Portage

**PLN-5005**
**Rev. 1**

# Reclamation Work Plan for the Broken Hill Mine Site, Sanders County, Montana

| Applicability: Broken Hill Mine | Effective Date: 04/03/09 | Owner: Pat Seccomb |
|---|---|---|
| For most recent revision or additional information: https://sharepoint.portageinc.com/default.aspx | | Signature: |

## History of Revisions

| Revision | Issue Date | Action | Description |
|---|---|---|---|
| 0 | 02/20/09 | New Document | Initial Issue |
| 1 | 04/03/09 | Revise Document | Incorporation of MDEQ comments. |
| | | | |
| | | | |

# Table of Contents

## Figures



## Tables

# Acronyms and Abbreviations

| | |
| --- | --- |
| AA | atomic adsorption |
| ABA | acid base accounting |
| ASA | American Society of Agronomy |
| BHMS | Broken Hill Mine Site |
| CEC | cation exchange capacity |
| CLP | contract laboratory program |
| CVAA | cold vapor atomic absorption |
| DEQ/MWCB | Montana Department of Environmental Quality/Mine Waste Cleanup Bureau |
| DO | dissolved oxygen |
| DQO | data quality objective |
| EA | evaluation of alternatives |
| ED | engineering design |
| EEE/CA | expanded engineering evaluation and cost analysis |
| ELI | Energy Laboratories, Inc. |
| EPA | U.S. Environmental Protection Agency |
| FHC | Frontier Historical Consultants |
| FSP | field sampling plan |
| ft | foot |
| GW | groundwater |
| $H_2SO_4$ | sulfuric acid |
| HHS | human health standards |
| HMI | hazardous materials inventory |
| $HNO_3$ | nitric acid |
| HSP | health and safety plan |
| in. | inch |

| | |
| --- | --- |
| ICP | inductively coupled plasma |
| J | estimated quantity |
| LAP | laboratory analytical plan |
| lb | pound |
| LCS | laboratory control standard |
| MBMG | Montana Bureau of Mines and Geology |
| MCL | maximum contaminant level |
| µg/L | micrograms per liter |
| $mg/m^3$ | milligrams per cubic meter |
| mg/kg | milligrams per kilogram |
| MS | matrix spike |
| MSD | matrix spike duplicate |
| ORP | oxygen reduction potential |
| oz | ounce |
| ppm | parts per million |
| PRG | preliminary reclamation goal |
| QA | quality assurance |
| QAPP | quality assurance protocol plan |
| QC | quality control |
| RA | risk assessment |
| RBCG | risk-based cleanup guidelines |
| RI | reclamation investigation |
| RPD | relative percent difference |
| RSL | regional screening levels |
| RWP | reclamation work plan |
| SC | site characterization |

| | |
|---|---|
| SPLP | synthetic precipitation leaching procedure |
| SS | soil |
| TAL | target analyte level |
| TDS | total dissolved solids |
| TPR | technical procedure |
| TRL | target reporting level |
| U | undetected |
| USDA | U.S. Department of Agriculture |
| USFS | United States Forest Service |
| XRF | x-ray fluorescence |
| $yd^3$ | cubic yard |

# 1. INTRODUCTION

Portage, Inc. (Portage) signed Task Order Number 7 from the Montana Department of Environmental Quality, Mine Waste Cleanup Bureau (DEQ/MWCB). Task Order Number 7 was issued pursuant to DEQ Contract No. 407025 between Portage and DEQ/MWCB and was effective as of November 10, 2008. The purpose of this task order is to prepare a Phase I Reclamation Work Plan (RWP) report, conduct an onsite reclamation investigation (RI), and prepare a RI report for the Broken Hill Mine Site (BHMS). The BHMS is an abandoned hard rock mine in Sanders County, Montana. It was a historical producer of silver, lead, and zinc. The mine lies approximately 3 miles from the Montana-Idaho border, approximately 4 miles north of Heron, Montana.

## 1.1 Work Plan Organization

Prior to preparing this RWP, existing data for the BHMS were obtained from DEQ/MWCB. The RWP is organized into four sections with references presented at the end of the document. The RWP satisfies Task 1 under Portage Task Order No. 7. The contents of each section are briefly described below.

Section 1 presents the purpose, organization, and management of the BHMS investigation.

Section 2 describes the environmental setting of the BHMS, including (1) climatic, geologic, and hydrologic characteristics of the site; (2) the biological setting such as the wildlife resources and the vegetation indigenous to the area; and (3) present land uses and local population.

Section 3 presents a summary of past metal mining activities and the results of past sampling and analysis at the site; a summary of the estimated types, volumes, and contaminant concentrations from existing data; and provides a discussion of land ownership information and cultural issues.

Section 4 presents the RWP for the BHMS, including (1) preliminary reclamation objectives and goals; (2) field sampling plan (FSP); (3) quality assurance protocol plan (QAPP); (4) laboratory analytical plan (LAP); (5) health and safety plan (HSP); (6) permitting requirements; and (7) estimated RI costs.

## 1.2 Project Management Plan

The DEQ/MWCB and Portage team of professionals working on the investigation and evaluation of the BHMS is presented in Section 1.2.1. The preliminary schedule for completing tasks and submitting plans and reports is presented in Section 1.2.2.

### 1.2.1 Project Team

The successful completion of this project requires the continual cooperation between DEQ/MWCB and Portage personnel. The DEQ/MWCB and Portage personnel working on this project are presented in Table 1.

The responsibilities of the DEQ/MWCB and the Portage project team members are presented below.

Table 1. Project team for the Broken Hill Mine.

| Agency/Firm | Personnel | Project Title | Contact Information |
|---|---|---|---|
| DEQ/MWCB | John Koerth | Section Supervisor | 841-5026 |
| | Pebbles Clark | BHMS Project Manager | 841-5028 |
| Portage | Pat Seccomb | Project Liaison/Project Manager | 406-782-2822 |
| | Meg Babits | Field Team Leader | |
| | Mike Towler | Field Team Member | |
| | Ray Schwaller, P.E. | Civil Engineer | |
| | Brienne Meyer | Health and Safety | |
| | Jennifer Norman | Quality Assurance | |
| | Edward Roemer | Technical Support Team Member | |
| | Jennifer Hancock | Technical Support Team Member | |

#### *1.2.1.1 MWCB Personnel*

- Section Supervisor—The section supervisor oversees all DEQ/MWCB activities.
- Project Manager—The DEQ/MWCB project manager will monitor the performance of the contractor, review and approve quality assurance (QA) measures, and provide direction to the Portage project liaison, project manager, and field team leader, as well as coordinate all site activities with the property owner.

#### *1.2.1.2 Portage Personnel*

- Project Liaison/Manager**—**The project manager will administer all project activities, staffing, and budgets and coordinate project activities with the DEQ/MWCB project manager. They will oversee project field activities and work products. The project manager/project liaison will keep the field team informed of all project activities.
- Field Team Leader—The field team leader will oversee the field sampling activities and coordinate with the DEQ/MWCB project manager to schedule all field activities.
- Field Team Member—The field team member will have primary responsibility for completing the engineering evaluation, the development and screening of reclamation alternatives during the expanded engineering evaluation and cost analysis (EEE/CA) phase, and assist the field team leader to complete the field activities.
- Civil Engineer—Support the field team to identify engineering data needs for the RI, review all engineering products completed as part of the EEE/CA.
- Health and Safety Coordinator—Review the health and safety plan and provide guidance and direction to the field team leader on the safe conduct of the RI.

- QA Manager—The QA manager will review all work products for technical quality and consistency and coordinate data review, validation, and auditing requirements as necessary.

- Technical Support Team Members—The technical support team members will assist the Portage project manager to complete all work products.

### 1.2.2 Project Schedule

The preliminary project schedule is presented in Table 2. This schedule assumes that field work can be conducted in June 2009, and that the work assignments and agency and stakeholder review(s) proceed in a steady and continuous manner. The effective dates of Task Order No. 7 are November 10, 2008, through September 30, 2009.

Table 2. Broken Hill Mine project schedule.

| Document Submittal and Task | Date |
|---|---|
| Draft Reclamation Work Plan | February 2009 |
| Final Reclamation Work Plan | April 2009 |
| Reclamation Field Activities | June 2009 |
| Draft Reclamation Investigation Report | August 2009 |
| Final Reclamation Investigation Report | September 2009 |

# 2. ENVIRONMENTAL SETTING

The environmental setting of the BHMS is provided in Sections 2.1 through 2.6.

## 2.1 Setting and Climate

The BHMS is located in Sanders County, Montana, approximately 4 miles north of Heron, Montana (Figure 1). The site falls within the Blue Creek Mining District, which is bordered to the west by the Clark Fork District, to the south by the Clark Fork River, and the drainage of Blue Creek and the East Fork of Blue Creek form the northeastern boundary. The BHMS is situated at an elevation of approximately 4,200 feet (ft) above mean sea level in Section 10, Township 27 North, Range 34 West, Montana, principle meridian (Latitude North 48° 07’ 15” and Longitude West 115° 58’ 06”). The BHMS is comprised of approximately 1.5 acres of metal mining impacted land. The surrounding area consists of moderately steep to steep mountain slopes and hillsides (25°).

The climate of the BHMS is based on the nearest climate station at the Kalispell, Montana, airport. Average monthly temperatures range from a high of 80.1°F in July to a low of 12.7°F in January. Average annual precipitation is 50 to 60 inches (in.) per year with June (16.5 in.) as the wettest month of the year (WRCC 2008). Precipitation predominantly comes in the form of snow in the winter months, as snow and rain in the spring and fall, and as rain in the summer.

## 2.2 Geology and Soils

During the Proterozoic Era, a shallow subsiding marine basin formed in Northwestern Montana where great thicknesses of homogeneous sand, silt, clay, and carbonate sediments accumulated.

Low-grade regional metamorphism later indurated these sediments into a mixture of resistant quartzites, siltites, argillites, and limestones; this thick sequence of fine-grained, quartzite-rich calcareous and non-calcareous rocks is the Belt Series. The Belt Series is subdivided into four general groups in ascending order: Lower Belt or Pre-Ravalli, Ravalli, Middle Belt Carbonate, and Missoula Groups (Montana Agricultural Experiment Station and USDA 1980). The BHMS is in the Ravalli Group. The Montana Bureau of Mines and Geology (MBMG) reported that selected dump samples at the BHMS contained pyrite, pyrrhotite, sphalerite, galena, chalcopyrite, and arsenopyrite. They are present in a gangue of quartz, tourmaline, and tremolite. The dominant geologic feature of the district is the Hope fault, a large northwest-trending transverse fault that extends from at least Hope, Idaho, to Heron, Montana (MBMG 1963).

Hard fine-grained Belt Series rocks typically weather to fine sandy or loamy soils with high percentages of coarse fragments. Most soils are weakly developed. These Sharrott series soils consist of shallow residual or colluvial soils, developed on the moderately sloping to steep ridges and mountain slopes of hard thinly-bedded argillite at 3,000 to 4,500 ft elevation. They are well-drained soils with medium runoff and moderate permeability ranging from 0.6 to 2.0 in. per hour (in./hr). Depth to bedrock is typically 4 to 20 in. and coarse fragment content is 50 to 80%. Clay content is usually 5 to 20%. They are slightly sticky (after pressure, soil adheres to both thumb and finger and tends to stretch somewhat before pulling apart) to slightly plastic (moderate pressure is required to deform soil mass) when wet. Soils may be classified as a loamy-skeletal, mixed Lithic Ustocrept (Montana Agricultural Experiment Station and USDA 1980).

## 2.3 Hydrogeology

The MBMG Groundwater Information Center database lists one well log within a 1-mile radius of the BHMS. The well is located one mile to the northwest in Section 2 of Township 27North and Range 34 West. The well has a static water level of 92 ft below ground surface, a yield of 5 gallons per minute, and is used for domestic purposes (GWIC 2008). There are no lithologic details available for this well. The Groundwater Information Center database lists 35 well logs within a 4-mile radius of the BHMS.

## 2.4 Hydrology

The BHMS is located within the watershed of an unnamed, ephemeral tributary to the East Fork of Blue Creek. The unnamed, ephemeral tributary of the East Fork of Blue Creek lies 100 ft to the north of the BHMS and reaches its confluence with the East Fork of Blue Creek approximately 0.75 mile downstream from the BHMS. The East Fork of Blue Creek reaches its confluence with Blue Creek 2 miles from there.

Blue Creek empties into Cabinet Gorge Reservoir of the Clark Fork River 0.5 mile from the confluence of the East Fork with Blue Creek proper. The unnamed, ephemeral tributary of the East Fork of Blue Creek begins approximately 4,000 ft above the BHMS (USGS 1997). All previous site visits have noted the unnamed, ephemeral tributary as being dry; however, all previous site visits (see Section 3.2) occurred in August or October (the August 1993 inventory completed by Pioneer was a year with abnormally wet conditions; 1993 precipitation is recorded as approximately 100% above normal).

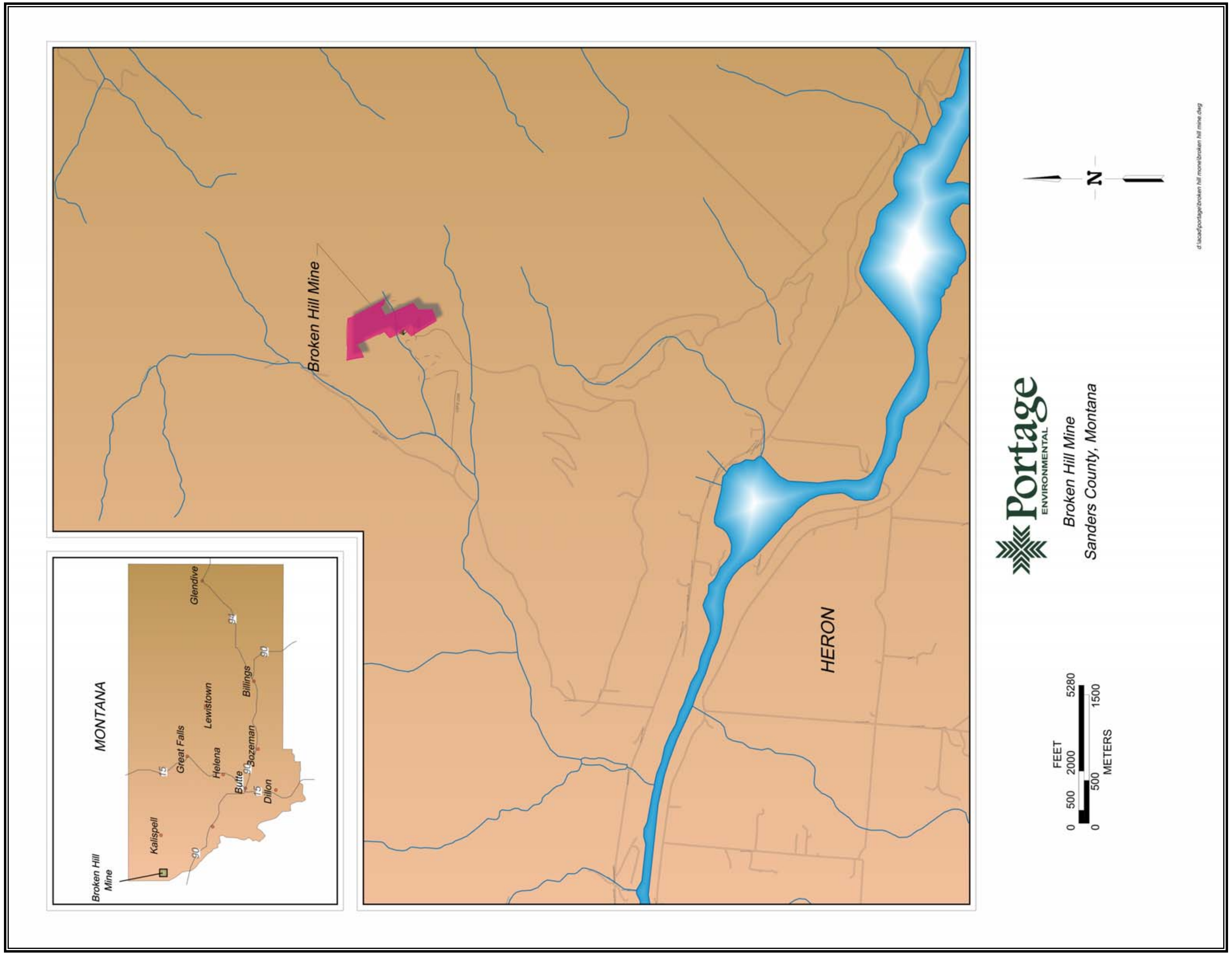



Figure 1. Broken Hill Mine site location map.

THIS PAGE INTENTIONALLY LEFT BLANK

## 2.5 Vegetation and Wildlife

The BHMS is characterized by native plants growing on undisturbed areas around the site; little or no vegetation is currently growing on the waste rock piles. Dominant trees on site include Douglas fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), and Sitka Alder. Shrubs and other vegetative species include thimbleberry (MNHP 2008). Other trees, shrubs, and forbs are found across and around the site in lower densities. There is regrowth of the forest in some mining impacted areas particularly on the lower haul road used for mining operations. Knapweed is widespread in all areas of relatively recent disturbance, with the exception of the waste rock dumps.

The habitat type supports a variety of wildlife—deer, elk, bobcat, black bear, potentially lynx and wolverine, and miscellaneous smaller mammals such as rabbits, squirrels, mice, and voles (MNHP 2008). Many species of birds are found around the site throughout the year including various songbirds, owls, and raptors.

## 2.6 Land Use and Population

The BHMS is located on private land and the Kootenai National Forest. The primary land use in the vicinity of the site is commercial (logging) and recreational. The population in Sanders County is 10,227 people, with four persons per square mile (USCB 2000).

# 3. DESCRIPTION OF THE PROPERTY

The following sections describe the history of mining operations, previous studies, and the current environmental condition of the BHMS property.

## 3.1 Site History

The early history of the Broken Hill Mine contains conflicting accounts. Early Mine Inspector reports state the first period of significance for the Broken Hill Mine was in 1906 when there was intermittent small-scale production. However, later sources put the development of the mine in the early 1920s, which is consistent with the original patent filing in 1920 (FHC 2002). The mine was worked by varying owners and operators until 1930 when it became inactive.

The 1920 patent survey recorded two tunnels, seven drifts, two crosscuts, and a raise. The mine was worked through a series of tunnels. The ore was oxide of iron carrying as much as 80% excess iron which made it desirable for fluxing. The MBMG reports that the Federal Bureau of Mining production records indicate 273 tons of ore were produced from 1925 to 1927, 942 ounces (oz) of silver, 53,057 pounds (lb) of lead, and 176,632 lb of zinc. The Federal Bureau of Mining reported two adits (opening of a tunnel): one 350 ft long and another 108 ft long with a raise connecting the two adits (MBMG 1963).

The mine remained closed until 1965 when other owners and operators had renewed interest in mining at the Broken Hill Mine. Approximately 94 tons of ore were shipped in 1966. Road improvements, tunnel repair, and ore removal were performed; however, in 1973, the mine was inactive again and remains inactive today. Less than 400 tons of ore were recorded as being shipped from the Broken Hill Mine since its original discovery (RTI 2002).

## 3.2 Previous Site Work

### 3.2.1 Northern Engineering and Testing Inventory 1988

The DEQ/MWCB contracted with Northern Engineering and Testing (currently Tetra Tech, Inc.) to inventory abandoned mines throughout the state in 1988. Northern personnel visited the site in August 1988. The inventory reported a partially collapsed, suspended ore loading chute at the lower waste rock dump (which has since completely collapsed), two adits (still present), water discharging from the lower adit at 25 gallons per minute (still flowing), and a small caved shaft above the upper adit. This small caved shaft reported by Northern personnel is called a small excavation or cut by Pioneer (Section 3.2.2) and an adit by Frontier Historical Consultants (FHC) personnel (Section 3.2.3). No shaft was ever reported by the owners and the MBMG did not report any shafts present during mine visits in the 1960s. A copy of the inventory field form is presented in Appendix A.

### 3.2.2 Pioneer Hazardous Material Inventory 1993

The DEQ/MWCB contracted with Pioneer, to inventory 276 abandoned mines throughout the state in 1993 and 1994. Pioneer visited the BHMS in August 1994. Pioneer personnel estimated approximately 6,200 cubic yards ($yd^3$) of waste rock were located within the BHMS boundary associated with two collapsed adits and a small excavation (cut). Water discharge was noted from the lower adit; however, there was no direct runoff pathway to surface water identified (Pioneer 1994).

Two waste rock samples, one composite waste rock sample from each of the waste rock dumps, and one unfiltered water sample collected at the adit discharge, were submitted to the laboratory for analysis (WR-1, WR-2, and GW-1, respectively). Using these data, a hazardous materials inventory (HMI) was completed for the BHMS and was included in the HMI summary report. A copy of the HMI report is included in Appendix B.

### 3.2.3 Frontier Historical Consultants Cultural Resources Inventory 2001

The DEQ/MWCB contracted with FHC in 2001 to perform a Cultural Resource Inventory at the BHMS. FHC visited the site in October 2001. FHC reports the site has greatly diminished integrity due to salvage and natural forces and recommended the site not be considered for the National Register of Historic Places. FHC's report, based on research and a site visit, was submitted in 2002. FHC noted seven features at the site:

- Four collapsed adits
- A building platform
- Two ore storage and transportation structures.

The first collapsed adit, referred to as Feature F-1 by FHC, was located 58 ft above United States Forest Service (USFS) road 2290. This adit was referred to as a shaft by Northern and a small excavation (cut) by Pioneer. Feature FI was estimated at 20 by 5 ft and oriented 130°. The waste rock platform was estimated to be 2 by 8 ft and had a 30-ft toe slope oriented at 284°.

The second collapsed adit (noted as the adit associated with WR-1 in the HMI) was on USFS road 2290. The collapsed adit was reported as 12 ft wide and backwasted 27 ft. The waste rock forms a semi-circular platform 48 ft wide and extended out 46 ft at 260°. The toe slope was 48 ft and oriented 210°.

The third collapsed adit (noted as the adit associated with WR-2 in the HMI) was reported as 150 ft from the top of the toe slope of WR-1. It was reported as backwasted 48 ft at 85° and was 30 ft wide near the headwall. At the time, it was noted piles of timbers flanked the 8-ft-wide collapsed portal and water was discharging. The FHC personnel reported the waste rock associated with this adit as having two lobes.

The fourth collapsed adit is to the north (41 ft at 0°) of the adit associated with WR-2. This adit was not noted in the text of the Northern or Pioneer reports. The report states this adit is 40 by 16 ft and oriented at 90°. It was overgrown with Douglas fir and alder trees and probably produced the north lobe of WR-2.

The building platform was reported 12 ft at 320° from the collapsed adit at WR-2. The building is reported as entirely removed with only an indistinct outline and a few degraded, discarded building materials. The ore storage structure is the ore bin located 81 ft at 230° from the top of the toe of WR-2. The log structure was reported as 12 ft wide with an indeterminate length because waste rock material obscures it; however, 14 log tiers were visible. The ore transportation structure was the collapsed load-out. No mine rail or mine carts were reported as present.

### 3.2.4 Renewable Technologies Landowner/Operator Investigation 2002

The DEQ/MWCB contracted with Renewable Technologies, Inc., in 2002 to prepare an owner/operator history for the BHMS. Renewable Technologies, Inc. did not visit the site. Their summary findings are presented in Sections 3.1 and 3.3 of this report.

### 3.2.5 Portage Site Visit 2008

The DEQ/MWCB contracted with Portage to complete an initial site visit in fall 2008. On October 9, 2008, MDEQ/MWCB and Portage personnel toured the BHMS, accessing the site via USFS road 2290. The road had a locked gate 2 miles from the BHMS. The USFS road 2290 had some tight switch backs, rocks, and small trees.

