ABANDONED MINE SITE INVESTIGATION

OF THE

IDORA MINE SITE

ALONG

BEAVER CREEK IDAHO

Prepared for:

U.S. Army Corps of Engineers, Sacramento District and
U.S. Army Corps of Engineers, Omaha District

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July 23, 2003

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EXECUTIVE SUMMARY

In a collaborative effort by the United States Army Corps of Engineers - Restoration of Abandoned Mine Site program and the United States Forest Service, Bitterroot Restoration, Inc. completed a fall 2002 field characterization of the Idora Mine/Mill site north of Wallace, Idaho. The purpose of the site characterization is to determine the nature, extent and magnitude of environmental disturbance in the drainage and to assess potential impacts to human health and the environment. The findings of the characterization will guide future restoration efforts in the Beaver Creek stream drainage. The Idora Mine/Mill site assessment is the first Restoration of Abandoned Mine Site project undertaken in the State of Idaho.

Developed in the early twentieth century, the Idora Mine was active through the mid 1950s. The mine produced commercial quantities of silver and zinc, but the primary ore was lead. The mill site and tailings are located in and adjacent to Beaver Creek and are being actively eroded. Preliminary evidence indicates that the site is the source of a significant amount of heavy metal contamination to the downstream reaches, which contain residences, frequent recreation usage, and wildlife habitat.

The Idora mine and mill sites are located in the headwaters of Beaver Creek, a tributary of the North Fork of the Coeur d'Alene River, Idaho Panhandle National Forests, Shoshone County, Idaho. The Beaver Creek watershed has been identified by the United States Forest Service as a priority watershed for Abandoned Mine Land reclamation. In addition, the United States Bureau of Land Management and State of Idaho are also actively involved with abandoned mine reclamation at other sites in the Beaver Creek watershed.

This characterization occurred between July 2002 and March 2003, and the field investigation took place over six days, from October 1 to October 8, 2002. It involved creating a topographic site map, as well as collecting and analyzing surface water, sediment, soil, and mine waste samples from Beaver Creek, downstream from the Idora mine site. Additional information related to the vegetative and geomorphic characteristics within the drainage aided in our understanding of the site. Seven surface water samples, seven sediment samples, and 17 soil/mine waste samples were collected and analyzed. In addition, 135 soil and mine waste samples were analyzed for total metals concentrations via X-ray fluorescence.

It is estimated that the injured area on Beaver Creek contains approximately 2.3 million cubic feet of contaminated materials. The materials are spread fairly evenly across the site. The upper 1,100 feet of the site (accounting for 17 percent of the total injured area), however, contains 25 percent of the total volume of materials. A disproportionately high volume of materials is found in this area because it houses the Idora Mine and Mill.

The results from this site investigation indicate that the levels of contamination in and around the Idora Mine project site exceed established protective limits for recreational populations. Lead is the major Chemical of Potential Concern in the system. Over 75 percent of soil/mine waste samples and over 85 percent of the sediment samples contained total lead concentrations above Chemicals of Potential Concern limits for recreational visitors. In addition, all soil/mine waste samples were acidic in nature, with three-quarters of samples exhibiting continuing acid

generating properties. Other metals in the soil are elevated, although not above action thresholds. The surface water in the Idora Mine project site does not show levels of Chemicals of Potential Concern elevated above health limits.

The riparian health assessments also indicate that the ecological integrity of the system is compromised. Many parts of the flood-prone zone are devoid of vegetation, likely due to a combination of soil chemistry and physical disturbance. In addition, the Beaver Creek channel is deeply entrenched with high levels of mobile cobbles and pebbles, reflecting probable historic changes in the hydrology of the system caused by mining and milling activities.

Based upon the site investigation, the Idora Mine project site appears significantly impacted, with levels of Chemicals of Potential Concern in the floodplain materials and streambed sediments exceeding the limits for recreational exposure and human health. It is recommended that approximately 2.3 million cubic feet of contaminated tailings materials be removed, the impacted stream channel and floodplain areas reconstructed, and the impacted riparian zone restored.

1.0 PROJECT GOALS AND OBJECTIVES

In a collaborative effort by the United States Army Corps of Engineers (USACE) - Restoration of Abandoned Mine Site (RAMS) program and the United States Forest Service (USFS), and Bitterroot Restoration, Inc. (BRI), a field characterization of the Idora Mine/Mill site north of Wallace, Idaho was completed in the fall of 2002. The purpose of the site characterization was to determine the nature, extent and magnitude of environmental disturbance in the drainage and to assess potential impacts to human health and the environment. The findings of the characterization will guide future efforts to remove contaminated materials and restore the stream drainages. The Idora Mine/Mill site assessment is the first RAMS project undertaken in the State of Idaho.

The investigation involved collecting and analyzing surface water, sediment, soil, and mine waste samples from the Idora mine site. Additional information related to the vegetative and geomorphic characteristics within the drainage aided in our understanding of the site. For this project, seven surface water samples, 17 soil/mine waste samples, and seven sediment samples were collected and analyzed. The analytical results are being used to gain information about the extent of mine-related contamination.

This document has been prepared in fulfillment of the requirements of the USACE contract DACW05-01-D-0019 / Idora, Delivery Order 004.

2.0 PROJECT SETTING

The Idora mine and mill sites are located in the headwaters of Beaver Creek, a tributary of the North Fork of the Coeur d'Alene River, Idaho Panhandle National Forests, Shoshone County, Idaho (refer to Figure 1). The Beaver Creek watershed has been identified by the USFS as a priority watershed for Abandoned Mine Land reclamation. In addition, the United States Bureau of Land Management (BLM) and State of Idaho are actively involved with abandoned mine reclamation at other sites in the Beaver Creek watershed.

Photo of the Idora Mine looking down on Beaver Creek

The elevation of the Beaver Creek project site ranges from 3,501 feet at the Idora Mine to 3,068 feet at the confluence of Beaver and Carbon Creeks. The area experiences warm summers (the average high temperature in July is of 83.7 degrees F) and moderately cold, wet winters (the average low in January is 20.2 degrees F). The area's annual average rainfall is approximately 40 inches and average annual total snowfall is six feet. (Western Regional Climate Center, 2002).

The predominant vegetation around the site consists of Western Red Cedar (*Thuja plicata*) in the overstory and numerous shrubs, ferns, and forbs in the understory. Ladyfern (*Athyrium filix-femina*) is the dominant understory plant.

3.0 PROJECT BACKGROUND

Idora Mine Site on Beaver Creek

Developed in the early twentieth century, the Idora Mine was active through the mid 1950s. The mine produced commercial quantities of silver and zinc, but the primary ore was lead. The mill site and tailings, located in and adjacent to Beaver Creek, are being actively eroded. Preliminary evidence indicates that the site is the source of a significant amount of heavy metal contamination to the downstream reaches, which contain residences, frequent recreation usage, and wildlife habitat.

Spot samples of tailings collected in 1999 by the United States Geographic Service (USGS) both at the mill site and along the stream, contained lead concentrations greater than 20,000-70,000 parts per million (ppm). Similar spot samples of tailings in the streambed sediments of Beaver Creek contained lead concentrations of 5,000-10,000 ppm (USGS, 2000).

4.0 SITE ASSESSMENT METHODS

Project Planning

The Standard Operating Procedures (SOPs), outlined in the *Restoration of Abandoned Mine Sites Final Workplan* (U.S. Army Corps of Engineers, Omaha District, 2002), were adhered to during the course of this field investigation: A1 (Surface Soil/Rock Sampling Equipment and Procedures); A3 (Subsurface Soil/Rock Sampling Equipment and Procedures); A4 (Soil/Rock Homogenization Equipment and Procedures); A7 (Investigative Derived Waste Procedures); A11 (Surface Water and Sediment Sampling Equipment and Procedures), A12 (Equipment Decontamination Procedures); A13 (Sample Handling, Documentation, and Tracking Procedures); and A14 (Field Documentation).

Figure 1. Idora Site Location Map

Figure 1. Idora Locational Map

0 0.2 0.4 0.6 0.8 1 Miles

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4.1.1 Health and Safety Plans

Prior to conducting fieldwork, BRI developed a health and safety plan for the Idora project. Information on health and safety issues associated with this field effort may be found in the *Idora Site Safety and Health Plan (SSHP),* Sept. 2002.

4.1.2 Sampling Methodology

Sampling plans were developed for the collection of surface water, sediment, soil, and mine waste material. Information on sampling methods followed is found in *The Standard Operating Procedures (SOPs), Surface Soil/Rock Sampling Equipment and Procedures* (U.S. Army Corps of Engineers, Omaha District, 2002).

4.1.3 Sample Identification Scheme

The sample identification (ID) scheme for soil and mine waste samples, described in *The Standard Operating Procedures (SOPs)* (U.S. Army Corps of Engineers, Omaha District, 2002), used the following designation.
A-BB-CC-DD where:

A = Designation of sampling area location – **I** (For Idora)
BB = A numerical digit that indicates if the sample is normal, a duplicate, or a confirmation. 01 = Normal; 02 = Duplicate; 04 = Confirmation
CC = A numerical digit that indicates the depth from which the sample is extracted. 01 = between 0 inches and 1 foot; 02 = greater than 1 foot to 2 feet; 03 = greater than 2 feet to 3 feet; 04 = greater than 3 feet to 4 feet;
DD = two or three digit sample identification number

For example, a confirmation soil sample collected from a depth of 1.5 feet at the Idora Mine site would be coded I-04-02-75. The last two digits (75) are the sample identification number.

The sample identification scheme for water and stream sediment samples used the designation below.
AA-CSB-CCC where:

AA= Designation of sampling area location – ID (for Idora in Idaho)
CSB = Three character identification code that identifies the sample with the subreach where it was collected. CS stands for "Cross-Section."
CCC = Identifies if the sample is water (H2O) or sediment (SED)

For example, a water sample collected from Subreach 3 at the Idora Mine site in Idaho would be coded ID-CS3-H2O.

4.2 Field Investigation Activities

This investigation occurred between July 2002 and March 2003. The field investigation, described in the *Site Specific Addendum to RAMS General Work Plan and Safety and Health Plan for Idora Mine* (Bitterroot Restoration, Inc. [BRI], 2002), took place over seven days, from October 1 through October 8, 2002. The first project task involved developing sampling and safety plans. Fieldwork was conducted by BRI and EMC^2. A topographic/site features survey of the mine waste impacted area was completed by Territorial Engineering and Surveying, Inc., a licensed professional surveying company, from November 1 through November 6, 2002. Data analysis and reporting occurred between March 15 and March 31, 2003.

Upon arrival at the project site, the field team first delineated the boundary of the injured area. The field team then collected mine waste, soil, surface water, and sediment data; estimated the volume of contaminated material; and completed riparian health assessments. Finally, Territorial Engineering and Surveying, Inc. created a topographic site map on one-foot contours, delineated areas of interest, and surveyed all sampling locations (See Appendix B). Field notes from the field investigation are contained in Appendix A.

4.3 Boundary Delineation

Delineating the project boundary first involved a physical examination of the project site. Boundary limits were based upon visual clues regarding the extent of contamination including: the absence of ground cover; type, quantity, and diversity of plant species; the location of the floodplain; old stream channels; tailings/waste materials; and erosion features on either side of the stream. Boundaries were subsequently confirmed or relocated according to contamination levels recorded with an X-ray Fluorescence (XRF) unit. White flags were placed every 100 feet along the border of the project site. Boundaries were used to determine the extent of the professional survey, to delineate the riparian assessment survey subreaches, and to provide XRF sampling boundaries. Sampling location coordinates, obtained from a hand-held Garmin Etrex Global Positioning System (GPS) device with an accuracy of 15 meters, were recorded in the field logbook. The boundaries and sampling locations were also mapped by Territorial Engineering and Surveying, Inc. The survey met minimum conventional theodolite traverse control standards (third order geodetic control and 1:5000 accuracy).

In addition to boundary determinations, seven hydrologic subreaches (displayed in Figures 2-A and 2-B) were delineated across the injured area. Subreach boundaries were based upon hydrologic and geomorphic changes within the stream channel, as well as distinct changes in mine waste deposition. Subreaches are described below sequentially from the top (highest elevation) boundary on Beaver Creek to the lower boundary at the confluence of Beaver and Carbon Creeks.

Subreach 1 lies immediately upstream of the injured area on Beaver Creek. The intent was to use this site as a reference reach, but after further exploration upstream of Subreach 1, it was discovered that historic mining impacted the entire length of Beaver Creek. Hence, the full suite of vegetation, hydrologic, and chemical data was not collected on this subreach, nor was a suitable reference reach found for this investigation.

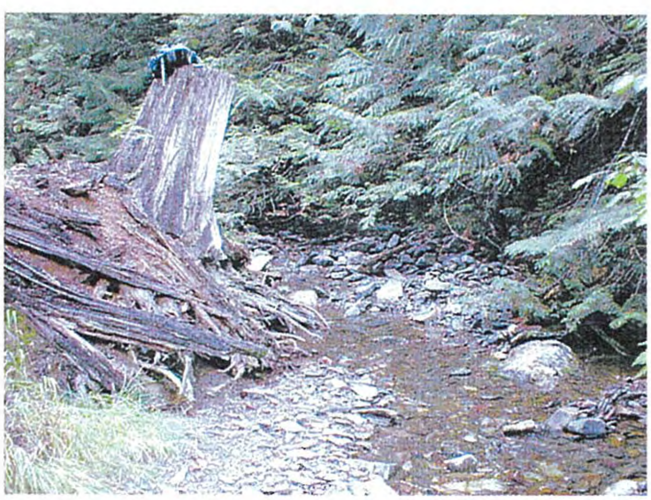
Subreach 2 includes the Idora Mine and Mill. The top of Subreach 2 is near the main Idora mill, which is the main source of tailings and waste rock found in the system. The stream channel in Subreach 2 is incised several feet down into the surrounding tailings.

Tailings piles on Subreach 2

The stream gradient (8 percent) is moderately steep. The tailings piles are virtually devoid of vegetation. However, the remaining 80 percent of the subreach floodplain is well vegetated, both in terms of plant coverage and plant diversity. One habitat type, defined by the dominance of Western Redcedar in the overstory and Lady Fern in the understory, is found in Subreach 2. This short segment is approximately 400 feet long and ranges from 3,501 feet to 3,469 feet in elevation.

Subreach 3 is characterized by numerous braids cut down into terraced tailings. The stream incline is moderately steep, eight percent. Similar to Subreach 2, the area surrounding the stream is a barren tailings and waste rock terrace. Most of the floodplain, however, is well vegetated by numerous plants that fall into a single habitat type: Western Redcedar/ Lady Fern. This approximately 800 feet long segment ranges in elevation from 3,469 feet to 3,406 feet.

Creek braid cut into a terraced tailings pile on Subreach 3



Forested hummocks pile and cedar forest on Subreach 4

Subreach 4 ranges from 3,406 to 3,375 feet in elevation. This 430 feet long subreach is confined on the right side by relatively high embankments and an old road. The left side is open, containing a wide cobbled floodplain. Forested hummocks (tailing piles) and cobble piles are interspersed throughout the floodplain as a result of aggradation. Subreach 4 is characterized as a boulder/log cascade sequence with a moderate (seven percent) incline. It is also classified as a Western Redcedar/ Lady Fern habitat type.

Approximately 20 percent of the floodplain contains unvegetated cobblebars.

Subreach 5, spanning over 2,400 feet in length, is the longest subreach in the injured area. The elevation is 3,375 feet at the top of Subreach 5 and 3,223 feet at the bottom. It is confined by a flat cobble, narrow floodplain on the left bank and a cedar grove on the right bank. An old road, located directly north of the stream, is present throughout Subreach 5. Although this subreach is classified as a Western Redcedar/ Lady Fern habitat type, vegetation coverage is moderate due to excessive aggradation by gravel and cobbles and a lack of fine soil material.

Subreach 6, located within a wide cobble floodplain, is approximately 1,500 feet long. The elevation is 3,223 feet at the top of Subreach 5 and 3,142 feet at the bottom. It is characterized as boulder/log cascade sequence. The old road is present on the upper length of Subreach 6, but disappears into the cobble floodplain on the lower half of the subreach. The stream gradient decreases to five percent on this subreach. Subreach 6 is also classified as a Western Redcedar/ Lady Fern habitat type, although vegetation coverage is modest. Cobble accumulations and a lack of fine soil material are evident on this subreach.

Subreach 7 is also located within a wide cobble floodplain. The top of Subreach 7 is 3,142 feet in elevation. The bottom of the subreach, at 3,068 feet in elevation, is at the confluence of Beaver and Carbon Creeks. Its lower end is populated with tailings and cobble piles. This approximately 1,500 feet long reach has a moderate incline (five percent) with numerous high flow scour channels. The wide, rocky floodplain associated with this subreach is sparsely vegetated. There are, however, a few bermed areas with grasses, forbs, and conifers. An estimated 30 percent of Subreach 7 is dominated by the Western Redcedar/Lady Fern habitat type. An additional 70 percent is categorized as an unclassified habitat type that is dominated by cobbles. This subreach lacks fine soil material.

Wide cobble floodplain on Subreach 7

4.4 Mine Waste and Soil Sampling

Field analyses were completed on 135 samples using a Spectrace 9000 portable XRF, which allows for an on-site rapid assessment of the elemental spectrum. The XRF's detection limits, precision, and accuracy are provided in Appendix F. The samples were analyzed for total metals concentration following EPA Method 6200. In addition, a subset of 17 confirmation

In-field sample analysis using an XRF

Figure 2-A.

