**	0	**2**	**2**	**2**	**2**	**5**	6	4	3	2	3
Sodium Absorption Ratio (SAR)	NAPT S-1.60	**2**	0	**2**	**2**	**2**	**2**	**5**	6	4	3	2	3
Organic Matter and Total Organic Carbon	NAPT S-9.20 and S-9.30	**2**	0	**2**	**2**	**2**	**2**	**5**	**2**	**2**	**2**	**2**	**2**
Cation Exchange Capacity	NAPT S-10.10	**2**	0	**2**	**2**	**2**	**2**	**5**	**2**	**2**	**2**	**2**	**2**
Soluble Salts (dS/m)	NAPT S-1.20	**2**	0	**2**	**2**	**2**	**2**	**5**	**2**	**2**	**2**	**2**	**2**
Nitrogen, Phosphorus, and Potassium (NPK)	NAPT S-4.20 (Weak Bray) and S-4.10 (Olsen)	**2**	0	**2**	**2**	**2**	**2**	**5**	6	4	3	2	3

Notes: Bold face, larger font values indicate data gaps to be filled or data to be added; non-bold values represent existing data (see Table 2-2)

NAPT = North American Proficiency Testing Program

[1] In addition to the six results from NDEP, plus two duplicates (Brown and Caldwell, 2009d; Appendix G), implementation of the VLT XRF Characterization Work Plan will result in an additional 48 results for a total of 54 analyses plus duplicates

[2] SPLP (not MWMP) testing was performed by NDEP on six samples, plus two duplicates (Brown and Caldwell, 2009d; Appendix G), which are not included in the 10 samples

[3] South WRA samples will be obtained from alluvial overburden and bedrock materials.

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Table 4-2. Data Quality Objectives for Potential Cover Materials Characterization

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Problem Statement	**Identify Study Goals**	**Identify Information Inputs**	**Study Boundaries**	**Develop the Analytical Approach**	**Specify Performance or Acceptance Criteria**	**Develop the Plan for Obtaining Data**
In order to evaluate the suitability of potential cover materials for interim and final remedies at the Site, additional geochemical and, geotechnical characterization is required.	The study goals associated with this Work Plan are to provide sufficient data to make decisions for the cover materials to be used for interim covers for the LEP and UEP, and to provide the framework for additional data collection during future remedial investigations for Site OUs that will support decisions to be made during the feasibility study phase regarding final covers. The data to be collected will provide the framework to understand the degree to which potential cover materials will: 1. Provide some degree of soil moisture storage, soil evaporation, and/or evapotranspiration properties to assess the flux of meteoric water through an interim or final cover; 2. Support volunteer vegetation of native plant species to promote the evapotranspiration of soil moisture; 3. Leach chemicals to underlying soils and groundwater; and 4. Minimize fugitive dust immediately after construction and in the future.	Lithologic, geochemical and, geotechnical and other data from representative materials sampled from: ▪ Waste rock areas including alluvial overburden and non- to weakly mineralized bedrock; ▪ Oxide tailings (VLT); ▪ Arimetco heap leach pads; ▪ Sulfide tailings; and ▪ Native alluvium located west of the Site.	Figures 5-1 through 5-5 identify the two-dimensional extent of the areas with potential cover material areas (Table 2-2 describes the vertical extent of the potential borrow areas for cover materials. The temporal boundary for the field investigation is anticipated from August through September 2010. Laboratory analytical results are anticipated by mid-December 2010. The DSR for this Work Plan is anticipated in February 2011. Supplemental characterization data may be required for interim covers for the LEP and UEP, which would be obtained in 2011. Supplemental data from future RI/FS activities will be required for final cover designs, anticipated to be obtained from 2011 through 2015.	Lithologic information and grain-size distribution analyses for sampled potential cover materials. Laboratory analyses of metal and radiochemical concentrations in samples of potential cover materials. Leachate (MWMP) testing of potential cover material samples, and laboratory analyses of the samples for leachate chemistry (i.e., metal and radiochemical concentrations). Unsaturated hydraulic properties for potential cover materials, and plant growth parameters properties listed in Table 4-1 of this Work Plan.	Acceptance of chemical analytical results will be based on verification and validation criteria specified in the Site-Wide QAPP - Revision 5. Acceptance of geotechnical laboratory results per the American Society of Testing and Materials (ASTM) standards.	Refer to Section 5.0 of this Work Plan for the field sampling and analysis plan (FSAP).