The road accesses the BHMS at the pad for the upper waste rock dump (WR-1). The adit to WR-1 is quite collapsed.

Feature F1, as reported in the Cultural Resources report (58 ft above the collapsed adit of WR-1), is barely observable (just a surface disturbance of 2 to 3 ft) with no waste rock or the waste rock is indistinguishable from surrounding material). In consultation with MDEQ/MWCB, there are no plans to sample or evaluate the feature as part of this plan because doing so would cause more damage than its current state.

The lower waste rock dump and its discharging adit is located downslope from the upper waste rock dump or the lower mine road, which enters at the pad of the lower waste rock dump. As noted, this road is densely overgrown with saplings 5 to 6 ft high.

The adit continues to discharge as of October 2008, and the discharge appears to behave as it did during prior site inspections, disappearing into the waste rock as it exits the adit. Photos from the 2008

MDEQ/MWCB visit are presented in Appendix C.

## 3.3 Current Owners

The following details the land ownership for the discrete elements of the BHMS (RTI 2002):

1. The upper adit and waste rock dump are located on the patented Broken Hill claim, MS #10572. The Broken Hill claim is currently owned by a private company Cabinet Mountain Properties, Heron, Montana.

2. The lower adit and waste rock dump are located on the unpatented Tuesday lode MS #10572. These and the surrounding lands are administered by the Kootenai National Forest.

## 3.4 Description of the Current Property

The BHMS is on the southwest slope of Billiard Table Mountain in Sanders County, Montana. The site elevation is approximately 4,200 ft above mean sea level and is located in Section 10, Township 27 North, Range 34 West (Figure 1). An unnamed, ephemeral tributary of the East Fork of Blue Creek lies to the north of the BHMS. The unnamed, ephemeral tributary enters the East Fork of Blue Creek 0.75 of a mile below the BHMS. The small community of Heron is about 4 miles to the south. The Scotchman No. 7 claim, MS #10568 is in proximity.

### 3.4.1 Waste Characteristics

Pioneer personnel completed a hazardous materials inventory at the BHMS for DEQ/MWCB in 1993 during which solid (waste rock) and liquid (groundwater) matrices were investigated (Figure 2). The following summarizes the sampling efforts.

- One waste rock sample was collected from the west of Feature F1 in the Cultural Resources report at the top of the hill (WR3), which is estimated at 30 $yd^3$ of material. Pioneer did not note the location on a map.

- Three waste rock samples were collected from the small excavation (WR1-A) and the upper waste rock dump (WR1--B, and -C) which was estimated at 170 $yd^3$.

- Two samples were collected from the lower waste rock dump (WR2-A and -B), which was estimated at 6,000 $yd^3$.

All the waste rock samples were analyzed on-site with a portable x-ray fluorescence (XRF) spectrometer for metals. Field pH and radioactivity were also collected onsite. Based on XRF analyses, WR1-A, -B, and -C, and WR-3 were combined into sample WR-1 and WR2-A and -B were combined into sample WR-2. Both WR-1 and WR-2 were sent to an offsite laboratory for total metals analyses and acid/base accounting (total sulfur, sulfate sulfur, pyretic sulfur, and organic sulfur).

The results of the metals analyses from the laboratory are presented in Table 3. Arsenic, cadmium, copper, iron, mercury, lead, antimony, and zinc were measured above background levels (i.e., contained levels three times above the background soil or any level if background level was a nondetect) as determined from a soil sample collected at the Holliday Mine site in Sanders County. The XRF analytical results can be viewed in Table 4.

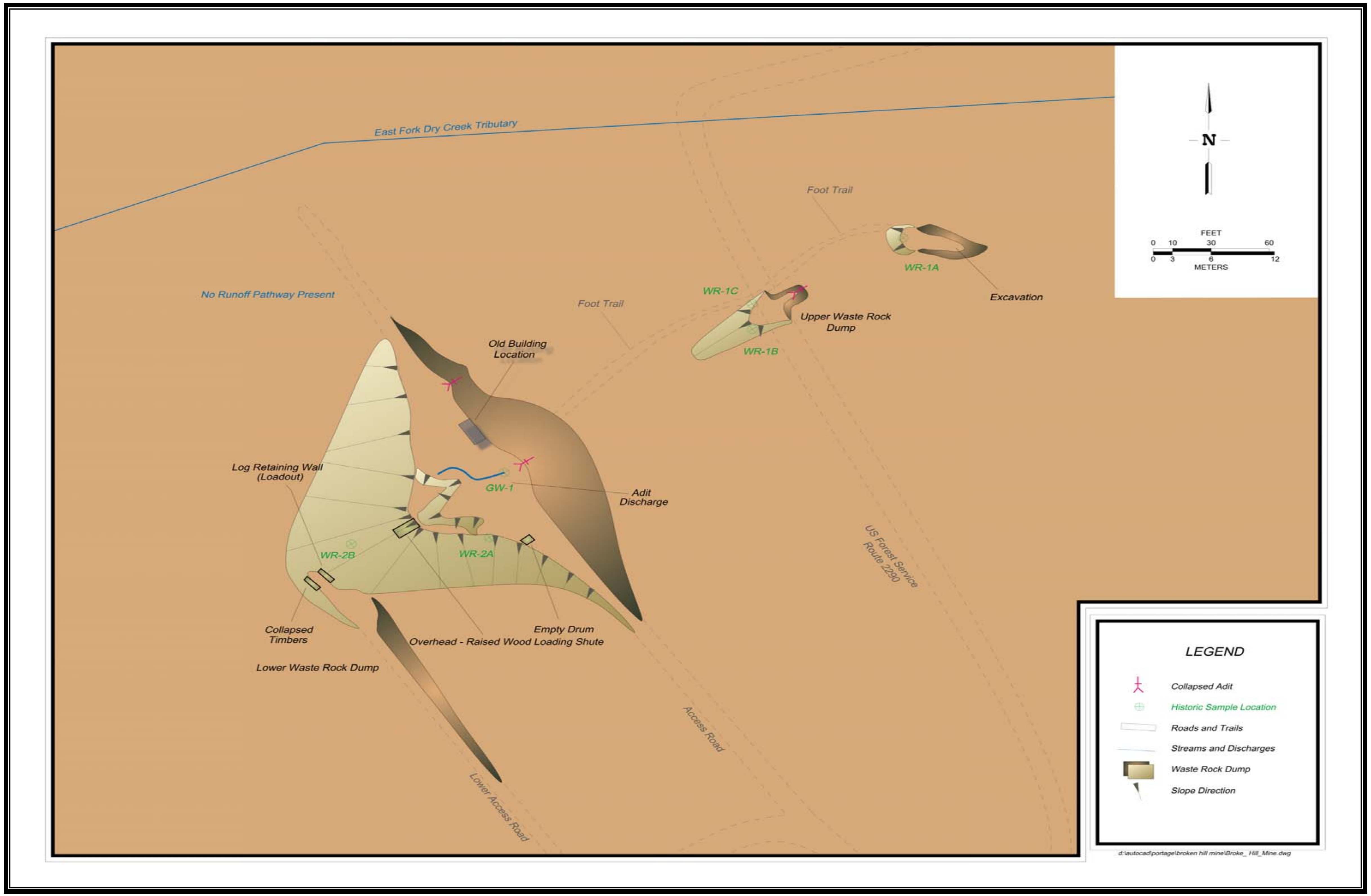



Figure 2. Historic sample location map Broken Hill Mine site.

THIS PAGE INTENTIONALLY LEFT BLANK

Table 3. Broken Hill Mine historic laboratory analytical results.

| Field ID | As | Ba | Cd | Co | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Waste Rock Samples** | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| WR-1 | 1140 | 27.9 | 15.2 | 7.25 | 5.25 | 342J | 94400 | 24.2J | 992 | 3.84 | 55900J | 344 | 9600 |
| WR-2 | 508 | 19.8 | 26 | 5.86 | 4.5 | 140J | 44200 | 2.53J | 426 | 6.23 | 18700J | 61.3 | 11400 |
| **Water Sample** | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| GW-1 | 30.4 | 2.01U | 2.57U | 9.7U | 6.83U | 2.97 | 69.6 | 0.044J | 15.2 | 12.7U | 107 | 30.7U | 867 |

J = Estimated quantity
U = Not detected
µg/L = micrograms per liter
mg/kg = milligrams per kilogram

Table 4. Broken Hill Mine historic XRF results.

| Field ID | Silver | Arsenic | Barium | Calcium | Cadmium | Cobalt | Chromium (High) | Chromium (Low) | Copper | Iron |
|---|---|---|---|---|---|---|---|---|---|---|
| **Waste Rock Samples** | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm |
| WR1-A | 180.738* | | 140.934 | 1300.84 | | 550.725 | 365.038* | 203.588* | 98.4646* | 94962.8 |
| WR1-B | | | 48.8326* | 997.152 | 255.897* | 674.602 | 621.981* | | 400.884 | 89196.9 |
| WR1-C | | 230.7 | 304.392 | 1396.52 | | | | 174.768* | 86.1975* | 32126.4 |
| WR2-A | | | 174.889 | 945.541 | | | | | 173.514* | 65176.6 |
| WR2-B | | | 413.322 | 2994.29 | | | | | 142.261* | 51254.8 |
| WR3 | 616.526* | | 89.8487* | 3732.81 | | 1455.75* | 482.43* | | 597.114 | 181063 |
| WR-1 | 231.406* | | 125.317 | 2195.92 | 251.935* | 918.133* | | | 406.608 | 110745 |
| WR-2 | | | 257.347 | 2159.34 | | | 383.543* | | 171.66* | 65835.8 |
| WR-2 (duplicate) | | | 296.306 | 2236.71 | | 432.031* | | | 175.765 | 68796.6 |
| **Field ID** | **Potassium** | **Manganese** | **Lead** | **Rubidium** | **Antimony** | **Strontium** | **Thorium** | **Titanium** | **Zirconium** | **Zinc** |
| **Waste Rock Samples** | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm |
| WR1-A | 14752.2 | 1566.44 | 16486.4 | 125.755 | 128.867* | 27.5093* | | 1259.48 | 198.968 | 8067.61 |
| WR1-B | 5090.21 | | 43946.3 | 83.04* | 201.859 | 386474* | | 437.957 | 130.446 | 5482.23 |
| WR1-C | 26241.3 | 4204.74 | 1158.45 | 197.226 | | 181062* | 21.5592* | 2106.73 | 229.568 | 2979.45 |
| WR2-A | 18830.4 | 1060.29* | 11575.7 | 181.219 | 76.9297* | 21.7083* | 33.8282* | 1544.67 | 217.387 | 4655.63 |
| WR2-B | 16079.5 | 1134.57* | 12926.9 | 170.8 | 69.382* | 54.2273 | 28.4652* | 2090.41 | 244.608 | 2030.36 |
| WR-3 | 5549.98 | | 47270.2 | | 1911.44 | | | 1165.8 | 136.79 | 506406 |
| WR-1 | 10866.8 | 1529.46* | 34122.8 | 99.3553* | 636.824 | 64.3026 | | 1180.72 | 187.831 | 5352.95 |
| WR-2 | 171.42.4 | 663.145* | 15142.1 | 175.841 | 100.177* | 39.3539 | 33.586* | 1725.75 | 239.503 | 5517.7 |
| WR-2 (duplicate) | 16466.6 | 891.663* | 14008.6 | 167.834 | 155.472* | 37.4987 | 24.3571* | 1724.56 | 251.803 | 3046.92 |

ppm = part per million
* Estimated quantity.

One unfiltered water sample was collected from the discharge at the lower adit (GW-1). The sample was analyzed on-site for pH, specific conductance, Eh, temperature, and alkalinity as calcium carbonate. The sample was sent to the laboratory for total metals, total dissolved solids (TDS) hardness, chloride, sulfate, and nitrate-nitrite analyses. A split sample was collected for the owner. Arsenic and lead were found to be higher than the Montana Numeric Water Quality Standards (DEQ-7) for human health in the groundwater sample (DEQ 2008).

# 4. RECLAMATION WORK PLAN

This RWP has been prepared as a functional guide for conducting the RI at the BHMS. The Montana DEQ/MWCB has directed Portage to prepare a RWP to include: a FSP, a QAPP, a LAP, and a HSP. The four supporting plans are presented in Sections 4.2 through 4.5.

## 4.1 Preliminary Reclamation Objectives and Goals

The preliminary reclamation objectives and goals for the BHMS are discussed in the following sections.

### 4.1.1 Preliminary Reclamation Objectives

The overall objective of the BHMS reclamation project is to protect human health and the environment. Specifically, site reclamation should limit human and ecological exposure to mineral processing-related contaminants and reduce the mobility of those contaminants through associated solid media and water exposure pathways. The final reclamation objectives, including the specific amount of contaminant exposure and mobility reduction required, will be determined after site characterization, risk assessment, and analysis of the applicable or relevant and appropriate requirements are completed.

***4.1.1.1 Groundwater.*** Preliminary reclamation goals (PRGs) for groundwater at the BHMS are based on Human Health Standards (HHS) reported in the Montana Numeric Water Quality Standards circular (DEQ-7). The HHS is derived from priority pollutant criteria and maximum contaminant levels (MCLs) from drinking water regulations (DEQ 2008). Water discharging from the lower adit flows onto the waste rock dump, with no evident surface flows downstream. Groundwater is presumed to have filled the underground mine workings of the BHMS and is discharging from the lower adit. There is no apparent surface pathway for water from the discharging adit to the unnamed, ephemeral drainage of the East Fork of Blue Creek.

Laboratory metal analyses for the unfiltered water sample collected from the adit discharge (GW-1) as part of the 1993 HMI, showed arsenic and lead concentrations to be higher than the groundwater HHS (DEQ 2008). Arsenic and lead are human health contaminants of concern. Table 5 presents the groundwater PRGs for metals of concern at the BHMS.

The adit discharge forms a 1-ft × 1-ft × 3-in. basin at the adit outlet. While field notes were not available for the 1993 sampling effort, it would be difficult to acquire a water sample here, without also acquiring sediment. As a result, it is not clear to what extent the arsenic and lead concentrations are dissolved in the discharge.

Table 5. Broken Hill Mine preliminary reclamation goals for groundwater (µg/L).

| Contaminant | 1993 Level | HHS[a] |
|---|---|---|
| Arsenic | 30.4 | 10[b] |
| Lead | 107 | 15[c] |

µg/L = micrograms per liter
a. HHS = Human Health Standards for Water, Circular DEQ-7, Montana Numeric Water Quality Standards (DEQ 2008).
b. Maximum Contaminant Level, Circular DEQ-7 Montana Numeric Water Quality Standards (DEQ 2008).
c. Priority Pollutant, Circular DEQ-7 Montana Numeric Water Quality (DEQ 2008).

***4.1.1.2 Soil.*** PRGs for soil (which includes mineral processing wastes) at the BHMS are based on U.S. Environmental Protection Agency (EPA) Region 9 regional screening levels (RSLs) for residential soil (EPA 2008) and DEQ risk-based cleanup guidelines (RBCG) for abandoned mine sites (DEQ 1996). The EPA RSLs and/or DEQ RBCG will be used for the BHMS for metals concentrations in soil for Montana.

Analysis of solid samples (waste rock) collected during the HMI in 1993 revealed concentrations of arsenic, cadmium, copper, iron, mercury, lead, antimony, and zinc at levels of potential concern (at least three times background levels or above the detection limit if the background level was undetected). Table 6 presents the soil PRGs for the metals of concern at the BHMS.

Table 6. Broken Hill Mine preliminary reclamation goals for soil (mg/kg).

| Contaminant | 1993 Level | | EPA RSL[a] | DEQ RBCG |
|---|---|---|---|---|
| | WR-1 | WR-2 | | |
| Arsenic | 1,140 | 508 | 0.39 (40)[b] | 0.7** |
| Cadmium | 15.2 | 26 | 70 | 19.5** |
| Copper | 7.25 | 5.86 | 3,100 | 27,100 |
| Iron | 94,400 | 44,200 | 55,000 | Not applicable |
| Mercury | 24.2J | 2.53J | 6.7 | 220 |
| Lead | 55,900J | 18,700J | 400 | 1,100 |
| Antimony | 344 | 61.3 | 310 | 220,000 |
| Zinc | 9,600 | 11,400 | 23,000 | 220,000 |

J = Estimated quantity
mg/kg = milligrams per kilogram
a. EPA RSL = Regional Screening Level Table, Residential Soil Values (EPA 2008).
b. 0.39 is the arsenic residential soil RSL for the carcinogenic endpoint. The Montana DEQ uses a soil screening value of 40 mg/kg for arsenic based on background arsenic values for Montana soils (DEQ 2005).
** - carcinogenic risk of 5E–07.

## 4.2 Field Sampling Plan

This FSP has been prepared as a guide for conducting the RI of the BHMS. The FSP presents sampling objectives and procedures, sample documentation and custody procedures, sample preservation and handling requirements, and decontamination procedures.

The purpose of the RI is to collect the information necessary to perform the risk assessments, to complete a future EEE/CA, and to select a reclamation alternative. Once the reclamation alternative has been selected, site- and alternative-specific engineering data may need to be collected to support design efforts. Data collected to support the human health and ecological risk assessments will aid in determining:

- The magnitude and extent of soil contamination
- The levels of dissolved metals in groundwater
- Metals concentration in background soil.

Data collected to support the development and evaluation of reclamation alternatives during the RI and EEE/CA will include:

- Accurate estimates of the area and volume of solid waste material requiring reclamation
- Data to determine if waste material requires special offsite handling
- Data to determine reclamation requirements for disturbed areas including soil texture and grain size, liming requirements, fertilizer requirements, percent organic matter, and identification of native species
- Location and characterization of potential repository sites
- Location of potential cover soil borrow area.

### 4.2.1 Sampling Objectives

Soil and water samples will be collected from the BHMS as part of the RI. Table 7 lists the sample number, analysis, location, and depth. These samples will be used to fulfill the sampling objectives. Figure 3 shows the proposed sampling locations. The sampling objectives for the BHMS are:

- Determine the nature and extent of soil contamination
- Determine soil background concentrations
- Collect additional data on metals contamination in groundwater present in the adit to determine current concentrations.

Table 7. Broken Hill Mine proposed soil, wasterock, and groundwater samples.

| Sample Location | Laboratory Analysis | Sample Number | Sample Depth (in.) |
|---|---|---|---|
| Upper waste rock dump | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-SS-1 | 0–3 |
| Upper waste rock dump | TAL Metals | BHMS-SS-2 | 0–3 |
| Upper waste rock dump | SPLP | BHMS-WR-1 | 0–3 |
| Lower waste rock dump | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-SS-3 | 0–3 |
| Lower waste rock dump | TAL Metals | BHMS-SS-4 | 0–3 |
| Lower waste rock dump | TAL Metals | BHMS-SS-5 | 0–3 |
| Lower waste rock dump | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-SS-6 | 0–3 |
| Lower waste rock dump | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-SS-7 Duplicate of SS-6 | 0–3 |
| Lower waste rock dump | SPLP | BHMS-WR-2 | 0–3 |
| Background | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-BG-1 | 0–3 |
| Background | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-BG-2 | 0–3 |
| Background | TAL Metals plus particle size (texture), CEC, agricultural analyses, ABA | BHMS-BG-3 | 0–3 |
| Opportunity sample | TAL Metals | BHMS-WR-3 | 0–3 |
| Opportunity sample | TAL Metals | BHMS-WR-4 | 0–3 |
| Lower waste rock dump | TAL total metals plus water quality parameters | BHMS-GW-1 | Not applicable |
| Lower waste rock dump | TAL dissolved metals plus water quality parameters | BHMS-GW-2 | Not applicable |
| Lower waste rock dump | TAL dissolved metals plus water quality parameters | BHMS-GW-3 Duplicate of GW-2 | Not applicable |
| Not applicable | TAL total metals plus water quality parameters | BHMS-GW-4 Rinsate of sampling equipment | Not applicable |

ABA = Acid base accounting (total sulfur, sulfate sulfur, pyretic sulfur, and organic sulfur)
Agricultural analyses = pH, conductivity, nitrogen, phosphorus, potassium, organic matter, and lime including a fertilizer requirement
CEC = Cation exchange capacity
SPLP = Synthetic precipitation leaching procedure
TAL = Target analyte list (antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc)
Water quality parameters = chloride, sulfate, nitrate/nitrite, forms of alkalinity/acidity, and total dissolved solids

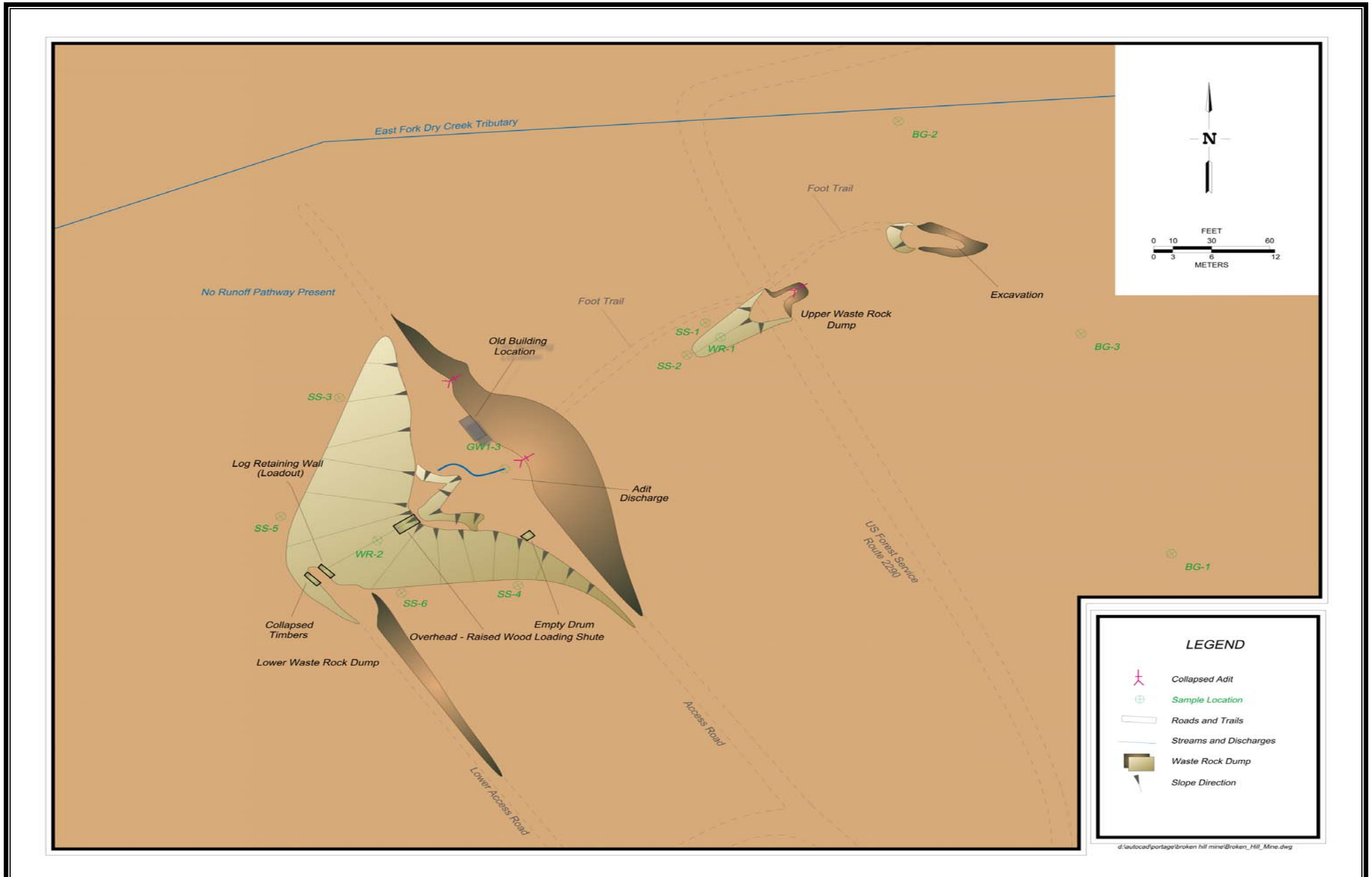



Figure 3. Proposed sample location map Broken Hill Mine site.