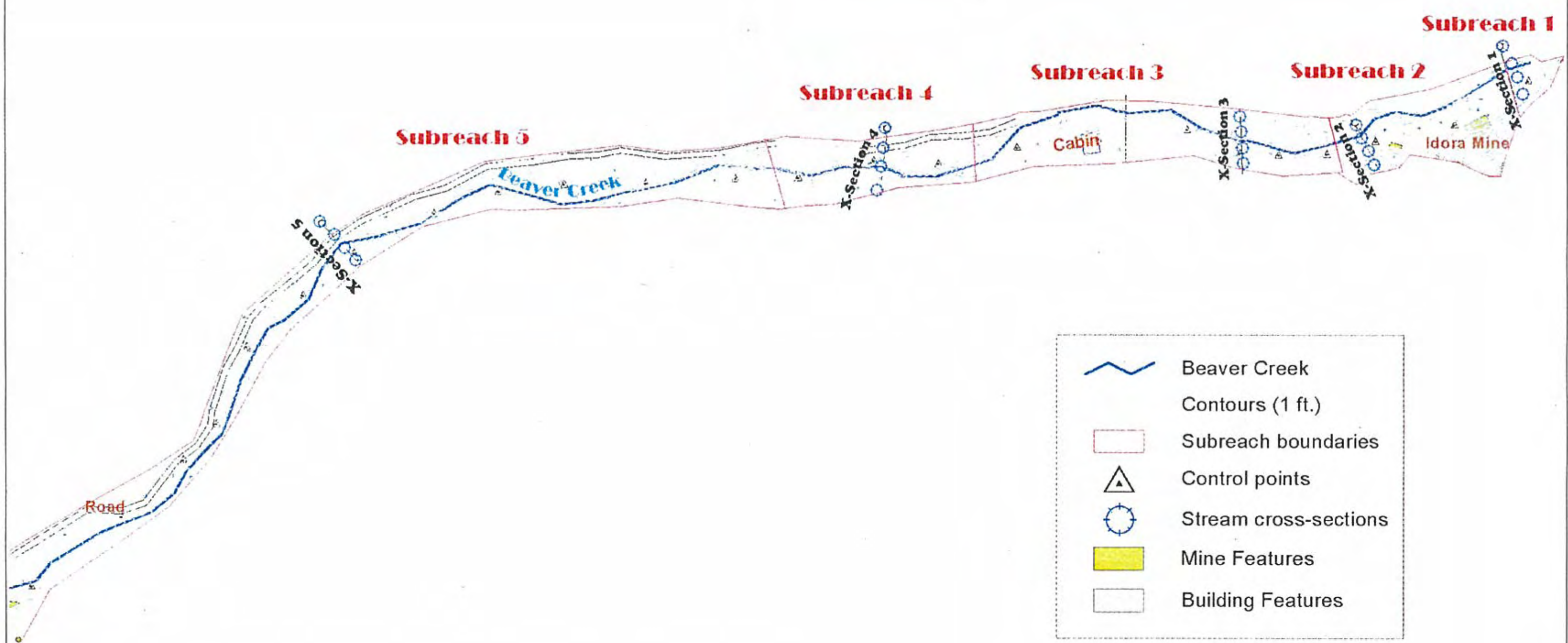


FIGURE 2-A
Subreaches & Features
Beaver Creek
Idora Mine Site NE

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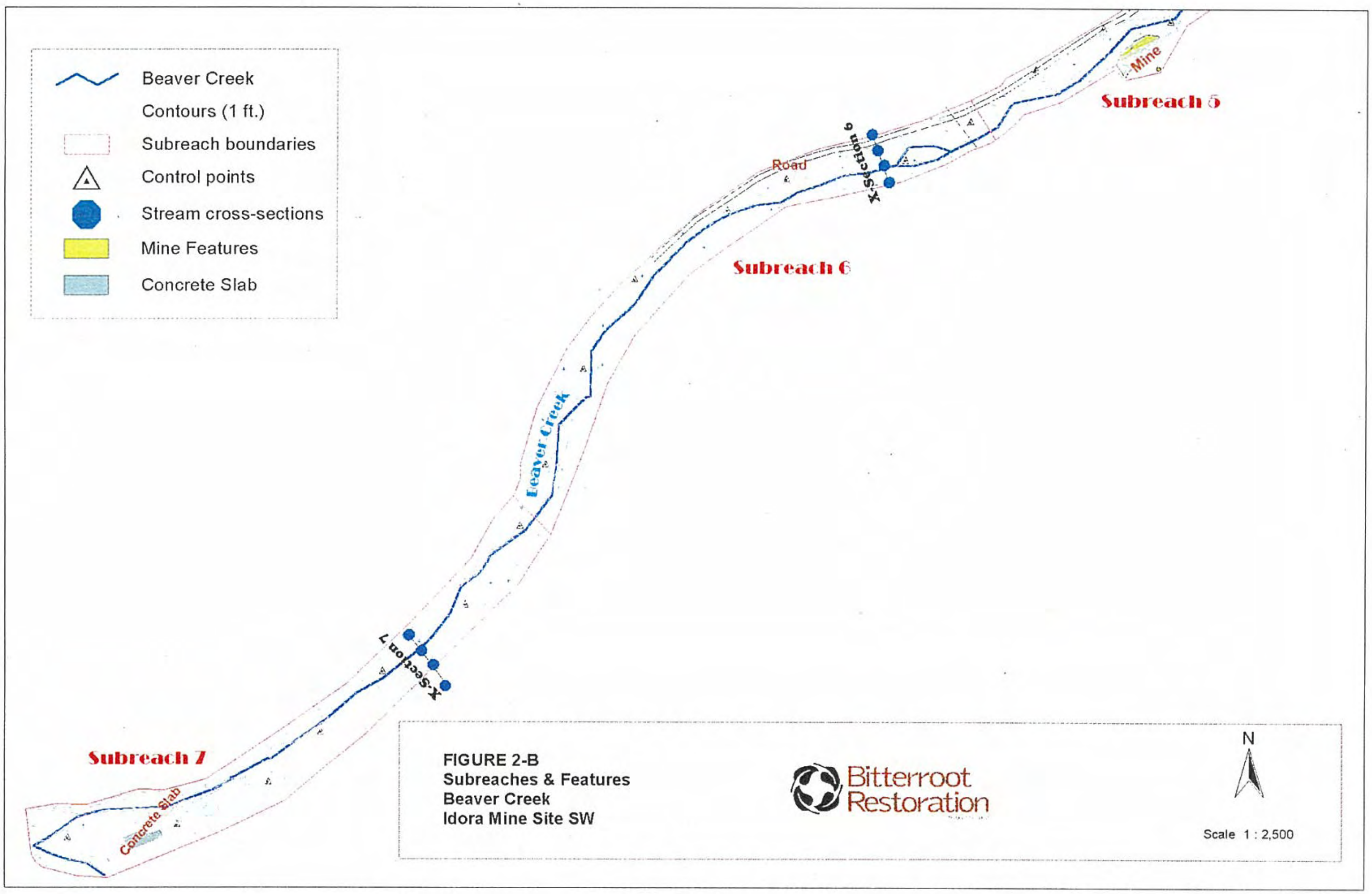
Figure 2-B.


Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Stream cross-sections
Mine Features
Concrete Slab
Subreach 5
Subreach 6
Subreach 7
Mine
Road
X-Section 6
X-Section 7
Beaver Creek
Concrete Slab
FIGURE 2-B
Subreaches & Features
Beaver Creek
Idora Mine Site SW
Bitterroot
Restoration
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Scale 1 : 2,500

samples, co-located with the XRF sampling sites, was analyzed for total metals, water extractable metals, pH, electrical conductivity and Acid-Base Accounting (ABA). Total metals concentration results from the 17 co-located sites were used for confirmatory analysis and to calibrate the XRF against the more accurate laboratory-analyzed samples. Laboratory analyses for Contaminants of Potential Concern (COPC) occurred at SVL Analytic using atomic emission spectrometry (EPA Methods 200.2 Series).

Due to the disturbance ecology of the Idora Site riparian system, field personnel found that it was impossible to distinguish between "soil" and "mine waste" materials. Cobbles, pebbles, sand, fines and organic-rich material were mixed together, and neither texture, color, nor position on the floodplain correlated with elemental concentrations as determined by field XFR readings. As a result, the soil/mine waste samples were composited into a single set of samples.

The sampling locations were situated on and around mine waste tailings piles, as well as in areas adjacent to mine waste materials, such as surface soils in places exposed to runoff/erosion from waste areas and/or soils beneath waste piles. The sampling sites, located at cross-sections along the contaminated stream, were designed to determine the types and amounts of contamination. For the most part, sampling locations were evenly distributed throughout the site. Samples were extracted to a maximum depth of one meter (39.4 inches). The samples were composited by mixing them in a clean container (a new heavy gauge plastic "trash compactor" bag for each sample, lining a five-gallon plastic bucket). Sample locations are displayed on maps in Figures 3-A and 3-B.

Following collection, laboratory samples, each weighing approximately one kilogram, were stored in individually sealed containers and shipped on ice to SVL Analytic in Kellogg, Idaho for analysis. Standard Chain of Custody (COC) procedures were followed to track and identify the individual samples. COC procedures are described in SOP A13 – Sample Handling, Documentation, and Tracking Procedures.

4.5 Surface Water Sampling

Representative cross-section location

Surface water sampling was performed to monitor stream water volumes, flows, and analyte concentrations. Surface water quality analyses included total metals concentrations, hardness, temperature, and pH. Laboratory analyses for COPC concentrations occurred via atomic emission spectrometry (EPA Methods 200.7 series). Samples were collected at seven representative cross-sections, one within each subreach. Cross-section locations are displayed and numbered on the map in Figures 2-A and 2-B. At each cross-section, the stream channel was

Figure 3-A.

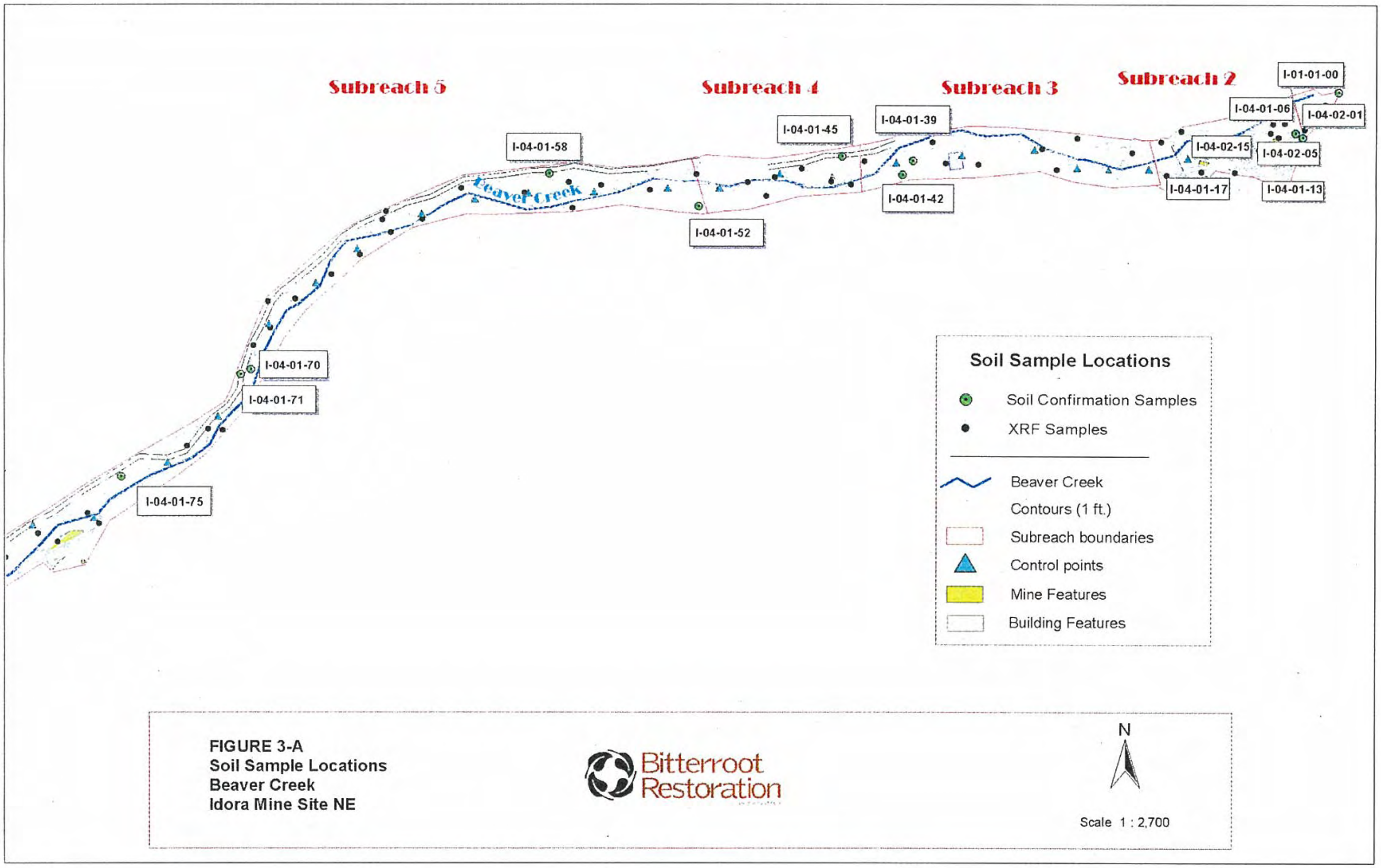
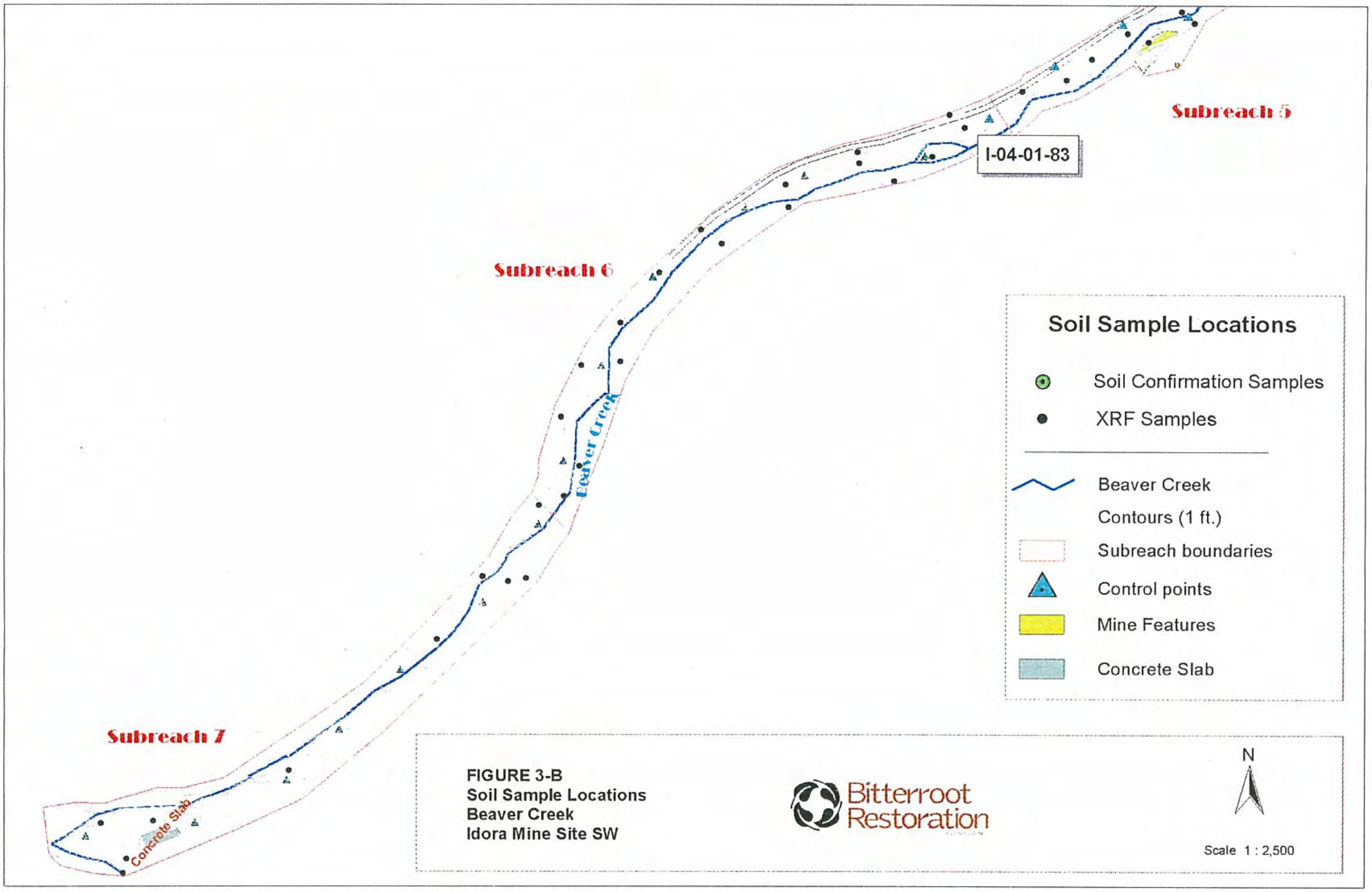

Subreach 5
Subreach 4
Subreach 3
Subreach 2
Beaver Creek
I-01-01-00
I-04-01-06
I-04-02-01
I-04-02-15
I-04-02-05
I-04-01-17
I-04-01-13
I-04-01-39
I-04-01-42
I-04-01-45
I-04-01-52
I-04-01-58
I-04-01-70
I-04-01-71
I-04-01-75
Soil Sample Locations
Soil Confirmation Samples
XRF Samples
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Building Features
FIGURE 3-A
Soil Sample Locations
Beaver Creek
Idora Mine Site NE
Bitterroot
Restoration
N
Scale 1 : 2,700

Figure 3-B.


Subreach 5
Subreach 6
Subreach 7
I-04-01-83
Beaver Creek
Concrete Slab
Soil Sample Locations
Soil Confirmation Samples
XRF Samples
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Concrete Slab
FIGURE 3-B
Soil Sample Locations
Beaver Creek
Idora Mine Site SW
Bitterroot
Restoration
N
Scale 1 : 2,500

subdivided into one to ten segments of equal length depending on the width of the channel. The depth of the stream was measured in the middle of each segment. Velocity measurements were obtained from each stream segment using an FP201 Global Flow Probe hand-held flow meter with a five- to 15-foot expandable handle. Velocity readings were measured in feet per second with accuracies of plus-or-minus 0.1 feet per second for instantaneous velocity and plus-or-minus 0.01 feet per second for average and maximum velocity.

Velocity readings were determined by extending the flow meter handle to the appropriate length and placing the probe in the center of the channel of each stream segment within the respective cross-sections. The flow probe was moved slowly back and forth from the top of the water surface to the bottom of the channel for a minimum of one-minute to obtain a vertical flow profile. The average flow velocity for the stream cross-section, along with the date and time, was recorded in the field logbook. The stream discharge was calculated by first determining the cross-sectional area of each stream channel segment, then multiplying the average velocity by the cross-sectional area, and finally averaging together the discharge of each segment to obtain a total stream discharge. If flows were below the instrument's Limit of Detection (LOD) of 0.3 feet per second, velocity was estimated as half the difference between zero and the LOD (i.e., 0.15 feet per second).

Stream temperature and pH measurements were collected using a waterproof Hanna instruments HI-9023 microcomputer pH and temperature meter. To use the instrument, the probe was placed in the stream at the cross-section. Keeping the probe submerged, it was moved slowly back and forth across the stream until the pH and temperature readings stabilized (approximately two minutes). The results were recorded into a permanent notebook. The instrument was calibrated before each set of samples was obtained. The pH meter is accuracy to 0.01 units and its collection capabilities range from 0.00 to 14.00 pH. The temperature meter can record temperatures ranging from 32 to 212 degrees Fahrenheit and is accurate to 0.7^{o} F.

Surface water samples were collected at each of the seven cross-sections with a depth-integrated wading device and were stored in sample containers supplied by SVL. To operate the wading device, it was moved up and down through the water column at set locations across the stream for a predetermined timeframe that depended on the stream size. The device was calibrated to collect equal amounts of water through the water column and across the stream. All excess water was disposed of by pouring it gently onto the stream bank adjacent to the sampling location.

Once collected, the water samples were immediately preserved with nitric acid. The filled sample bottles and jars were labeled as specified in the *RAMS Final Work Plan, 2002*. The labeled bottles were placed in ice chests and cooled to approximately 4^{O} C with the appropriate chain-of-custody paperwork. The cooler was delivered to SVL Analytic in Kellogg, Idaho.

4.6 Sediment Samples

Seven streambed sediment samples were collected from the streambed directly under the surface water sampling locations. Samples, gathered at depths ranging from one-half inch to four inches, were collected in the interstices of cobbles with a stainless steel spoon. The samples were labeled and stored in one-liter sample containers provided by SVL Analytic with the appropriate

COC paperwork as specified in the *RAMS Final Work Plan, 2002*. The labeled bottles were stored in ice chests and cooled to approximately 4^{O} C. They were delivered to SVL Analytic in Kellogg, Idaho. Laboratory analyses followed EPA Method 200.7.

4.7 Riparian Health Assessment

Riparian assessments were conducted with a focus on vegetative health. The rationale for looking at vegetation data is that the condition of plants in the riparian zone is a major component in determining the vigor of riparian ecosystems.

The injured area along Beaver Creek was divided into four Riparian Reaches. Each reach was representative of unique stream and vegetation characteristics found on Beaver Creek. Detailed vegetation data, physical site data, some wildlife data, trend commentary, and photographs were collected. Concerning vegetation, data were gathered on species identification and canopy cover estimations, as well as age class breakdowns for each tree and shrub species. Physical site data included channel morphology and condition, substrate composition, disturbance degree and kind, amount and cause of bare ground, and commentary. Wildlife data included details of beaver activity and observations of fishery, amphibian, and reptile data.