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SECTION 5.0
FIELD SAMPLING AND ANALYSIS PLAN

This FSAP describes: 1) field activities to be conducted in the on- and off-Site potential cover material borrow source areas; 2) laboratory analyses for the collected samples; and 3) the integration and interpretation of the collected geotechnical and geochemical data. These activities are designed to achieve the DQOs presented in Table 4-2 and satisfy the data gaps required to select the material(s) to be used as interim covers for the LEP and UEP, and to provide the framework for additional investigations to support final re-grading and cover designs for Site OUs. Table 4-1 identifies (in bold-face font) the number of samples for geotechnical and geochemical analyses and plant growth parameters from each area, and as indicated in Section 1.3 and Section 3.0, supplemental data for cover materials will be conducted.

5.1 Sample Locations and Quantities

The specific number of samples from each material type and associated analytical parameters are presented in Table 4-1 and shown in Figures 5-1 through 5-5. As noted in Table 4-1, a number of samples have been, or will be, obtained from other characterization activities. Sample locations for each potential cover material borrow source area are discussed below.

- Waste Rock Areas: a total of eight sampling locations have been identified for the South WRA as shown in Figure 5-1. One group of four samples (WRA-CM-01 through -04) was located near the western margin of the South WRA because these are likely borrow areas for a future cover removal action. A second group of four samples (WRA-CM-05 through -08) was located near the middle, top surface of the South WRA where there are discrete, uncompacted dump piles that are readily accessible for sampling. At each of the two sampling groups, one sample will be collected of alluvial overburden and three samples from the weakly- or non-mineralized bedrock. As shown in Figure 5-2, two sample locations have been identified in the W-3 WRA (WRA-CM-09 through -10) and in the S-32 WRA (WRA-CM-11 and -12) that are in areas readily accessible for sampling (i.e., away from steep slopes and spacious enough to accommodate a backhoe).

- Oxide Tailings: a total of 10 sampling locations (VLT-CM-01 through-10) have been identified as shown in Figure 5-3. Six samples are located in the northern borrow area and four samples are located in the southern borrow area. The locations coincide with 10 of the sampling locations from the XRF Work Plan.

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- Arimetco HLPs: two sample locations have been identified for each HLP, and where possible, were co-located with previous samples associated with the OU-8 RI (CH2M Hill, 2008).
  - Phase I/II HLPs: sample HLP-CM-03 was located near RI sample H12SU01, and sample HLP-CM-04 was located near RI sample H12SS04 as shown in Figure 5-2.
  - Phase III South HLP: sample HLP-CM-05 was located near RI sample H3SSS01, and sample HLP-CM-06 was located near RI sample H3SSS07 as shown in Figure 5-2.
  - Phase III 4X HLP: sample HLP-CM-07 was located near RI sample H3XSS07, and sample HLP-CM-08 was located near RI sample H3XSS08 as shown in Figure 5-3.
  - Phase IV Slot HLP: sample HLP-CM-01 was located near RI sample H4SS05, and sample HLP-CM-02 was located near RI sample H4SS02 as shown in Figure 5-2.
  - Phase IV VLT HLP: sample HLP-CM-09 was located near RI sample H4VSS09, and sample HLP-CM-10 was located near RI sample H4VSU03as shown in Figure 5-3.

- Sulfide Tailings: two sample locations (SUL-CM-01 and -02) have been identified as shown in Figure 5-4.

- Native Alluvium West of Site: two reference sub-areas west of the Site were identified for the background soils investigation (Brown and Caldwell, 2009b) as shown in Figure 5-5. For this Work Plan, two sample locations for native alluvium have been identified: sample BGS-CM-01 in Sub-Area 1 near background sample location BGS-A1-15; and sample BGS-CM-02 in Sub-Area 2 near background sample location BGS-A2-43.