THIS PAGE INTENTIONALLY LEFT BLANK

### 4.2.2 Data Uses

The selected analyses (Table 7) will support the evaluation of the chemical, physical, and toxicological properties of the solid and liquid media found at the BHMS. The following sections summarize the importance of each analysis in developing a remedy for the BHMS.

***4.2.2.1 Metals.*** The TAL metals for all media at the BHMS will support a number of evaluations. Principally, the metals results will form the basis of human health and ecological risk assessments performed for the site. The total metals values will be used to determine cancer risks and systemic toxicity (hazards) based on contact with the media at the site, as well as to estimate potential ecological effects on the surrounding environment. These assessments will be used to direct the selection and design of a remedy, as risk reduction serves as the main driver for selecting remedy alternatives and implementing a remedy.

Secondarily, metals data will also be used to examine water quality from the discharging adit and potential impacts to water quality from metals in solid media, if they demonstrate a high degree of mobility in the environment under acidic conditions (synthetic precipitation leaching procedure [SPLP]). Prior sampling efforts at the BHMS have sought to identify contaminants and their concentrations in the various media (waste rock, soils, water). The RI will seek to better define concentrations and distribution in solid media, while examining if metals measured during the BHMS inventory in the adit discharge resulted from suspended sediment captured during sampling or reflect dissolved metals concentrations. This will be accomplished by collecting both filtered and unfiltered samples from the adit water and comparing the metals concentrations to one another.

***4.2.2.2 Water Quality.*** Wet chemistry/water quality parameters will be performed to augment the examination described for metals, by defining the composition of the water flowing from the adit. These parameters will also aid in understanding how conditions at the site may be affecting key parameters affecting environmental health such as chloride, sulfate, nitrate/nitrite, forms of alkalinity/acidity, and total dissolved solids.

***4.2.2.3 Solid Media Characteristics.*** In addition to the potential toxicity posed by metals, other chemical and physical characteristics are important when considering the effect of solid mine wastes on the long-term health of the watershed. They are also important in evaluating possible remedies during the EE/CA. Acid base accounting (ABA), cation exchange capacity (CEC), and nutrients such as pH, nitrogen, phosphorus, and organic matter are analyzed:

- To support an evaluation of solid wastes with respect to their ability buffer against metals mobility in the environment
- To aid in determining if final remedy requires chemical amendments to stabilize them
- If amendments are necessary to support revegetation at the site.

Soil type/particle size is analyzed to determine the types of solid material (particularly soils) will be considered in evaluating and selecting a remedy, providing insights to project engineers as they evaluate potential remedies such as repository sites, regarding, etc.

### 4.2.3 Soil Sampling Procedures

Two waste rock dumps have been identified for reclamation at the BHMS. Sample locations will include soil adjacent to the edge of the waste rock dumps, the waste rock, and native, undisturbed soil located a short distance from the obvious waste rock dump. Soil adjacent to the edge of the waste rock dumps will adequately represent soil underlying the waste rock dumps. These soil samples will aid in the determination of the extent of contamination. The edge of the waste rock will be determined using visual characteristics of soil texture, iron staining, and vegetative cover. Waste rock will be sampled to address the levels of contamination. Native, undisturbed soil located a short distance away from the obvious waste rock located in dumps will adequately represent soil that can be used for revegetation and levels of metals in naturally occurring soil.

Sample locations will be discrete, biased grab samples. Discrete samples are samples from separate locations (i.e., not composited) used to retain the character of the individual location. Biased grab samples are collected from locations not statistically determined and are intended to quantify the maximum concentration of constituents. A maximum of 12 solid matrix samples are proposed to be collected from the BHMS; they include:

- Three samples will be collected from the upper waste rock dump area; one sample from the waste rock dump and two samples from soil adjacent to the waste rock dumps.

- Six samples will be collected from the lower waste rock dump area; one sample from the waste rock dump and five samples from the soil adjacent to the waste rock dumps (one sample will be a duplicate and sent to the laboratory with a separate label to check data quality).

- Three samples will be collected from undisturbed, native soil adjacent to the waste rock dumps. Additionally, the plan allows for the collection of up to two opportunistic, bias grab samples, if necessary. For example, if disturbed material is found onsite that is not in the waste rock dumps.

All solid matrix samples will be obtained from a depth between surface and 3 in. below ground surface and will be collected using a disposable polyethylene sampling scoop or a stainless steel trowel. All reusable sampling equipment will be decontaminated in the field (see Section 4.2.6). Soil samples will be placed in quart-size or larger Ziploc® bags and labeled with sample number, location, time, date, and other required information (see following sections). Samples will be cooled to 4$^{o}$C following collection. The soil samples will be analyzed for 13 target analyte list (TAL) metals including: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc. The samples will be sent to Energy Laboratories, Inc., a DEQ-approved laboratory for total metals analysis (inductively coupled plasma [ICP]-atomic emission spectrometry methods). Selected samples will also be analyzed for particle size (texture), CEC, and agricultural analyses (pH, conductivity, nitrogen-phosphorus-potassium, organic matter, lime recommendation, and fertilizer recommendation) because of the possibility that the soil may be reclaimed in place if the total metals concentrations are below the PRG values. Technical procedure (TPR) -5008, “Surface Soil Sampling,” is used for the collection of a soil sample (see Attachment 1). All soil sampling locations will be staked and marked in the field and will be included in the site topographic survey.

### 4.2.4 Groundwater Sampling Procedures

There is one discharging adit at the BHMS at the lower waste rock dump. A total of four water matrix samples are proposed to be collected from the BHMS, they include:

- Two water samples will be collected from the adit discharge; one sample for total metals analyses and one for dissolved metals analyses. Dissolved metals analyses require the water sample to be filtered in the field prior to preservation. Filtering the water sample removes particles that may get in the sample bottle from stirring up sediment at the adit discharge.

- One water sample will be collected as a field duplicate. The dissolved metals groundwater sample will be collected in duplicate amount and sent to the laboratory with a separate label to check data quality.

- One water sample will be a rinsate of a piece of decontaminated, reusable, sampling equipment. This water sample checks the quality of the decontamination procedure.

The samples will be submitted for laboratory analyses of the TAL and water quality parameters including: nitrate/nitrite, total dissolved solids, chloride, sulfate, and forms of alkalinity/acidity. Hardness will be calculated from the calcium and magnesium levels measured in the total metals analyses. The groundwater samples will be preserved with nitric acid and submitted to Energy Laboratories, Inc., a DEQ-approved laboratory. Three sample bottles will be filled for each sample, one for metals analysis, one for nitrate/nitrite analysis, and one for total dissolved solids, sulfate, chloride, and alkalinity/acidity analyses. TPR-5011, “Stream Sampling,” is used for the collection of a groundwater sample flowing above ground as surface water or a stream (see Attachment 1).

Field analysis will be conducted on the water sampling location at the BHMS during sample collection. Field measurements will be recorded in the field logbook for each groundwater sample. The water quality parameters that will be measured in the field include: pH, specific conductance, oxygen reduction potential (ORP), dissolved oxygen (DO), and temperature and will be gathered using a field portable meter(s). The instruments will be calibrated using the manufacturer’s recommended procedures. The probes will be inserted into the water and the pH, specific conductance, ORP, DO, and temperature readings will be recorded. A check standard will be measured to verify instrument calibration prior to measuring the sample. The TPRs for using the pH meter, specific conductance and eh meter, and DO meter are TPR-5012, “Field Measurement of pH in Water,” TPR-5013, “Field Measurement of Specific Conductance and Oxidation-Reduction Potential,” and TPR-5007, “Measurement of Dissolved Oxygen Concentration in Water,” respectively (see Attachment 1).

#### 4.2.5 Sample Documentation and Custody

The possession and handling of each sample will be properly documented to promote timely, correct, and complete analysis for all required parameters. To promote sample integrity, each sample will be traceable from the point of collection through analysis and final disposition.

The field records and documentation control measures to be used during sample collection, identification, handling, and shipping include the following:

- Sample labels

- Custody seals

- Field sample data and chain-of-custody record.

The Portage field team leader is responsible for obtaining these items and distributing them to field personnel. All paperwork will be completed using indelible ink.

***4.2.5.1 Sample Designation.*** A sample numbering scheme has been developed that allows each sample to be uniquely identified and provides a means of tracking the sample from collection through analysis. The numbering scheme indicates the sample type and location. The unique sample number will be entered on sample labels, field tracking sheets, chain-of-custody forms, and other records documenting sampling activities. The following sample numbering system will be used for this investigation:

BHMS-WR-1

BHMS = Abbreviated Site Name

WR/SS/BG/GW = Sample Type

WR = Waste Rock Sample

SS = Soil Sample

BG = Background Soil Sample

GW = Groundwater Sample

1 = Sample Location

(i.e., BHMS-WR-06 would be a BHMS waste rock sample collected from the sixth soil sampling location.)

***4.2.5.2 Field Logbook.*** Daily field activities will be documented through journal entries in a bound field logbook, dedicated to the BHMS. Logbook entry and custody procedures will follow National Enforcement Investigation Center policies and procedures (EPA 1986). The logbook will be water-resistant, and all entries will be made in indelible ink. The logbook contains all pertinent information about sampling activities, site conditions, field methods used, general observations, and other pertinent technical information. Examples of typical logbook entries include the following:

- Personnel present
- Daily temperature and other climatic conditions
- Field measurements, activities, and observations
- Referenced sampling location description (in relation to a stationary landmark) and map
- Media sampled
- Sample collection methods and equipment
- Date and time of sample collection
- Types of sample containers used

- Sample identification and cross-referencing
- Sample types and preservatives used
- Analytical parameters
- Sampling personnel, distribution, and transporters
- Site sketches
- Instrument calibration procedures and frequency
- Visitors to the site.

The Portage field team leader or designee will be responsible for the daily maintenance of all field records. Each page of the logbook will be numbered, dated, and signed by the person making the entry. Corrections to the logbook will be made by using a single strike mark through the entry to be corrected, then recording and initialing the correct entry. For corrections made at a later date, the date of the correction will be noted.

Color photographs taken during the sampling activities will be numbered to correspond to logbook entries. The name of the photographer, date, time, site location, and photograph description will be entered sequentially in the logbook as photographs are taken.

***4.2.5.3 Chain-of-Custody Record.*** A chain-of-custody record establishes the documentation necessary to trace sample possession from time of collection through sample analysis and disposition. A sample is in the custody of a person if any of the following criteria are met:

- The sample is in a person’s physical possession
- The sample is in a person’s view after being in his or her physical possession
- The sample was in a person’s physical possession and was then locked up or sealed to prevent tampering
- The sample is kept in a secured area.

The sample collector will complete a chain-of-custody record to accompany each sample delivery container (cooler) and will be responsible for hand delivering or shipping samples to the laboratory. The sample collector will provide the project name (Broken Hill Mine), the DEQ tracking number, and the sample collector’s signature as header information on the chain-of-custody record. The billing contact will be listed as Ms. Pebbles Clark, MDEQ/AMWB. Section 4.4.2.6 details the laboratory report transmittal. For each sample location, the sample collector will indicate the date, time, sample location, number of containers, analytical parameters, and designated sample numbers. When shipping or delivering the samples, the sample collector will sign the bottom of the form and enter the date and time (military) that the samples were relinquished. If shipping the samples, the sample collector will enter the carrier name and air bill number on the form. The original signature copy of the chain-of-custody record will be enclosed in a plastic bag and secured to the inside of the cooler lid. A copy of the chain-of-custody record will be retained for Portage files and a copy will be included in the final RI report.

***4.2.5.4 Sample Shipment.*** Samples collected at the BHMS are proposed to be hand-delivered to Energy Laboratories, Inc. (ELI), in Helena, Montana. If another laboratory will be used that requires sample shipment, the following process will be used. All samples will be packaged and labeled for shipment in compliance with current regulations. Only metal or plastic ice chests will be used for shipping samples. The samples will be placed in the cooler and padded with bubble wrap to absorb shock. The chain-of-custody form will then be placed in a sealed plastic bag and taped to the inside of the cooler lid. The ice chest will be securely taped shut and the custody seals and shipping airbill will be attached. TPR-5009, "Soil and Water Sample Packaging and Shipping," is used for sample packing and shipping (see Attachment 1).

### 4.2.6 Sample Preservation and Handling

The preservation and holding time requirements for the samples are listed in Table 8. TPR-5010, "Inorganic Preservation (Water)," is used for sample preservation (see Attachment 1).

### 4.2.7 Decontamination Procedures

Decontamination will be required for all sampling equipment, personal protective gear, and field monitoring equipment used during field activities. Sampling equipment will be decontaminated between each sample. Liquinox or Alconox cleaning solutions and distilled water rinses will be used for all sampling equipment and tools. Decontamination procedures for specific equipment used in association with field activities are described in the following sections.

***4.2.7.1 Sampling Equipment.*** All nondisposable sampling equipment will be decontaminated before and after use. Disposable equipment will have gross contamination removed and then will be placed in a garbage bag and disposed of in the municipal trash. Sampling equipment may include shovels or hand trowels. Laboratory-supplied sample containers are provided pre-cleaned and will not require decontamination. TPR-5006, "Equipment Decontamination," is used for the decontamination of sampling equipment (see Attachment 1).

***4.2.7.2 Personnel.*** All personnel will be decontaminated prior to leaving the site according to TPR-5005, "Personnel Decontamation" (see Attachment 1).

### 4.2.8 Additional Information

The field team will also investigate the area for preliminary, potential repository locations. Depending on RI results, a repository for the waste rock may be necessary. The site is steep and a broad investigation will be necessary to determine if potential sites may exist. Both patented (owners of the Broken Hill claim own all patented claims in the area) and public land (the Forest Service may be willing to host a repository) will be evaluated.

Roads will be investigated for site access for machinery that may be required in the future. Information on road stability, slope, and angles of turns will be recorded in the field logbook. Finally, potential locations of soil available for borrow material will be evaluated. The DEQ/MWCB will subcontract surveying services to the BHMS. The survey data will be used to develop the EEE/CA to refine waste rock extent and quantity estimates.

Table 8. Broken Hill Mine sample collection, preservation, and holding time requirements.

| Matrix | Analyte | Preservation | Holding Time | Sample Size | Bottle |
|---|---|---|---|---|---|
| Solid | TAL Metals[a] | Cool to 4°C | 180 days; Mercury 28 days | 4 oz | 4-oz glass jar or quart-size Ziploc® bag |
| Solid | Particle Size[a] | None | None | 4 oz | 4-oz glass jar or quart-size Ziploc® bag |
| Solid | Cation Exchange Capacity[a] | None | None | 4 oz | 4-oz glass jar or quart-size Ziploc® bag |
| Solid | Complete agricultural (pH; N-P-K; OM; lime and fertilizer requirement)[a] | Cool to 4°C | None | 4 oz | 4-oz glass jar or quart-size Ziploc® bag |
| Water | TAL Metals | Cool to 4°C, $HNO_3$ to pH <2 | 180 days; Mercury 28 days | 250 mL | 250-mL polyethylene |
| Water | Total Dissolved Solids[b] | Cool to 4°C | 7 days | 500 mL | 500-mL polyethylene |
| Water | Alkalinity/Acidity[b] | | 7 days | | |
| Water | Sulfate[b] | | 28 days | | |
| Water | Chloride[b] | | 28 days | | |
| Water | Nitrate/Nitrite | Cool to 4°C, $H_2SO_4$ to pH <2 | 28 days | 250 mL | 250-mL polyethylene |

a. Analytes can be analyzed from the same 4-oz sample jar.
b. Analytes can be analyzed from the same 500-mL sample bottle.
$HNO_3$ = Nitric acid
$H_2SO_4$ = Sulfuric acid

## 4.3 Quality Assurance Protocol Plan

This QAPP has been prepared to support the RWP and FSP and describes the QA for the RI of the BHMS. This QAPP presents the data quality; QA objectives; QA sample collection procedures; sample documentation and custody; equipment operation, maintenance, and calibration; analytical procedures; data reduction, validation, and reporting; and corrective action procedures. A copy of this QAPP will be provided to the project laboratory for compliance.

### 4.3.1 Data Quality

The data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality of the data required to support the RI activities. The DQOs for the project and the type, analytical level, and use of the data are presented below.

***4.3.1.1 Data Quality Objectives.*** The DQOs were prepared using EPA guidance for the DQO process (EPA 2006). The EPA guidance presents the DQOs as a seven-step process:

1. State the Problem—Concisely describe the problem to be studied.
2. Identify the Decision—Identify what questions the study will attempt to resolve and what actions may result.
3. Identify the Inputs to the Decision—Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.
4. Define the Study Boundaries—Specify the time periods and spatial area to which the decisions will apply.
5. Develop a Decision Rule—Define the statistical parameter of interest, specify the action level, and integrate the previous DQO outputs into a single statement that describes the logical basis for choosing among alternative actions.
6. Specify Tolerable Limits on Decision Errors—Define the decision maker's tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.
7. Optimize the Design—Evaluate information from the previous steps and generate alternative data collection designs.

The following sections describe each step, as listed above, and how it pertains to the investigation of the BHMS.

***4.3.1.1.1 Step 1: Stating the Problem—***The BHMS is an abandoned mine site located north of Heron, Montana. Previous data indicate waste rock residing at this site contains elevated concentrations of arsenic, cadmium, copper, iron, mercury, lead, antimony, and zinc and the adit discharge contains elevated arsenic and lead. The waste rock poses a risk to groundwater and soil receptors, as well as human recreational users. The adit discharge poses a risk to water receptors and recreational users. The objective for the project is to protect human health and the environment.

***4.3.1.1.2 Step 2: Identify the Decision—***Previous data and inspections of the site revealed waste rock samples with elevated levels of arsenic, cadmium, copper, iron, mercury, lead, antimony, and zinc, and water with elevated levels of arsenic and lead. These materials may cause adverse impacts to human health and the environment. The following decisions will be made:

- What reclamation action is necessary at the site to protect human health and the environment?
- What is the areal extent and volume of waste rock and metal contaminated soil?
- How will the characteristics of the mine waste rock and underlying soil impact revegetation of the site?
- How will the physiography of the site affect reclamation alternatives?
- Are there suitable repository sites and soil borrow areas near the site?

***4.3.1.1.3 Step 3: Identify the Inputs to the Decision—***The areal extent of waste rock and metal contaminated soil and the characteristics of soil underlying the wastes will be determined by analyzing soil and groundwater samples for metals and reclamation parameters. The volume of wastes and the physiography of the site will be determined by completing a survey of site topography and site features.

***4.3.1.1.4 Step 4: Define the Study Boundaries—***The disturbed area at the BHMS covers approximately 1.5 acres in the SW1/4 of the SW1/4 of the NE1/4 of Section 10, Township 27 North, Range 34 West, in Sanders County, Montana.

***4.3.1.1.5 Step 5: Develop a Decision Rule—***The potential receptors at the site include recreational users, terrestrial wildlife, and vegetation. Reclamation of the site will be necessary if levels of contaminants in soil samples exceed the PRGs and pose unacceptable risks to human health and the environment. Reclamation may include, but is not limited to, mine waste removal and reclamation-in-place actions.

***4.3.1.1.6 Step 6: Specify Tolerable Limits on Decision Errors—***In general, environmental data may be strongly indicative of site conditions, but data are not absolutely definitive; therefore, decisions based upon the data could be in error. This is known as the decision error. This section discusses the limits on decision errors for this investigation.

Sampling error and measurement error are associated with environmental data collection and may lead to decision error. Sampling error occurs because it is impossible for a sampling effort to measure conditions at every point of a site or at every point in time. Sampling error occurs when the sample is not representative of the true state of the environment at a site. Measurement error occurs because of random and systematic errors associated with sample collection, handling, preparation, analysis, data reduction, and data handling. The two types of errors may lead to incorrect decisions or recommendations. In general, decision errors are controlled by adopting a scientific approach that uses hypothesis testing to minimize the potential for decision errors. EPA guidance suggests the following steps to identify and control decision errors:

- Define the possible range of the parameter of interest

- Define both types of decision errors and the consequences of each

- Specify a range of parameter values for which the consequences of decision errors are relatively minor.

Decision errors are evaluated through hypothesis testing. The reclamation may result in members of the public coming into contact with site wastes. Therefore, the null hypothesis for recreational use is that the site waste contains concentrations of contaminants above the risk-based recreation cleanup levels. The site may also have terrestrial wildlife and vegetation that are exposed to site wastes. Therefore, the null hypothesis for vegetation and terrestrial wildlife receptors is that site waste materials are contaminated. There are two types of decision errors:

1. False-Negative Error—A false-negative decision error occurs when the hypothesis is rejected although it is true. In the case of this project, the decision-maker would determine that the site does not contain mineral processing wastes, soil, or groundwater that requires additional reclamation although concentration levels do require additional reclamation. The consequences of a false-negative error would be that contaminated soil and groundwater are left in place instead of being reclaimed.

2. False-Positive Error.—A false-positive decision error occurs when the hypothesis is not rejected although it is false. In the case of this project, the decision-maker would determine that the site contains mineral processing wastes, soil, and groundwater that require reclamation (based on the results of the analytical data), although the concentrations of contaminants in the wastes, soil, or groundwater do not require reclamation. The consequences of a false-positive error would be that unnecessary resources may be spent to perform additional reclamation to address contamination that does not exist at levels exceeding action levels or acceptable risk levels.

Limits on decision errors due to sampling error will be minimized by using the analytical results from the site inspection and HMI (see Appendix B) and visual observations to identify contaminated areas. The sampling approach will be to collect enough data to define the areal and vertical extent of contamination.

***4.3.1.1.7 Step 7: Optimize the Design—***The collection of soil samples should be adequate to accept or reject the null hypothesis for recreational exposure. Visual examination of the site together with incorporation of previous site analytical data will be used to bias the collection of samples. The analytical results will be used to locate and characterize the extent of contamination, risk assessment, and reclamation design.

***4.3.1.2 Data Type, Analytical Level, and Use.*** Table 9 presents DQOs, including data analysis or measurement, location of that measurement, analytical method, analytical support level, sample media, and the data use.

The analytical support levels are the analytical options available to support data collection activities. There are five general levels that are distinguished by the types of technology, documentation use, and degree of sophistication, which are:

1. Level V—Nonstandard methods. Analyses that may require method modification and development.

Table 9. Broken Hill Mine summary of data quality objectives.

| Analysis | Location | Analysis Method | Analytical Support Level | Media | Data Use |
|---|---|---|---|---|---|
| TAL Metals | Laboratory | EPA 6020a/7471b | IV | SS, GW | SC, RA, EA, ED |
| Particle Size | Laboratory | ASA15-5 | III | SS | SC |
| Cation Exchange Capacity | Laboratory | EPA 6020a | III | SS | SC |
| Complete and Partial Agricultural Analysis | Laboratory | ASA and USDA | III | SS | SC |
| Nitrate/Nitrite | Laboratory | EPA 353.2 | III | GW | SC, RA, EA, ED |
| Total Dissolved Solids | Laboratory | EPA 160.1 | III | GW | SC, RA, EA, ED |
| Alkalinity/Acidity | Laboratory | EPA 310.1 | III | GW | SC, RA, EA, ED |
| Sulfate | Laboratory | EPA 300.0 | III | GW | SC, RA, EA, ED |
| Chloride | Laboratory | EPA 300.0 | III | GW | SC, RA, EA, ED |
| Specific Conductivity, Temperature | Field | Manufacturer's Instructions | II | GW | SC |
| pH, Oxygen Reduction Potential, Dissolved Oxygen | Field | Manufacturer's Instructions | II | GW | SC |

ASA = American Society of Agronomy (ASA 1996)
EA = Evaluation of Alternatives
ED = Engineering Design
GW = Groundwater
RA = Risk Assessment
SC = Site Characterization
SS = Soil
TAL = Target analyte list (antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc)
USDA = U.S. Department of Agriculture

2. Level IV—This level is characterized by rigorous QA protocols and documentation and provides qualitative and quantitative analytical data. The documentation includes all information required to complete the full data validation as defined in the National Functional Guidelines for Inorganic Data Review (EPA 1994).