In general, the Riparian Reaches corresponded with the hydrologic subreaches described in ***Section 4.3 Boundary Delineation*** of this report. In cases where stream and vegetation characteristics were uniform over more than one hydrologic subreach, the subreaches were combined into a single Riparian Reach. The relationship between subreach and riparian reach boundaries follows.

- Riparian Reach A (referred to as *Record ID No. 2020380* or *Polygon 1* on the Wetland Inventory Forms) corresponds with the hydrologic Subreaches 2 and 3.
- Riparian Reach B (referred to as *Record ID No. 2020381* or *Polygon 2* on the Wetland Inventory Forms) corresponds with Subreach 4.
- Riparian Reach C (referred to as *Record ID No. 2020379* or *Polygon 3* on the Wetland Inventory Forms) corresponds with Subreaches 5 and 6.
- Riparian Reach D (referred to as *Record ID No. 2020382* or *Polygon 4* on the Wetland Inventory Forms) corresponds with Subreach 7.

A goal of this investigation was to perform a riparian health assessment on a reference reach above the Idora Mine site, but after exploring upstream of the mine, it was discovered that historic mining impacted the entire length of Beaver Creek. Hence, the full suite of vegetation, hydrologic, and chemical data was not collected on a reference reach for this project.

The riparian inventory data collected for this project was originally gathered on the entire riparian zone, which extends laterally out to the valley toe slope foot. This area includes both the near-channel zone of mine tailing deposits, and a wide outer band on both sides unimpacted by these tailings contaminants. Subsequently, the width dimension was adjusted to reflect only the narrower floodplain impacted by deposition of mine tailings. The species data was also adjusted by eliminating those species found only under the forest canopy at the outer edge of the riparian zone. These steps were undertaken to reflect conditions within the narrower impacted zone, as opposed to the entire riparian habitat area.

The assessment was developed by Dr. Paul Hansen and his team at the Riparian and Wetland Research Program, University of Montana at Missoula. Refer to BRI's riparian and wetland website (http://bitterrootrestoration.com/index.html) for more information on the methodology used to conduct the riparian health assessments.

4.8 Rosgen Stream Classification—Level II

Reaches of stream channel may be classified according to morphological characteristics that reflect the stream's capacity to store/transport sediment. The relevant parameters, in order of importance, are channel slope, channel pattern, channel material size, the ratio of channel width to depth, the entrenchment ratio, and channel sinuosity (Rosgen, 1996).

The bankfull channel width, flood prone width, maximum and mean stream depths at bankfull stage, and the average channel material size were measured at a representative cross-section within each subreach. These measurements were used to determine the width-to-depth ratio (bankfull width divided by bankfull mean depth), the width of the flood prone area (defined as the area of floodplain inundated by a flood that reaches a depth twice the maximum bankfull stage depth), and the entrenchment ratio (entrenchment is the ratio of width of the channel at bankfull stage and that of the flood prone area). The channel material size was visually estimated within each subreach.

The channel slope and channel pattern data were derived in a GIS from the one-foot contour survey map. For each riparian reach classified, average channel slope was computed as the percent drop(rise/run). The change in elevation and the segment length were used for this calculation. Channel pattern refers to sinuosity and number of threads (split around islands or a single stream body). Sinuosity was calculated as the ratio of channel length to valley length for the reach. These parameters are described by Rosgen (1996) and the calculations are in Appendix C.

4.9 Volume of Contaminated Material

The volume of material within the Beaver Creek floodplain was estimated by calculating the area, the amounts and size classes of materials within distinctive features (e.g., roads, cobble floodplains, and tailing piles) on 21 reaches along the stream. The length of the reaches, ranging from 250 to 465 feet, varied according to changes in the stream geomorphology and mining features. The size classes of materials in each feature were divided into the following categories: fines, sand, gravel, cobbles, and boulders.

In the office, a representative cross-section within each reach was drawn on the one-foot contour survey map (See Appendix D). The area of 15 cross-sections was computed using an area calculation technique, described by Landphair and Motloch (1985). This technique assumes that the stream cross-section is an unequal trapezoid. The steps involved in the area calculation technique follow. First, the cross-section, which spans the width of the floodplain, is divided into five to ten intervals of equal length. The area of each interval is determined by measuring the height on both ends of the interval section. Then the average height and the interval length are multiplied, resulting in the area of the interval. The areas of the intervals are added together, giving the total area of the cross-section. Next, the volume is derived by multiplying the total area by the length of the reach. Finally, the volume is calculated for each materials size class. The volume estimate used in this report includes materials in the gravel, sand, and fines size classes.

The following assumptions were used:

- All locations in the streambed equal zero. In other words, no materials would be excavated from the actual streambed.
- The height of materials used in the calculation assumes that the elevation of the streambed is the lowest point, and ground level is the highest point. The width extends from floodplain right to floodplain left.
- No material would be removed below groundwater level.
- The final volume excludes materials in the boulder and cobble size class categories.

4.10 Topographic/Site Features Survey

A Topographic/Site Features Survey of the mine-waste impacted area, displayed in Appendix B, was completed by Territorial Engineering and Surveying, Inc., a licensed professional surveying company. The site was mapped on a local coordinate system using traditional surveying methods. Key points were mapped in latitude/longitude using a survey grade (sub-centimeter accurate) Global Positioning System (GPS) unit. The survey met minimum conventional theodolite traverse control standards (third order geodetic control and 1:5000 accuracy). In addition to constructing a survey with one-foot contours of the injured area, the surveying team mapped features of interest (adits and buildings, for example), stream cross-sections, and mine waste and soil sampling locations.

4.11 Quality Assurance and Control

Quality Control (QC) procedures used for mine wastes, soil, and water testing were consistent with methods described by the EPA and the *RAMS Final Workplan* (U.S. Army Corps of Engineers, Omaha District, 2002). All samples collected in the field were prepared with appropriate COC documentation, including sample logs, sample identification (ID) numbers, and appropriate seals.

All samples were individually sealed in plastic bags prior to shipment. Mine waste and soil sample containers were wrapped in bubble wrap or other protective wrapping and stored in plastic boxes. Upon collection, nitric acid (reagent grade) was added to all water samples. The samples were immediately placed in ice chests and cooled to 4^{O} C or less. Boxes and ice chests were taped shut and sealed with custody seals. COC forms were signed as relinquished and sealed in bags and taped inside each box. COC forms were reviewed and signed by the laboratory upon receipt. The laboratory sent the final analytical results to BRI.

Field notes were kept in bound, waterproof notebooks. Notes were written in waterproof ink or pencil. Sample numbers were transferred to COC forms.

QC of the XRF analysis was ensured by following EPA Standard Operating Procedure No. 1713 (1995). The XRF calibration procedures included verification of potential multiple soil matrix types. Matrix differences, such as large variations in calcium or iron content, may affect XRF measurements.

5.0 LABORATORY ANALYSIS

5.1 Mine Waste and Soil Analysis

Seventeen confirmation samples, co-located with XRF sampling sites, were analyzed for total metals. Sample results from the 17 co-located sites were used to calibrate the XRF against the more accurate laboratory-analyzed samples. Total metal concentrations were analyzed in the laboratory analyses through atomic emission spectrometry (see Table 5.1 below). In addition, the confirmation samples were assessed for acid-generating potential.

TABLE 5.1 TOTAL METALS ANALYSIS

Target Constituent	Analytical Method
Arsenic	EPA M200.2 ICP-Total metals
Cadmium	EPA M200.2 ICP- Total metals
Copper	EPA M200.2 ICP- Total metals
Lead	EPA M200.2 ICP- Total metals
Zinc	EPA M200.2 ICP- Total metals

Six mine waste samples (surface rock/soil samples) were analyzed for water extractable metals (see Table 5.2).

TABLE 5.2 WATER EXTRACTABLE METALS ANALYSIS

Target Constituent	Analytical Method
Arsenic	EPA M200.7 ICP-water-extractable
Cadmium	EPA M200.7 ICP- water-extractable
Copper	EPA M200.7 ICP- water-extractable
Lead	EPA M200.2 ICP- water-extractable
Zinc	EPA M200.7 ICP- water-extractable

5.2 Surface Water and Sediment Analysis

Table 5.3 presents the analytical methods used to determine total metals and water quality variables for the seven surface water and streambed sediment samples.

TABLE 5.3 WATER AND STREAMBED SEDIMENT ANALYSES

Target Constituent	Analytical Method
Arsenic	EPA M200.2 ICP-Total metals
Cadmium	EPA M200.2 ICP- Total metals
Copper	EPA M200.2 ICP- Total metals
Lead	EPA M200.2 ICP- Total metals
Zinc	EPA M200.2 ICP- Total metals
PH	EPA M150.1
Conductivity	EPA M120.1
Hardness	EPA M120.1
Temperature	EPA M120.1

Sample analysis followed the quality control criteria set by the Environmental Chemistry Branch Laboratory and/or as per the *RAMS Final Work Plan* (June 2002). Laboratory QC data are included with the raw analytic results in Appendix E.

6.0 DATA SCREENING CRITERIA

6.1 Mine Waste and Soil Standards

This report concentrates on the following five COPCs: Arsenic, Cadmium, Copper, Lead, and Zinc. These COPCs are the standard suite of contaminants investigated on minelands in western Montana and northern Idaho. The remoteness of the site suggests that recreational users (e.g., rock hounds, gold panners, hunters, and hikers) will be the population most likely to visit. The EPA's exposure limits for recreational users, presented in Table 6.1, govern contact to the COPCs in soil material. The primary exposure pathways are soil contact, inhalation and water ingestion. The standards assume that potential carcinogenic and non-carcinogenic health risks vary between recreational populations. The cleanup guidelines used in this report are based on a Hazard Index of 0.5 or an increased cancer risk of 5×10^{-4}. The latter is the carcinogenic risk for the gold panner/rock hound recreational population (Tetra Tech, 1996).

TABLE 6.1 EPA CLEANUP GUIDELINES FOR FIVE CHEMICALS OF POTENTIAL CONCERN FOR RECREATIONAL VISITORS

COPC	Arsenic	Cadmium	Copper	Lead	Zinc
Soil Ingestion/ Inhalation Cleanup Guideline (mg/kg)*	700	19,500	27,100	1,100	220,000

* Concentrations for Arsenic and Cadmium are based on an increased cancer risk of 5×10^{-4}, while Copper, Lead, and Zinc are based on a Hazard Index of 0.5.

6.2 Surface and Groundwater Standards

Table 6.2 presents water quality guidelines for the COPCs of concern for this study. These standards govern exposure to COPCs by water ingestion.

TABLE 6.2 WATER QUALITY GUIDELINES

COPC	National Recommended Water Quality Criteria for Aquatic Life		Required Reporting Value	EPA National Primary Drinking Water Standards
	Acute	Chronic		
Arsenic	340	150	3	10 (as of 1/23/06)
Cadmium	2.0*	0.25*	0.1	5
Copper	13*	9.0*	1	1,300
Lead	65*	2.5*	3	15
Zinc	120*	120*	10	n/a

All values stated as micrograms/liter (µg/L)
* @ 100 mg/L hardness

7.0 RESULTS AND DISCUSSION

7.1 Mine Waste and Soil Results and Discussion

Field personnel could not distinguish between "soil" and "mine waste" materials. Cobbles, pebbles, sand, fines and organic-rich material were mixed together. Neither texture, nor color, nor position on the floodplain correlated with elemental concentrations as determined by field XRF reading. As a result, the 17 soil/mine waste samples were composited into a single set of samples, which were analyzed for total metals via ICP, water extractable metals, pH, conductivity and Acid-Base Accounting (ABA). In addition, 135 soil/mine waste samples were analyzed for total metals concentrations via XRF. Lab analyses data are in Appendix E, and XRF field analyses data are included in Appendix F.

7.1.1 Total Metals from Field XRF Results

Table 7.1 and Figures 4-A and 4-B present total metal concentrations statistics for the soil/mine waste samples collected from the Idora Mine project site, as analyzed by field XRF. The XRF trends for the trace elements follow the results of the ICP analyses, with lead having the greatest percentage of samples above the COPC limits for recreational visitors.

TABLE 7.1 TOTAL METAL CONCENTRATIONS FROM FIELD XRF RESULTS

COPCs	Average sample concentration from the Idora Mine project site (mg/kg)	Minimum sample concentration from the Idora Mine project site (mg/kg)	Maximum sample concentration from the Idora Mine project site (mg/kg)	COPCs limits (mg/kg) for recreational visitors	Percent of samples above COPC limits for recreational visitors
Arsenic	29 (18)	22	167	700	0 percent
Cadmium	122 (70)	90	623	19,500	0 percent
Copper	201 (174)	34	1301	27,100	0 percent
Lead	4,190 (5,988)	15	58,297	1,100	82 percent
Zinc	1,247 (1,455)	131	14,649	220,000	0 percent

Shading indicates exceedance of screening criteria.

7.1.2 Total Metals from Laboratory Results

Table 7.2 presents total metal concentration statistics for the soil/mine waste samples collected from the Idora Mine project site. The results show that lead is the major contaminant of concern in this system. Over three-quarters of all samples analyzed in the laboratory had lead levels above limits set for recreational visitors.

TABLE 7.2 TOTAL METAL CONCENTRATIONS FROM LABORATORY RESULTS

COPCs	Average sample concentration from the Idora Mine project site (mg/kg)	Minimum sample concentration from the Idora Mine project site (mg/kg)	Maximum sample concentration from the Idora Mine project site (mg/kg)	COPCs limits (mg/kg) for recreational visitors	Percent of samples above COPC limits for recreational visitors
Arsenic	21 (10)	9	48	700	0 percent
Cadmium	7 (5)	2	17	19,500	0 percent
Copper	207 (216)	28	896	27,100	0 percent
Lead	4,754 (5,252)	31	17,000	1,100	76 percent
Zinc	1,164 (908)	168	3,740	220,000	0 percent

Shading indicates exceedance of screening criteria.

7.1.3 Statistical Comparison of XRF Results and Laboratory Results

EPA Method 6200 stipulates that the correlation coefficient (R-squared) between ICP and XRF data needs to be greater than 0.7 for the XRF data to be considered screening level data. The method also stipulates that if the data range spans greater than one magnitude, a log scale shall be used for analysis. For the Idora samples, a least squares regression analysis was utilized to determine whether the apparent trend is statistically significant. As both data sets for all elements range across multiple magnitudes, a log-log correction was utilized. Least squares regression analysis, utilized to determine whether the apparent trend was statistically significant, is described in Appendix G. A comparison of the two, log-corrected data sets via least squares regression analysis indicates a strong, statistically significant relationship between results obtained by the two methods for lead and zinc concentrations (see Table 7.3). The regression relationship was not statistically significant for copper and there were too many readings below the laboratory's limit of detection for calculation of a regression between the laboratory and XRF results for arsenic and cadmium.

TABLE 7.3 LEAST SQUARES COMPARISON OF LOG-CORRECTED METAL CONCENTRATIONS VIA ICP AND FIELD XRF

COPCs	R^2 for regression line	p-Value of regression line	R for regression
Copper	0.407	0.1730	0.2035
Lead	0.897	<0.0001*	0.4485
Zinc	0.777	<0.0001*	0.3885

*Statistical significance at alpha = 0.05

? does not understand statistics. linear regression

The XRF analytic results for lead and zinc concentrations can be used as screening level data. This strongly supports the contention that a large proportion of the Idora Mine project site floodplains contain significantly elevated levels of lead.

7.1.4 Water-Extractable Metals Results for Soils and Mine Wastes

Table 7.4 presents water-extractable metal concentrations statistics for the soil/mine waste samples collected from the Idora Mine project site, as analyzed by EPA Method 200.7. Zinc had the highest concentration, which was expected given that it is among the most soluble of trace elements. Lead followed, reflecting the high concentrations of this metal found in the drainage. COPC concentrations in all of the samples, however, were well within the national threshold for human health concerns.

TABLE 7.4 WATER-EXTRACTABLE METAL CONCENTRATIONS OF SOILS AND MINE WASTES VIA ICP

COPCs	Average Sample Concentration from the Idora Mine Project Site (mg/kg)*	Minimum Sample Concentration from the Idora Mine Project Site (mg/kg)	Maximum Sample Concentration from the Idora Mine Project Site (mg/kg)	Surface Water Threshold Concentration (mg/kg) for Human Health Concerns
Arsenic	0 (0)	0.005	0.005	18
Cadmium	0.03 (0.04)	0.002	0.096	5
Copper	0.1 (0.2)	0.0068	0.605	1300
Lead	2.1 (3.7)	0.007	9.37	15
Zinc	4.3 (6.1)	0.0314	15.8	2000

* Mean and standard deviation are reported as #(#)

7.1.5 pH and Conductivity Results for Soils and Mine Wastes

Table 7.5 and Figures 5-A and 5-B present pH and conductivity statistics for the soil/mine waste samples collected from the Idora Mine project site. All samples had acidic values (i.e., less than 7.0 standard units). Fourteen of the 17 samples had pH values less than 5.8 standard units, an indication of significant acidity and low percentage base saturation. Four of the samples had pH values lower than 3.5 and 4.5, a level of high acidity at which exchangeable aluminum can be significantly phytotoxic.

TABLE 7.5 pH AND CONDUCTIVITY VALUES OF SOILS AND MINE WASTES

Analyses	Average sample values from the Idora Mine project site*	Minimum sample values from the Idora Mine project site	Maximum sample values from the Idora Mine project site
pH (standard units)	5.2 (0.7)	3.99	6.51
Conductivity (μmho/cm)	718.5 (576.3)	73.2	2690

* Mean and standard deviation are reported as #(#)

There are two major diagnostic thresholds that use soil electrical conductivity as a prime measure. Conductivity of greater than 2,000 μmho/cm @ 25° C is one of the indications of an

Aridisol, while conductivity of greater than 4,000 μmho/cm @ 25° C defines a saline soil (Boul and others, 1989). Only one sample from Idora Mine project site exceeds the 2,000 μmho/cm threshold, indicating that soil salinity and/or excessive conductivity was not a significant problem in these soils.

7.1.6 Acid-Base Accounting Results for Soils and Mine Wastes

Table 7.6 presents ABA results for the soils and mine wastes from Idora Mine project site. The most significant results were the Acid-Base Potential values. Thirteen of 17 samples (76 percent) had values less than zero, indicating that they were acid generating. A significant proportion of the floodplain materials was acidic and had the potential to generate acidity.

Acid mine drainage is damaging to both aquatic and riparian life. Many forms of aquatic life cannot tolerate low pH levels caused by high acidity. Indirectly, the bio-availability of potentially phytotoxic metals increases in acidic water and soil, which limits plant growth (Pennsylvania Department of Environmental Protection, 1998).

TABLE 7.6 ACID-BASE ACCOUNTING RESULTS FOR SOILS AND MINE WASTES

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
Total sulfur (mg/kg)	0.3 (0.4)	0.005	1.19
Pyritic sulfur (mg/kg)	0.1 (0.2)	0.005	0.64
Sulfate sulfur (mg/kg)	0.1 (0.3)	0.005	1.04
Non-extractable sulfur (mg/kg)	0.0 (0.1)	0.005	0.21
Acid generating potential ($TCaCO_3/1000T$)	3.2 (5.0)	0.15	20
Acid neutralizing potential ($TCaCO_3/1000T$)	1.2 (1.8)	0.25	5.57
Acid-Base potential ($TCaCO_3/1000T$)	-2.1 (4.7)	-17.2	3.9

* Mean and standard deviation are reported as #(#)

7.2 Surface Water Quality

Seven water quality samples were collected and analyzed for total metals, pH, temperature, and hardness. The results of these analyses are shown in Table 7.7 and on Figures 6-A and 6-B.