5.2 Sample Collection Approach

The cover materials to be sampled vary widely in their composition, size fraction, and compaction. Samples will be collected from the near-surface (1 to 5 feet bgs) to avoid any materials that have undergone surface effects such as weathering. The samples will be collected with a combination of trenches (backhoe- or trackhoe-excavated) and hand-augered borings, depending on the sample location, compaction of the materials, and type of sample. In the Waste Rock Areas, there is a significant percentage of gravels and rock, with rock as large as 3 feet plus in diameter. Rocks greater than 6 inches will be screened from each sample due to limitations of laboratory analytical equipment. However, the field technician will estimate the percentage of material in the original sample that was greater than 6 inches. Note that the use of cover materials in the future is likely to include some rock that is greater than 6 inches.

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5.3 Geotechnical Characterization

The geotechnical and hydraulic properties of the potential cover materials (e.g., the potential flux of meteoric water and potential mobilization of chemicals) will be determined by conducting the analyses summarized in Table 5-1. Each geotechnical sample will consist of filling a lined, 5-gallon bucket. The liner will be sealed to preserve moisture present in the sample. In addition, the lid will be sealed to the 5-gallon bucket with packing tape. The samples will be analyzed by Daniel B. Stephens Laboratory in Albuquerque, New Mexico, using the methods indicated.

Table 5-1. Geotechnical/Hydraulic Analyses

Analysis	Method
Saturated hydraulic conductivity	ASTM D5084
Gravimetric water content (soil moisture)	ASTM D2216
Dry bulk density	ASTM D2937/D6836
Calculated total porosity	ASTM D6836
Moisture characteristics curve (5-7 points)	ASTM D6836/D2325
Calculated unsaturated hydraulic conductivity	ASTM D6836
Standard sieves (wash)	ASTM D422
Atterberg Limits: liquid limit, plastic limit, plasticity index	ASTM D4318
Soil Classification for Engineering Purposes	ASTM D2487
Specific Gravity	ASTM D854

5.4 Geochemical Characterization

The geochemical/hydraulic properties of the potential cover material samples will be determined by conducting the analyses summarized in Table 5-2. The samples will be analyzed for 27 total metals by TestAmerica in Irvine, California, using the methods indicated. The reporting limits for these analytes are consistent with those presented in the QAPP. Each total metals sample will consist of filling an 8-ounce polyethylene or glass jar. The samples will be analyzed for Ra-226/228 isotopes by TestAmerica in Richland, Washington, using the methods indicated. Each radiochemical sample will consist of filling a Zip-lock bag, then double-bagging the sample.

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Table 5-2. Geochemical Analyses

Analysis	Method	Unit	Reporting Limit
Total Metals			
Aluminum	EPA 6010B	mg/kg	10
Antimony	EPA 6020	mg/kg	1.0
Arsenic	EPA 6020	mg/kg	0.5
Barium	EPA 6020	mg/kg	0.5
Beryllium	EPA 6020	mg/kg	0.3
Boron	EPA 6010B	mg/kg	5.0
Cadmium	EPA 6020	mg/kg	0.5
Calcium	EPA 6010B	mg/kg	15
Chromium	EPA 6020	mg/kg	1.0
Cobalt	EPA 6020	mg/kg	0.5
Copper	EPA 6020	mg/kg	1.0
Iron	EPA 6010B	mg/kg	5.0
Lead	EPA 6020	mg/kg	0.5
Magnesium	EPA 6010B	mg/kg	10
Manganese	EPA 6020	mg/kg	0.5
Mercury	EPA 1631	mg/kg	0.001
Molybdenum	EPA 6020	mg/kg	1.0
Nickel	EPA 6020	mg/kg	1.0
Potassium	EPA 6010B	mg/kg	50
Selenium	EPA 6020	mg/kg	1.0
Silver	EPA 6020	mg/kg	0.5
Sodium	EPA 6010B	mg/kg	50
Thallium	EPA 6020	mg/kg	0.5
Thorium (total)	EPA 6020	mg/kg	0.2
Uranium (total)	EPA 6020	mg/kg	0.1
Vanadium	EPA 6020	mg/kg	1.0
Zinc	EPA 6020	mg/kg	10
Radiochemicals			
Radium-226	HASL 300 (Section 4.5.2.3)	pCi/g	1.0
Radium-228		pCi/g	1.0
Meteoric Water Mobility Procedure			
27 metals listed above	ASTM E2242	n/a	n/a
Acid Generation/Neutralization Potential			
Acid-Base Accounting	EPA M600/2 -78-054 1.3 (Sobek, 1978)	n/a	n/a
Net Acid Generation		n/a	n/a