3. Level III—This level is used primarily in support of engineering studies using standard EPA-approved procedures. Some procedures may be equivalent to Level IV analysis without the requirements for documentation.

4. Level II—Field analysis. This level is characterized by the use of portable analytical instruments on site or in mobile laboratories stationed near the site. Examples of field screening instruments include portable X-ray fluorescence spectrometers, gas-chromatographs, and water quality meters.

5. Level I—Field screening. This level is characterized by the use of portable instruments that can provide real-time data to assist in optimizing sampling point locations and for health and safety support. Examples of Level I analysis include photoionization detector, explosive atmosphere, and oxygen content measurements.

Analytical levels to be implemented during the BHMS activities are Levels II, III, and IV.

### 4.3.2 Quality Assurance Objectives

The overall QA objective for the BHMS is to produce well-documented data of known quality. Meeting this objective involves establishing and meeting goals for precision, accuracy, completeness, representativeness, comparability, and target reporting limits for the analytical methods. The Portage QA manager for the BHMS project will be responsible for communicating QA objectives and expectations with the project laboratory and working with the DEQ/MWCB project manager to meet designated QA standards.

If analytical data fail to meet the QA objectives described in this section, Portage will explain in the RI report why the data failed to meet the objectives (i.e., because of matrix interferences), and will describe the limitations and usability of the data. The following corrective actions may be taken for data that do not meet QA objectives: (1) verify that the analytical measurement system was in control, (2) thoroughly check all calculations, (3) use data qualifiers, and (4) assuming a sufficient quantity of sample is available, reanalyze the affected samples, if authorized by the DEQ project manager. Corrective actions for internal QA and quality control (QC) are presented in detail in Section 4.3.8.

The data precision, accuracy, and completeness requirements are listed in Table 10 and Table 11 lists the target reporting limits (TRLs) for all analytes of concern by each analytical method. The quantitative and qualitative QA objectives are presented below.

***4.3.2.1 Quantitative QA Objectives.*** Quantitative QA objectives that will be evaluated for the laboratory data include completeness, accuracy, precision, and method detection limits. The following sections discuss the calculation of each QA objective.

***4.3.2.2 Precision and Accuracy.*** Precision and accuracy are indicators of data quality. Generally, precision is a measure of the variability of a group of measurements compared to their mean value. Laboratory analytical precision is estimated by calculating the relative percent difference (RPD) between the analytical results from the laboratory matrix spike (MS) and matrix spike duplicate (MSD) samples and the field duplicate samples. There is no extra sample volume required for the laboratory to perform MS/MSD sample analysis.

The RPD between the analyte levels measured in the MS and MSD sample (or sample duplicates) will be calculated using Equation (1).

$$RPD = \frac{MS\text{-}MSD}{0.5(MS\text{-}MSD)} \times 100\% \qquad (1)$$

where

RPD = Relative percent difference

MS = Matrix spike

MSD = Matrix spike duplicate.

Accuracy is a measure of the bias in a measurement system. Analytical accuracy for laboratory data is assessed by evaluating matrix spike sample percent recovery, instrument calibration data, and laboratory control sample results.

Table 10. Broken Hill Mine precision, accuracy, and completeness requirements.

| Analyte | Matrix | Precision | Accuracy | Completeness |
|---|---|---|---|---|
| Metals | Soil | <35% RPD between homogenized sample aliquots | Calibration, LCS to CLP data validation<br>Functional guideline criteria<br>Matrix Spike Recovery 75 to 125% | 90% |
| | Water | <20% RPD between duplicate samples | Calibration, LCS to CLP data validation<br>Functional guideline criteria<br>Matrix Spike Recovery 75 to 125% | 90% |
| Particle Size | Soil | <35% RPD between homogenized sample aliquots | Method-specified calibration | 90% |
| Cation Exchange Capacity | Soil | <35% RPD between homogenized sample aliquots | Method-specified calibration | 90% |
| Sulfate | Water | <20% RPD between duplicate samples | Method-specified calibration | 90% |
| Chloride | Water | <20% RPD between duplicate samples | Method-specified calibration | 90% |
| Field Parameters | Water | <10% RPD between replicate measurements | Method-specified calibration | 90% |

CLP = Contract Laboratory Program
LCS = Laboratory check sample
RPD = Relative percent difference

Table 11. Broken Hill Mine target reporting limits for soil and water metal analysis.

| Analyte Type | Method | Analyte | Reporting Limit Soil (mg/kg) | Reporting Limit Water (µg/L) |
| --- | --- | --- | --- | --- |
| TAL Metals | EPA 6020a, 7471b | Antimony | 5 | 5 |
| | | Arsenic | 5 | 5 |
| | | Barium | 5 | 100 |
| | | Cadmium | 1 | 1 |
| | | Chromium | 5 | 10 |
| | | Copper | 5 | 10 |
| | | Iron | 5 | 30 |
| | | Lead | 5 | 10 |
| | | Manganese | 5 | 10 |
| | | Mercury | 0.5 | 1 |
| | | Nickel | 5 | 10 |
| | | Silver | 5 | 5 |
| | | Zinc | 5 | 10 |

µg/L = micrograms per liter
mg/kg = milligrams per kilogram

Accuracy will be estimated by calculating the percent recovery of laboratory MS samples using Equation (2).

$$\%R = \frac{(C_j - C_o)}{C_t} \times 100\% \qquad (2)$$

where

%R = Percent recovery

$C_j$ = Measured concentration in spiked sample aliquot

$C_o$ = Measured concentration in unspiked sample aliquot

$C_t$ = Actual concentration of spike added.

Precision and accuracy goals depend on the types of samples and analysis to be performed and the ultimate use of the analytical data. The project laboratory is responsible for calculating precision and accuracy for the BHMS samples. These values will be reviewed by the Portage QA manager to determine if the values are within the specified project DQOs.

***4.3.2.3 Completeness.*** Completeness is defined as an assessment of the amount of valid analytical data obtained from a measurement system compared to the amount of analytical data needed to achieve a particular statistical level of confidence. The percent completeness is calculated by dividing the number of samples with acceptable data by the total number of samples planned to be collected, and multiplying the result by 100. For this project, the QA objective for degree of completeness for the laboratory is 90%.

If completeness is less than 90%, Portage will provide documentation explaining why this objective was not met, and the impact, if any, of a lower percentage on the project. Completeness will be reported as the percentage of all measurements judged valid. Equation (3) will be used to determine completeness:

$$\%C = (V/T) \times 100\% \qquad (3)$$

where

%C = Percent completeness

V = Number of measurements judged valid

T = Total number of measurements.

The completeness target for this project is 90%.

***4.3.2.4 Target Reporting Limits.*** The TRLs for soil and water metals analyses are listed in Table 11. The TRL is defined as the lowest concentration that needs to be reported for undiluted samples to obtain project objectives. The laboratory will try to achieve the lowest reporting limits possible for all measurements and will notify the Portage QA manager if the detection limits for the samples exceed the TRLs. If samples are diluted to qualify constituents present at high concentration levels or to reduce matrix interferences, the reporting limit will be calculated as the reporting limit for the particular matrix multiplied by the dilution factor. The actual matrix reporting limits for each sample will vary depending on the concentration of analytes present and the presence of any interference.

***4.3.2.5 Qualitative QA Objectives.*** Qualitative QA objectives that will be evaluated include sample representativeness and comparability. The following sections present an analysis of the representativeness and comparability for each matrix to be sampled.

***4.3.2.6 Representativeness.*** Representativeness is the degree to which sample data represent the site conditions. Sampling locations will be selected to obtain representative soil and groundwater samples. Representative data will also be obtained through the proper collection and handling of samples and will be measured with the equipment rinsate sample and the laboratory blank.

***4.3.2.7 Comparability.*** Comparability expresses the confidence with which one data set can be compared to another. Comparability will be maximized by using standard EPA methods and standard sampling techniques. Portage will document all sample locations, conditions, and field sampling methods. All results will be reported in standard units or, for field parameters, as defined in the method. All laboratory calibrations will be performed with standards traceable to the National Institute for Standards and Technology or to EPA-approved sources.

### 4.3.3 Quality Assurance Sample Collection Procedures

Various types of QA/QC samples will be collected during the field investigation activities: sample duplicates and a rinsate sample.

***4.3.3.1 Duplicate Samples.*** The RI field team will collect one duplicate sample of each media type (water and solid matrix) from the BHMS to be analyzed for metals.

***4.3.3.2 Rinsate Sample.*** The RI field team will collect one rinsate sample of decontaminated sampling equipment if nondisposable sampling equipment is used.

### 4.3.4 Sample Documentation and Custody

The possession and handling of each sample will be properly documented to promote timely, correct, and complete analysis for all required parameters. To promote sample integrity, each sample will be traceable from the point of collection through analysis and final disposition. Sample documentation and custody procedures are presented in Section 4.2.4.

### 4.3.5 Equipment Operation, Maintenance, Calibration, and Standardization

The procedures and frequency for field instrument operation, initial and continuing calibration verification, and maintenance requirements are described in the analytical methods or instrument manufacturer's calibration procedures (Appendix C). Calibration data will be recorded in the field logbook as will the source and method of preparation of the standard solutions used. Portage will calibrate all field analytical equipment before it is shipped to the field, and daily, before and after use. All calibration standards will be prepared from commercially available NIST, EPA-traceable, or EPA-certified standards. The laboratory instrument operation, calibration, and maintenance procedures are described in the analytical method.

### 4.3.6 Analytical Procedures

The field and laboratory analytical methods that will be used are listed in Table 9. Laboratory analysis of samples collected during the RI will be completed by ELI in Helena, Montana. ELI has established QA protocols that meet or exceed EPA guidelines. The EPA methods will be used whenever they are available for the target analyte.

### 4.3.7 Data Reduction, Validation, and Reporting

Procedures must be used to ensure that all laboratory data generated and processed are scientifically valid, defensible, and comparable. The following sections describe the data reduction, validation, and reporting procedures that will be used in this RI. This information will be provided with ELI to ensure DQOs are met.

***4.3.7.1 Data Reduction.*** In accordance with standard document control procedures, ELI will maintain on file the original copies of all data sheets and logbooks containing raw data, signed and dated by the responsible analyst. Separate instrument logs will also be maintained by the laboratory to enable a reconstruction of the run sequences for individual instruments.

The laboratory will store all residual samples as per the contract with DEQ. For the first 60 days after the laboratory receives the samples, samples and sample extracts will be stored in a refrigerator at 4°C. After that time, they may be stored at room temperature.

***4.3.7.2 Data Validation.*** Portage and the laboratory will validate all laboratory data by comparing the QC data to the criteria listed in the analytical method or in the National Functional Guidelines for Inorganic Data Review (EPA 1994). Analytical outlier data are defined as QC data lying outside a specific QA objective range for precision or accuracy for a given analytical method. If QC data are outside control limits, corrective action procedures will be applied to determine the probable causes of the problem. If necessary, the sample will be reanalyzed, and only the reanalyzed results reported. If the problem is with the matrix, both initial and reanalyzed results will be reported and identified in the laboratory report. If reanalysis is not feasible, the initial analysis results will be reported and the results will be flagged and identified in the laboratory report.

The laboratory project manager and QA coordinator will be responsible for laboratory data validation. The Portage project manager and Portage QA manager will be responsible for post-laboratory data validation of all data generated by the laboratory. The soil and water metal data will be validated using the procedures described in National Functional Guidelines for Inorganic Data Review (EPA 1994).

***4.3.7.3 Reporting.*** Data will be reported in standard units as described in the analytical methods. The laboratory project manager will be responsible for reviewing the laboratory report. The completed laboratory report will be approved by the laboratory project manager. The laboratory will provide all raw data necessary to fully validate the data. Each data package will include the following items:

- Case narrative including a statement of samples received, description of any deviation from standard procedures, explanation of any data qualifiers used, and any problems encountered during analysis.
- A QC summary report including applicable surrogate recoveries, MS and MSD, recoveries, method blank results, and laboratory control sample recoveries. This report must identify all QC outliers and describe their impact on data quality and usability.
- Chain-of-custody records.
- Reporting limits.
- Analytical instrument run logs.
- Analytical instrument raw data for samples, blanks, and standards.
- Initial calibration information.
- Continuing calibration information.
- Laboratory accuracy and precision limits.
- All values below reporting limits and above method detection limits.
- Date of analysis.

The final report will contain a QA/QC summary that discusses whether the final data meet the original project QA objectives. If the QA objectives are not met, the report will contain an explanation of the impact on the evaluation of the project objectives.

### 4.3.8 Corrective Action Procedures

Corrective actions will be taken when any problems are identified in the program that affects product quality. The laboratory project manager and the Portage QA manager, or their designees, are responsible for identifying the causes of the problems and developing a solution.

The cause of the problem must first be determined so that the effect of the problem on the overall program can be identified. The field team (and if necessary, the DEQ/MWCB project manager) will then develop a plausible corrective action. The effects of the action will be examined to determine whether the problem is addressed.

If the corrective action is initially successful, the laboratory project manager, or designee, will prepare a corrective action memorandum describing the corrective action, how and when it will be implemented, and the expected results. A copy of the memorandum will be sent to the Portage project manager and QA manager and then to the DEQ/MWCB project manager. The laboratory project manager, or designee, will be responsible for implementing the corrective action and assessing its effectiveness. Procedures are presented below for correcting (1) problems detected during audits, (2) laboratory problems, and (3) data outside control limits.

***4.3.8.1 Laboratory Corrective Actions.*** The laboratory QA manager will review laboratory procedures to identify conditions or procedures that may have an adverse impact on data quality. The QA manager will then assess the impact on the quality of the associated data, and then identify the corrective actions to be implemented. All conditions or procedures that may have an adverse impact on data quality will be included in the laboratory reports.

***4.3.8.2 Data Outside Control Limits.*** The manner in which data outside of control limits are handled will depend on where the nonconformance is discovered. During data review in the laboratory, if QC checks fail to meet acceptance criteria, either the data will be flagged in accordance with standard EPA-defined data flags, or the nonconformance will be discussed in the case narrative. During the post-laboratory data validation, the data will be reviewed and assigned to one of the following three categories:

1. Valid-Unqualified—This category is used for all data that meet all QC criteria without any qualifier. These data are useful for any purpose, and are not flagged.

2. Valid-Qualified—Data placed in this category are valid, but their usefulness may be limited in certain situations. These data may be qualified as “estimated,” which is indicated by use of a “J” flag, or by the use of a specific flag that conveys information about the limitations of the data.

3. Invalid or Rejected—Data are considered to be invalid in cases such as failure to properly ice samples that require storage at $4^{o}$C during shipment. These data are flagged with an “R” and are considered to be unusable for any purpose.

Data will be validated using EPA guidance documents and the specific requirements of this QAPP. If certain data appear to be borderline between two categories, the data validator may seek the advice of the individuals cited in Section 1.3.1 as having a QA function.

## 4.4 Laboratory Analytical Plan

This LAP describes laboratory requirements for conducting the RI at the BHMS. Analysis of the solid matrix samples (soil and wasterock) and liquid matrix samples (groundwater) will be conducted during the RI. All analytical work is to follow the requirements listed in this LAP for the duration of the project. This LAP contains four sections including sample collection requirements, laboratory requirements, QA requirements, and analytical methods.

#### 4.4.1 Sample Collection Requirements

Samples will be collected from soil and groundwater at the BHMS. The number and type of samples are specified in Table 7 (Section 4.2).

The matrix, analyte, required preservation, holding time, sample size, and containers to be used during the BHMS RI are specified in Table 8 (Section 4.2). Whenever possible, standard EPA protocols will be used.

#### 4.4.2 Laboratory Requirements

The primary laboratory will be contracted by DEQ for all total metals, particle size (texture), CEC, agricultural analyses, and water quality analyses. The primary laboratory may use a separate laboratory for certain physical and chemical analyses. All analyses performed by the project laboratories should follow the analytical methods listed in Table 9, which includes the applicable reference for each method.

***4.4.2.1 Qualifications and Experience.*** The laboratory shall designate and use key personnel meeting the minimum requirements, as specified below, and comply with all terms and conditions of the contract. Experience is defined as more than 50% of the person's productive work time in active participation on a given task and includes the following:

1. The ICP emission spectroscopist responsible for work under this contract must have at least 1 year of experience in the operation of the ICP on soil and water samples.

2. The furnace atomic absorption (AA) spectroscopist responsible for the work on this contract must have at least one year of experience in the operation of a furnace AA on soil and water.

3. The hydride generation AA and cold vapor AA (CVAA) spectroscopist responsible for work on this contract must have specific training in hydride applications and at least 1 year of experience in the operation of hydride generation AA and CVAA.

4. The inorganic sample preparation expert performing sample preparation for this contract must have at least 3 months of experience in the preparation of environmental samples for ICP and AA analysis.

5. The analyst or technician responsible for determining soil pH on the contract must have at least 6 months of experience in the technique and instrumentation.

6. The sample custodian, who is responsible for receiving, logging, and tracking the samples for the laboratory, must have at least 3 months of experience. This requirement is necessary because of the large number of samples and complexity of the project.

The laboratory shall have in place an acceptable QA plan. The plan shall designate key QA individuals by name and shall define their responsibilities. The plan shall detail the mechanisms for checking whether laboratory procedures are within control and shall detail the corrective actions and responsibilities for out-of-control conditions.

***4.4.2.2 Subcontracting.*** Subcontracting portions of this work by the primary laboratory is acceptable for special analysis, but subcontracting must be approved by the DEQ/MWCB BHMS project manager, Ms. Pebbles Clark. All laboratories in this project must abide by the LAP and the QAPP.

***4.4.2.3 Confidentiality.*** Analytical results are to be held in the strictest of confidence and will be discussed with only those individuals approved by the DEQ/MWCB BHMS project manager, Ms. Pebbles Clark.

***4.4.2.4 Reporting Times.*** Analytical results are to be reported within 30 working days of sample receipt by the laboratory. If at all possible, holding, analysis, and reporting times should be minimized.

***4.4.2.5 Reporting Format.*** The data report package for the TAL metals will not initially include a standard EPA Contract Laboratory Program (CLP) package, but the laboratory must save all the run data on magnetic media in order to generate a CLP package on request for a period of 2 years following completion of the analysis. The laboratory should obtain written permission from the Montana DEQ/MWCB prior to disposing of any archived data support packages. The data support package provided as a deliverable should include the following:

1. Cover letter documenting analytical protocols used.

2. Copies of completed chain-of-custody forms.

3. Cross-reference table of contractor and laboratory identification numbers.

4. Data summary tables (hard copy and electronic media in format to be negotiated between Portage and the laboratory).

5. QA/QC summaries including laboratory control samples (LCS), spikes, duplicates, and preparation blank results.

The physical parameters and other specialized chemical analyses, such as particle size, CEC, and fertilizer and lime requirements, should comply with the above five components, when applicable.

***4.4.2.6 Report Transmittal.*** All data reports are to be sent directly to Ms. Pebbles Clark, DEQ/MWCB, P.O. Box 200901, Helena, Montana 59620 and to Pat Seccomb, Portage, Inc., 103 N. Main St., Butte, Montana 59701. An electronic copy of the data report should be sent to Ms. Pebbles Clark, pclark2@mt.gov, and Mr. Pat Seccomb, pat-seccomb@qwest.net.

### 4.4.3 Quality Assurance Requirements

The mechanism used to monitor the precision and accuracy of environmental data is the analysis of field and laboratory QC samples. The required field QC types and frequency are provided in the QAPP. The required laboratory QC requirements are specified in this LAP when the CLP statement of work for inorganics (EPA 1992), or the analytical method does not define the QC requirement. Laboratory QC includes method blanks, duplicates, matrix spikes, and LCS. These QC requirements are to be performed at a frequency of one per 20 samples except for particle size analysis, components of the lime requirement, and CEC. The CEC will only have duplicates performed. The ranges for precision (duplicates) and accuracy (matrix spikes) acceptability are presented in the QAPP. The method blank should have a reported value within the method detection limit of the instrument detection limit.

### 4.4.4 Analytical Methods

Analytical methods are summarized in Table 8 with the appropriate reference document(s). The project laboratories should contact Ms. Pebbles Clark or Ms. Jennifer Norman for permission to deviate from the listed analytical methods for the project analyses.

***4.4.4.1 Detection Limits.*** The instrumentation used must be sensitive enough to meet the required detection limits. Instruments for target analyte analyses are ICP, AA, and CVAA. The detection limits for the parameters presented in Table 11 (Section 4.3) are included in the analytic reference methods.

***4.4.4.2 Storage Requirements.*** The contracted laboratory is required to have a secured sample bank for storage of samples, digestates, and extracts. Original samples will be stored in the sample bank for a standard 6-month interval. All other forms of the sample to be analyzed will be stored in this area for the standard 6-month interval after analysis or to the end of the analyte holding time, whichever comes first. This will provide the DEQ and Portage ample time to review data and request reanalysis if necessary. At the end of the 6-month time period, the laboratory will be responsible for sample disposal.

***4.4.4.3 Chain-of-Custody.*** A sample is physical evidence collected from a facility or from the environment. An essential part of hazardous waste investigations is that samples and data may be used as evidence in legal proceedings. Laboratories performing analyses will use document control and chain-of-custody procedures as specified in Exhibit F for the CLP statement of work for inorganics (EPA 1992).

***4.4.4.4 Sample Stream.*** In accordance with EPA procedures, field QC samples (i.e., duplicates) will be treated in the same manner as the natural samples. This provides external QC checks of laboratory data.

## 4.5 Health and Safety Plan

The health and safety plan for RI activities at the BHMS is attached (Appendix D).

## 4.6 Permitting Requirements

Permits will not be required in order to complete the RI or to conduct the site survey. Federal and state permits maybe required to complete reclamation activities in and around the east fork of Blue Creek. These requirements will be determined as part of the RI and will be presented in the final RI report.

## 4.7 Projected Reclamation Investigation Costs

Portage costs associated with completing the RI consist of preparing the RWP, field sampling, and generating a RI report. Laboratory analyses will be conducted by ELI in Helena, Montana. The projected costs for both Portage and ELI are presented in Table 12.

Costs provided in Table 12 for Portage include both direct and indirect costs and project administration fees, but does not include profit. Laboratory costs will be direct-billed to DEQ/MWCB by ELI. The laboratory estimate is based on 14 soil samples and four groundwater samples analyzed in accordance with Table 7and the ELI price quote is listed in Appendix E. The site survey costs are not known at this time and will be in addition to the price listed. In total, the projected RI costs would be approximately $38,249.

Table 12. Broken Hill Mine projected reclamation investigation costs.

| Contractor | Task Description | Cost |
|---|---|---|
| Portage | Prepare Reclamation Work Plan | $13,478 |
| | Conduct Onsite Reclamation Investigation | $6,727 |
| | Prepare Reclamation Investigation Report | $13,826 |
| | *Subtotal* | *$34,031* |
| Laboratory | Analyze Field Samples Collected During RI | $4,218 |
| | **Total** | **$38,249** |
| * Site survey is not included in this table because the cost is unknown at this time. | | |

# 5. REFERENCES

ASA, 1996, *Methods of Soil Analysis, Part 3, Chemical Methods*, Number 5 in the Soil Science Society of America Book Series, American Society of Agronomy, Madison, Wisconsin, 1390 p.