TABLE 7.7 WATER SAMPLE RESULTS

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
Arsenic (dissolved metal mg/L)	<0.01 (0.0)	<0.01	<0.01
Cadmium (dissolved metal mg/L)	<0.002 (0.0)	<0.002	<0.002
Copper (dissolved metal mg/L)	<0.003 (0.0)	<0.003	<0.003
Lead (dissolved metal mg/L)	0.009 (0.0052)	<0.005	0.0144
Zinc (dissolved metal mg/L)	0.239 (0.908)	0.118	0.341

TABLE 7.7 WATER SAMPLE RESULTS (continued)

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
pH (standard units)	7.0 (0.05)	6.96	7.11
Temperature (° F)	47.8 (1.40)	46.22	48.92
Hardness (mg/L)	16.5 (0.3)	16.2	17

* Mean and standard deviation are reported as #(#)

Table 7.8 displays the percent of samples with values above the national drinking water standards. None of the analytes exceeded thresholds for water quality, although several samples contained lead concentrations near the EPA National Primary Drinking Water Standards. The proximity of the Beaver Creek arsenic levels to the EPA National Primary Drinking Water Standards was impossible to discern as the SVL Analytic detection limits for arsenic are 10 μg/L.

TABLE 7.8 WATER QUALITY SAMPLE COMPLIANCE WITH HUMAN HEALTH STANDARDS

COPC	Average Sample Values from the Idora Mine Project Site	EPA National Primary Drinking Water Standards	Percent of Samples Above EPA National Primary Drinking Water Standards: Beaver Creek
Arsenic (dissolved metal (μg/L)	<10	10 (as of 1/23/06)	0
Cadmium (dissolved metal μg/L)	<2	5	0
Copper (dissolved metal (μg/L)	<5	1,300	0
Lead (dissolved metal (μg/L)	8.9	15	0
Zinc (dissolved metal (μg/L)	239.4	N/A	N/A

As Table 7.9 illustrates, two analytes, lead and zinc, had values exceeding the aquatic life criteria. For lead, none of the values exceeded the aquatic life criterion acute levels, but 100 percent of the sample values surpassed the chronic values. Eighty-six (86) percent of the zinc sample values exceeded both the acute and chronic water quality criteria for aquatic life.

TABLE 7.9 WATER QUALITY SAMPLE COMPLIANCE WITH AQUATIC LIFE STANDARDS

COPC	Average Sample Values from the Idora Mine Project Site	National Recommended Water Quality Criteria for Aquatic Life		Percent of Samples Above the National Recommended Water Quality Criteria for Aquatic Life: Beaver Creek	
		Acute	Chronic	Acute	Chronic
Arsenic (mg/L)	<0.01	0.340	0.150	0	0
Cadmium (mg/L)	<0.002	0.002*	0.025*	0	0
Copper (mg/L)	<0.003	0.013*	0.009*	0	0
Lead (mg/L)	0.009	0.065*	0.0025*	0	100**
Zinc (mg/L)	0.239	0.120*	0.120*	86	86

Shading indicates exceedance of screening criteria.

* @ 100 mg/L hardness

** All samples (57%) that fell within the detection limits for zinc had levels above the recommended water quality criteria for aquatic life. Three samples (43%) fell below the detection limits.

Figure 4-B.

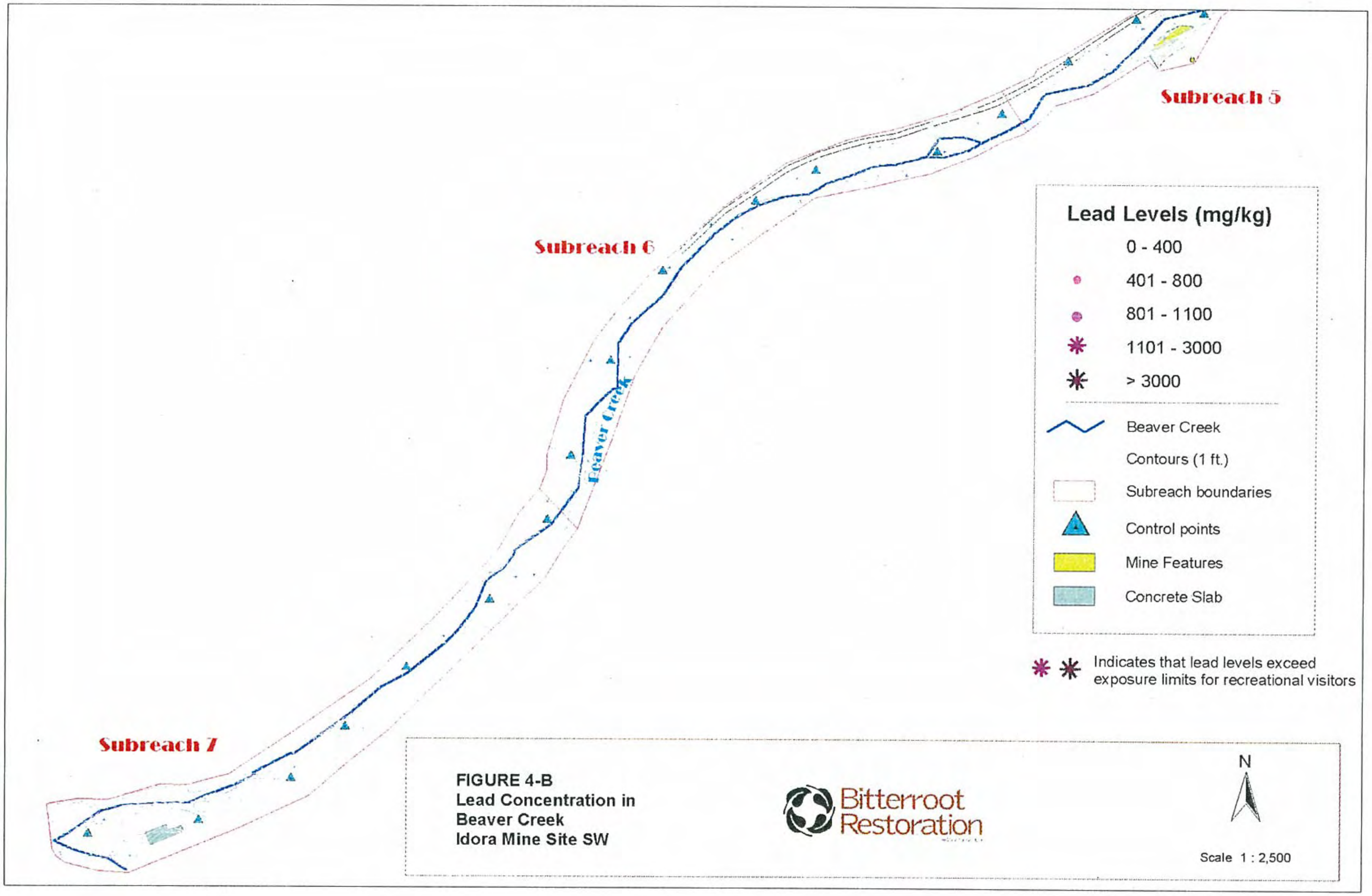

Subreach 5
Subreach 6
Subreach 7
Beaver Creek
Lead Levels (mg/kg)
0 - 400
401 - 800
801 - 1100
1101 - 3000
> 3000
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Concrete Slab
Indicates that lead levels exceed exposure limits for recreational visitors
FIGURE 4-B
Lead Concentration in
Beaver Creek
Idora Mine Site SW
Bitterroot Restoration
N
Scale 1 : 2,500

Figure 4-A.

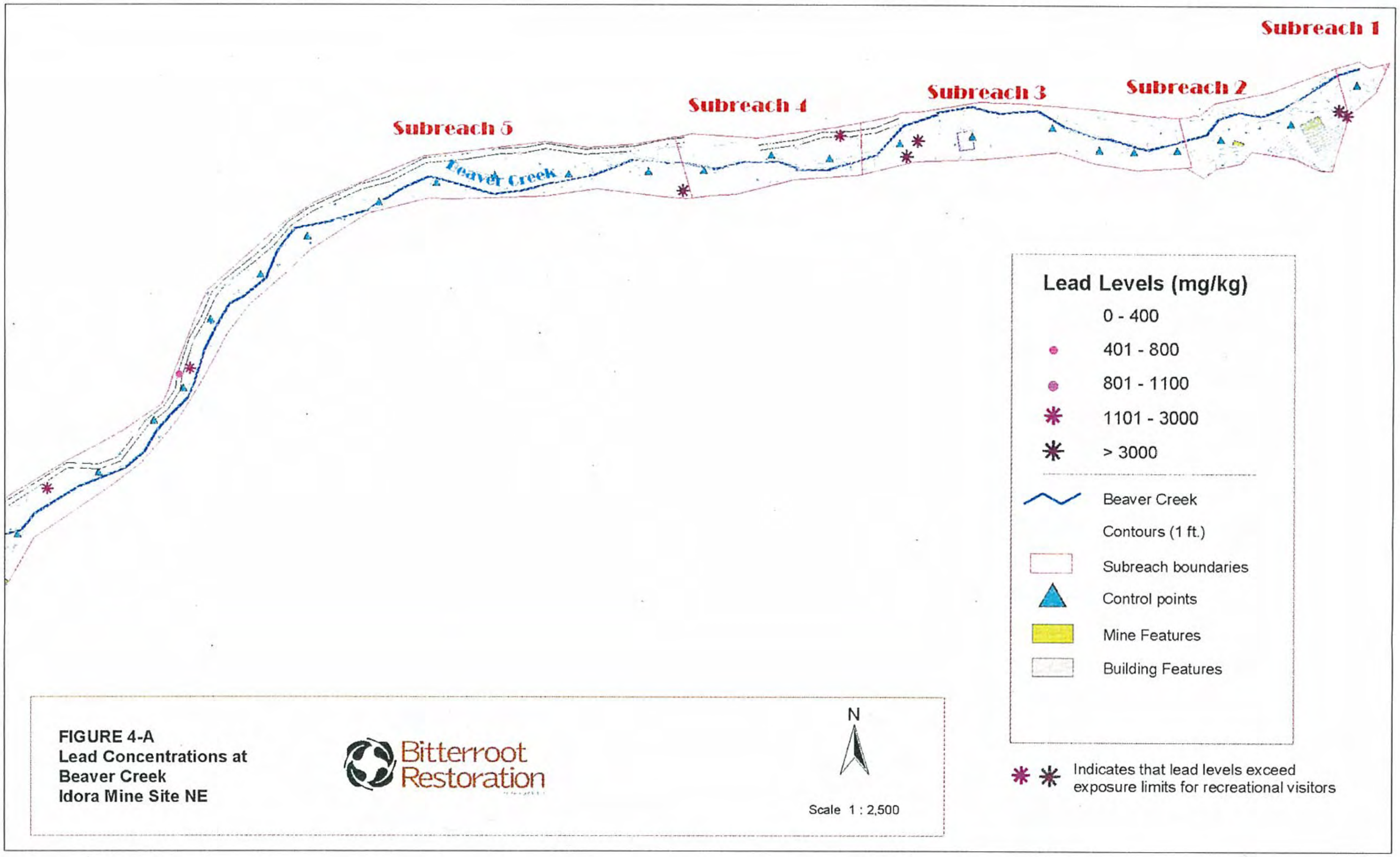

Subreach 1
Subreach 2
Subreach 3
Subreach 4
Subreach 5
Beaver Creek
Lead Levels (mg/kg)
0 - 400
401 - 800
801 - 1100
1101 - 3000
> 3000
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Building Features
Indicates that lead levels exceed exposure limits for recreational visitors
FIGURE 4-A
Lead Concentrations at
Beaver Creek
Idora Mine Site NE
Bitterroot Restoration
N
Scale 1 : 2,500

Figure 5-A.

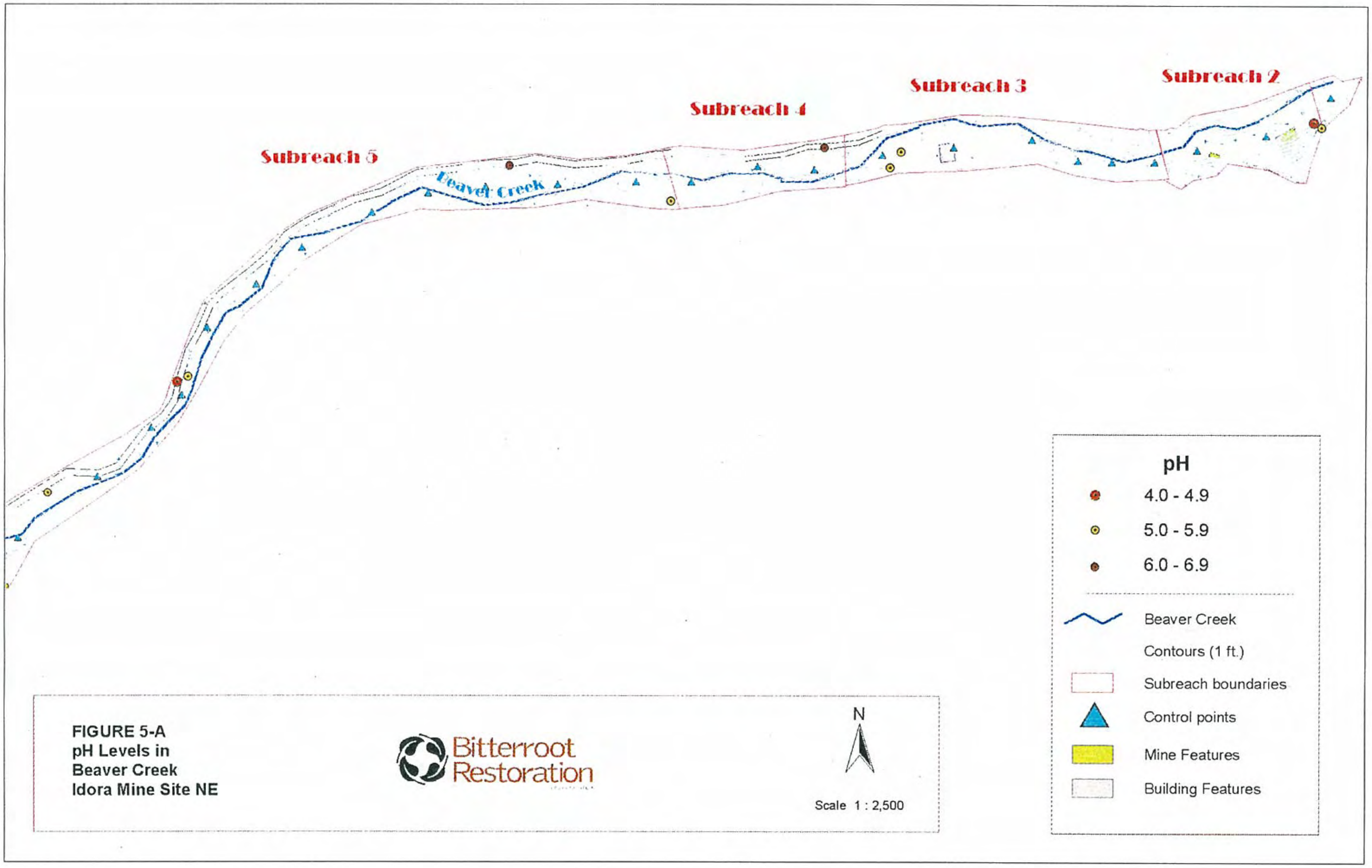

Subreach 5
Subreach 4
Subreach 3
Subreach 2
Beaver Creek
pH
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Building Features
FIGURE 5-A
pH Levels in
Beaver Creek
Idora Mine Site NE
Bitterroot
Restoration
N
Scale 1 : 2,500

Figure 5-B.

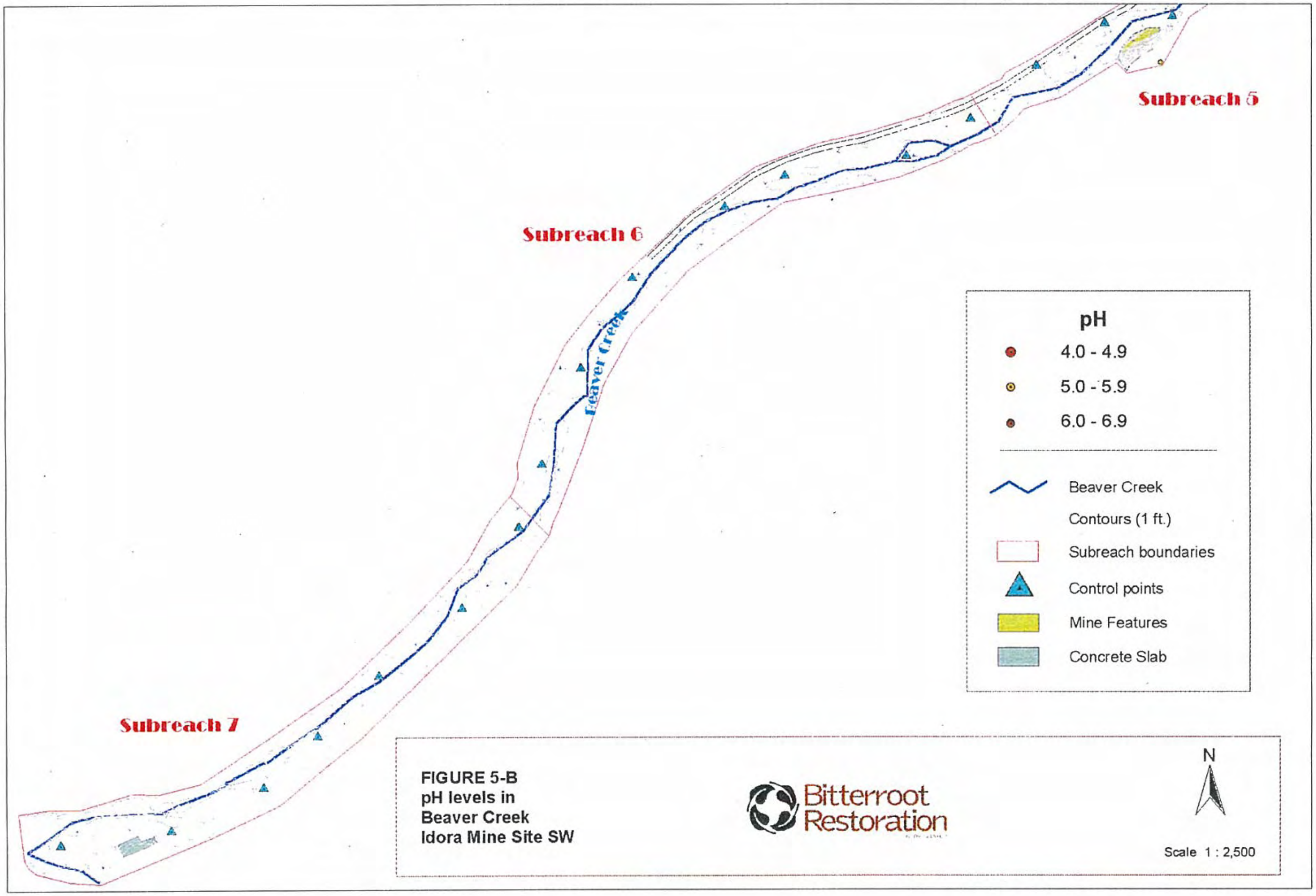

Subreach 5
Subreach 6
Subreach 7
Beaver Creek
pH
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Concrete Slab
FIGURE 5-B
pH levels in
Beaver Creek
Idora Mine Site SW
Bitterroot
Restoration
N
Scale 1 : 2,500

Figure 6-A.