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The Meteoric Water Mobility Procedure (MWMP; ASTM E2242) will be conducted on samples from each potential cover material source area. The MWMP consists of a single-pass column leach test over a 24-hour period using Type II reagent-grade water of a quality and pH that reflects anticipated climate conditions in Nevada, including the Site. The purpose of the MWMP is to evaluate the potential for the mobilization of the metals and radiochemicals listed in Table 5-2 from cover materials (the same analytical suite for Site-wide groundwater monitoring).

Each MWMP sample will consist of filling a lined, 5-gallon bucket. The liner will be sealed to preserve moisture present in the sample. In addition, the lid will be sealed to the 5-gallon bucket with packing tape. The samples will first undergo the MWMP at Sierra Environmental Monitoring in Reno, Nevada. The leachate will then be sent under chain-of-custody to TestAmerica in Irvine and Richland for analysis of metals and radiochemicals, respectively.

Acid-base characteristics of potential cover materials will be assessed by conducting two conventional static tests on the samples, Acid-Base Accounting (ABA) and Net Acid Generation (NAG). The ABA test determines the acid producing potential of a material by measuring sulfur content and the neutralization potential of neutralizing agents in the material. The NAG measures the net amount of acid generated by the oxidation of the material. The test simulates the net amount of acid generated due to the weathering of the material. The NAG test is generally used to confirm ABA results and ascertain whether theoretical acid producing potential and neutralization potential would be generated and available when the material undergoes oxidation. The ABA/NAG tests will be conducted by Sierra Environmental Monitoring using a portion of the materials in the 5-gallon buckets prepared for the MWMP.

5.5 Plant Growth Parameters

In addition to geotechnical and geochemical characterization activities described above, potential cover materials will be evaluated for the analytical parameters listed in Table 5-3 for their potential to support volunteer plant growth. These samples will be analyzed by A&L Western Agricultural Laboratory in Modesto, California, using the methods indicated. Each sample will consist of filling a Zip-lock bag, then double-bagging the sample.

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Table 5-3. Plant Growth Parameters	
Analysis	**Method**
pH	NAPT S-1.10
Calcium, Magnesium and Sodium	NAPT S-5.10
Sodium Absorption Ratio (SAR)	NAPT S-1.60
Organic Matter and Total Organic Carbon	NAPT S-9.20 and S-9.30
Cation Exchange Capacity	NAPT S-10.10
Soluble Salts (dS/m)	NAPT S-1.20
Nitrogen, Phosphorus, and Potassium (NPK)	NAPT S-4.20 (Weak Bray) and S-4.10 (Olsen)

Notes: NAPT = North American Proficiency Testing Program

Results of these analyses will provide the basis for potential future characterization activities subsequent investigations. Potential cover materials (e.g., spent ore materials) that will not likely support volunteer plant growth of native species, as observed in the South WRA alluvial overburden materials that were stripped during open pit mining, will not be subject to further analyses or other related investigations. Alluvial soils found within the South WRA and as undisturbed native materials located west of the Site will likely support volunteer plant growth of native species, and will be subject to further characterization (i.e., vegetation survey) as indicated in Section 3.0.

5.6 Preliminary Project Schedule

ARC anticipates that the scope of activities described above, through the submittal of the DSR, will require approximately 11 months from the start of field activities (e.g., if ARC can begin field work on August 15, 2010, the DSR can be submitted to EPA by March 21, 2011). Once EPA approves this Cover Materials Work Plan (or a modified, version based on EPA comments), ARC will develop a detailed project schedule. An integrated schedule that includes the activities described in this Work Plan and other activities associated with the evaporation ponds removal action is presented in Figure 1-3.