DEQ, 1996, *Risk-Based Cleanup Guidelines for Abandoned Mine Sites*, Montana Department of Environmental Quality, 1996.

DEQ, 2005, Action Level for Arsenic in Surface Soil, Montana Department of Environmental Quality Remediation Division, http://www.deq.state.mt.us/StateSuperfund/PDFs/ArsenicPositionPaper.pdf.

DEQ, 2008, "Montana Numeric Water Quality Standards," Circular DEQ-7, Montana Department of Environmental Quality, February 2008.

EPA, 1986, *National Enforcement Investigations Center Policies and Procedures*, EPA 300/9-78-001-R, U.S. Environmental Protection Agency, 1986.

EPA, 1992, *Statement of Work, Inorganic Analysis, Multimedia, Multiconcentration*, Document ILM02.0, U.S. Environmental Protection Agency Contract Laboratory Program, 1992.

EPA, 1994, *National Functional Guidelines for Inorganic Data Review*, U.S. Environmental Protection Agency Contract Laboratory Program, February 1994.

EPA, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, U.S. Environmental Protection Agency, February 2006.

EPA, 2008, Regional Screening Levels for Chemical Contaminants at Superfund Sites, U.S. Environmental Protection Agency Region 9 Superfund Program, http://www.epa.gov/region09/waste/sfund/prg/index.html, web page updated December 19, 2008.

FHC, 2002, "Cultural Resource Inventory and Assessment for the Broken Hill Mine," Frontier Historical Consultants, September 2002.

GWIC, 2008, Well Log List in T8N, R6W, Section 15, with a 5-Mile Buffer, Groundwater Information Center Resource Information System, http://maps2.nris.state.mt.us.

MBMG, 1963, "Mines and Mineral Deposits of Sanders County, Montana, Bulletin 34," F.A. Crowley, Montana Bureau of Mines and Geology, May 1963.

Montana Agricultural Experiment Station and U.S. Department of Agriculture (USDA), 1980, "Geologic Parent Materials of Montana Soils, Bulletin 721, November 1980.

MNHP, 2008, Montana Field Guide (http://fieldguide.mt.gov/) and TRACKER (http://nhp.nris.mt.gov/Tracker/NHTMap.aspx) web pages, Montana Natural Heritage Program, Accessed from MNHP website: http://nhp.nris.mt.gov/).

RTI, 2002, Past and Present Landownership/Mine Operators Investigation Phase I, Renewable Technologies, Inc., August 2002.

USCB, 2000, 2000 U.S. Census Estimate, U.S. Census Bureau.

USGS, 1997, Heron Quadrangle. Montana-Sanders County. 7.5. minute series (topographic), U.S. Geologic Survey, 1997.

WRCC, 2008, Western Regional Climate Center, http://www.wrcc.dri.edu.

# Appendix A
# 1988 Inventory Field Form

12

Brown Hill? is marked on map 4/29/93

**ABANDONED MINE RECLAMATION INVENTORY FIELD FORM**

MINE/SITE NAME: Broken Hill Mine COUNTY: Sanders
LEGAL DESCRIPTION: T27N, R34 W, sec. 10, SW 1/4 NE 1/4
MINING DISTRICT: Blue Creek MINE TYPE: Hardrock
LATITUDE: 48° 07' 05" DRAINAGE BASIN:
LONGITUDE: 115° 57' 45" USGS CODE: 17010213
QUAD: Heron 7.5' PRIMARY: Clark Fork River
P.A. #: 45-005 SECONDARY: E. Fork of Blue Creek
INSPECTOR: W. Henning DATE: 8/7/88
ORGANIZATION: Northern

**ACCESSIBILITY:**

___ HARD X MODERATE ___ EASY

RECLAMATION ACCESS: Very narrow and steep road with many sharp curves. Road is overgrown with brush.

**AFFECTED POPULATION:**

X <10 ___ 10-100 ___ 101-500 ___ > 500

**LAND USE:**

___ URBAN ___ PARK ___ RESIDENTIAL X RECREATIONAL
___ AGRICULTURAL X MINING ___ OTHER (SPECIFY)

PHYSIOGRAPHIC FEATURES: Elev. of the mine is approx. 4200'. The slopes are moderately steep, heavily wooded and vegetated. A dry drainage is present just to the north of the mine.

STRUCTURES/CULTURAL FEATURES: An old partially fallen down suspended ore loading chute is present on top of the upper dump. It looks like it could fall down any time, very dangerous situation.

TOTAL NUMBER OF HAZARDOUS STRUCTURES: 1

**MINE OPENINGS:**

| TYPE | DIMENSIONS | COMMENTS | PHOTO# |
|---|---|---|---|
| adit | Completely Caved | Consid. amount of water flowing from | R10-12 |
| | | adit | |
| | | Suspended ore loading chute | R10-13 |
| adit | partially caved in front | adit opens up to 4'x5' v. deep 5' past | R10-14 |
| | | slough material | |
| shaft | 1'x1'x 10' deep | small caved shaft | R10-15 |
| | | | |

TOTAL NUMBER OF HAZARDOUS OPENINGS: 2

**GENERAL SITE PROBLEMS:** Large unvegetated areas of approx. .5 acre total.

**WATER QUALITY:**

6.1 : — pH RANGE 30 : — SC RANGE 25 : gpm FLOW RANGE ______ SAMPLE SOURCE

COMMENTS: Mine discharge is acidic, and there is a considerable flow. No erosion of the dump exists. The mine discharge splits and either percolates into the dump or runs over the side of the road and percolates into the natural colluvium.

**ACTIVITY STATUS:**

___ OPERATING ___ EXPLORATION ___ PARTIALLY ACTIVE ___ INACTIVE _X_ ABANDONED

COMMENTS: The mine has not been worked for a very long time

**LAND OWNERSHIP:**

_X_ PRIVATE ___ PUBLIC ___ PUBLIC/UNPATENTED CLAIM

**CONTACT PERSON:**

_X_ OWNER ___ LESSEE ___ CLAIMANT

NAME: J.P. Swann

ADDRESS: Spokane, WA.

PHONE: ______

ATTACH MAP DOCUMENTATION: Cable net to close upper open adit is best option. Access is v. poor and bedrock is at surface. To close small open shaft, either backfill or use cable net [illegible]

Northern Engineering and Testing, Inc.

# MINE OPENING FIELD DESCRIPTION FORM

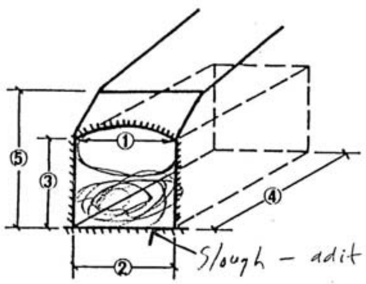
SITE: Broken Hill Mine DATE: 8/7/88

OPENING TYPE: Adit

LOCATION: T27N, R34W, sec. 10, SW 1/4, NE 1/4
48° 07' 05"
115° 57' 45"

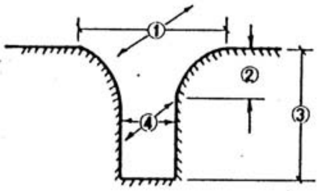
ACCESS: hard

## ADIT



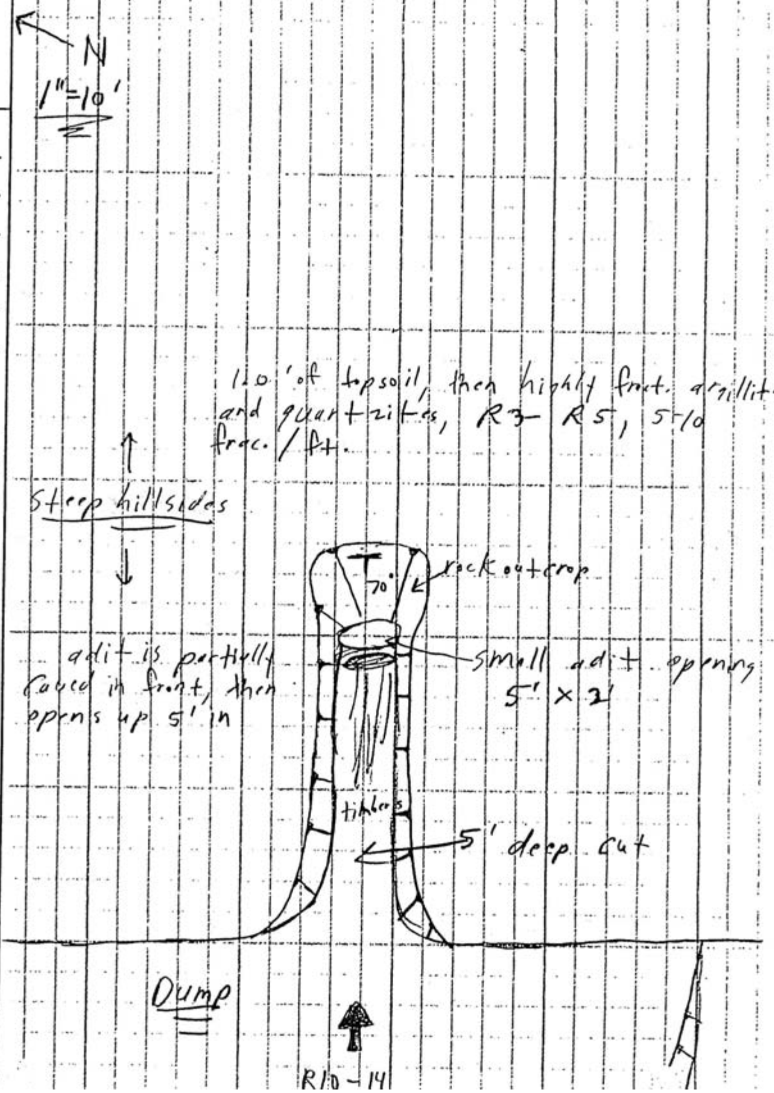

TOP WIDTH ① 4'
BOTTOM WIDTH ② 4'
HEIGHT ③ 5'
DEPTH ④ deep
CUT FACE HEIGHT ⑤ 14'
SUPPORT (Y/N) Y
WATER (Y/N) N

## SHAFT



TOP LENGTH ① ______
TOP WIDTH ① ______
BEDROCK DEPTH ② ______
TOTAL DEPTH ③ ______
INSIDE LENGTH ④ ______
INSIDE WIDTH ④ ______
SUPPORT (Y/N) ______
WATER (Y/N) ______

## SITE SKETCH AND NOTES



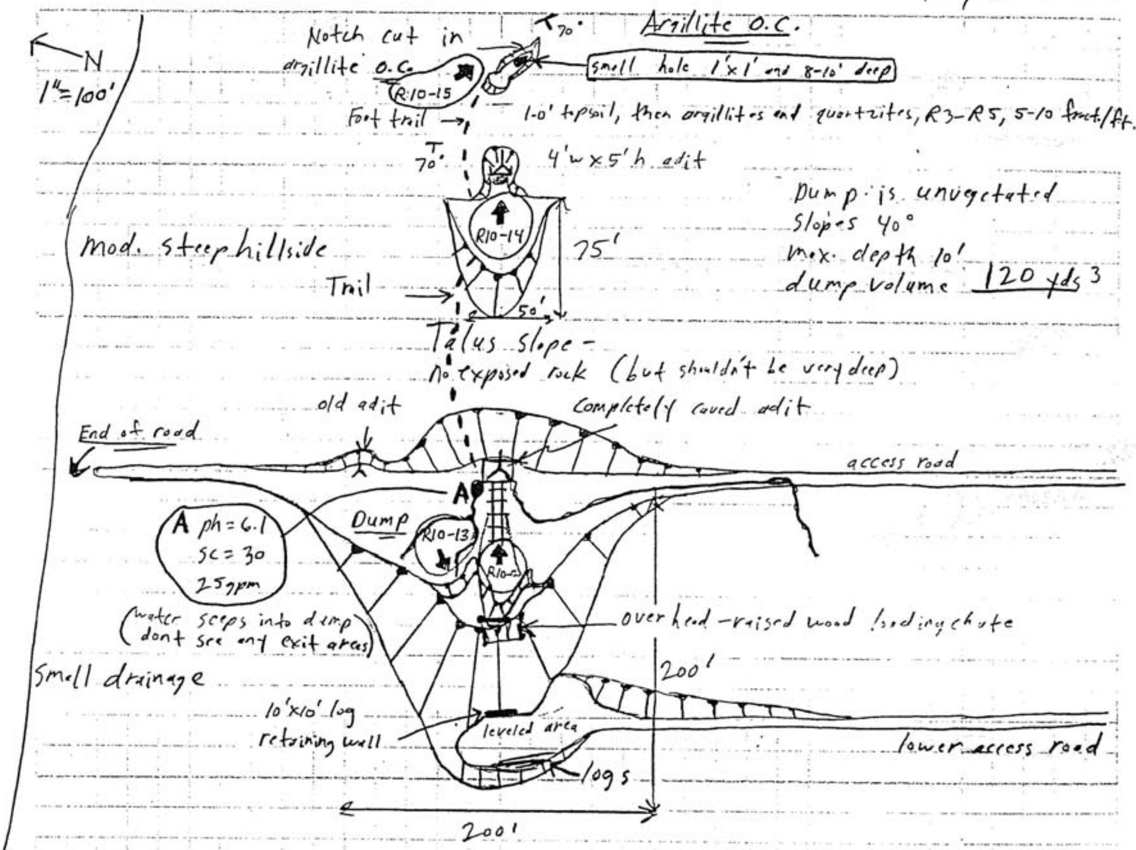
Northern Engineering and Testing, Inc.

**STANDARD COMPUTATION SHEET**

PROJECT: Broken Hill Mine  JOB NO.: 88-3005.D

PURPOSE: AMR  SHEET 1 OF 1

COMPUTED BY: L. H.  CHECKED BY: ______  DATE: 8/7/88




Dump is unvegetated
Slopes 40°
max. depth is 20'
dump volume 700 yds³

[Total mine area ≅ 1 acre]

# Appendix B
# 1993 Hazardous Materials Inventory Site Summary

# MONTANA DEPARTMENT OF STATE LANDS
# ABANDONED MINE RECLAMATION BUREAU
# HAZARDOUS MATERIALS INVENTORY
# SITE SUMMARY

ne/Site Name: Broken Hill
gal Description: T 27N R 34W
ning District: Blue Creek
titude: N 48° 07' 15"
ngitude: W 115° 58' 06"
nd Status: Private/Public
ad: Heron
spectors: Bullock, Flammang, Clark
ganization: Pioneer Technical Services, Inc.

County: Sanders
Section(s): SW 1/4, SW, 1/4, NE 1/4, Sec. 10
Mine Type: Hardrock/Ag, Pb, Zn
Primary Drainage: East Fork Blue Creek
USGS Code: 17010213
Secondary Drainage: East Fork Blue Creek
Date Investigated: August 3, 1993
P.A. # 45-005

There were no mill tailings associated with this site.

The volume of waste rock associated with this site was estimated to be 6200 cubic yards. The following elements were elevated at least three times background:

Arsenic: 508 to 1140 mg/kg
Cadmium: 15.2 to 26 mg/kg
Copper: 140J to 342J mg/kg
Iron: 94,400 mg/kg
Mercury: 2.53J to 27.2J mg/kg.
Lead: 18,700J to 55,900J mg/kg
Antimony: 61.3 to 344 mg/kg
Zinc: 9600 to 11,400 mg/kg.

The waste rock dumps were mostly unvegetated.

A collapsed discharging adit (GW-1) was present, with a flow of approximately 25 gpm, a pH of 8.71, and a specific conductance of 75 umhos/cm. The adit discharge did not exceed any MCL/MCLGs. Chronic aquatic life criteria for mercury, lead and zinc and acute aquatic life criteria for lead and zinc were exceeded in this sample of the discharge.

A dry tributary to the East Fork of Dry Creek was approximately 100 feet north of the site. There were no direct runoff pathways to surface water identified during this investigation. Therefore, surface water and stream sediment samples were not collected.

One plastic barrel half full of an unknown material was present at the base of WR-1.

**Broken Hill PA# 45-005**
**AMRB HAZARDOUS MATERIALS INVENTORY**
**INVESTIGATOR: PIONEER -BULLOCK**
**INVESTIGATION DATE: 08/03/93**

## SOLID MATRIX ANALYSES

**Metals in soils**
**Results per dry weight basis**

| FIELD ID | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Co (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) | CYANIDE (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45-005-WR-1 | 1140 | 27.9 | 15.2 | 7.25 | 5.25 | 342 J | 94400 | 27.2 J | 992 | 3.84 | 55900 J | 344 | 9600 | NR |
| 45-005-WR-2 | 508 | 19.8 | 26 | 5.86 | 4.5 | 140 J | 44200 | 2.53 J | 426 | 6.23 | 18700 J | 61.3 | 11400 | NR |
| BACKGROUND | 8.68 | 142 | 0.6 U | 10.4 | 10.5 | 21.2 J | 22100 | 0.06 J | 710 | 14.4 | 33.8 J | 6.84 U | 78.2 | NR |

U - Not Detected; J - Estimated Quantity; X - Outlier for Accuracy or Precision; NR - Not Requested

**Acid/Base Accounting**

| FIELD ID | TOTAL SULFUR % | TOTAL SULFUR ACID BASE t/1000t | NEUTRAL. POTENT. t/1000t | SULFUR ACID BASE POTENT. t/1000t | SULFATE SULFUR % | PYRITIC SULFUR % | ORGANIC SULFUR % | PYRITIC SULFUR ACID BASE t/1000t | SULFUR ACID BASE POTENT. t/1000t |
|---|---|---|---|---|---|---|---|---|---|
| 45-005-WR-1 | 2.80 | 87.5 | -5.78 | -93.3 | 1.86 | 0.08 | 0.86 | 2.50 | -8.28 |
| 45-005-WR-2 | 2.46 | 76.9 | -4.12 | -81.0 | 0.59 | 0.15 | 1.72 | 4.69 | -8.81 |

## WATER MATRIX ANALYSES

**Metals in Water**
**Results in ug/L**

| FIELD ID | As | Ba | Cd | Co | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | HARDNESS CALC. (mg CaCO3/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45-005-GW-1 | 30.4 | 2.01 U | 2.57 U | 9.7 U | 6.83 U | 2.97 | 69.6 | 0.044 J | 15.2 | 12.7 U | 107 | 30.7 U | 867 | 23.4 |

U - Not Detected; J - Estimated Quantity; X - Outlier for Accuracy or Precision; NR - Not Requested

**Wet Chemistry**
**Results in mg/l**

| FIELD I.D. | TOTAL DISSOLVED SOLIDS | CHLORIDE | SULFATE | NO3/NO2-N | CYANIDE |
|---|---|---|---|---|---|
| 45-005-GW-1 | 52 | 6.7 | < 5 | < 0.05 | NR |

**LEGEND**

WR1 - Composite of subsamples WR1A, 1B, 1C, and 3.
WR2 - Composite of subsamples WR2A and 2B.
BACKGROUND - From the Holliday Mine (45-009-SS-1).
GW1 - From the flow out of adit #2.

# I. BACKGROUND INFORMATION

This information is to be collected to the extent practical prior to conducting the Site Investigation. Data gaps shall be filled in during the investigation.

Mine/Site Name(s): BROKEN HILL PA#: 45-005

Legal Description: T 27N ;R 34W ;Sec. 10 , SW1/4 SW1/4 NE1/4

County: SANDERS Mining District: BLUE CREEK

Latitude: N 48° 07' 15" Longitude: W 115° 58' 06"

Primary Drainage Basin and Code: East Fork Blue Creek/17010213
Secondary Drainage Basin: East Fork Blue Creek

USGS Quadrangle map name(s): Heron

Mine Type/Commodities: Hardrock/Silver, Lead, Zinc

Activity Status: Active___,Inactive/Exploration X ,Abandoned___.

Ownership status: Known YX N__; private/public? Private/Public
Owner, Agent, or Contact (Include address and phone when available): William Swan, 57888 Tall Mines Road, Coeur d'Alene, ID 83814. (208) 664-1764; Kootenai National Forest.

Relationship to other mines/sites in the area/district: This site is located 3/4 mile southeast of the Scotchman Mine. Mines in the district are all replacement deposits along or near faults associated with the Hope Fault.

Regulatory Status (Activity by other agencies)? Hardrock permits?
Past Reclamation Activities? N/A

General site features: Elevation 4200', Slope 25°,
Aspect Southwest

Land use: Mining X , Recreational X , Residential___, Urban___,
Agricultural___, Other(Specify) Logging

Area of disturbed/unvegetated lands? 1.5 acres.
Dimensions:

Predominant vegetation types: Douglas fir, spruce, cottonwood, Mountain maple, Sitka alder, thimbleberry

Access: roads - good___,poor___,4wd X ,trail___.
Other logistical considerations (proximity to other sites). This site is located 3.5 miles north of U.S. Highway 10-A; locked gate on Forest Service Road 2290.

**Well logs within 1 mile radius; water rights 15 mi downstream** (Attach MBMG Well Log Printout(s)): There is 1 well log within a 1 mile radius.

**General site geologic, hydrologic, and hydrogeologic settings** (Also note presence of radioactive minerals). Site is underlain by Burke quartzite of the Ravalli Formation. Mineralization occurred in shear zones, in small faults along the Hope Fault, a large northwest trending transverse fault that has been traced from Hope, Idaho to Heron, Montana. The site lies approx. 500 feet to the south of an unnamed intermittent drainage to East Fork Blue Creek, a perennial stream. Water from the site would flow north into the creek and then west to junction with East Fork Blue Creek approx. 1 mile away.

**Mining/milling history, ore type/tenor, host rock, gangue:** First recorded production was in 1925; for the years 1925 to 1927 inclusive, 942 oz. Ag, 53,057 lbs. Pb, and 176,632 lbs. Zn was produced from 273 tons of ore. Both adits caved before 1960. Pyrite, pyrrhotite, sphalerite, galena, chalcopyrite, and arsenopyrite are present in a gangue of quartz, tourmaline, and tremolite.