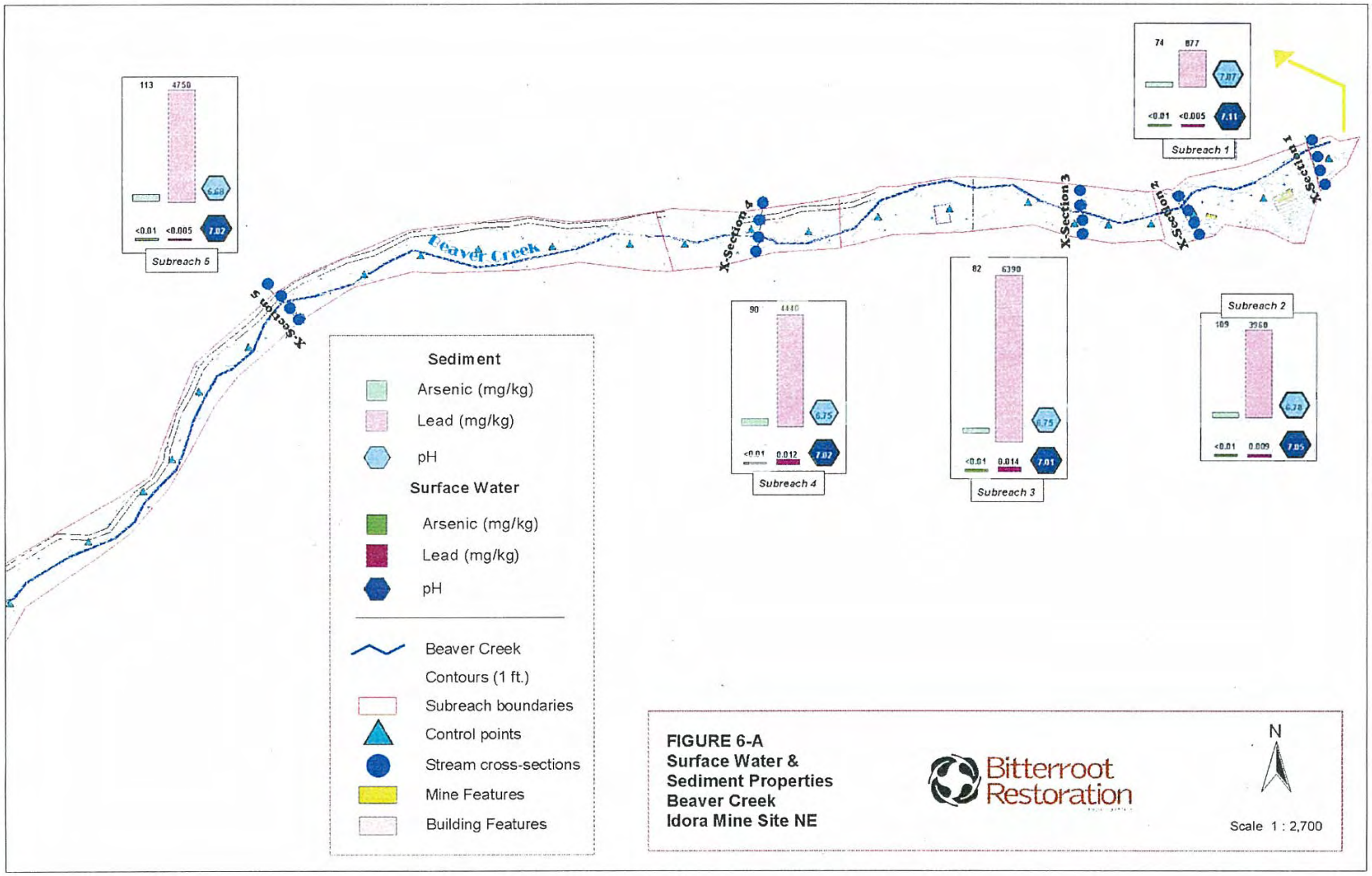
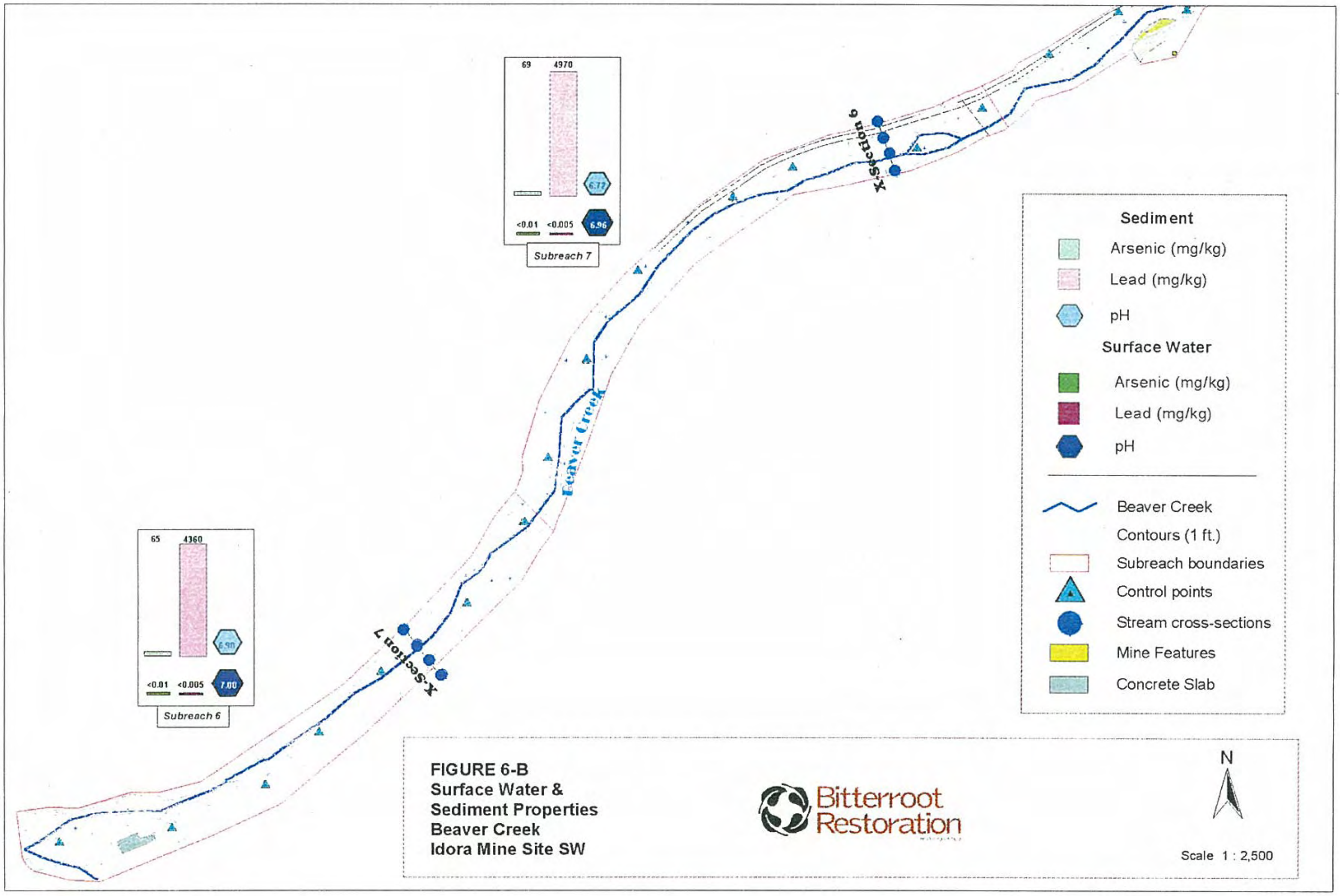

74
877
7.07
<0.01
<0.005
7.11
Subreach 1
113
4750
6.68
<0.01
<0.005
7.02
Subreach 5
Beaver Creek
X-Section 1
X-Section 2
X-Section 3
X-Section 4
X-Section 5
Subreach 2
109
3960
<0.01
0.009
7.05
90
4440
6.75
<0.01
0.012
7.02
Subreach 4
82
6390
6.75
<0.01
0.014
7.01
Subreach 3
Sediment
Arsenic (mg/kg)
Lead (mg/kg)
pH
Surface Water
Arsenic (mg/kg)
Lead (mg/kg)
pH
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Stream cross-sections
Mine Features
Building Features
FIGURE 6-A
Surface Water &
Sediment Properties
Beaver Creek
Idora Mine Site NE
Bitterroot
Restoration
N
Scale 1 : 2,700

Figure 6-B.


69
4970
6.77
<0.01
<0.005
6.96
Subreach 7
X-Section 6
65
4360
6.90
<0.01
<0.005
7.00
Subreach 6
X-Section 7
Beaver Creek
Sediment
Arsenic (mg/kg)
Lead (mg/kg)
pH
Surface Water
Arsenic (mg/kg)
Lead (mg/kg)
pH
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Stream cross-sections
Mine Features
Concrete Slab
FIGURE 6-B
Surface Water &
Sediment Properties
Beaver Creek
Idora Mine Site SW
Bitterroot
Restoration
N
Scale 1 : 2,500

7.3 Streambed Sediment

Seven sediment samples were collected and analyzed for total metals, pH and conductivity. These results (see Table 7.10 and Figures 6-A and 6-B) indicate that, like surface soil/mine waste samples, a significant percentage of streambed samples contained high concentrations of lead. Although other metal concentrations are elevated, they do not exceed the recommended thresholds for recreational users.

TABLE 7.10 SEDIMENT ANALYTICAL RESULTS

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site	Screening Criteria for Recreational Visitors (mg/kg)	Percent of Samples above COPC Limits for Recreational Visitors
Arsenic (total metal mg/kg)	86 (19)	65	113	700	0 percent
Cadmium (total metal mg/kg)	24 (6)	18	37	19,500	0 percent
Copper (total metal mg/kg)	240 (74)	108	323	27,100	0 percent
Lead (total metal mg/kg)	4,250 (1,676)	877	6390	1,100	86 percent
Zinc (total metal mg/kg)	3,399 (1,256)	1770	5900	220,000	0 percent

Shading indicates exceedance of screening criteria.
* Mean and standard deviation are reported as #(#)

Illustrated in Table 7.11, sediment samples exhibit an essentially neutral pH.

TABLE 7.11 pH AND CONDUCTIVITY VALUES OF SEDIMENTS

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
pH (standard units)	7 (0)	6.7	7.1
Conductivity (µmho/cm)	253 (90)	157	358

* Mean and standard deviation are reported as #(#)

Conductivity of greater than 2,000 µmho/cm @ 25° C is one of the indications of an Aridisol, while conductivity of greater than 4,000 µmho/cm @ 25° C defines a saline soil (Boul and others, 1989). No samples from the Idora Mine project site exceeded the 2,000 µmho/cm threshold; soil salinity was not a problem in these soils.

7.4 Riparian Health Assessment

Table 7.12 demonstrates the functional scores and habitat/community types found on the project site. Functional scores, ranging from zero to 100 percent, were derived by rating riparian vegetation and soil/hydrology conditions. A stream that scores between 100 and 80 percent is in proper functioning condition (healthy). Scores between 79 and 60 percent indicate that the stream is functional, but at-risk of degradation (healthy, but with problems). Nonfunctioning

(unhealthy) streams score below 60 percent. The vegetation and soil/hydrology factors assessed included diversity, cover, and regeneration of vegetation, as well as the amount of bare ground present, and the condition of the stream banks. A healthy stream system supports dense vegetation that is regenerating and has little to no exposed ground. The stream banks do not experience much erosion due to armoring from large rocks and binding root mass.
This assessment/scoring system, developed by Dr. Paul Hansen, is thoroughly described on BRI's riparian and wetland website (http://bitterrootrestoration.com/index.html).

Vegetation within the Idora project site, with scores ranging from 78 to 63 percent, was functional, but at-risk of further degradation. Vegetation in the upper three subreaches was healthier than vegetation in the mid and lower sections of the stream. Upstream, the tailings were confined to areas in close proximity to the mill and mine. Downstream, however, contaminated materials and cobbles were spread over the entire flood prone area. So, although vegetation was absent near the mine/mill on the upstream riparian reaches, it was fairly healthy throughout most of the floodplain. Downstream, vegetation health was compromised throughout the floodplain.

The soils and hydrology in the upper two riparian reaches, with scores of 80 percent, were in proper functioning condition. In the two lower reaches, with scores of 67 to 60 percent respectively, the they were functional, but at-risk of further degradation. The soils and hydrology were the poorest at the bottom of the injured area (Riparian Reach D) because the fine soil materials were washed away, leaving large accumulations of cobbles. This presents a particular challenge to restoration, as the re-establishment of plant life in this reach will require the addition of substantial amounts of fine soil materials and organics.

The only habitat type identified in the four Riparian Reaches was Western Red Cedar/Ladyfern. In other words, Western Red Cedar (*Thuja plicata*) is the dominant overstory species and Ladyfern (*Athyrium filix-femina*) is the dominant understory species. This is not to say that other overstory and understory species are not present. In fact, the site is diverse, containing 14 tree species, over 30 types of shrubs, nine grasses, and more than 30 forb species. Grand fir (*Abies grandis*) and Douglas fir (*Pseudotsuga menziesii*) are common trees on the site, typical shrubs include mountain alder (*Alnus incana*) Rocky Mountain maple (*Acer glabrum*), and thimbleberry (*Rubus parviflorus*). Two graminoid species – Bluejoint reedgrass (*Calamagrostis canadensis*) and redtop (*Agrostis stolonifera*) – are commonly found. A significant portion of Riparian Reach D is a sparsely vegetated cobble floodplain. Although grasses and sedges are found on the cobbled floodplain, the coverage is too sparse to qualify as a specific vegetation habitat or community class. This area is therefore categorized as an "Unclassified" Wetland habitat/community type. The riparian health assessments for the Idora project are contained in Appendix C.

TABLE 7.12 RIPARIAN HEALTH ASSESSMENT RESULTS, FUNCTIONAL SCORES, & HABITAT TYPES

Location	Vegetation	Soil/ Hydrology	Overall Health	Habitat/ Community Type 1	Habitat/ Community Type2
Riparian Reach A	78	80	79	Western Red Cedar/Ladyfern	N/A
Riparian Reach B	78	80	79	Western Red Cedar/Ladyfern	Cobble bars
Riparian Reach C	63	67	65	Western Red Cedar/Ladyfern	N/A
Riparian Reach D	78	60	68	Western Red Cedar/Ladyfern	Unclassified wetland

7.5 Hydrologic and Geomorphic Characteristics (Rosgen Stream Classification—Level II)

The hydrologic subreaches in the injured area are similar topographically and geomorphically. Using the Rosgen stream typing method, the upper five subreaches (correspond with Riparian Reaches A, B, and C) were rated as A3 systems, and the bottom reach, Subreach 7 (corresponds with Riparian Reach D) was an A4. A brief description of Rosgen Stream Types A3 and A4 follows.

- ***Rosgen Stream Type A3:*** The upstream sections of Beaver Creek (Subreaches 2 through 5) are A3 Rosgen stream types. An A3 stream is a cascading step/pool sequence that is steep, confined, and entrenched. These high-energy systems with low sinuosity are capable of heavy debris transport. The substrate materials are mainly composed of cobble.

- ***Rosgen Stream Types A4*:** Subreach 7 on Beaver Creek is rated as A4. Like the A3 stream type, an A4 stream is a cascading step/pool sequence that is steep, confined, and entrenched. It has low sinuosity and is capable of heavy debris transport. The substrate materials are mainly composed of gravel.

The stream gradient decreases as one moves downstream, from an average slope of eight percent on the upper reaches to five percent on the lower reaches. Sinuosity scarcely changes from the upper (1.05) to lower subreaches (1.03). The flood-prone width is narrow on Subreaches 2 through 6. It widens to 76 feet at the confluence of Beaver and Carbon Creeks on Subreach 7.

Stream discharge ranges from 0.74 cubic feet per second (cfs) on Subreach 5 to 2.61 cfs on Subreach 3. Differences in discharge rates are probably due to changes in gradient and bed materials. These two factors influence the amount of water flowing above ground in the channel versus underground. On Beaver Creek, the upper subreaches with steeper inclines have the highest discharges because water in the channel is flowing too fast to infiltrate into the bed materials and run underground. Midway down Beaver Creek, discharge rates decrease. The streambed gradient in this area begins to level off, allowing the channel water to infiltrate into the surrounding bed materials. Areas where this occurs tend to have large boulders and cobbles in the bed material, providing interstitial space for the water to flow underground. The discharge rate increases in Subreach 7, probably due to changes in the underlying bed material. Analytical data are presented in Table 7.13.

TABLE 7.13 HYDROLOGIC AND GEOMORPHIC CHARACTERISTICS

Location	Discharge (ft^3/sec)	Flood prone Width (ft.)	Slope (%)	Sinuosity	Rosgen Stream Type	Channel Materials
Subreach 1	0.96	17.7	---*	---*	---*	---*
Subreach 2	1.84	25.5	8	1.04	A3	Cobbles
Subreach 3	2.61	34.7	8	1.05	A3	Cobbles
Subreach 4	1.23	31.5	7	1.03	A3	Cobbles
Subreach 5	0.74	14.3	6	1.03	A3	Cobbles
Subreach 6	0.98	24.6	5	1.05	A3	Cobbles
Subreach 7	1.41	76.1	5	1.03	A4	Gravel

* Information not available

7.6 Volume Estimate of Contaminated Materials

Based upon methods previously discussed, the following field estimate of contaminated materials was developed at the Idora site. These figures were not calculated using formal engineering tools and are not intended to take the place of a thorough engineering estimate and cost analysis. They are an approximation of the volume of contaminated materials at the Idora project site. The soil depth to groundwater or bedrock was not computed due to the high amounts of cobbles and gravel throughout the site. Therefore, more detailed studies are needed to make accurate removal calculations.

The removal scenario presented in this report assumes that the materials under consideration for excavation will include all rock-based substances smaller than cobbles. Boulders and cobbles will not be removed from the site. It also assumes that the area of removal spans from the site boundaries on stream right and left (width) down to groundwater or bedrock (depth), extending from ground level to water's edge in the stream.

With these assumptions, it is estimated that approximately 2.3 million cubic feet of materials should be considered for removal. The volume of materials is spread fairly evenly across the site. The upper 1,100 feet of the site (accounting for 17 percent of the total injured area), however, contains 25 percent of the total volume of materials. A disproportionately high volume of materials is found in this area because it houses the Idora Mine and Mill.

As Table 7.14 illustrates, volume estimates were calculated for five size classes of material. Gravel is the most common material, with over 1 million cubic feet residing on the site. Boulders are the least common material, amounting to 141,857 cubic feet.

TABLE 7.14 VOLUME ESTIMATE OF CONTAMINATED MATERIALS

Volume (cu. ft.)	Boulders	Cobbles	Gravel	Sand	Fines
	141,857	700,354	1,084,354	706,785	555,246

8.0 CONCLUSIONS

The results from this site investigation indicate that the levels of contamination in and around the Idora Mine project site exceed established protective limits for recreational populations. Lead is the major COPC in the system. Over 75 percent of soil/mine waste samples and over 85 percent of sediment samples contained total lead concentrations above screening criteria for recreational visitors. In addition, all soil/mine waste samples were acidic in nature, with three-quarters of samples exhibiting continuing acid generating properties.

Nonetheless, the surface water in the Idora Mine project site does not contain metal levels elevated above water quality standards for human health. This is likely due to the neutral sediment and water chemistry, as well as to the low relative solubility of lead, the major metal in the system.