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SECTION 6.0
QUALITY ASSURANCE PLAN

The goals of the Quality Assurance (QA) Plan are to: 1) conduct FSAP activities in accordance with the *Quality Assurance Project Plan – Revision 5* (QAPP; ESI and Brown and Caldwell, 2009); and 2) produce high quality analytical data that achieve the DQOs described in Section 4.0. QA procedures will be implemented on field data collection and sampling as well as laboratory analytical methods. A review of data results will be completed by the project QA oversight contractor, ESI, in order to determine whether the project data goals have been met and if any data must be qualified or rejected due to data quality issues. The QA/QC elements for this Work Plan include:

- Standard operating procedures;
- Sample handling and preservation;
- Field documentation;
- Equipment decontamination;
- Field and laboratory QC samples; and
- Data verification/validation.

6.1 Standard Operating Procedures

Standard Operating Procedures (SOPs) provide consistent procedures for field work at the Site. The following SOPs from the QAPP are applicable to this Work Plan and are provided in electronic format in Appendix D:

- SOP-01 Environmental Sample Handling
- SOP-02 Sample Preservation
- SOP-03 Field Notes and Documentation
- SOP-05 Equipment Decontamination
- SOP-11 Soil Sampling
- SOP-12 Field Classification and Description of Soil and Rock
- SOP-13 Soil Excavation
- SOP-14 Utility Clearance

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6.2 Sample Handling and Preservation

Sample handling and preservation will be conducted according to the requirements of each analytical method and to *SOP-01 Sample Handling* and *SOP-02 Sample Preservation*. The required sample volume, container, preservative and holding time required for each analytical method required in this Work Plan are provided in Table 6-1. Variations in sample volume may be requested by the project laboratories.

Table 6-1. Sample Containers, Preservation, and Holding Times

Parameter	Suggested Volume	Container	Preservative	Holding Time from Collection
Geotechnical/Hydraulic	5 gallon	Lined bucket	None	n/a
SWCC	6 inch	Plastic core sleeve	None	n/a
Metals	8 ounce	Plastic or glass jar	≤6°C	180 days; 28 days for mercury
Radiochemicals	1 liter	Plastic bag	None	180 days
MWMP	5 gallon	Lined bucket	None	180 days
ABA/NAG				n/a
Plant Growth Parameters	1 liter	Plastic Bag	None	n/a

Each sample will be placed in a clean, unused sample container provided by the laboratories (if applicable) and will be labeled with the sample identification number. The labels will be filled out with a permanent marker and will include the following information:

- Sample identification
- Date and time of sample collection
- Sampler's initials
- Analyses requested
- Preservation method (if required)
- Project name

Each sample will be tracked according to its unique sample field identification number assigned when the sample is collected and recorded clearly in the field notebook. All final sample locations and designations will be presented in the Data Summary Report.

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Chain-of-custody protocols will be followed throughout the transport process, and each chain-of-custody form will contain the following information:

- Project name
- Sampler's name and signature
- Sample identification
- Date and time of sample collection
- Sample matrix
- Number and volume of sample containers
- Analyses requested
- Filtration completed or required
- Method of shipment

Immediately following collection and labeling, samples will be placed into an insulated cooler and chilled with ice if temperature preservation is required. The samples will be transported to the analytical laboratory via overnight mail or ground delivery depending on sample hold times.

6.3 Field Documentation

Sample documentation will be conducted according to *SOP-03 Field Notes and Documentation*. A summary of all field measurement and sampling activities will be recorded in a field notebook with integral bound pages, and entries will contain accurate and inclusive documentation of project activities in objective and factual language. Entries will be made using permanent waterproof ink, and erasures are not permitted. Errors will be single-lined out, should not be obscured, and initialed and dated. The person making the entries will sign at the beginning and the end of the day's entries, and a new page would be started for each day. The following entries would be made to the bound logbook and/or filed log sheets:

- General descriptions of weather conditions;
- Location of each sampling point and sample identification;
- Date and time of sample collection;
- Field measurements made, including the date and time, and calibration information;

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- Reference to photographs taken;
- Date and time of equipment decontamination;
- Field observations and descriptions of problems encountered; and
- Duplicate sample location.