**Mine Operation?**

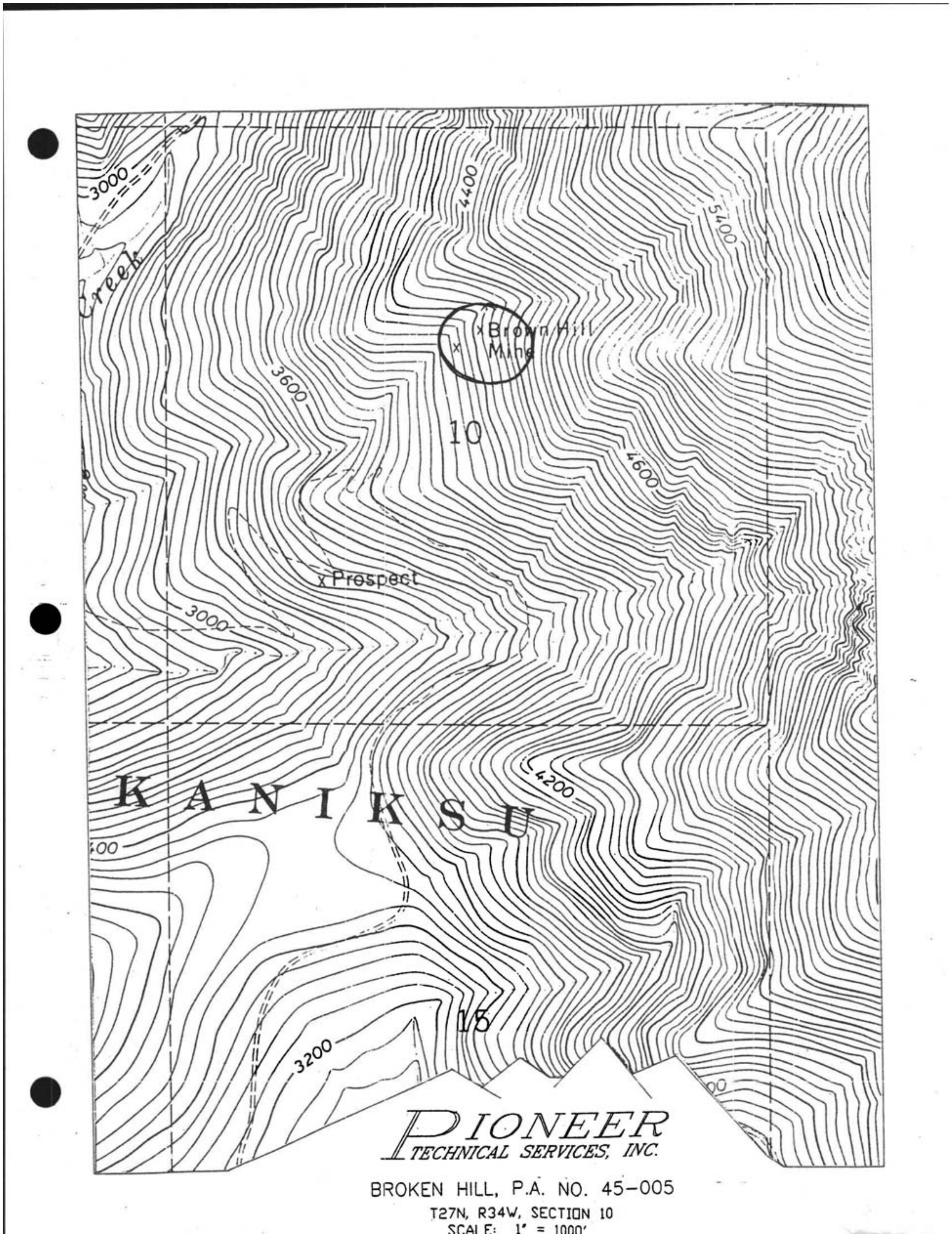
| | Yes | No | # | Comment |
| --- | --- | --- | --- | --- |
| Shafts | X | | | Possible; caved |
| Adits | X | | 2 | Caved |
| Pits | | X | | |
| Placers | | X | | |
| Other | | X | | |

**Mill Operation?** Yes____, No X . If yes answer the next three questions:

**Period(s) of Operation:** N/A

**Origin of Ore Milled - Custom Mill___ Dedicated Mill___; Number and names of mines that supplied mill feed:** N/A

**Process? Hg-amalgam, CN⁻ leach (vat, heap), floatation, smelting?**
N/A


3000
Creek
4400
5400
x Brown Hill Mine
3600
10
4600
x Prospect
3000
KANIKSU
4200
3200
15
PIONEER TECHNICAL SERVICES, INC.
BROKEN HILL, P.A. NO. 45-005
T27N, R34W, SECTION 10
SCALE: 1" = 1000'

Montana Bureau of Mines and Geology
Water Well Log Data

11/10/1993

| ..l No. | Location | Depth | Yield | Static Water Level |
| --- | --- | --- | --- | --- |
| M:81393 | 27N 34W 02 B | 180.0 | 5.0 | 92.00 |

# II. INFORMATION COLLECTED ON SITE

## A. SOLID MATRIX WASTE CHARACTERIZATION

1. Waste Characteristics - Use table on following page.

Unique source identification (e.g. west waste rock dump #2) and abbreviation on sketch map and source list (e.g. WWRD2). Locate source on sketch map with any measured distances from at least two landmarks.

Source types: Waste rock dumps and piles (WR); tailings impoundments and piles (TAIL); vats, vessels, tanks that contain something (VAT); barrels - not empty (BAR); soils contaminated by spills or leaks (SP); suspected asbestos containing materials (ACM); garbage/refuse/junk dumps (DMP); other sources (OTH).

Source size: Estimated volumes (cu. yards or feet, # of barrels) for each source identified above.

Location/Description: List location and description for each source identified above.

Waste containment: Is the source contained with respect to groundwater, surface water, and airborne releases or the potential to release? Good, adequate, poor, or none. Are waste structures / vessels sound, are runon/runoff controls in place, are wastes covered or vegetated, pond liners intact?

2. TAILINGS IMPOUNDMENTS - If tailings impoundments are also present, complete the following questions.

Describe the tailings grain size distribution (approximate % sand, silt, & clay): N/A

Determine tailings impoundment depth and describe stratification of the tailings if observable (based on texture and color): N/A

Are tailings wet or dry (Describe location of partially wetted tailings impoundments): N/A

Describe condition of the tailings impoundment (Note condition of dams or structures, location of breaches): N/A

Comments on potential for mitigation: N/A

## SOURCE INVENTORY FORM

SAMPLERS: Bullock, Flammang, Clark

| SOURCE I.D. NO. | SOURCE TYPE | SOURCE VOLUME ($yd^3$) | LOCATION/DESCRIPTION | CONTAIN-MENT | pH SU (D/S)* | RADIO-ACTIVITY (mR/HR) | LAB. SAMPLE NO. | DATE/ TIME | ANALYSES |
|---|---|---|---|---|---|---|---|---|---|
| WR-1A | WR | 170 | Southeast side of WR-1 near top | None | 4.47 (S) | 0.04 | 45-005-WR-1 | 08/03/93 0950 | T-Metals, ABA |
| WR-1B | WR | | West side of WR-1 straight out from adit | None | 4.04 (S) | 0.03 | | | |
| WR-1C | WR | | North side of WR-1 near top | None | 6.61 (S) | 0.03 | | | |
| WR-2A | WR | 6,000 | South side of dump, southwest of adit near top | None | 3.45 (S) | 0.03 | 45-005-WR-2 | 08/03/93 1000 | T-Metals, ABA |
| WR-2B | WR | | North side of dump, northwest of adit near top | None | 4.59 (S) | 0.06 | | | |
| WR-3 | WR | 30 | West of cut near top of hill | None | 4.44 (S) | 0.04 | | | |
| SS-1 | BKGRND | N/A | Background soil sample approx. 50 feet above and 50 feet north of top of most cut | N/A | 5.99 (S) | 0.04 | N/A | N/A | XRF Analysis |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

*D-Direct reading(Kelway Meter); S-Saturated Paste(Orion Meter)

Comments or deviations from SOPs: 45-005-WR-1 is composite of WR-1A through -1C, and WR-3. 45-005-WR-2 is composite of WR-2A and -2B. See Holliday (45-009) for background soil sample.

MDSL AMRB/PIONEER 4/9/93

## B. GROUNDWATER CHARACTERISTICS

Use table on following page. Identify all locations on sketch map or topographic map.

Flowing adits: Yes X , No___, Number: 1 Identification: Adit #2

Filled shafts: Yes___, No X , Number:____ Identification:____________

Seeps/Springs: Yes___, No X , Number:____ Identification:____________

Groundwater wells within 4 miles?: Yes X , No___;
Number of well logs: 35

Distance to nearest well used for drinking? Approx. 2.1 miles

Sample types: Flowing adits (AD); filled shafts (SH);
Residential wells (RW); Monitoring wells (MW); Seeps/Springs (SP).

Field Measurements: Flow (measured or estimated), pH (meter), Eh (meter), SC (meter), temperature (meter), Alkalinity (test kit)?

Potential for groundwater contamination (explain)?
Definite____, Probable____, Possible X , Unlikely____.
Metal values in dumps are high; water from adit drains onto dump and vanishes.

Other observations/notes: N/A

# GROUNDWATER INVENTORY FORM

SAMPLERS: Bullock

| SAMPLE I.D. NO. | SAMPLE TYPE | DESCRIPTION OF SOURCE | FLOW* cfs/gpm | pH SU | SC µS/cm @ 25°C | Eh mV | Temp °C | ALK. mg/L as $CaCO_3$ | Depth ft | LAB. SAMPLE NO. | DATE/ TIME | ANALYSES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW-1 | AD | From flow out of Adit #2 | 25 gpm (E) | 8.71 | 75 | 275 | 6.3 | 25 | N/A | 45-005-GW-1 | 08/03/93 1830 | T-Metals, TDS, Hardness, Cl, SO4, NO2/NO3 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

*FLOW: Estimated (E) or Measured (M) from adit, shaft, seep or spring?

Comments or Deviations from the SOPs (Pioneer SAP, 1993): Split was collected for owner.

MDSL AMRB/PIONEER 4/9/93

## C. SURFACE WATER CHARACTERISTICS

Use table on following page. Identify all locations on sketch map or topographic map. Indicate drainage patterns (run-on/runoff) and directions on sketch maps.

Flowing streams: Yes____, No X , Name(s):____________________

Dry streambeds: Yes X , No___, Name(s): Intermittent tributary to the East Fork Dry Creek approximately 100 feet north of the site.

Other surface water: Yes____, No X , Name(s)/Description:__________

Waste materials within any floodplain: Yes____, No X Source ID(s):_

Approximate Flood frequency?___1 yr,___10 yr,___100 yr

Estimated seasonal flow of stream(s) (cfs)? N/A
High Flow:___________, Average Flow:_____________

Distance between waste source(s) and nearest surface water body (ft)?_
0 feet; Water from Adit #2 flows over WR-2 and disappears.

Surface water draining onto or through waste sources: Yes X , No____,
Describe: Water from Adit #2 flows over WR-2 and disappears.

Surface water use within 15 miles downstream? (Drinking water supply, irrigation, residential use? Sensitive environments within 15 miles downstream? Park, Wilderness, Fishery, Wetland, T&E habitat?)
Stock watering, possible fishery

Observed erosional/sedimentation/stream turbidity problems? Yes_____, No X , Distance downstream (ft)?________ Describe/explain (Note streambank stability and condition of streambank vegetation and any manmade structures or channel changes present):________

## SURFACE WATER INVENTORY FORM

SAMPLERS:____________________

| SAMPLE I.D. NO. | SAMPLE TYPE | DESCRIPTION OF SAMPLE LOCATION | pH SU | SC µS/cm @ 25°C | Eh mV | Temp °C | ALK. mg/L as $CaCO_3$ | Flow* cfs/gpm | LAB. SAMPLE NO. | DATE/ TIME | ANALYSES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No samples were taken. | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

*FLOW: Estimated (E) or Measured (M)?

**Comments or Deviations from the SOPs (Pioneer SAP, 1993):**____________________

MDSL AMRB/PIONEER 4/9/93

## D. ACID MINE DRAINAGE (AMD) POTENTIAL

Evaluate each source in table on next page.

AMD Characteristics:

- Presence and abundance of sulfides? ($SO_3$)
- Presence of evaporative salt deposits? (ESD)
- Discolored or turbid seepage? (SPG)
- Presence of long filamentous algae in drainages, mosses in moist areas?
- Presence of ferric hydroxide precipitates? (FEOX)
- Presence of burned or stressed vegetation? (VEG)
- pH ≤ 5.0 (pH)

General Potential for AMD Mitigation:

Area available for treatment (acres)? None

Wetlands present: Yes___, No X , Describe:

Carbonate rocks/soils: Yes___, No X , Describe:

## E. AIR PATHWAY CHARACTERISTICS

Population within 4-mile radius: 1-10___; 10-30___; 30-100 X ; 100-300___; 300-1,000___; 1,000-3,000___; 3,000-10,000___; 10,000 or greater___; Comments

Nearest residence(ft or miles)? Approx. 2.1 miles

For each source (table next page):

- Available fine materials? Surface area?
- Uncovered and unvegetated? Wet or dry?
- Overall dust propagation potential: observed high moderate low none

## ACID DRAINAGE/AIR PATHWAY INVENTORY FORM

SAMPLERS: Bullock, Flammang, Clark

| SOURCE I.D. NO. | ACID MINE DRAINAGE CHARACTERISTICS (LIST) | MOISTURE CONTENT (WET/DRY/PARTIAL) | SURFACE AREA (SQUARE FEET) | UNCOVERED/UNVEGETATED AREA (SQUARE FEET) | AVAILABLE FINES (YES/NO) | DUST PROPAGATION POTENTIAL (OBSERVED/HIGH/MODERATE/LOW/NONE) |
|---|---|---|---|---|---|---|
| WR-1 | pH | Dry | 1,080 | 864 | Yes | Low |
| WR-2 | pH; SO3 | Dry | 22,500 | 22,275 | Yes | Low |
| WR-3 | pH | Dry | 720 | 720 | Yes | Low |
| Adit #2 | Algae | N/A | N/A | N/A | N/A | N/A |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Notes and Clarifications:**

MDSL AMRB/PIONEER 4/9/93

## F. DIRECT CONTACT CHARACTERISTICS

Residents or workers within 200 feet of sources: Yes____, No_X_, Describe:____

Population within 1 mile: 1-10___; 10-30___; 30-100___; 100-300___; 300-1,000___; 1,000-3,000___; 3,000-10,000___; 10,000 or greater___; Comments None

Evidence of recreational use on site: Yes___, No_X_, Describe:____

Accessibility - Fences, warning signs, closed roads? There is a locked gate approx. 1/4 mile after the turnoff (F.R. 2290) from East Fork Blue Creek (F.R. 409).

Sensitive environments on-site or adjacent to site:

State or National Parks - Yes___, No_X_, Comment____
Wilderness Area - Yes___, No_X_, Comment____
T&E Species Habitat - Yes_X_, No___, Comment Grizzly
Bat Habitat - Yes___, No_X_, Comment____

Primary Drainage___; Secondary Drainage_X_; No Information___:

Riparian Habitat Quality - High_X_, Medium___, Low___
Wetlands Frontage - High___, Medium___, Low_X_
Fisheries Habitat and Species Classification - Not Rated
Sport Fishery Classification - Not Rated

## G. SAFETY CHARACTERISTICS

Verify completeness of AMRB Inventory

Hazardous openings: Yes___, No_X_, Number____, types and locations:___

Hazardous structures: Yes___, No_X_, Number____, types and locations:_

Unstable highwalls, pits, trenches, slopes: Yes_X_, No___, Number_1_, types and locations: Slope behind Adit #1 is steep.

Unstable waste piles, impoundments, undercut banks: Yes_X_, No____, Number_2_, types and locations: WR-1 and WR-2 have steep slopes, are unvegetated, and at angle of repose.

Fire and/or Explosion hazards: Yes___, No_X_, Explain:____

## Bibliography

MBMG, Mines and Mineral Deposits (Except Fuels), Sanders County, Montana, Bulletin 34, Written by F.A. Crowley, May 1963, pp. 14-15.

MBMG, State Technical Services Mine Visit Report for Broken Hill, Prepared by K.T. Bondurant, June 27, 1967.

MBMG, Well Log Database, September 8, 1993.

MDFWP, Montana Rivers Information System Rivers Report, Version 2.0, Prepared by Montana Natural Resource Information System, December 1989.

MDSL/AMRB Files, Abandoned Mine Reclamation Inventory Field Form for Broken Hill, Prepared by Northern Engineering and Testing, August 7, 1988.

USGS, Geology and Ore Deposits of the Libby Quadrangle, Montana, Bulletin 956, Written by Russell Gibson, Date Unknown.

USGS, Topographic Map, Heron, Montana, 7 1/2 minute Quadrangle, 1966.

# LABORATORY ANALYTICAL DATA

BROKEN HILL
PA NO. 45-005

**Broken Hill PA# 45–005**
**AMRB HAZARDOUS MATERIALS INVENTORY**
**INVESTIGATOR: PIONEER –BULLOCK**
**INVESTIGATION DATE: 08/03/93**

## SOLID MATRIX ANALYSES

Metals in soils
Results per dry weight basis

| FIELD ID | As (mg/Kg) | Ba (mg/Kg) | Cd (mg/Kg) | Co (mg/Kg) | Cr (mg/Kg) | Cu (mg/Kg) | Fe (mg/Kg) | Hg (mg/Kg) | Mn (mg/Kg) | Ni (mg/Kg) | Pb (mg/Kg) | Sb (mg/Kg) | Zn (mg/Kg) | CYANIDE (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45–005–WR–1 | 1140 | 27.9 | 15.2 | 7.25 | 5.25 | 342 J | 94400 | 27.2 J | 992 | 3.84 | 55900 J | 344 | 9600 | NR |
| 45–005–WR–2 | 508 | 19.8 | 26 | 5.86 | 4.5 | 140 J | 44200 | 2.53 J | 426 | 6.23 | 18700 J | 61.3 | 11400 | NR |
| BACKGROUND | 8.68 | 142 | 0.6 U | 10.4 | 10.5 | 21.2 J | 22100 | 0.059 J | 710 | 14.4 | 33.8 J | 6.84 U | 78.2 | NR |

U – Not Detected; J – Estimated Quantity; X – Outlier for Accuracy or Precision; NR – Not Requested

Acid/Base Accounting

| FIELD ID | TOTAL SULFUR % | TOTAL SULFUR ACID BASE t/1000t | NEUTRAL. POTENT. t/1000t | SULFUR ACID BASE POTENT. t/1000t | SULFATE SULFUR % | PYRITIC SULFUR % | ORGANIC SULFUR % | PYRITIC SULFUR ACID BASE t/1000t | SULFUR ACID BASE POTENT. t/1000t |
|---|---|---|---|---|---|---|---|---|---|
| 45–005–WR–1 | 2.80 | 87.5 | –5.78 | –93.3 | 1.86 | 0.08 | 0.86 | 2.50 | –8.28 |
| 45–005–WR–2 | 2.46 | 76.9 | –4.12 | –81.0 | 0.59 | 0.15 | 1.72 | 4.69 | –8.81 |

## WATER MATRIX ANALYSES

Metals in Water
Results in ug/L

| FIELD ID | As | Ba | Cd | Co | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Sb | Zn | HARDNESS CALC. (mg CaCO3/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45–005–GW–1 | 30.4 | 2.01 U | 2.57 U | 9.7 U | 6.83 U | 2.97 | 69.6 | 0.044 J | 15.2 | 12.7 U | 107 | 30.7 U | 867 | 23.4 |

U – Not Detected; J – Estimated Quantity; X – Outlier for Accuracy or Precision; NR – Not Requested

Wet Chemistry
Results in mg/l

| FIELD I.D. | TOTAL DISSOLVED SOLIDS | CHLORIDE | SULFATE | NO3/NO2–N | CYANIDE |
|---|---|---|---|---|---|
| 45–005–GW–1 | 52 | 6.7 | < 5 | < 0.05 | NR |

**LEGEND**

WR1 – Composite of subsamples WR1A, 1B, 1C, and 3.
WR2 – Composite of subsamples WR2A and 2B.
BACKGROUND – From the Holliday Mine (45–009–SS–1).
GW1 – From the flow out of adit #2.

# XRF ANALYSIS RESULTS

## BROKEN HILL
## PA NO. 45-005

Mine Name: Broken Hill PA# 45-005
XRF Field Analyses
Results in PPM

| XRF SAMPLE ID | CrHI | K | Ca | Ti | CrLO | Mn | Fe | Co | Cu | Zn | As | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45-005-SS-1 | | 8954.69 | 8324.01 | 2567.26 | | 3780.19 | 25954.6 | | | 369.353 | 52.8292 * | 177.798 |
| 45-005-WR1-A | 365.038 * | 14752.2 | 1300.84 | 1259.48 | 203.588 * | 1568.44 | 94982.8 | 550.725 * | 98.4646 * | 8067.61 | | 27.5093 * |
| 45-005-WR1-B | 621.981 * | 6090.21 | 997.152 | 437.957 | | | 89196.9 | 674.602 | 400.884 | 5482.23 | | 38.6474 * |
| 45-005-WR1-C | | 26241.3 | 1398.52 | 2106.73 | 174.768 * | 4204.74 | 32126.4 | | 86.1975 * | 2979.45 | 230.7 * | 18.1062 * |
| 45-005-WR2-A | | 18830.4 | 945.541 | 1544.67 | | 1060.29 * | 65176.6 | | 173.514 * | 4655.63 | | 21.7083 * |
| 45-005-WR2-B | | 16079.5 | 2994.29 | 2090.41 | | 1134.57 * | 51254.8 | | 142.261 * | 2030.36 | | 54.2273 |
| 45-005-WR-1-COMP | | 10866.8 | 2195.92 | 1180.72 | | 1529.46 * | 110745 | 918.133 * | 406.608 | 5352.95 | | 64.3026 |
| 45-005-WR-2-COMP | 383.543 * | 17142.4 | 2159.34 | 1725.75 | | 663.145 * | 65835.8 | | 171.66 * | 5517.7 | | 39.3539 |
| 45-005-WR-2-COMP-DUP | | 16466.6 | 2236.71 | 1724.56 | | 891.663 * | 68796.6 | 432.031 * | 175.765 * | 3046.92 | | 37.4987 |
| 45-005-WR-3 | 482.43 * | 5549.98 | 3732.81 | 1165.8 | | | 181063 | 1455.75 * | 597.114 | 5064.06 | | 98.72 |

| XRF SAMPLE ID | Zr | Hg | Mo | Pb | Rb | Cd | Sb | Ba | Ag | U | Th |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45-005-SS-1 | 186.205 | | | 455.401 | 74.2341 | | | 270.072 | | | 10.1168 * |
| 45-005-WR1-A | 198.968 | | | 16486.4 | 125.755 | | 128.867 * | 140.934 | 180.738 * | | |
| 45-005-WR1-B | 130.446 | | | 43946.3 | 83.04 * | 255.897 * | 201.859 | 48.8326 * | | | |
| 45-005-WR1-C | 229.568 | | | 1158.45 | 197.226 | | | 304.392 | | | 21.5592 * |
| 45-005-WR2-A | 217.387 | | | 11575.7 | 181.219 | | 76.9297 * | 174.889 | | | 33.8282 * |
| 45-005-WR2-B | 244.608 | | | 12926.9 | 170.8 | | 69.382 * | 413.322 | | | 28.4652 * |
| 45-005-WR-1-COMP | 187.831 | | | 34122.8 | 99.3553 * | 251.935 * | 636.824 | 125.317 | 231.406 * | | |
| 45-005-WR-2-COMP | 239.503 | | | 15142.1 | 175.841 | | 100.177 * | 257.347 | | | 33.586 * |
| 45-005-WR-2-COMP· | 251.803 | | | 14008.6 | 167.834 | | 155.472 * | 296.306 | | | 24.3571 * |
| 45-005-WR-3 | 136.79 | | | 47270.2 | | | 1911.44 | 89.8487 * | 616.526 * | | |