The riparian health assessments also indicate that the ecological integrity of the system is compromised. Many parts of the flood-prone zone are devoid of vegetation, likely due to a combination of soil chemistry and physical disturbance. In addition, the Beaver Creek channel is deeply entrenched with high levels of mobile cobbles and pebbles, reflecting probable historic changes in the hydrology of the system caused by mining and milling activities.

The Idora Mine project site is significantly impacted, with levels of COPCs in the floodplain materials and streambed sediments exceeding the limits for recreational exposure and human health. The removal of approximately 2.3 million cubic feet of contaminated tailings materials, the reconstruction of the impacted stream channel and floodplain areas, and the restoration of the impacted riparian zone are recommended.

9.0 REFERENCES

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APPENDICES

For

ABANDONED MINE SITE INVESTIGATION OF THE IDORA MINE SITE ALONG BEAVER CREEK, IDAHO

Prepared for:

U.S. Army Corps of Engineers, Sacramento District and
U.S. Army Corps of Engineers, Omaha District

Prepared By:

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Bitterroot Restoration INCORPORATED
PIONEERING SCIENTIFICALLY-BASED ECOLOGICAL RESTORATION

July 23, 2003

Appendix A.
Idora Investigative Field Notes

Appendix B.
Topographic/Site Features Survey
of the
Impacted Area at Idora Mine

Appendix C.
Riparian Assessment Data
and
Rosgen Stream Classification Calculations

SUMMARY OF CROSS-SECTION DATA IDORA MINE/MILL SITE

Cross-Section	Channel Area (ft2)	Discharge (cfs)	Floodplain width (ft)	pH	Temperature	Gradient	Sinuosity
CS1	0.95	0.96	32.50	7.11	46.22	N/A	N/A
CS2	1.72	1.84	39.50	7.05	48.92	8%	1.04
CS3	1.99	2.61	44.75	7.01	48.2	8%	1.05
CS4	0.73	1.23	31.50	7.02	60.98	7%	1.03
CS5	1.08	0.74	15.00	7.02	n/a	6%	1.03
CS6	0.66	0.98	24.50	7.00	n/a	5%	1.05
CS7	2.02	1.41	76.50	6.96	n/a	5%	1.03

SUMMARY OF
CROSS-SECTION DATA USED TO
DETERMINE THE ROSGEN STREAM TYPE
IDORA MINE/MILL SITE

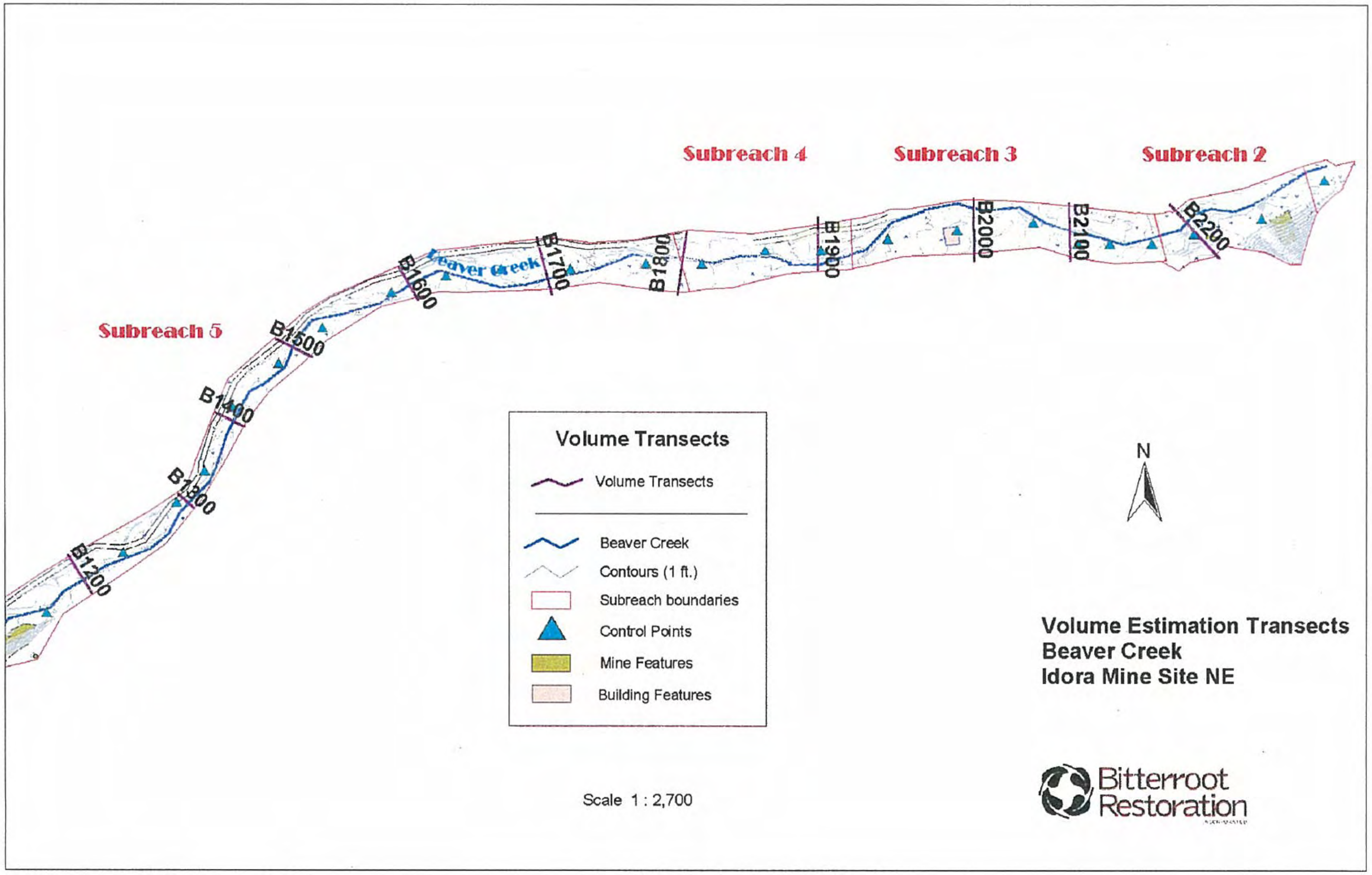
Variable	Cross-section 1	Cross-section 2	Cross-section 3	Cross-section 4	Cross-section 5	Cross-section 6	Cross-section 7
bankfull width (ft)	8.58	15.67	15.33	3.27	9.42	14.42	28.50
bankfull mean depth (ft)	2.07	2.16	1.22	1.33	1.20	1.23	2.89
bankfull area (ft2)	0.95	1.72	1.51	0.73	1.01	0.66	2.02
width/depth ratio	4.15	7.25	12.59	2.46	7.86	11.72	9.87
bankfull max. depth (ft)	2.30	2.45	1.50	1.55	1.45	1.40	3.10
flood-prone width (ft)	17.67	25.50	34.75	31.50	14.34	24.58	76.08
entrenchment ratio	2.06	1.63	2.27	9.63	1.52	1.70	2.67
channel materials (D50)	N/A	Small Cobbles	Small Cobbles	Small Cobbles	Small Cobbles	Small Cobbles	Course Gravel
water surface slope (rise/run)	N/A	8%	8%	7%	6%	5%	5%
channel sinuosity	N/A	1.04	1.05	1.03	1.03	1.05	1.03

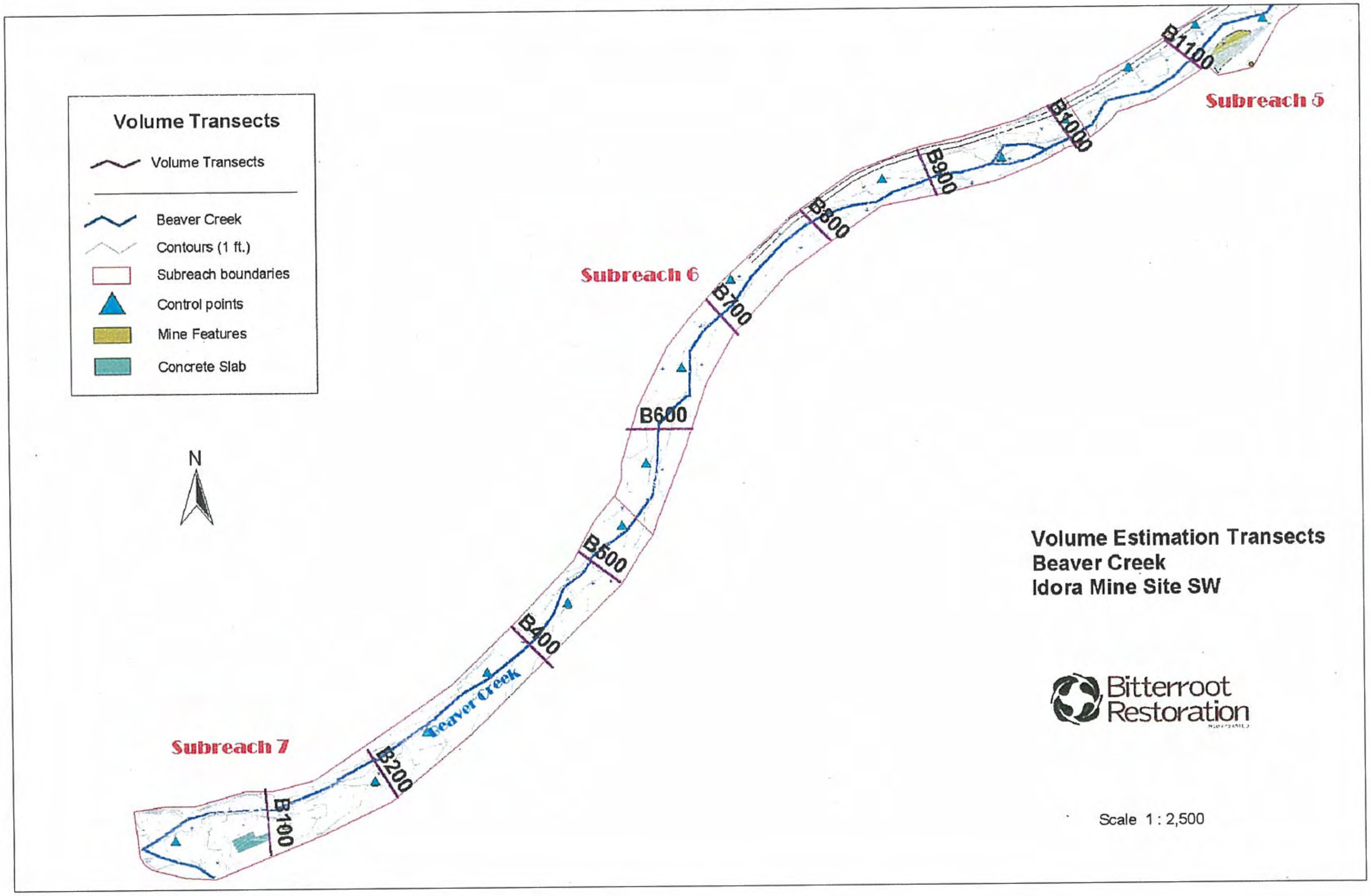
Appendix D.
Volume of Contaminated Material Calculations

VOLUME CALCULATIONS BY REACH & BY MATERIAL SIZE CLASS AT IDORA MINE/MILL

Reach	Boulders	Cobbles	Gravel	Sand	Fines	Mill Tailings	Concrete
2300-2200	16323.48	30748.88	70861.62034	70861.62	44288.51	19993.00	0.00
2200-2100	7160.44	17453.57	26851.64	25732.82	34683.37	0.00	0.00
2100-2000	15904.35	27292.64	42215.24	45160.48927	64601.13	0.00	0.00
2000-1900	14489.82	45943.34	75394.19659	66847.96	33245.19	0.00	0.00
1900-1800	8055.17	94168.8087	102607.56	122937.28	57536.95	0.00	0.00
1800-1700						0.00	0.00
1700-1600	8488.56	43308.97	45041.33	17901.04	750.69	0.00	0.00
1600-1500						0.00	0.00
1500-1400	3050.15	10939.76	10609.23	7956.92	729.38	0.00	0.00
1400-1300	1888.15	27766.93	37763.02	19992.19	21658.23	0.00	0.00
1300-1200	1577.34	78649.23	162354.35	36954.60	43998.47	0.00	0.00
1200-1100						0.00	0.00
1100-1000	1440.54	69011.91	133667.69	73032.02	58291.61	0.00	0.00
1000-900						0.00	0.00
900-800	26310.98	75896.06	93605.38	53126.95	6071.77	0.00	0.00
800-700						0.00	0.00
700-600	21073.46	68154.48	91309.67	49635.00	2809.53	0.00	0.00
600-500						0.00	0.00
500-400	7034.13	35390.45	57152.28	41765.13	78035.84	0.00	0.00
300-200	2484.57	32643.95	66376.04	25389.74	54406.59	0.00	0.00
200-100						0.00	0.00
100-0	6575.62	42985.50	68544.44	49491.41	54138.49	0.00	10918.00
SUM	**141856.76**	**700354.48**	**1084353.69**	**706785.16**	**555245.75**	**19993.00**	**10918.00**
Grand Total	**3219506.85**						

Units of measurement are cubic feet.
The total volume of Gravel, Sand, Fines, Mill Tailings, and Concrete is 2,377,296 cubic feet.


Subreach 4
Subreach 3
Subreach 2
Subreach 5
Beaver Creek
B1200
B1300
B1400
B1500
B1600
B1700
B1800
B1900
B2000
B2100
B2200
Volume Transects
Volume Transects
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control Points
Mine Features
Building Features
N
Volume Estimation Transects
Beaver Creek
Idora Mine Site NE
Scale 1 : 2,700
Bitterroot Restoration


Volume Transects
Volume Transects
Beaver Creek
Contours (1 ft.)
Subreach boundaries
Control points
Mine Features
Concrete Slab
N
Subreach 5
Subreach 6
Subreach 7
B100
B200
B400
B500
B600
B700
B800
B900
B1000
B1100
Beaver Creek
Volume Estimation Transects
Beaver Creek
Idora Mine Site SW
Bitterroot Restoration
Scale 1 : 2,500

Appendix E.
SVL Laboratory Raw Analytic Results

Appendix E. SVL Laboratory Raw Analytic Results for Idora Mine/Mill Site
Soil Analysis for Acid-Base Accounting and Soil/Mine Waste Results

Sample Number	Sample Date	Job_Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	pH	Conduct-ivity (umhos/cm)	S-Total (%)	S-Pyritic (%)	S-Sulfate (%)	S-Non-Extractable (%)	AGP ($TCaCO_3$/1000T)	ANP ($TCaCO_3$/1000T)	ABP ($TCaCO_3$/1000T)
I-01-01-00	10/8/02	105221	15.5	2.96	28	217	446	6.51	822	0.02	0.02	<0.01	<0.01	0.63	0.56	<0.07
I-04-01-04	10/8/02	105221	13.7	2.2	29.8	30.9	168	6.39	73.2	0.01	0.01	<0.01	<0.01	0.31	<0.5	-0.31
I-04-01-06	10/8/02	105221	24.4	14.6	896	17000	3740	3.99	2690	1.13	0.06	1.04	0.03	1.88	0.56	-1.32
I-04-01-13	10/8/02	105221	48.4	5.46	267	7570	1160	4.35	639	0.55	0.24	0.23	0.08	7.5	<0.5	-7.5
I-04-01-17	10/8/02	105221	22.6	7.17	329	16900	1760	5.31	660	1.19	0.64	0.34	0.21	20	2.78	-17.2
I-04-01-39	10/8/02	105221	26.9	6.8	136	8560	1520	4.87	315	0.29	0.09	0.17	0.03	2.81	<0.5	-2.81
I-04-01-42	10/8/02	105221	39.1	10.7	524	6890	2180	5.15	857	0.63	0.29	0.21	0.13	9.06	5.57	-3.49
I-04-01-45	10/8/02	105221	11	4.53	90.1	1370	487	6	890	0.03	0.03	<0.01	<0.01	0.94	4.45	3.51
I-04-01-58	10/8/02	105221	9.3	2.39	30	146	217	5.76	443	<0.01	<0.01	<0.01	<0.01	<0.3	3.9	3.9
I-04-01-70	10/8/02	105221	12.9	6.19	113	2060	1170	5.11	1150	0.2	0.12	0.08	<0.01	3.75	<0.5	-3.75
I-04-01-71	10/8/02	105221	17.9	2.03	71.6	741	196	4.43	390	0.04	0.04	<0.01	<0.01	1.25	<0.5	-1.25
I-04-01-75	10/8/02	105221	14.4	4.99	191	2410	780	5.45	194	0.06	0.03	0.02	0.01	0.94	<0.5	-0.94
I-04-01-83	10/8/02	105221	14.6	4.52	99.2	1920	831	5.29	589	0.13	0.03	0.08	0.02	0.94	<0.5	-0.94
I-04-02-01	10/8/02	105221	20.1	17.1	184	3450	1890	5.63	431	0.05	0.05	<0.01	<0.01	1.56	<0.5	-1.56
I-04-02-05	10/8/02	105221	23.4	11.2	177	3450	1300	5.07	704	0.04	0.02	0.01	0.01	0.63	<0.5	-0.63
I-04-02-15	10/8/02	105221	16.1	14.6	167	4230	1390	5.25	809	0.05	0.04	<0.01	0.01	1.25	<0.5	-1.25
I-04-01-52	10/8/02	105221	23.4	3.21	190	3870	550	4.49	559	0.12	<0.01	0.09	0.03	<0.3	<0.5	<0.3

Appendix E. SVL Laboratory Raw Analytic Results for the Idora Mine Site Water Extractable Analysis

Sample Number	Sample Date	Comments	Job_Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
I-01-01-00	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0035	0.0092	0.014	0.254
I-04-01-13	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.096	0.605	9.37	15.8
I-04-01-39	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0341	0.0846	2.85	5.43
I-04-01-58	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	<0.002	0.0068	0.007	0.0314
I-04-01-71	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0079	0.012	0.184	0.265
I-04-01-83	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0259	0.0264	0.183	4.06

Appendix E. SVL Laboratory Raw Analytic Results for the Idora Mine Site
Stream Sediment Sample Results

Sample Number	Sample Date	Comments	Job_Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	pH	Conductivity (umhos/cm)
ID-CS1-SED	10/5/02		105185	74.4	22.5	108	877	1770	7.07	159
ID-CS2-SED	10/5/02		105185	109	24.4	210	3960	3660	6.78	358
ID-CS3-SED	10/5/02		105185	81.6	36.9	279	6390	5900	6.75	350
ID-CS4-SED	10/5/02		105185	89.7	23.8	217	4440	3370	6.75	263
ID-CS5-SED	10/5/02		105185	113	18.3	313	4750	2810	6.68	312
ID-CS6-SED	10/5/02		105185	65.1	20	229	4360	3080	6.9	170
ID-CS7-SED	10/5/02		105185	68.9	23.2	323	4970	3200	6.72	157

Appendix E. SVL Laboratory Raw Analytic Results for the Idora Mine Site Surface Water Sample Results

Sample Number	Sample Date	Job_Id	Calcium (mg/L)	Magnesium (mg/L)	Hardness (mg/L)	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)
ID-CS1-H2O	10/5/02	105186	4.7	1.28	17	<0.01	<0.002	<0.003	<0.005	0.118
ID-CS2-H2O	10/5/02	105186	4.68	1.27	16.9	<0.01	<0.002	<0.003	0.0094	0.126
ID-CS3-H2O	10/5/02	105186	4.61	1.24	16.6	<0.01	<0.002	<0.003	0.0144	0.209
ID-CS4-H2O	10/5/02	105186	4.48	1.23	16.2	<0.01	<0.002	<0.003	0.0105	0.321
ID-CS5-H2O	10/5/02	105186	4.51	1.2	16.2	<0.01	<0.002	<0.003	<0.005	0.264
ID-CS6-H2O	10/5/02	105186	4.58	1.18	16.3	<0.01	<0.002	<0.003	<0.005	0.297
ID-CS7-H2O	10/5/02	105186	4.58	1.2	16.4	<0.01	<0.002	<0.003	0.0128	0.341

QUALITY CONTROL REPORTS - SOIL

SVL ANALYTICAL, INC. Quality Control Report

Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC SVL JOB No: 103571

Analyte	Method	Matrix	Units	Prep Blank	True—LCS	—Found	LCS %R	Analysis Date
Arsenic	6010B	SOIL	mg/kg	<1.0	192	186	96.9	10/21/02
Cadmium	6010B	SOIL	mg/kg	<0.20	125	123	98.4	10/21/02
Copper	6010B	SOIL	mg/kg	<0.30	93.9	96.4	102.7	10/21/02
Lead	6010B	SOIL	mg/kg	<0.50	160	156	97.5	10/21/02
Zinc	6010B	SOIL	mg/kg	<0.50	246	228	92.7	10/21/02

LEGEND:

LCS = Laboratory Control Sample LCS %R = LCS Percent Recovery N/A = Not Applicable

10/22/02 13:56

QUALITY CONTROL REPORTS - SOIL

SVL ANALYTICAL, INC.