Soil borings will be logged at the time of sample collection using the United Soil Classification System (USCS) D2487-92, developed by ASTM. Classification of soil types will include grain size, sorting, and plasticity among others and will be recorded on a separate log sheet. Observations of soil horizons or changes in soil characteristics as observed in the excavation will be recorded. *SOP-12 Field Classification and Description of Soils and Rock* further defines the characteristics to be described during soil logging.

6.4 Equipment Decontamination

As needed, with the exception of disposable equipment, all sample collection equipment will be decontaminated between each sample according to *SOP-05 Equipment Decontamination*. In general, sampling equipment will be hand-washed with a solution of tap water and Alconox detergent, rinsed with distilled or tap water, rinsed with a weak nitric acid solution, and a final rinse in clean distilled water.

6.5 Quality Control Samples

Field and laboratory quality control (QC) samples will be prepared and submitted to verify that sample collection, packaging and shipping, and laboratory practices are not introducing variables into the sampling and analysis chain that could provide any basis to question the validity of the analytical results. All blanks and duplicate samples will be labeled in the same manner as regular samples, with no indication that they are QC samples, and will be submitted for the complete suite of analytes as the related original sample.

The following field and laboratory QC samples will be included in the execution of this Work Plan.

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- Field Duplicates: these are used to check for sampling and analytical error, reproducibility, and homogeneity. Duplicate samples will be collected at a frequency of one per every 10 investigation samples (10 percent) and each sample from a duplicate set will have a unique sample identification. Duplicate sediment and soil samples will be collected by gathering twice the sample volume in a plastic bag or stainless steel bowl, blending the entire volume to homogenize the soil, and splitting the blended soil into separate containers for the original and the duplicate samples. Splitting of the sample will be completed by alternately spooning portions of the blended sample into the original and duplicate sample containers. Duplicate water samples will be collected by filling a separate set of sample containers at the same time and from the same sample location as the original.
- Equipment Rinsate Blanks: analyses of equipment rinsate blanks are used to assess the efficiency of field equipment decontamination procedures in preventing cross-contamination between samples. Equipment rinsate blanks will be collected at a frequency of one per 20 samples (5 percent), and at least once each day samples are collected, by pouring laboratory grade de-ionized water over the reusable sampling equipment and collecting in a clean container.
- Matrix Spike/Matrix Spike Duplicate Samples: MS/MSD samples are investigative samples to which known amounts of analytes are added in the lab before analysis. The recoveries for spiked compounds can be used to assess how accurate the analytical method is for the site-specific sample matrix. One MS/MSD sample should be analyzed for every 20 samples (5 percent) submitted to the lab.

6.6 Data Verification/Validation

Final geochemical data reported by the laboratories will undergo review by a QA oversight contractor under the direction of ARC. The purpose of analytical data verification/validation is to review data for completeness and confirm that requested methods and procedures were followed as required by this Work Plan and the QAPP.

The outcome of the verification/validation process is to qualify data results that may be inaccurate due to data quality limitations (e.g., contaminated blanks, exceedance of sample holding times, or laboratory control sample [LCS] recoveries outside acceptable limits).

Data verification will be completed on 80 percent of all project samples and includes review of the following measures:

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- Sample holding times,
- Accuracy (by evaluating MS/MSD and LCS recovery),
- Precision (by evaluating field and lab duplicate results),
- Blank contamination,
- Surrogate compound recoveries,
- Chain-of-custody, and
- Case narrative.

Level IV data validation will be completed on the remaining 20 percent of samples that, in addition to the verification review listed above, will include a review of all raw laboratory data and calculations such as:

- Initial and continuing instrument calibration logs;
- Interference check samples;
- Reporting limits and sample recovery summaries; and
- Sample preparation and analytical run logs.

Analytical results will be evaluated during the verification/validation review of data received from the laboratories, and will also include a completeness check to ensure that all data has been properly loaded into the database used for report generation. Data that fail to meet the QA objectives for the characterization of background materials associated with the Yerington Mine Site will be qualified as to usability and potential low or high bias. The review of analytical data will follow the basic guidance provided in the National Functional Guidelines for Inorganic Data Review (EPA, 2004), unless specified otherwise.