* – Estimated Quantity
$ – Unvalidated Data

# ABANDONED AND INACTIVE MINES SCORING SYSTEM (AIMSS) SCORESHEET

## BROKEN HILL
## PA NO. 45-005

## AIMSS SCORESHEET

SITE NAME: BLUEBIRD
PA NUMBER: 41-009

| LINE NO. | | | | |
|---|---|---|---|---|
| | | **GROUNDWATER PATHWAY** | | |
| 1 | GW - LIKELIHOOD OF RELEASE | OBSERVED RELEASE | | 0 |
| 2 | | EXCEEDENCES | | 0 |
| 3A | | CONTAINMENT | | 20 |
| 3B | | GW DEPTH | | 10 |
| 3C | | POTENTIAL TO RELEASE | LINES 3A x 3B | 200 |
| 4 | | LIKELIHOOD SCORE | LINES 1 + 2 + 3C | 200 |
| 5 | GW - WASTE CHAR. | CALCULATED SCORE | (SEE WORKSHEET) | 0.050 |
| 6 | GW - TARGETS | WELLS - 1 MI. x 2.5 | | 287.5 |
| 7 | | WELLS - 1 TO 4 MI | | 991 |
| 8 | | NEAREST WELL | | 5 |
| 9 | | TARGETS SCORE | LINES 6 + 7 + 8 | 1283.5 |
| 10 | | GROUNDWATER SCORE | LINES 4 x 5 x 9 | 12835 |
| | | **SURFACE WATER PATHWAY** | | |
| 11 | SW - LIKELIHOOD OF RELEASE | OBSERVED RELEASE | | 300 |
| 12 | | EXCEEDENCES | | 0 |
| 13A | | CONTAINMENT | | 20 |
| 13B | | DISTANCE TO SW | | 20 |
| 13C | | POTENTIAL TO RELEASE | LINES 13A x 13B | 400 |
| 14 | | LIKELIHOOD SCORE | LINES 11 + 12 + 13C | 700 |
| 15 | SW - WASTE CHAR. | CALCULATED SCORE | (SEE WORKSHEET) | 0.057 |
| 16 | SW - TARGETS | DRINKING WATER POP'N | | 0 |
| 17 | | IMPACTED DRAINAGE | | 0 |
| 18 | | WETLANDS | | 10 |
| 19 | | FISHERY | | 0 |
| 20 | | RECREATION | | 5 |
| 21 | | IRRIGATION/STOCK | | 2 |
| 22 | | T & E SPECIES HABITAT | | 0 |
| 23 | | TARGETS SCORE | SUM LINES 16 THRU 22 | 17 |
| 24 | | SURFACE WATER SCORE | LINES 14 x 15 x 23 | 678 |
| | | **AIR PATHWAY** | | |
| 25 | AIR - LIKELIHOOD OF RELEASE | OBSERVED RELEASE | | 0 |
| 26A | | CONTAINMENT | | 10 |
| 26B | | DISTANCE TO POPULATION | | 10 |
| 26C | | POTENTIAL TO RELEASE | LINES 26A x 26B | 100 |
| 27 | | LIKELIHOOD SCORE | LINES 25 + 26C | 100 |
| 28 | AIR - WASTE CHAR. | CALCULATED SCORE | (SEE WORKSHEET) | 0.006 |
| 29 | AIR - TARGETS | POPULATION - 4 MILES | | 300 |
| 30 | | NEAREST RESIDENCE | | 5 |
| 31 | | WETLANDS | | 0 |
| 32 | | PARKS / WILDERNESS | | 0 |
| 33 | | T & E SPECIES HABITAT | | 0 |
| 34 | | TARGETS SCORE | SUM LINES 29 THRU 33 | 305 |
| 35 | | AIR PATHWAY SCORE | LINES 27 x 28 x 34 | 183 |
| | | **DIRECT CONTACT PATHWAY** | | |
| 36 | LIKELIHOOD OF EXPOSURE | OBSERVED EXPOSURE | | 200 |
| 37A | | ACCESSIBILITY | | 5 |
| 37B | | DISTANCE TO POPULATION | | 10 |
| 37C | | POTENTIAL EXPOSURE | LINES 37A x 37B | 50 |
| 38 | | LIKELIHOOD SCORE | LINES 36 + 37C | 250 |
| 39 | D. C. WASTE CHAR. | CALCULATED SCORE | (SEE WORKSHEET) | 0.005 |
| 40 | DIRECT CONTACT TARGETS | POPULATION - 1 MILE | | 30 |
| 41 | | NEAREST RESIDENCE | | 5 |
| 42 | | RECREATIONAL USE | | 0 |
| 43 | | TARGETS SCORE | SUM LINES 40 THRU 42 | 35 |
| 44 | | DIRECT CONTACT SCORE | LINES 38 x 39 x 43 | 44 |
| 45 | TOTAL SITE HUMAN & ENVIRONMENTAL HAZARD SCORE (LINES 10 + 24 + 35 + 44) / 100,000 | | | 0.14 |

| LINE NO. | | | SITE NAME:<br>PA NUMBER: | BLUEBIRD<br>41-009 |
|---|---|---|---|---|
| | | **SITE SAFETY** | | |
| 1 | THREAT | ACCESSIBILITY | | 5 |
| 2 | | OPEN SHAFTS | 100 EA. | 20[illegible] |
| 3 | | OPEN ADITS | 50 EA. | 0 |
| 4 | HAZARDS | UNSTAB. HIWALLS / PITS | 75 EA. | 75 |
| 5 | | HAZ. STRUCTURES | 40 EA. | 0 |
| 6 | | EXPLOSIVES | | 0 |
| 7 | | HAZ. MATERIALS | | 0 |
| 8 | | HAZARDS SCORE | SUM LINES 2 THRU 7 | 275 |
| 9 | | POPULATION - 1 MILE | | 30 |
| 10 | TARGETS | NEAREST RESIDENCE | | 5 |
| 11 | | RECREATIONAL USE | | 0 |
| 12 | | TARGETS SCORE | SUM LINES 9 THRU 11 | 35 |
| 13 | | SITE SAFETY SCORE | (LINES 1 x 8 x 12) / 1,000 | 48.13 |

# Appendix C
# 2008 Site Visit

Figure C-1. Location of Feature F1 in Cultural Resources report above the upper waste rock dump.

Figure C-2. Upper waste rock dump.

Figure C-3. Adit at the upper waste rock dump.

Figure C-4. Adit at the lower waste rock dump.

Figure C-5. Adit discharge at the lower waste rock dump.

Figure C-6. Lower waste rock dump with the ore loading chute.

# Appendix D
# Health and Safety Plan

## A. GENERAL INFORMATION

SITE NAME: Broken Hill Mine Site, near Heron, Montana

CLIENT CONTACT NAME: Ms. Pebbles Clark/ 406-841-5028

SITE LOCATION: near Heron, Montana

PLAN PREPARED BY: Meg Babits

PLAN APPROVED BY: Brienne Meyer

OBJECTIVES: Sample soil and water at BHMS to determine nature and extent of contamination.

PROPOSED DATE OF INVESTIGATION: June 2009

BACKGROUND REVIEW (CHECK ONE): Complete: Preliminary: X

OVERALL HAZARD (CHECK ONE): Serious: Moderate:

Low: X Unknown:

## B. SITE/WASTE CHARACTERISTICS

WASTE TYPE (CHECK ALL APPROPRIATE): Liquid: X Solid: X

Gas: Sludge:

CHARACTERISTICS (CHECK ALL APPROPRIATE): Corrosive: Ignitable:

Volatile: Toxic: X Reactive: Potential Unknown(s): Other:

FACILITY DESCRIPTION: The BHMS is an abandoned mine with contaminated soil and water.

PRINCIPAL DISPOSAL METHOD (Type and Location): Waste rock dumped on-site.

UNUSUAL FEATURES (Confined Spaces, Power Lines): Steep slopes

STATUS (Active, Inactive, Unknown): Inactive.

HISTORY (on-site injury, previous action, complaints from public): A silver, lead, and zinc mine from the early 1920's that has been inactive for 30 years.

## C. HAZARD EVALUATION

List TLVs, exposure routes, etc.: Arsenic TLV = 0.01 milligrams per cubic meter ($mg/m^3$), Cadmium TLV = 0.01 $mg/m^3$, Copper TLV = 1 $mg/m^3$, Iron TLV = 5 $mg/m^3$, Mercury TLV = 0.025 $mg/m^3$, Lead TLV = 0.050 $mg/m^3$, Antimony TLV = 0.5 $mg/m^3$, and Zinc TLV = 0.01 $mg/m^3$

Contaminants of Concern: Arsenic, Cadmium, Copper, Iron, Mercury, Lead, Antimony, and Zinc.

## D. SAMPLING PLAN

TYPE OF SAMPLES: Solid and Liquid.

SAMPLING APPARATUS: Solid – disposable scoop and Liquid – directly into bottle.

NUMBER OF SAMPLES OF EACH TYPE: Solid – 10 and Liquid – 2

FIELD PARAMETERS TO BE MEASURED: Liquid – pH, specific conductance (sc), oxygen reduction potential (ORP), temperature, and dissolved oxygen (DO).

SAMPLE CONTAINERS (Number and Type): Solid – 30 plastic bags and Liquid – 6 poly bottles

FIELD MEASUREMENT EQUIPMENT: pH meter, sc meter, ORP meter, temperature meter, DO meter.

## E. SITE SAFETY WORK PLAN

PERIMETER ESTABLISHED (Y/N): Map attached: Y Site secured: N
Perimeter identified: Y Zones of contamination identified: N

SITE CONTROL: The clean zone will be off the property boundaries.

LEVEL OF PROTECTION: A: B: C: D: X

SPILL CONTAINMENT PROGRAM: On-site drum is empty.

DECONTAMINATION PROCEDURES: Equipment decontamination according to TPR-5006

SPECIAL DECONTAMINATION EQUIPMENT: None.

SITE ENTRY PROCEDURES: A minimum of two persons will conduct the sampling (buddy system).

| Name Responsibility | Required Training/Medical 40-hr | 8-hr | Mgr | CPR | 1st Aid | Med Surv | Resp App |
|---|---|---|---|---|---|---|---|
| M. Babits - Sampler | X | X | X | | | X | X |
| M. Towler - Sampler | X | X | X | X | X | X | X |

WORK LIMITATIONS (Time of day, Season): Work will take place in daylight hours. The temperatures may be hot in mid-day and cold early morning and late afternoon. Precautions include providing drinking water and breaks in cool area and proper clothing to keep warm. Afternoon thunderstorms may occur. Seek lower elevation if lightening occurrs.

INVESTIGATION-DERIVED MATERIAL (Handling and Disposal): The only investigation-derived material will be the used disposable personal protective equipment (PPE) and sampling equipment. The IDW will be bagged and taken to a landfill for disposal.

## F. EMERGENCY INFORMATION

AMBULANCE PHONE NUMBER: 911

HOSPITAL PHONE NUMBER: 208-263-1441 (Bonner General Hospital, Sandpoint, ID)

From the BHMS, travel on FS road 2290 to Montana Highway 200. Travel west on Montana Highway 200 until Sandpoint (approximately 35 miles), Idaho. Turn east (left) on Cedar Street. Turn north (left) on 3rd Street. The hospital is at 520 N. Cedar St.

POISON CONTROL CENTER: 1-800-525-5042

SHERIFF: 911

FIRE DEPARTMENT: 911

WATER SUPPLY: None

TELEPHONE: None

RADIO: Portable two - way

OTHER: None

# Appendix E
# Energy Laboratories
# Quote For Analytical Services

ENERGY LABORATORIES, INC. * 3161 E Lyndale (59604) * PO Box 5688 * Helena, MT 59601
Toll Free 877.472.0711 * 406.442.0711 * FAX 406.442.0712 * helena@energylab.com

## Quotation for Analytical Services # H373

| | | | |
|---|---|---|---|
| Company: | Portage Inc. | Submitted By: | |
| Contact: | Meg Babits | Project: | Broken Hill Mine |
| Address: | | TAT: | 10 Working days |
| | , | QC Level: | STD |
| Phone: | Fax: | Quote Date: | 17-Mar-09 Expires: 17-Mar-10 |

| Matrix | Test Name | Test | Remarks | # Samp | Unit Price | | Test Total |
|---|---|---|---|---|---|---|---|
| **Schedule:** | **Set 1-Complete Set** | | | **No. Samples: 7** | | | |
| Soil | Cation Exchange Capacity | Test Group | | 1 | $40.00 | 1 | $280.00 |
| | *Cation Exchange Capacity | SW6010B | | 1 | | 1 | |
| | *CEC NH4AC Soil Extraction | USDA19 | | 1 | | 1 | |
| | Complete Analysis-1 Depth-Lawn and Garden | Test Group | | 1 | $68.50 | 1 | $479.50 |
| | *Conductivity | ASA10-3 | | 1 | | 1 | |
| | *NH4AC Soil Extraction | ASA13-3 | | 1 | | 1 | |
| | *Potassium | ASA13-3 | | 1 | | 1 | |
| | *Particle Size Analysis / Texture | ASA15-5 | | 1 | | 1 | |
| | *Particle Size Analysis / Texture | ASA15-5 | | 1 | | 1 | |
| | *Particle Size Analysis / Texture Prep | ASA15-5 | | 1 | | 1 | |
| | *NaHCO3 Soil Extract | ASA24-5 | | 1 | | 1 | |
| | *Phosphorus-Olsen | ASA24-5 | | 1 | | 1 | |
| | *CaCl2 Hot Water Soil Extraction | ASA25-9 | | 1 | | 1 | |
| | *Organic Matter-Walkley/Black | ASA29-3 | | 1 | | 1 | |
| | *Total Organic Matter Prep | ASA29-3 | | 1 | | 1 | |
| | *Nitrate as N, CaCL2 Extract | ASA33-8 | | 1 | | 1 | |
| | *Saturated Paste pH | ASAM10-3.2 | | 1 | | 1 | |
| | *Cations, Saturated Paste | SW6010B | | 1 | | 1 | |
| | *Saturated Paste Extraction | USDA2 | | 1 | | 1 | |
| | *Lime Percentage | USDA23c | | 1 | | 1 | |
| | *Lime as CaCO3, % | USDA23c | | 1 | | 1 | |
| | Acid Base Potential w/Sulfur Forms | Test Group | | 1 | $55.00 | 1 | $385.00 |
| | *Acid/Base Potential | Sobek Modified | | 1 | | 1 | |
| | Sodium Adsorption Ratio | Calculation | | 1 | $0.00 | 1 | $0.00 |
| | Sulfur Forms | E3.2.3 | | 1 | $0.00 | 1 | $0.00 |
| | Metals by ICP/ICPMS, Total | E6010.20 | | 1 | $120.00 | 1 | $840.00 |
| | Digestion, Total Metals | SW3050 B | | 1 | $25.00 | 1 | $175.00 |
| | Mercury in Solid By CVAA | SW7471A | | 1 | $10.00 | 1 | $70.00 |
| | Digestion, Mercury by CVAA | SW7471A | | 1 | $25.00 | 1 | $175.00 |
| | | | **Schedule Sample Price:** | **$343.50** | | | |
| | | | **Schedule Total:** | | | | **$2,404.50** |
| **Schedule:** | **Set 2-TAL Metals** | | | **No. Samples: 5** | | | |
| Soil | Metals by ICP/ICPMS, Total | E6010.20 | | 1 | $120.00 | 1 | $600.00 |
| | Digestion, Total Metals | SW3050 B | | 1 | $25.00 | 1 | $125.00 |
| | Digestion, Mercury by CVAA | SW7471A | | 1 | $25.00 | 1 | $125.00 |
| | Mercury in Solid By CVAA | SW7471A | | 1 | $10.00 | 1 | $50.00 |

**To assure that the quoted analysis and pricing specifications are provided, please include the Quote ID number referenced above on the Chain of Custody or sample submittal documents .**

* Methods and/or parameters included in the indicated test group.
Subcontracting of sample analyses to an outside laboratory may be required. If so, Energy Laboratories will utilize its branch laboratories or qualified contract laboratories for this service. Any such laboratories will be indicated within the Laboratory Analytical Report.

ENERGY LABORATORIES

*ENERGY LABORATORIES, INC. * 3161 E Lyndale (59604) * PO Box 5688 * Helena, MT 59601*
*Toll Free 877.472.0711 * 406.442.0711 * FAX 406.442.0712 * helena@energylab.com*

## Quotation for Analytical Services # H373

| | | | | | |
|---|---|---|---|---|---|
| Company: | Portage Inc. | | Submitted By: | | |
| Contact: | Meg Babits | | Project: | Broken Hill Mine | |
| Address: | | | TAT: | 10 Working days | |
| | , | | QC Level: | STD | |
| Phone: | | Fax: | Quote Date: | 17-Mar-09 | Expires: 17-Mar-10 |

| Matrix | Test Name | Test | Remarks | # Samp | Unit Price | | Test Total |
|---|---|---|---|---|---|---|---|
| **Schedule:** | **Set 2-TAL Metals** | | | **No. Samples: 5** | | | |
| | | | **Schedule Sample Price:** | **$180.00** | | | |
| | | | **Schedule Total:** | | | | **$900.00** |
| **Schedule:** | **Set 3-SPLP Metals** | | | **No. Samples: 2** | | | |
| Soil | Metals by ICP/ICPMS, Total | E6010.20 | | 1 | $120.00 | 1 | $240.00 |
| | SPLP Extraction, Regular | SW1312 | | 1 | $75.00 | 1 | $150.00 |
| | Mercury, SPLP | SW7470A | | 1 | $10.00 | 1 | $20.00 |
| | | | **Schedule Sample Price:** | **$205.00** | | | |
| | | | **Schedule Total:** | | | | **$410.00** |
| **Schedule:** | **Water Total Metals** | | | | | | |
| Aqueous | Acidity, Total as CaCO3 | A2310 B | If pH is <4.5 | 1 | $11.25 | 0.8 | $11.25 |
| | Alkalinity | A2320 B | | 1 | $7.50 | 0.8 | $7.50 |
| | Solids, Total Dissolved | A2540 C | | 1 | $7.50 | 0.8 | $7.50 |
| | Metals Digestion by EPA 200.2 | E200.2 | | 1 | $11.25 | 0.8 | $11.25 |
| | Metals by ICP/ICPMS, Total | E200.7_8 | | 1 | $97.50 | 0.8 | $97.50 |
| | Anions by Ion Chromatography | E300.0 | | 1 | $15.00 | 0.8 | $15.00 |
| | Nitrogen, Nitrate + Nitrite | E353.2 | | 1 | $11.25 | 0.8 | $11.25 |
| | | | **Schedule Sample Price:** | **$161.25** | | | |
| | | | **Schedule Total:** | | | | **$161.25** |
| **Schedule:** | **Water Dissolved Metals** | | | **No. Samples: 2** | | | |
| Aqueous | Acidity, Total as CaCO3 | A2310 B | If pH is <4.5 | 1 | $11.25 | 0.8 | $22.50 |
| | Alkalinity | A2320 B | | 1 | $7.50 | 0.8 | $15.00 |
| | Solids, Total Dissolved | A2540 C | | 1 | $7.50 | 0.8 | $15.00 |
| | Metals Digestion by EPA 200.2 | E200.2 | | 1 | $11.25 | 0.8 | $22.50 |
| | Metals by ICP/ICPMS, Total | E200.7_8 | Sample filtered in the field | 1 | $97.50 | 0.8 | $195.00 |
| | Anions by Ion Chromatography | E300.0 | | 1 | $15.00 | 0.8 | $30.00 |
| | Nitrogen, Nitrate + Nitrite | E353.2 | | 1 | $11.25 | 0.8 | $22.50 |
| | | | **Schedule Sample Price:** | **$161.25** | | | |
| | | | **Schedule Total:** | | | | **$322.50** |

**Quote Comments:** 25% Discount given for Inorganics Waters over $150.00 per sample.

| | |
|---|---|
| Quote Sub Total: | $4,198.25 |
| Misc: | $0.00 |
| Discount: | 0.00% |
| WO Adjustment: | $0.00 |
| **QUOTE TOTAL:** | **$4,198.25** |

**To assure that the quoted analysis and pricing specifications are provided, please include the Quote ID number referenced above on the Chain of Custody or sample submittal documents .**

* Methods and/or parameters included in the indicated test group.
Subcontracting of sample analyses to an outside laboratory may be required. If so, Energy Laboratories will utilize its branch laboratories or qualified contract laboratories for this service. Any such laboratories will be indicated within the Laboratory Analytical Report.

ENERGY LABORATORIES

*ENERGY LABORATORIES, INC. * 3161 E Lyndale (59604) * PO Box 5688 * Helena, MT 59601*
*Toll Free 877.472.0711 * 406.442.0711 * FAX 406.442.0712 * helena@energylab.com*

## Quotation for Analytical Services # H373

| | | | | |
|---|---|---|---|---|
| Company: | Portage Inc. | | Submitted By: | |
| Contact: | Meg Babits | | Project: | Broken Hill Mine |
| Address: | | | TAT: | 10 Working days |
| | , | | QC Level: | STD |
| Phone: | | Fax: | Quote Date: | 17-Mar-09 Expires: 17-Mar-10 |

| Matrix | Test Name | Test | Remarks | # Samp | Unit Price | Test Total |
|---|---|---|---|---|---|---|

**General Comments:** Fertilizer recommendation requested on all Lawn & Garden Analysis. Wj

**To assure that the quoted analysis and pricing specifications are provided, please include the Quote ID number referenced above on the Chain of Custody or sample submittal documents .**

* Methods and/or parameters included in the indicated test group.
Subcontracting of sample analyses to an outside laboratory may be required. If so, Energy Laboratories will utilize its branch laboratories or qualified contract laboratories for this service. Any such laboratories will be indicated within the Laboratory Analytical Report.

# Attachment 1
# Technical Procedures

| PERSONNEL DECONTAMINATION | Identifier: TPR-5005<br>Revision: 0<br>Page: **1** of 2 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

To prevent exposure to field personnel and/or the spread of, hazardous or toxic chemicals originating on contaminated environmental sites (OSHA 2008).

# 2. SCOPE

All personnel must go through *decontamination* (see def.) procedures whenever leaving an uncontrolled hazardous waste site. Decontamination procedures shall be used in conjunction with industry standard best management practices to prevent personnel exposure and/or the spread of contamination, including minimizing contact with wastes and maximizing worker protective measures.

# 3. DECONTAMINATION

## 3.1 Protection

3.1.1 Follow protective measures outlined in the site-specific health and safety plan.

3.1.2 In the event that personnel decontamination becomes necessary, the outer, more heavily contaminated personal protective equipment items shall be washed using non-phosphate soap and tap water, followed by a continuous tap water rinse until all residues are gone.

3.1.3 Next, the inner, less-contaminated personal protective equipment items shall be washed using non-phosphate soap and tap water, followed by a continuous tap water rinse until all residues are gone.

3.1.4 Store the personal protective equipment items separately so they are used in contaminated areas only.

3.1.5 For contaminants other than those found typically at uncontrolled hazardous waste sites, alert the health and safety officer.

## 3.2 Emergency Decontamination

3.2.1 If the decontamination procedure is essential to life-saving process, decontamination must be performed immediately as described in Step 3.1.2.

**NOTE:** *Wash, rinse, and/or cut off protective clothing/equipment.*

3.2.2 However, if medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized. Wrap the victim to reduce contamination of others.

3.2.3 Alert medical personnel to the emergency and instruct them about potential contamination. Instruct medical personnel about specific decontamination procedures.

3.2.4 Dispose of contaminated clothing and equipment properly.

### 3.3 Disposal of Decontamination Solutions

3.3.1 Proper disposal of the soap/water solution is to the ground surface, unless otherwise specified in the sampling and analysis plan or waste management plan.

## 4. DEFINITIONS

*Decontamination*—Removal of dangerous, hazardous, toxic, or unwanted residues from field personnel and/or equipment.

*Uncontrolled Hazardous Waste Site*—Any site where a hazardous substance has been deposited, stored, disposed of, treated, placed or otherwise come to be located, and which is known, suspected, or considered capable of presenting endangerment to the public or environment.

## 5. REFERENCES

29 CFR 1910.120, “Hazardous Waste Operations and Emergency Response,” *Code of Federal Regulations*, Office of the Federal Register, as amended.

# 1. PURPOSE

To prevent cross-contamination from occurring between locations on a contaminated environmental site (EPA 2007).

# 2. SCOPE

All equipment leaving the contaminated portions of a site must undergo *decontamination* (see def.). Decontamination methods include physical removal, chemical removal, or a combination of both. Decontamination procedures, in some cases, are to be performed in the same level of protection used in the contaminated area of a site. However, decontamination personnel may be sufficiently protected by wearing one level of lower protection.

# 3. DECONTAMINATION

The following decontamination procedures are for typical uncontrolled hazardous waste sites. For a more specific or unusual contaminants, see the site-specific health and safety plan. Decontamination procedures should be used in conjunction with best management practices to prevent contamination of field equipment whenever possible (EPA 2001).

## 3.1 Inorganic Contaminants

3.1.1 Remove gross contamination with a water rinse using pressurized or gravity-flow tap water.

3.1.2 Wash equipment in a solution of water and Alconox, Liquinox, or equivalent detergent using a stiff brush.

3.1.3 Triple rinse the equipment with distilled water.

3.1.4 Rinse the equipment with a mixture of 10:1 nitric acid in distilled water (10 parts water to one part nitric acid).