Quality Control Report
Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC — SVL JOB No: 105221

Analyte	Method	Matrix	Units	Prep Blank	True—LCS	—Found	LCS %R	Analysis Date
pH	9045	SOIL		5.42	9.02	8.52	94.5	3/19/03
Spec. Cond.	120.1	SOIL	umhos/cm	1.30	465	449	96.6	3/20/03
ABP	EPA600	SOIL	TCaCO3/k	N/A	42.0	42.9	102.1	3/26/03
Acid Neut. Pot.	EPA600	SOIL	TCaCO3/k	N/A	52.0	52.6	101.2	3/26/03
Pyritic Sulfur,S	LECO	SOIL	%	N/A	0.298	0.310	104.0	3/26/03

LEGEND:
LCS = Laboratory Control Sample   LCS %R = LCS Percent Recovery   N/A = Not Applicable

3/27/03 9:30

QUALITY CONTROL REPORTS - SOIL

SVL ANALYTICAL, INC.

Quality Control Report
Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC

SVL JOB No: 105221

Test	Method	Matrix	QC SAMPLE ID	Units	Result	Duplicate or MSD Found	RPD%	Matrix Spike Result	SPK ADD	%R	Analysis Date
pH	9045	SOIL	1		6.51	6.55	0.6	N/A	N/A	N/A	3/19/03
COND	120.1	SOIL	1	umhos/c	822	609	29.8	N/A	N/A	N/A	3/20/03
ABP	EPA600	SOIL	1	TCaCO3/	-0.07	-0.07	0.0	N/A	N/A	N/A	3/26/03
AGP	EPA600	SOIL	1	TCaCO3/	0.63	0.63	0.0	N/A	N/A	N/A	3/26/03
ANP	EPA600	SOIL	1	TCaCO3/	0.56	0.56	0.0	N/A	N/A	N/A	3/26/03
S N-EX	LECO	SOIL	1	%	<0.010	<0.010	UDL	N/A	N/A	N/A	3/26/03
S-PYR	LECO	SOIL	1	%	0.020	0.020	0.0	N/A	N/A	N/A	3/26/03
S-SO4	LECO	SOIL	1	%	<0.010	<0.010	UDL	N/A	N/A	N/A	3/26/03
S-TOT	LECO	SOIL	1	%	0.020	0.020	0.0	N/A	N/A	N/A	3/26/03

LEGEND:
RPD% = (|SAM - DUP|/((SAM + DUP)/2) * 100) UDL = Both SAM & DUP not detected. *Result or *Found: Interference reqired dilution.
RPD% = (|SPK - MSD|/((SPK + MSD)/2) * 100) M in Duplicate/MSD column indicates MSD.
SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added
QC Sample 1: SVL SAM No.: 327055 Client Sample ID: I10100

3/27/03 9:27

QUALITY CONTROL REPORTS – WATER EXTRACTABLE

SVL ANALYTICAL, INC.

Quality Control Report
Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC SVL JOB No: 105220

Analyte	Method	Matrix	Units	Prep Blank	True—LCS	—Found	LCS %R	Analysis Date
Arsenic	200.7	ESOIL	mg/L Ext	<0.010	1.25	1.29	103.2	3/20/03
Cadmium	200.7	ESOIL	mg/L Ext	<0.0020	1.25	1.30	104.0	3/20/03
Copper	200.7	ESOIL	mg/L Ext	<0.0030	1.25	1.17	93.6	3/20/03
Lead	200.7	ESOIL	mg/L Ext	<0.0050	1.25	1.27	101.6	3/20/03
Zinc	200.7	ESOIL	mg/L Ext	<0.0050	1.25	1.30	104.0	3/20/03

LEGEND:
LCS = Laboratory Control Sample   LCS %R = LCS Percent Recovery   N/A = Not Applicable

3/21/03 9:04

QUALITY CONTROL REPORTS – WATER EXTRACTABLE

SVL ANALYTICAL, INC.

Quality Control Report
Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC SVL JOB No: 105220

Test	Method	Matrix	QC SAMPLE ID Units	Result	Duplicate or MSD Found	RPD%	Matrix Spike Result	SPK ADD	%R	Analysis Date
As	200.7	ESOIL	2 mg/L Ex	<0.010	<0.010	UDL	1.01	1.00	101.0	3/20/03
Cd	200.7	ESOIL	2 mg/L Ex	<0.0020	<0.0020	UDL	0.967	1.00	96.7	3/20/03
Cu	200.7	ESOIL	2 mg/L Ex	0.0068	<0.0030	200.0	0.961	1.00	95.4	3/20/03
Pb	200.7	ESOIL	2 mg/L Ex	0.0070	<0.0050	200.0	0.975	1.00	96.8	3/20/03
Zn	200.7	ESOIL	2 mg/L Ex	0.0314	0.0075	122.9	0.975	1.00	94.4	3/20/03

LEGEND:
RPD% = (|SAM - DUP|/((SAM + DUP)/2) * 100) UDL = Both SAM & DUP not detected. *Result or *Found: Interference reqired dilution.
RPD% = (|SPK - MSD|/((SPK + MSD)/2) * 100) M in Duplicate/MSD column indicates MSD.
SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added
QC Sample 1: SVL SAM No.: 327047 Client Sample ID: I10100
QC Sample 2: SVL SAM No.: 327050 Client Sample ID: I40158

3/21/03 9:04

QUALITY CONTROL REPORTS – WATER

SVL ANALYTICAL, INC.

Quality Control Report
Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC SVL JOB No: 105186

Analyte	Method	Matrix	Units	Prep Blank	True—LCS	—Found	LCS %R	Analysis Date
Arsenic	200.7	WATER	mg/L	<0.010	1.00	0.996	99.6	3/20/03
Calcium	200.7	WATER	mg/L	<0.040	20.0	19.9	99.5	3/20/03
Cadmium	200.7	WATER	mg/L	<0.0020	1.00	0.997	99.7	3/20/03
Copper	200.7	WATER	mg/L	<0.0030	1.00	1.04	104.0	3/20/03
Hardness	200.7	WATER	mg/L	<0.265	132	131	99.2	3/20/03
Magnesium	200.7	WATER	mg/L	<0.040	20.0	19.8	99.0	3/20/03
Lead	200.7	WATER	mg/L	<0.0050	1.00	1.01	101.0	3/20/03
Zinc	200.7	WATER	mg/L	<0.0050	1.00	1.00	100.0	3/20/03

LEGEND:
LCS = Laboratory Control Sample   LCS %R = LCS Percent Recovery   N/A = Not Applicable

3/21/03 9:01

QUALITY CONTROL REPORTS – WATER

SVL ANALYTICAL, INC.

Quality Control Report
Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC — SVL JOB No: 105186

Test	Method	Matrix	QC SAMPLE ID	Units	Result	Duplicate or MSD Found	RPD%	Matrix Spike Result	SPK ADD	%R	Analysis Date
As	200.7	WATERS	1	mg/L	<0.010	<0.010	UDL	0.919	1.00	91.9	3/20/03
Ca	200.7	WATERS	1	mg/L	4.70	4.75	1.1	24.2	20.0	97.5	3/20/03
Cd	200.7	WATERS	1	mg/L	<0.0020	<0.0020	UDL	0.960	1.00	96.0	3/20/03
Cu	200.7	WATERS	1	mg/L	<0.0030	<0.0030	UDL	1.01	1.00	101.0	3/20/03
Hdns	200.7	WATERS	1	mg/L	17.0	17.1	0.6	143	132	95.5	3/20/03
Mg	200.7	WATERS	1	mg/L	1.28	1.28	0.0	20.1	20.0	94.1	3/20/03
Pb	200.7	WATERS	1	mg/L	<0.0050	<0.0050	UDL	0.966	1.00	96.6	3/20/03
Zn	200.7	WATERS	1	mg/L	0.118	0.119	0.8	1.05	1.00	93.2	3/20/03

LEGEND:
RPD% = (|SAM - DUP|/((SAM + DUP)/2) * 100) UDL = Both SAM & DUP not detected. *Result or *Found: Interference reqired dilution.
RPD% = (|SPK - MSD|/((SPK + MSD)/2) * 100) M in Duplicate/MSD column indicates MSD.
SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added
QC Sample 1: SVL SAM No.: 326791 Client Sample ID: ID-CS1-H2O

3/21/03 9:01

QUALITY CONTROL REPORTS – SEDIMENT

MAR-25-03 09:44 From:SVL ANALYTICAL +2087830891 T-118 P.09/13 Job-132

SVL ANALYTICAL, INC.

Quality Control Report
Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC — SVL JOB No: 105185

Analyte	Method	Matrix	Units	Prep Blank	LCS True	LCS Found	LCS %R	Analysis Date
Arsenic	6010B	SOIL	mg/kg	<1.0	283	310	109.5	3/21/03
Cadmium	6010B	SOIL	mg/kg	<0.20	50.7	52.5	103.6	3/21/03
Copper	6010B	SOIL	mg/kg	0.55	169	183	108.3	3/21/03
Lead	6010B	SOIL	mg/kg	<0.50	84.7	89.6	105.8	3/21/03
Zinc	6010B	SOIL	mg/kg	<0.50	149	156	104.7	3/21/03
pH	9045	SOIL		5.42	9.07	8.52	93.9	3/19/03
Spec. Cond.	120.1	SOIL	umhos/cm	1.30	465	449	96.6	3/20/03

LEGEND:
LCS = Laboratory Control Sample LCS %R = LCS Percent Recovery N/A = Not Applicable

3/25/03 8:40

QUALITY CONTROL REPORTS – SEDIMENT

MAR-25-03 09:44 From:SVL ANALYTICAL +2087830891 T-118 P.10/13 Job-132

SVL ANALYTICAL, INC.

Quality Control Report
Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC SVL JOB No: 105185

Test	Method	Matrix	QC SAMPLE ID	Units	Result	Duplicate or MSD Found		RPD%	Matrix Spike Result	SPK ADD	%R	Analysis Date
As	6010B	SOIL	1	mg/kg	74.4	281	M	2.5	288	200	106.8	3/21/03
Cd	6010B	SOIL	1	mg/kg	22.5	208	M	3.3	215	200	96.3	3/21/03
Cu	6010B	SOIL	1	mg/kg	108	315	M	6.2	335	200	113.5	3/21/03
Pb	6010B	SOIL	1	mg/kg	877	970	M	1.7	987	200	R >4S	3/21/03
Zn	6010B	SOIL	1	mg/kg	1770	1790	M	4.4	1870	200	R >4S	3/21/03
pH	9045	SOIL	1		7.07	7.03		0.6	N/A	N/A	N/A	3/19/03
COND	120.1	SOIL	1	umhos/c	159 *	151		5.2	N/A	N/A	N/A	3/20/03

LEGEND:
RPD% = (|SAM - DUP|/((SAM + DUP)/2) * 100) UDL = Both SAM & DUP not detected. *Result or *Found: Interference reqired dilution.
RPD% = (|SPK - MSD|/((SPK + MSD)/2) * 100) M in Duplicate/MSD column indicates MSD.
SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added
QC Sample 1: SVL SAM No.: 326782 Client Sample ID: ID-CS1-SED

3/25/03 8:40

SVL ANALYTICAL

CHAIN OF CUSTODY RECORD

Page 1 of 2

Client: Bitterroot Restoration, Inc.
Contact: Grant Massey
Address: 445 Quast Lane
Corvallis, MT 59828
Phone Number: 406-961-4991
FAX Number: 406-961-4626

NOTES:
1) Ensure proper container packaging.
2) Ship samples promptly following collection.
* 3) Designate Sample Reject Disposition
PO#:
Project Name: Idora (7244001)

Table 1. -- Matrix Type
1 = Surface Water, 2 = Ground Water
3 = Soil/Sediment, 4 = Rinsate, 5 = Oil
6 = Waste, 7 = Other (Specify) ______

FOR SVL USE ONLY
SVL JOB # 103571

Samplers Signature: [signature]

Lab Name: SVL Analytical, Inc. (208) 784-1258 FAX (208) 783-0891
Address: One Government Gulch, Kellogg, ID 83837-0929

Sample ID	Collection: Date	Collection: Time	Collected by: (Init.)	Matrix Type From Table 1	No. of Containers	Sample Filtered ? Y/N	Unpreserved (~~Ice Only~~)	HNO3	HCL	H2SO4	NAOH	Other (Specify)	Analyses Required: Metals (As, Pb, Cu, Cd, Zn)	Comments
1. I10100	10/08/02	9:45	JFB	3	1	N	✓						✓	
2. I40104	↓	9:55	↓	3	1	↓	✓						✓	
3. I40106	↓	10:05	↓	3	1	↓	✓						✓	
4. I40113	↓	10:19	↓	3	1	↓	✓						✓	
5. I40117	↓	10:15	↓	3	1	↓	✓						✓	
6. I40139	↓	10:30	↓	3	1	↓	✓						✓	
7. I40142	↓	10:37	↓	3	1	↓	✓						✓	
8. I40145	↓	11:02	↓	3	1	↓	✓						✓	
9. I40158	↓	11:30	↓	3	1	↓	✓						✓	
10. I40170	10/08/02	11:45	JFB	3	1	N	✓						✓	

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
[signature] J.F. B.	10/08/02	3:15	J Burmeister	10-8-02	3:15PM
Relinquished by:	Date:	Time:	Received by:	Date:	Time:

* Sample Reject: [ ] Return [ ] Dispose [ ] Store (30 Days)

White: LAB COPY Yellow: CUSTOMER COPY SVL-COC 12/95

SVL ANALYTICAL

CHAIN OF CUSTODY RECORD

Page 2 of 2

Client: Bitterroot Restoration, Inc. (BRI)
Contact: Gant Massey
Address: 445 Quast Lane
Corvallis, MT 59828
Phone Number: 406-961-4991
FAX Number: 406-961-4626

NOTES:
1) Ensure proper container packaging.
2) Ship samples promptly following collection.
* 3) Designate Sample Reject Disposition
PO#:
Project Name: Idora (7244001)

Table 1. -- Matrix Type
1 = Surface Water, 2 = Ground Water
3 = Soil/Sediment, 4 = Rinsate, 5 = Oil
6 = Waste, 7 = Other (Specify) ______

FOR SVL USE ONLY
SVL JOB # 103571

Samplers Signature: J.F. Bay

Lab Name: SVL Analytical, Inc. (208) 784-1258 FAX (208) 783-0891
Address: One Government Gulch, Kellogg, ID 83837-0929

Sample ID	Collection: Date	Collection: Time	Collected by: (Init.)	Matrix Type From Table 1	No. of Containers	Sample Filtered ? Y/N	Unpreserved (~~Ice Only~~)	HNO3	HCL	H2SO4	NAOH	Other (Specify)	Metals (As, Pb, Cu, Cd, Zn)								Comments
1. I40171	10/08/02	12:07	JFB	3	1	N	✓						✓								As = Arsenic
2. I40175	↓	12:20	↓	↓	↓	↓	✓						✓								Pb = Lead
3. I40183	↓	12:45	↓	↓	↓	↓	✓						✓								Cu = Copper
4. I40201	↓	13:02	↓	↓	↓	↓	✓						✓								Cd = Cadmium
5. I40205	↓	13:35	↓	↓	↓	↓	✓						✓								Zn = Zinc
6. I40215	10/08/02	13:45	JFB	↓	↓	↓	✓						✓								
7. I40152	10/05/02	12:00	JGM	3	1	N	✓														
8.																					
9.																					
10.																					

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
James F. Bay	10/08/02	3:15 PM	G. Burmeister	10-8-02	3:15
Relinquished by:	Date:	Time:	Received by:	Date:	Time:

* Sample Reject: [ ] Return [ ] Dispose [ ] Store (30 Days)

White: LAB COPY Yellow: CUSTOMER COPY SVL-COC 12/95

CHAIN OF CUSTODY RECORDS - SURFACE WATER & SEDIMENT

MAR-21-03 10:11 From:SVL ANALYTICAL +2087830891 T-078 P.02/13 Job-088

SVL ANALYTICAL

Do Not Analyze Until Given Notice to Proceed by BRI.