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SECTION 7.0
DATA MANAGEMENT

Data generated during implementation of this Work Plan will be managed in accordance with the *Data Management Plan* (Brown and Caldwell, 2007b). The DMP supplements the requirements and specifications stated in the FSAP described in Section 4.0 and the *QAPP Revision 5*, and documents the guidelines for sample tracking, storage, access, delivery, and reporting of historical and new chemical analytical, geologic, biologic and spatial data generated by investigation operations. Key data management objectives include:

- Provide data users with tools that allow simple and rapid access to stored data of various types, and methods of data entry and data loading with known accuracy and efficiency;
- Apply well-documented data validation modifications to the electronic database;
- Manage sample data using a unique sample identification number;
- Establish a sample inventory of new data, provide methods of sample inventory reconciliation, and store sample-specific attributes (i.e., location identifier, sample type, sample media, depth, date, and target study area);
- Provide reporting and delivery formats from a single database source to support data analysis, site characterization, risk assessment, modeling, and spatial analysis;
- Provide the ability to electronically compare results to project-specific reference or screening criteria; and
- Identify needs for incorporating historical data and establish a database of this information when possible; otherwise, establish a data inventory plan that identifies and catalogues historical data not suited for database entry.

A Nevada-registered surveyor will survey the horizontal and vertical locations of each trench or borehole.

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SECTION 8.0
HEALTH AND SAFETY

All field activities will be conducted in accordance with the *Site-Wide Health and Safety Plan – Revision 1* (HASP; Brown and Caldwell, 2009g). The HASP identifies, evaluates and prescribes control measures for health and safety hazards, including radiological hazards, and describes emergency response procedures for the Site. HASP implementation and compliance is the responsibility of Brown and Caldwell, with ARC taking an oversight and compliance assurance role. Copies of the HASP are located at the Site, in ARC's La Palma, California office, and in Brown and Caldwell's Carson City, Nevada office. The HASP includes:

- Safety and health risk or hazard analysis;
- Employee training requirements;
- Personal protective equipment (PPE);
- Medical surveillance;
- Site control measures (including dust control);
- Decontamination procedures; and
- Emergency response.

The HASP includes a section for Site characterization and analysis that will identify specific Site hazards and aid in determining appropriate control procedures. Required information for Site characterization and analysis includes:

- Description of the response activity or job tasks to be performed;
- Duration of the planned employee activity;
- Site topography and accessibility by air and roads;
- Identified safety and health hazards;
- Hazardous substance dispersion pathways; and
- Emergency response capabilities.

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8.1 Training

All contractors will receive applicable training, as outlined in 29 CFR 1910.120(e) and as stated in the HASP. Site-specific training will be covered at the pre-entry briefing, with an initial Site tour and review of Site conditions and hazards. Records of pre-entry briefings will be maintained at the project site. Elements to be covered in site-specific training include:

- Persons responsible for site-safety;
- Site-specific safety and health hazards;
- Use of PPE;
- Work practices;
- Engineering controls;
- Major tasks; and
- Decontamination procedures and emergency response.

Other required training, depending on the particular activity or level of involvement, includes Occupational Safety and Health Administration (OSHA) 40-hour training and annual 8-hour refresher courses. Other training may include, but is not limited to, competent personnel training for excavations and confined space. Copies of Site personnel OSHA certificates will be maintained at the Site and in employee personnel records.

8.2 Personal Protective Equipment

Minimum PPE requirements while performing the sampling task or other field activities described in this Work Plan include:

- Hard hat;
- Safety glasses;
- Steel-toe boots;
- Long-sleeve shirt;
- High-visibility clothing or reflective vest; and
- Nitrile and/or leather work gloves (as needed).

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Additional PPE may be required depending on the work task and may include, but is not limited to, respirators, goggles, chemical protective suits, fall protection or hearing protection.

The use of respiratory protection is not anticipated to be necessary for the field activities identified in this Work Plan but each situation will be evaluated individually based on equipment used (potential to create dust), location (potential to encounter contaminated soils), and general field conditions. These items will be reviewed in a pre-start safety review that includes the Project Manager, field staff and the Site Safety Officer. If sufficient potential exists, all field personnel will be issued fit-tested respirators and monitoring will be conducted to determine actual dust or contaminant concentrations in the air. Actual use of respirators will only be required if concentrations exceed OSHA Permissible Exposure Levels (PELs). Further detail on the use and selection of respirators is provided in the HASP.