3.1.5 Rinse the equipment again with distilled water.

## 3.2 Organic Contaminants

3.2.1 Remove gross contamination physically with a disposable paper towel or a water rinse using pressurized or gravity-flow water.

3.2.2 Wash equipment in a solution of water and Alconox, Liquinox, or equivalent detergent using a stiff brush.

3.2.3 Triple rinse the equipment in tap water.

3.2.4 Triple rinse the equipment with distilled water.

3.2.5 Triple rinse the equipment with methanol.

**3.3 Equipment Used for Decontamination**

3.3.1 Triple rinse equipment (e.g., brushes, buckets, tubs) used in the decontamination process with water, preferably pressurized.

3.3.2 Agitate the equipment used in the decontamination process in the soap/tap water solution.

3.3.3 Triple rinse equipment with tap water.

3.3.4 Place equipment in appropriate areas so they are used for decontamination purposes only.

**3.4 Disposal of Decontamination Solutions**

3.4.1 Proper disposal of the soap/tap water solution, the tap water rinse, and the deionized rinse is to ground surface, unless otherwise specified in the sampling and analysis plan or waste management plan.

3.4.2 Proper disposal of the solvent rinse is to a waste container for proper disposal offsite.

**3.5 Effectiveness of Decontamination**

3.5.1 Effectiveness of the decontamination procedures will be measured using the field equipment rinsate blanks.

## 4. DEFINITIONS

*Decontamination*—Removal of dangerous, hazardous, toxic, or unwanted residues from field personnel and/or equipment.

## 5. REFERENCES

EPA, 2001, "Environmental Investigations Standard Operating Procedures and Quality Assurance Manual," U.S. Environmental Protection Agency, Region IV, November 2001.

EPA, 2007, "Field Equipment Cleaning and Decontamination," SESDPROC-205-R1, U.S. Environmental Protection Agency, Region IV, Science and Ecosystem Support Division, November 2007.

| MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION IN WATER | Identifier: TPR-5007<br>Revision: 0<br>Page: **1** of 3 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

To determine the quantity of oxygen dissolved in surface or groundwater samples (EPA 1983).

# 2. SCOPE

Dissolved oxygen (DO) is typically measured to monitor the oxidation-reduction state of contaminated water bodies. This procedure defines the steps to be taken in acquiring accurate measurements while in the field.

# 3. PROCEDURE

## 3.1 General Information

Measurements of the concentration of DO in water will be made with a YSI Model 55 Handheld Dissolved Oxygen System or equivalent. The instrument employed will display temperature in degrees Celsius (°C) and DO in units of both milligrams per liter (mg/L) or percent air saturation.

The DO probe must be prepared for operation as described in the manufacturer's operations manual. Examine the probe membrane before each use. If the membrane is dirty, contaminated, broken, cracked, or discolored, it must be replaced.

The DO meter shall be calibrated each time it is turned on using the procedures specified in the manufacturer's operating manual. The instrument must be calibrated for the altitude of measurement and within 10°C of the sample temperature.

**NOTE:** *Refer to manufacturer's operation manual regarding interferences.*

Dissolved organic materials are not known to interfere in the output from dissolved oxygen probes. Dissolved inorganic salts are a factor in the performance of dissolved oxygen probe. Probes with membranes respond to partial pressure of oxygen, which in turn is a function of dissolved inorganic salts. Conversion factors for seawater and brackish waters may be calculated from dissolved oxygen saturation versus salinity data conversion factors for specific inorganic salts may be developed experimentally. Broad variations in the kinds and concentrations of salts in samples can make the use of a membrane probe difficult. Reactive compounds can interfere with the output or the performance of dissolved oxygen probes.

Reactive gases, which pass through the membrane probes, may interfere.

For example, chlorine will depolarize the cathode and cause a high probe-output. Long-term exposures to chlorine will coat the anode with the chloride of the anode metal and eventually desensitize the probe.

Alkaline samples in which free chlorine does not exist will not interfere.

Hydrogen sulfide will interfere with membrane probes if the applied potential is greater than the half-wave potential of the sulfide ion.

If the applied potential is less than the half-wave potential, an interfering reaction will not occur, but coating of the anode with the sulfide of the anode metal can take place.

Prolonged use of membrane electrodes in waters containing gases such as hydrogen sulfide ($H_2S$) tends to lower cell sensitivity.

Eliminate this interference by frequently changing and calibrating the membrane electrode.

Dissolved oxygen probes are temperature sensitive, and the DO meter provides temperature compensation.

Plastic films used with membrane electrode systems are permeable to a variety of gases besides oxygen, although none is depolarized easily at the indicator electrode.

**3.2 Equipment and Supplies Needed**

1. Handheld DO meter, DO probe, and carrying case YSI Model 55 Handheld Dissolved Oxygen System or equivalent
2. DO meter operations manual and standard membrane kit
3. AA alkaline batteries (six)
4. Field notebook and pen
5. Distilled water and paper towels
6. Glass beaker(s) for each sample.

**3.3 Procedure**

3.3.1 Ensure that the instrument is powered on, set in the operating mode, and properly calibrated, and check the condition of the membrane.

3.3.2 Because DO concentration is dependent on temperature, measurements should be made immediately after sample collection. Samples should not be unnecessarily agitated.

3.3.3 Rinse a clean glass container with a portion of the sample and then place enough water in the container to cover the probe.

3.3.4 Place the probe in the container while gently, but continuously, stirring the sample with the probe tip.

3.3.5 When the reading on the instrument display has stabilized, record the temperature and DO concentration in the field book.

3.3.6 Rinse the container and probe after use. The probe may be temporarily stored wet in the chamber on the side of the instrument case.

# 4. DEFINITIONS

None

# 5. REFERENCES

EPA, 1983, "Oxygen, Dissolved (Membrane Electrode)," *Methods of Chemical Analysis of Water and Wastes*, Method 360.1, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1983.

| SURFACE SOIL SAMPLING | Identifier: TPR-5008<br>Revision: 0<br>Page: **1** of 2 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

The collection of soil samples that accurately represent surface conditions at an environmental site.

# 2. SCOPE

*Surface soil* (see def.) sampling will be completed in accordance with this TPR and the approved sampling and plan (SAP). This procedure defines the steps necessary to acquire surface soils in accordance with planned activities and is designed to acquire a surface soil sample from the ground surface to 2 in. below ground surface. The SAP outlines the locations and number of samples.

# 3. PROCEDURE

Depending on the specified depths for surface samples, the most desirable sampling device is the soil probe (EPA 1999). It allows uniform sample across the entire depth profile. Alternate sample collection devices include the stainless steel scoop, stainless steel trowels, and disposable Teflon® trowels (EPA 2000). Tools with plating may not be used because of the risk of contaminating the samples. The following describes the steps to be taken in acquiring surface soil samples. They may be modified in the field based on field conditions after appropriate annotations have been made in the field log book.

## 3.1 Discrete Sampling

3.1.1 Dig a 12-in.-square pit to a depth of approximately 8 in. If live plants or an organic layer are present, this will be peeled back.

3.1.2 Place a stainless steel bowl in the pit and collect a sample by scraping the face of the pit from 0 to 2 in. using a stainless steel spoon.

3.1.3 Remove all coarse fragments greater the 0.5 in. from the bowl.

3.1.4 Mix the remaining sample in the bowl with a stainless steel spoon.

3.1.5 Transfer the soil sample directly into the appropriate sample container.

3.1.6 Record the information specified in the SZP, in the field logbook.

3.1.7 Decontaminate the sampling tools according to TPR-5006, “Equipment Decontamination.”

### 3.2 Composite Sampling[a]

3.2.1 The most desirable method of compositing (see def.) soil subsamples (see def.) is with a large plastic sheet. The subsamples are mixed in the center of the sheet. Each corner is then pulled up and toward the opposing corner. A new plastic sheet is used for each sample location.

3.2.2 After the soil is mixed, it is again spread out on the sheet into a relatively flat pile, quartered, and equal subsamples are acquired from each quarter until the sample container is filled.

**NOTE:** *High concentrations of organic chemicals in soils can react with the plastic sheet.*

3.2.3 Subsamples are often collected in a five-point (star) pattern. At each point, a subsample of a predetermined depth is collected. The diagonal distance between points will be defined by the SAP.

3.2.4 Subsamples can also be collected in a three-point (triangular) pattern. At each point, a subsample of predetermined depth is collected. The diagonal distance between the points will be defined in the SAP.

## 4. DEFINITIONS

*Compositing*—The act of mixing sample aliquots to form a sample.

*Subsamples*—Sample aliquots that are combined to form a sample.

*Surface soil*—Surface soils are specified by the client and regulatory definition of surface material and may include any part from ground surface to 2 in. below ground surface.

## 5. REFERENCES

EPA, 1999, “Soil Sampling,” SOP No. 1205, Rev. 2, U.S. Environmental Protection Agency Region 9, September 1999.

EPA, 2000, “Soil Sampling,” SOP No. 2012, Rev. 0.0, U.S. Environmental Protection Agency Environmental Response Team, February 18, 2000.

TPR-5006, “Equipment Decontamination,” Portage, Inc., current revision.

a. Compositing may not to be used when sampling for volatile organic compounds.

| SOIL AND WATER SAMPLE PACKAGING AND SHIPPING | Identifier: TPR-5009<br>Revision: 0<br>Page: **1** of 2 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

Ensure environmental samples are properly handled following their collection to ensure the associated data represent site conditions.

# 2. SCOPE

This procedure defines the steps to be taken following the collection of the environmental samples to ensure the samples are delivered to the contract laboratory without damage, degradation, or other adverse conditions that might prevent the use of the sample results (EPA 2002).

# 3. INSTRUCTIONS

## 3.1 Soil and Water Sample Packaging and Shipping

3.1.1 Water samples will be chemically preserved in accordance with the sampling and analysis plan (SAP) prior to preparation of samples for shipment.

3.1.2 Following preservation, each full sample container will be placed in separate Ziploc© or equivalent bags to keep it clean, dry, isolated, and to protect the sample label.

3.1.3 Samples will then be placed in a cooler that has been lined with a plastic bag.

3.1.4 The samples will then be surrounded with packing material to reduce movement and absorb any leakage.

3.1.5 The garbage bag will then be tied to contain the packing material.

3.1.6 The project manager will check the accompanying sample paper work (chain-of-custody forms, traffic reports, tags, etc.) to ensure the samples are recorded on the associated paper work are in the cooler.

3.1.7 The project manager and the sampler will then sign the chain-of-custody form to relinquish *custody* (see def.).

3.1.8 The paper work will then be placed in a sealed Ziploc© or equivalent bag and taped to the inside of the cooler lid.

3.1.9 Bagged ice will be placed inside the cooler on top of the sealed bag.

3.1.10 The cooler will be labeled with the appropriate shipping labels.

3.1.11 The cooler will then be closed and an address label affixed to the lid (a Federal Express label will also be affixed, if used at this time).

3.1.12 The cooler will have chain-of-custody seals placed over the opening.

3.1.13 Tape will then be placed over the custody seals and around the cooler.

3.1.14 The cooler(s) will then be transported to the shipping agent, or directly to the laboratory.

**NOTE:** *Bagging of samples and lining the cooler is not necessary if samples are transported directly to the laboratory.*

## 4. DEFINITIONS

*Custody*—Physical control of a sample or group of samples.

## 5. REFERENCES

EPA, 2002, "Chain of Custody of Samples," Rev. 1, U.S. Environmental Protection Agency, March 25, 2002.

| INORGANIC PRESERVATION (WATER) | Identifier: TPR-5010<br>Revision: 0<br>Page: **1** of 3 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

*Preservation* (see def.) of constituents in water samples collected at environmental sites.

# 2. SCOPE

This procedure describes the techniques necessary to sample, prepare, and handle water after sampling. Sample handling and preservation shall be completed in accordance with the specified procedures (Section 5) for the following inorganic constituents:

- Total metals
- Dissolved metals
- Cyanide
- Sulfate
- Nitrate/nitrite
- Chloride
- Hardness (titration method).

# 3. INSTRUCTIONS

## 3.1 Total Metals, Hardness

3.1.1 A 1-L polyethylene bottle is recommended for each sample. A minimum of 250 mL of water will be collected for total metals.

3.1.2 Upon sample collection, the sample will be acidified using nitric acid to a pH of 2 or less to prevent metals from precipitating or volatilizing from solution. Normally, 3 mL of 50% nitric acid should be sufficient to preserve the samples.

3.1.3 Label and store the sample according to TPR-5009, "Soil and Water Sample Packaging and Shipping." The samples shall be stored in a refrigerator or portable cooler at temperature of 4°C +/- 2°C until sample preparation occurs at the laboratory.

**3.2 Dissolved Metals**

3.2.1 Immediately following sample collection, sufficient volume of sample will be filtered using a 0.45-μ filtration unit, to remove particulate in water. The filtration unit must be glass if the analysis is for boron or silicon.

3.2.2 Complete Steps 3.1.1 through 3.1.3.

**3.3 Cyanide**

3.3.1 A 1-L polyethylene bottle is required.

3.3.2 Upon sample collection, the sample is to be preserved using sodium hydroxide to a pH greater than 12.

3.3.3 Label and store the sample according to TPR-5009. The samples can be stored at room temperature for up to 4 hours prior to analyses; thereafter, they must be in a refrigerator or portable cooler at temperature of 4°C +/- 2°C until sample preparation occurs at the laboratory.

**3.4 Chloride and Sulfate**

3.4.1 Because these parameters can be analyzed from the same sample, a 1-L polyethylene bottle is required.

3.4.2 Following sample collection, label the sample and store in a refrigerator or portable cooler at temperature of 4°C +/-2°C until sample preparation occurs at the laboratory.

**3.5 Nitrate/Nitrite**

3.5.1 A 250-mL polyethylene bottle is required for this analysis.

3.5.2 Upon sample collection, the sample is to be acidified with sulfuric acid to a pH of 2. Following sample collection, label the sample and store in a refrigerator or portable cooler at temperature of 4°C +/-2°C until sample preparation occurs at the laboratory.

# 4. DEFINITIONS

*Preservation*—Using chemical, biological, or physical means to prevent degradation to a sample.

# 5. REFERENCES

EPA, 1983, "Sulfate (Colorimetric, Automated, Chloranilate)," *Methods of Chemical Analysis of Water and Wastes*, Method 375.1, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1983.

EPA, 1983, "Cyanide, Total (Colorimetric, Automatic UV)," *Methods of Chemical Analysis of Water and Wastes*, Method 335.3, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1978.

EPA, 1983, "Chloride (Titrimetric, Mercuric Nitrate," *Methods of Chemical Analysis of Water and Wastes*, Method 325.3, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1983.

EPA, 1983, "Hardness, Total (mg/L as $CaCO_3$) (Titrimetric, EDTA)," *Methods of Chemical Analysis of Water and Wastes*, Method 130.2, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1983.

EPA, 1993. "Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry," Method 353.2, Rev. 2.0, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1993.

EPA, 1994, "Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry," *Methods of Chemical Analysis of Water and Wastes*, Method 200.7, Revision 4.4, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1994.

TPR-5009, "Soil and Water Sample Packaging and Shipping," Portage, Inc., current revision.

| STREAM SAMPLING | Identifier: TPR-5011<br>Revision: 0<br>Page: **1** of 2 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

To acquire representative water samples from flowing surface water affected by environmental sites.

# 2. SCOPE

This sampling procedure shall be utilized to collect samples from flowing aboveground streams, rivers, and similar (USGS 2006). The following outlines the steps to be completed to ensure representative samples are acquired.

# 3. INSTRUCTIONS

## 3.1 Sample Collection

3.1.1 The samples collected will be *composite samples* (see def.) or *grab samples* (see def.) as directed in the sampling and analysis plan.

3.1.2 Always sample from downstream to upstream locations and stand downstream of the sample bottles to avoid stream bed solids.

3.1.3 Gloves will be worn at all times during water sampling.

3.1.4 If the channel is less than 5 ft across, collect grab samples from the center of the channel.

3.1.5 If the channel width is greater than 5 ft, divide the channel into 5-ft sections and collect a composite sample at the center of each section to obtain a channel integrated sample.

3.1.6 To acquire a water sample, submerse the container in the water, mouth pointing upstream and below the surface water.

3.1.7 If standing in the stream is required, always collect sample upstream of your location, while facing upstream.

3.1.8 Samples shall be collected at a depth from the approximate midpoint between the stream bed and the stream surface.

3.1.9 Take care not to collect any stream bed solids. If the stream bed is very shallow, a decontaminated ladle or cup may be necessary to collect water without disturbing the stream bed.

3.1.10 If collecting a grab sample, fill the sample bottle, and add required preservatives. Secure the cap tightly.

3.1.11 If collecting a composite sample, collect full bottles of water and pour into a decontaminated bucket.

3.1.12 Stir or swirl the contents of the bucket and fill each sample bottle.

3.1.13 Label the sample bottle, record the sampling information in the logbook and on the chain-of-custody form, and store the samples in accordance with TPR-5010, "Inorganic Preservation (Water)."

# 4. DEFINITIONS

*Grab sample*—A discreet sample collected in one point of time.

*Composite sample*—A sample collected over time or location.

# 5. REFERENCES

TPR-5010, "Inorganic Preservation (Water)," Broken Hill Mine Site, Sanders County Montana, Portage, Inc., current revision.

USGS, 2006, *Collection of water samples (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations*, Book 9, Chapter A4, U.S. Geological Survey.

| FIELD MEASUREMENT OF PH IN WATER | Identifier: TPR-5012<br>Revision: 0<br>Page: **1** of 2 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

This procedure will be used to determine the proportion of hydrogen/hydroxide ions in water at environmental sites.

# 2. SCOPE

This procedure defines the steps used to acquire measurements from surface and groundwater using a digital meter equipped with a *pH* (see def.) probe (EPA 1983). It can be used for all water samples at environmental/contaminated sites and is intended for use during field sampling.

# 3. INSTRUCTIONS

## 3.1 Calibration

3.1.1 If previous data are available, calibrate the instrument using the two *buffer solutions* (see def.) that best fit the expected pH range of the sample.

3.1.2 Place buffer solutions (4, 7, and 10) into chemical-free, plastic cups or sample jars to a level that will cover 2 in. of the pH probe.

3.1.3 Place the pH probe into the selected buffer solutions individually and record the readings in the field logbook.

3.1.4 If the pH meter in use can perform a best fit calibration, following the measurement of the second buffer, use this function to calibrate the pH meter.

3.1.5 Rinse the probe between measurements using deionized water, and blot excess water as necessary using a laboratory-grade paper towel.

3.1.6 Following calibration, take measurements of natural samples, if necessary.

## 3.2 Field Measurements

3.2.1 Fill sample cup, bottler, or beaker with water sample.

3.2.2 Submerge probe in sample. Stir for thorough mixing. Record the pH measurement in the field logbook to nearest 0.01 standard units.

3.2.3 Take a sample temperature measurement and record it in the logbook.

3.2.4 Remove probe from sample and rinse with deionized water. Blot excess water as necessary using laboratory grade paper towel

### 3.3 Maintenance

3.3.1 Decontaminate the sample probe following each use, in accordance with TPR-5006, “Equipment Decontamination.”

3.3.2 Store meter in case during transport.

3.3.3 Check batteries prior to leaving for the field and carry spare batteries.

**NOTE:** *pH may also be measured by placing the probe directly into the water body being tested. The probe must be moved slowly in a circular motion when measuring stagnant water.*

## 4. DEFINITIONS

*Buffer solution*—A mixture of weak acids and their salts or mixtures of weak bases and their salts that resist changes in hydrogen-ion concentration upon addition of small amounts of acids or bases.

*pH*—The concentration of hydrogen ions in terms of the negative logarithm of the hydrogen ion concentration.

## 5. REFERENCES

EPA, 1983, “pH (Electrometric),” *Methods of Chemical Analysis of Water and Wastes*, Method 325.3, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1983.

TPR-5006, “Equipment Decontamination,” Broken Hill Mine Site, Sanders County Montana, Portage, Inc., current revision.

| FIELD MEASURMENT OF SPECIFIC CONDUCTANCE AND OXIDATION-REDUCTION POTENTIAL | Identifier: TPR-5013<br>Revision: 0<br>Page: **1** of 3 |
|---|---|

| Applicability: Broken Hill Mine | Type: Procedure | Effective Date: 02/20/09 |
|---|---|---|

For most recent revision or additional information: https://sharepoint.portageinc.com Owner: Pat Seccomb

# 1. PURPOSE

Collection of field measurements from water acquired from environmental sites.

# 2. SCOPE

This procedure defines the steps to be completed for measurements completed in the field for surface and groundwater (EPA 1983). It includes provisions for both *specific conductance* (see def.) and *oxidation-reduction potential* (see def.).

# 3. INSTRUCTIONS

## 3.1 Field Procedure—Specific Conductance (SC)

3.1.1 Calibrate instrument as described in the manufacturer's instruction manual. Typically, the lowest concentration standard is appropriate.

3.1.2 Replace batteries and try fresh calibration solution if meter does not calibrate properly.

3.1.3 Rinse decontaminated beaker with sample water.

3.1.4 Fill beaker with water sample.

3.1.5 Rinse probe with deionized water.

3.1.6 Submerge probe in sample immediately after collection so that flow cell holes are immersed.

3.1.7 Stir to remove any bubbles from within flow cell.

3.1.8 Turn instrument on to appropriate scale. Read the specific conductance and record to nearest one Siemen (or micromho/cm).

3.1.9 Record the value in the field logbook. Results are typically reported at 25 degrees by collecting the measurement at that temperature or performing corrections.

3.1.10 Remove probe from sample and rinse with deionized water.

## 3.2 Maintenance

3.2.1 Store meter in case during transport.

3.2.2 Check batteries prior to leaving for the field and carry spare batteries.

### 3.3 Field Procedure—Oxidation-Reduction Potential (ORP)

3.3.1 The electrode shall be filled with one of the two solutions selected to best match the *ionic strength* (see def.) of the sample. The following solutions can be used:

- Dilute solution (total ionic strength less than 0.2 *molar [M]* [see def.])
- Concentrated solution (total ionic strength greater than 0.2 *M*)

3.3.2 Fill solution level in the electrode to at least 1 in. above the level of the solution being measured.

### 3.4 Connecting the Electrode to the Meter

3.4.1 Insert the connector in the electrode input jack in to the reference electrode input jack.

### 3.5 Calibration Procedure

3.5.1 Connect the electrode and place in a beaker of tap water. Turn on meter.

3.5.2 Add a drop of dilute (10:1) sodium hydroxide (NaOH) to the beaker and mix.

3.5.3 If the reading decreases sharply, the electrodes are sensitive and working properly.

3.5.4 If the reading does not decrease sharply, the electrodes must be cleaned.

3.5.5 Drain the filling solution and refill with fresh solution.

3.5.6 Pour a standard solution into a beaker and place the electrode in the standard solution.

3.5.7 The standard solution should read 439 +/- 30mV.

### 3.6 Measurement Procedure

3.6.1 Place the electrode in the sample solution.

3.6.2 When the reading stabilizes record the reading in the field logbook.

## 4. DEFINITIONS

*Ionic Strength*—Electrostatic forces causing a bond between substances.

*Molar*—A measurement of a quantity of a substance.

*Oxidation-Reduction Potential*—The possibility of a liquid to lose or gain electrons.

*Specific Conductance*—A measure of the ability of a water solution to conduct an electrical current.

# 5. REFERENCES

EPA, 1983, "Conductance (Specific Conductance, umhos at 25°C)," Methods of Chemical Analysis of Water and Wastes, Method 120.1, EPA-600/4-79-020, U.S. Environmental Protection Agency, 1983.