8.3 Ground Disturbance Safety Requirements

The proposed sample locations presented in this Work Plan are generally located on mine waste units, tailings and spent ore piles where underground utilities (e.g., electrical service, natural gas and other pipe lines), which have been deposited away from areas containing Site infrastructure. Because of the non-potential for these buried utilities in the investigation areas, standard underground utility locating procedures will not be implemented in the normal manner. As required by Nevada state law, a public utility locating service will be called and a ticket issued before the work begins, however, there will be no requirement for private utility locating service or hand clearance to 6.5 ft at each excavation area.

However, ARC will inspect each proposed location and verify that there are no visual indications that a utility may have been installed at the locations in the past. If any such indication is observed, the defined practice will be followed as described below. Also for any off-site sampling locations the defined practice will apply. The defined practice for full ground disturbance safety assessment includes implementation of the following steps:

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1. Call in a ticket request to the Nevada Utility Service Alert (USA) system at least 48 hours prior to the start of work for identification of any public utilities that may occur in the planned disturbance area.
2. Scan the disturbance area with electromagnetic and/or ground penetrating radar to identify the occurrence of any privately installed utilities such as pipelines or mine site electrical lines. This task must be done be a qualified line finder, typically a private utility locator.
3. Hand clear to a depth of 6.5 feet, or to the maximum depth of the disturbance, to confirm the absence of unidentified underground utilities in the work area.
4. Preparation and approval of a "Ground Disturbance Permit" by an authorized site issuing authority prior to the start of work.
5. Closure of the Ground Disturbance Permit at the completion of work to ensure the work site was left in a safe condition.

8.4 Safety Risk Analysis

Work Risk Assessment (WRA) is a tool that is used to identify the hazards associated with all aspects of a specific project and to then identify the preventive actions that can be implemented to minimize the hazards. Control of the hazards can be accomplished by: 1) elimination of the task; 2) use of engineering controls to reduce exposure to the hazard; or 3) use of PPE to protect personnel from injury.

WRAs are completed for the field tasks required in this Work Plan before the work is initiated and are developed jointly by the field staff conducting the work and the Site Safety Manager. All field staff and sub-contractors review the WRAs before conducting the work and frequently throughout the task to identify new hazards or controls. The preliminary WRA for this Cover Materials characterization project has been prepared and provided in Appendix E and is subject to revision at any time before or during implementation of these field activities. A general summary of the potential hazards for sample collection activities is provided in Table 8-1.

A more comprehensive safety assessment, called a Task Safety and Environmental Analysis (TSEA), will be prepared by the field staff for each task described in the WRA before work is initiated and all safety risk documents will be reviewed with all workers and shall be kept at the work site.

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Table 8-1. Work Risk Assessment Summary

Field Activities	Potential Hazards
1. Sample collection by excavation	▪ Physical injury from moving parts of machinery, hydraulic fluids. ▪ Physical hazards to personnel on the ground in the vicinity of the heavy machinery ▪ Potential to fall into open excavations. ▪ Lifting and ergonomic hazard from handling soil samples.
2. Sample collection by hand auger or shovel	▪ Muscle fatigue and back strain from twisting motion. ▪ Blisters on hands.
3. General Activities	▪ Heat stress due to high ambient temperature, improper clothing, lack of ventilation, lack of water, or lack of shade; or ▪ Hypothermia or frostbite due to low ambient temperature, improper clothing, damp or wet clothing, or lack of source for heat. ▪ Sunburn from lack of shade or improper clothing. ▪ Biological hazard from contact with spiders, insects or reptiles. ▪ Driving/mobilization related hazards. ▪ Wind related injuries including dust hazards to eyes.
4. Unsafe conditions	▪ Unexpected hazardous conditions such as wind, rain, snow, fire, earthquake, or other natural disaster can occur. ▪ Slip-trip hazards due to uneven ground surfaces.

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SECTION 9.0

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