Continue to archive, per G. Massey.... 2/27/03 gc

CHAIN OF CUSTODY RECORD

Pg 1 of 2

Client: Bitterroot Restoration, Inc (BRI)
Contact: Gant Massey
Address: 445 Quast Lane
Corvallis, MT 59828
Phone Number: 406-961-4991
FAX Number: 406-961-~~2646~~ 4626

Notes:
1) Ensure proper container packaging.
2) Ship samples promptly following collection.
* 3) Designate Sample Reject Disposition

PO#:
Project Name: RAMS- IDORA

Table 1 = Surface Water, 2 = Ground Water
3 = Soil/Sediment, 4 = Rinsate, 5 = Oil
6 = Waste, 7 = Other (Specify) ______

FOR SVL USE ONLY
SVL JOB# ______

Samplers Signature: Clare Fitzgerald, Paul Coffin

Lab Name: SVL Analytical, Inc. (208) 784-1258 FAX (208) 783-0891
Address: One Government Gulch, Kellogg, ID 83837-0929

Sample ID	Collection Date	Collection Time	Collected by: (Init.)	Matrix Type From Table 1	No. of Containers	Sample Filtered ? Y/N	Unpreserved (Ice Only)	HNO3	HCL	H2SO4	NAOH	Other (Specify)	Total metals	AS	CU	CD	PB	ZN				Comments
1. ID-CS1-SED	10-5-02	1:40 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
2. ID-CS2-SED	10-5-02	2:30 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
3. ID-CS3-SED	10-5-02	3:30 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
4. ID-CS4-SED	10-5-02	4:05 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
5. ID-CS5-SED	10-5-02	4:50 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
6. ID-CS6-SED	10-5-02	5:40 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
7. ID-CS7-SED	10-5-02	6:20 PM	CF/PC	3	1	N	✓						✓	✓	✓	✓	✓	✓				
8. ID-CS1-H2O	10-5-02	1:40 PM	CF/PC	1	1	N		✓					✓	✓	✓	✓	✓	✓				
9. ID-CS2-H2O	10-5-02	2:25 PM	CF/PC	1	1	N		✓					✓	✓	✓	✓	✓	✓				
10. ID-CS3-H2O	10-5-02	3:30 PM	CF/PC	1	1	N		✓					✓	✓	✓	✓	✓	✓				

Relinquished by:	Date:	Time:	Received by: Crystal Seay	Date: 10/7/02	Time: 8:00
Relinquished by:	Date:	Time:	Received by:	Date:	Time:

* Sample Reject: [ ] Return [ ] Dispose [ ] Store (30 Days)

White: LAB COPY Yellow: CUSTOMER COPY SVL-COC 12/95

CHAIN OF CUSTODY RECORDS - SURFACE WATER & SEDIMENT

MAR-21-03 10:10 From:SVL ANALYTICAL +2087830891 T-078 P.01/13 Job-088

SVL ANALYTICAL

Do Not Analyze Until Given Notice to Proceed by BRI

CHAIN OF CUSTODY RECORD

Page 2 of 2

Client: Bitterroot Restoration, Inc. (BRI)
Contact: Grant Massey
Address: 445 Quast Lane
Corvallis, MT 59828
Phone Number: 406-961-4991
FAX Number: 406-961-~~2646~~ 4626

NOTES:
1) Ensure proper container packaging.
2) Ship samples promptly following collection.
* 3) Designate Sample Reject Disposition
PO#:
Project Name: RAMS- IDORA

Table 1. -- Matrix Type
1 = Surface Water, 2 = Ground Water
3 = Soil/Sediment, 4 = Rinsate, 5 = Oil
6 = Waste, 7 = Other (Specify) ____

FOR SVL USE ONLY
SVL JOB #
105186

Samplers Signature: Chase Fitzgerald, [signature]

Lab Name: SVL Analytical, Inc. (208) 784-1258 FAX (208) 783-0891
Address: One Government Gulch, Kellogg, ID 83837-0929

Sample ID	Collection Date	Collection Time	Collected by: (Init.)	Matrix Type From Table 1	No. of Containers	Sample Filtered ? Y/N	Unpreserved (Ice Only)	HNO3	HCL	H2SO4	NAOH	Other (Specify)	Total Metals	AS	CU	CD	PB	ZN				Comments
1. ID-CS4-H2O	10-5-02	3:56 PM	CF/DC	1	1	N		✓					✓	✓	✓	✓	✓	✓				
2. ID-CS5-H2O	10-5-02	4:44 PM	CF/DC	1	1	N		✓					✓	✓	✓	✓	✓	✓				
3. ID-CS6-H2O	10-5-02	5:30 PM	CF/DC	1	1	N		✓					✓	✓	✓	✓	✓	✓				
4. ID-CS7-H2O	10-5-02	6:12 PM	CF/DC	1	1	N		✓					✓	✓	✓	✓	✓	✓				
5.																						
6.																						
7.																						
8.																						
9.																						
10.																						

Relinquished by:	Date:	Time:	Received by:	Date	Time
			[signature]	10/7/02	8:00
Relinquished by:	Date:	Time:	Received by:	Date	Time:

* Sample Reject: [ ] Return [ ] Dispose [ ] Store (30 Days)

White: LAB COPY Yellow: CUSTOMER COPY SVL-COC 12/95

Appendix F.
XRF Field Analytical Results for Total Metals

Emc2

7220 North 16th Street, Suite E
Phoenix, AZ 85020
(602) 331-3859
Fax (602) 331-4104

May 21, 2003 1034-1 & 1034-2

Ms. Clare Fitzgerald
Bitterroot Restoration, Inc.
445 Quast Lane
Corvallis, Montana 59828

X-Ray Fluorescence (XRF) Instrument Details – Response to United States Forest Service (USFS) Comments for Bullion and Idora Site Characterization Reports

Dear Clare:

As discussed during our telephone conversation on Friday, May 9, 2003 the USFS commented on the Bullion and Idora Site Characterization Reports and requested additional information regarding the XRF instrument used in the field. Information regarding the USFS' XRF comment, "To be consistent with the other sections below (e.g. pH, flow meters, etc.) this should state what type of XRF instrument was used, it's approximate upper and lower detection limits, precision, accuracy and limitations," is discussed below. I've included as attachments the XRF summary brief text for the Bullion and Idora sites submitted to BRI in March 2003 and EPA's Method 6200 – 'Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentration in Soil and Sediment' for your reference.

- The type of XRF instrument used: Spectrace 9000 portable XRF
- The approximate upper detection limits or quantitation limits is determined as 10 times the sample result's associated standard deviation, which is reported by the instrument. This quantitation limit varies from sample to sample. Typically, an average would be used to determine upper detection limits; however, because the XRF instrument was being used to characterize the site and site-specific characterization samples were not available the above method was employed.
- The approximate lower detection limits is determined as 3 times the sample result's associated standard deviation, which is reported by the instrument. This detection limit varies from sample to sample. Typically, an average would be used to determine lower

detection limits; however, because the XRF instrument was being used to characterize the site and site-specific characterization samples were not available the above method was employed. Additionally, the EPA Method 6200 includes a guide for lower detection limits based on no interference, 600 counts per source and quartz soil, they are as follows:

- Arsenic (As) 40 ppm
- Lead (Pb) 20 ppm
- Copper (Cu) 50 ppm
- Cadmium (Cd) 100 ppm
- Zinc (Zn) 50 ppm

- Precision: The precision for the XRF instrument is based on site-specific conditions and is discussed in detail in the Quality Assurance/Quality Control section of the XRF summary briefs submitted to BRI for Bullion and Idora sites on March 20, 2003 and March 24, 2003, respectively.

- Accuracy: The accuracy for the XRF instrument is based on site-specific conditions and is discussed in detail in the Quality Assurance/Quality Control section of the XRF summary briefs submitted to BRI for Bullion and Idora sites on March 20, 2003 and March 24, 2003, respectively.

- Limitations: The XRF instrument limitations are discussed in detail in EPA's Method 6200 Section 4.0 – 'Interferences'.

Sincerely,
EMC^2

(sent via email)

Lisa N. Gonzales
Principal

Enclosures

cc: Joe Flynn, EMC^2

Appendix G.

Statistical Procedures (Student's t-Test, Least Squares Regressions)

Regression Summary
L_XRF_COPPER vs. L_ICP_Copper

Count	6
Num. Missing	10
R	.638
R Squared	.407
Adjusted R Squared	.258
RMS Residual	.320

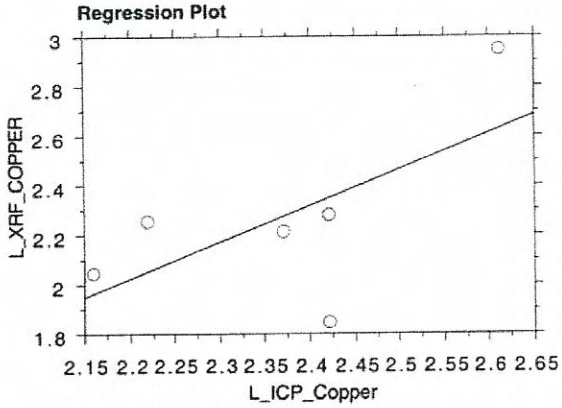
ANOVA Table
L_XRF_COPPER vs. L_ICP_Copper

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	.281	.281	2.743	.1730
Residual	4	.409	.102		
Total	5	.690			

Regression Coefficients
L_XRF_COPPER vs. L_ICP_Copper

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-1.221	2.111	-1.221	-.578	.5941
L_ICP_Copper	1.474	.890	.638	1.656	.1730

Regression Plot



Y = -1.221 + 1.474 * X; R^2 = .407

Regression Summary
L_XRF_LEAD vs. L_ICP_Lead

Count	15
Num. Missing	1
R	.947
R Squared	.897
Adjusted R Squared	.889
RMS Residual	.221

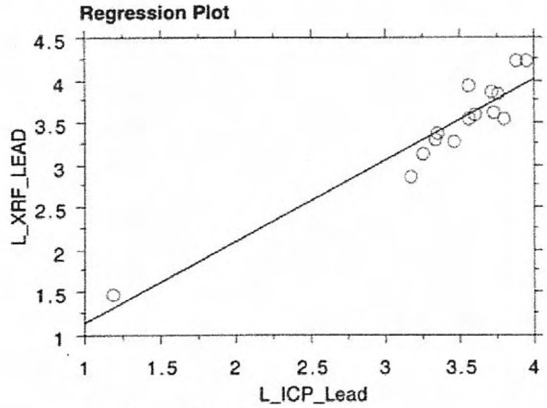
ANOVA Table
L_XRF_LEAD vs. L_ICP_Lead

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	5.542	5.542	113.057	<.0001
Residual	13	.637	.049		
Total	14	6.179			

Regression Coefficients
L_XRF_LEAD vs. L_ICP_Lead

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	.202	.312	.202	.649	.5278
L_ICP_Lead	.953	.090	.947	10.633	<.0001

Regression Plot



Y = .202 + .953 * X; R^2 = .897

Regression Summary
L_XRF_ZINC vs. L_ICP_Zinc

Count	16
Num. Missing	0
R	.882
R Squared	.777
Adjusted R Squared	.761
RMS Residual	.192

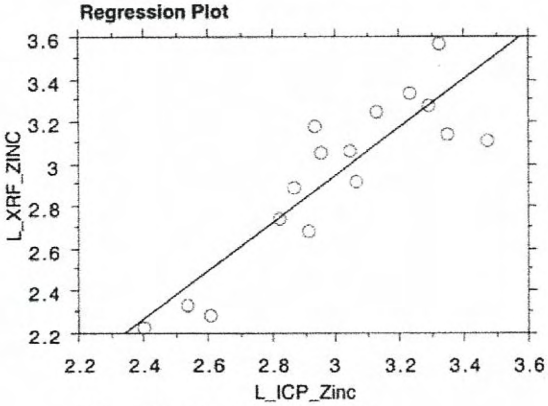
ANOVA Table
L_XRF_ZINC vs. L_ICP_Zinc

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	1.802	1.802	48.887	<.0001
Residual	14	.516	.037		
Total	15	2.318			

Regression Coefficients
L_XRF_ZINC vs. L_ICP_Zinc

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-.463	.490	-.463	-.945	.3606
L_ICP_Zinc	1.137	.163	.882	6.992	<.0001

Regression Plot



Y = -.463 + 1.137 * X; R^2 = .777

t-STATISTIC & P-VALUE DESCRIPTION

The **t statistic** is used for small samples (less than 30 samples) to determine the probability whether a sample mean is not equal to the expected population mean. In general terms, the greater the value of a t statistic for a given sample size, the stronger the probability a sample mean does not follow the expected population mean (i.e., the sample and population means are different). The **p-value** indicates this probability. The small the p-value, the greater the likelihood that the sample mean does not follow the expected population mean.

LEAST SQUARES REGRESSION DESCRIPTION

Least squares regression describes how two measurement variables are related. Most importantly for the purpose of this exercise, the least squares regression method describes how accurately we can predict the value of one variable (the cause) if we know the value of another variable (the response). The coefficient of determination (R^2) is interpreted as the proportion of the total variation of the response that can be explained by the cause. The rule of thumb for interpreting the R^2 and the correlation coefficient (R) is that there is a strong relationship between the cause and effect if $R^2 > 0.64$ ($|R| > 0.8$), a moderate relationship if $R^2 > 0.25$ ($|R| > 0.5$), and a weak relationship if $R^2 > 0.04$ ($|R| > 0.2$). In this test, the p-value indicates the probability that the observed relationship between the two variables is not false or artificial. The smaller the p-value, the greater the likelihood that the observed relationship is not false.

Idora Reclamation Options

These reclamation options describe possible reclamation alternatives for the Idora Mill site and upper Beaver Creek from the Idora Mill to the confluence with Carbon Creek. The Idora Mill is located on lands administered by the Idaho Panhandle National Forests. Lands below the Idora Mill to the Confluence with Carbon Creek are private. Three primary reclamation areas have been identified:

- Idora Mill
- Subreach 3 waste rock
- Beaver Creek throughout the investigation reach

Reclamation alternatives will address these three areas.

Reclamation Action Objectives

The following are proposed reclamation action objectives for the Idora Mill and Beaver Creek.

1. Remove tailings and waste rock from the floodplain of Beaver Creek at the Idora Mill and Subreach 3 waste rock area to eliminate erosion of those materials into the Creek.
2. Eliminate the human health risks associated with mill tailings and waste rock at the site.
3. Eliminate or reduce human health and environmental risks associated with metals in sediments of Beaver Creek.
4. Restore floodplain of Beaver Creek so that natural stream processes can occur.

Tailings Volume

Bitterroot Restoration Inc. (BRI) estimated tailings at 19,993 cubic feet, or 740 cubic yards. MCS estimated the area of tailings at 12,150 square feet, based on the BRI map of the Idora Mill area. Using the BRI volume and MCS area, tailings average 1.65 feet thick. Removal of an additional 0.5 feet of underlying topsoil would increase the average removal depth to 2.15 feet and removal volume to 968 cubic yards. BRI did not sample soil under the tailings. The assumption of removal of 0.5 feet of underlying material is based on MCS experience at other mine sites, but may not reflect conditions at this site. Additional sampling will be necessary during the design phase to confirm the depth of metals migration below the tailings. Each additional 0.5 feet of removal would add 225 cubic yards to the total. A design survey may be necessary to confirm removal areas and volumes.

Material on either side of the former mill building appears to be waste associated with the mill. BRI appears to have collected samples from the "talus" adjacent to the mill. Two samples analyzed using XRF appear to be composed of talus. BRI samples I10112 and I10113 from the talus contained 1,017 and 5,167 mg/kg lead, respectively. Based on these data, waste material on the hill side by the mill building will be considered for removal with tailings in the floodplain. Further sampling may allow for segregation of the hillside waste into two waste types, some of which may not need to be removed. Tailings and waste adjacent to the mill building were not included in the BRI volume (MCS assumption based on BRI methods which indicates only waste within the floodplain were included in calculations). An area of 6,000 square feet was used for the hillside waste. Average thickness was estimated at 3 feet. Estimated removal volume is 667 cubic yards. Waste volumes are summarized on Table 1.

BRI did not calculate the volume of waste below the cabin on Subreach 3. MCS assumes this to be waste rock removed from the adit on the north side of Beaver Creek near the midpoint of the dump. MCS did not characterize this waste area, except to map the extent of waste on the BRI base map. Beaver Creek has eroded a channel and floodplain through this waste. MCS estimates the area of the upstream waste dump to be 10,500 square feet and the other portion of the dump on the north side of the creek is estimated at 8,200 square feet. No data are available regarding the depth of waste in these areas. MCS estimates the depth to be 2.5 to 3.5 feet, based on memory and photos. MCS used an average depth of 2.5 feet for the upper area and 3.0 feet for the lower area in volume calculations. Estimated waste rock volume is 972 and 911 cubic yards for the upper and lower areas, respectively. These volumes will need to be confirmed during the design phase.

Table 1: Tailings and Waste Rock Volume Estimates

Location	Volume (cubic yards)
Idora Mill Flood Plain	970
Idora Mill Hill Side	667
Subreach 3 Waste Rock	1,983
Total	3,520

A waste rock dump is located on Subreach 5. This dump extends to the floodplain of Beaver Creek, but does not appear to have been eroded by the creek. MCS did not investigate this waste rock dump and MCS has not been able to identify any samples that BRI collected from this location. MCS assumes at this time that this waste rock dump will not be reclaimed, except possibly to reinforce the toe of the dump to protect it from potential erosion.

BRI estimated the volume of contaminated sediments on the investigation reach of Beaver Creek. Most of the waste in the creek sediments is in the finer fraction. Any removal action to address the contaminated sediments would likely focus on the finer fractions. This could be accomplished using a screening plant to separate the fractions. BRI estimated the sand and fines volume to be 706,785 and 555,246 cubic feet, respectively. This amounts to a total of 46,742 cubic yards. If gravel is included the total is 86,900 cubic yards. MCS will use the 86,900 cubic yards as the volume of sediment for reclamation in this report. This volume of contaminated sediment would need to be separated from the cobble and boulder fraction as part of any reclamation.

Alternative 1: No Action

The site would remain in its current state with no reclamation work under this alternative.

Alternative 2: On-Site Reclamation

Idora Mill

Under this alternative, all tailings would be removed from the floodplain of Beaver Creek near the Idora Mill and consolidated at an on-site location. Waste on the slope adjacent to the mill building would be reclaimed in place. Areas for consolidation at the site are limited. One possible location is against the hillside between the mill and the small waste rock dump. Placement of waste at this location would require removal of tailings present on the flat part of the consolidation area. Clean fill would be placed on the bottom of the consolidation area to ensure that the tailings would be placed at elevations that would protect the consolidation area from any floods. Waste would then be excavated from the tailings area and placed on the hill side between the mill and waste rock dump.

Waste on either side of the Idora Mill building would be reclaimed in place. The current state of the mill building indicates that it will have to be removed during reclamation. Two options for removal of the building are to dispose of the wood in a land fill, or collapse the building into the hill side excavation where it is constructed. A retaining wall would be constructed at the toe of the waste to contain the down slope migration of waste material. This may also allow for the slope to be reduced slightly, depending on the height of the retaining wall. The retaining wall would also extend around the waste consolidation area.

One foot of backfill followed by 6 inches of topsoil would be placed over the waste. The reclaimed area would be fertilized, seeded, and mulched. Because of the steepness of the reclaimed waste and consolidated tailings, erosion control mat would be placed over the entire disturbed areas on the hill slope.

Removal of the waste from the valley bottom would leave a surface that is similar to the natural ground surface before tailings were placed there. Topsoil would be placed over the removal area to bring the land surface up to approximate the original natural ground surface elevations. Disturbed areas would be seeded, fertilized, and mulched.

The main creek channel will not be disturbed in the vicinity of the Idora mill during reclamation. Tailings would be removed from the banks of the flood channel that flows across the tailings area. Banks of this channel would be shaped to a stable configuration. Removal may extend into the floodplain at the west end of the site. Floodplain stabilization will be accomplished primarily through establishing vegetation adjacent to the channel. Vegetation will match existing vegetation in healthy reaches of creek.

Subreach 3 Waste Rock
Waste rock below the cabin in Subreach 3 would be consolidated against the mountain side on the south side of the creek in the vicinity of the cabin. Waste rock may extend under the cabin. Further sampling may be required to verify the extent of waste rock in the area of the cabin. If the cabin is resting on waste rock, it may have to be removed to access the waste. Waste rock on the north side of the creek would be excavated and hauled across the creek to the consolidation area. This would require construction of a bridge or ford at this site, which may also be required for access to the Idora Mill. If necessary, fill would be placed in the consolidation area to ensure that the base of the consolidated waste is above the floodplain. Consolidated waste rock would be contained with a retaining wall similar to that at the Idora Mill to protect the toe of the waste. Backfill and topsoil would be placed over the consolidated waste and waste rock removal areas. The consolidation area and removal areas would be seeded, fertilized and mulched. Erosion control mat may be required to stabilize the slope of the consolidation area.

The creek channel would not be affected by this removal. Recontouring of the flood plain may be required where the creek has eroded its channel through the waste rock and where the removal extends to the floodplain. The floodplain would be contoured into a stable configuration and riparian vegetation would be planted to stabilize the banks.

Beaver Creek
Beaver creek is degraded throughout the investigation reach. Subreach 1 is above the Idora Mill and is not included in the reclamation. Subreaches 5, 6, and 7 comprise 5,400 feet of the 7,030 feet of creek from the Idora Mill to the confluence with Carbon Creek. Subreach 5 is where the excessive aggradation by gravel and cobbles begins. Beaver Creek is contained within a relatively stable channel through much of Subreaches 2, 3, and 4. These reaches contain some pockets of obvious tailings that would be removed during reclamation. Excavated tailings pockets would be hauled to the Subreach 3 waste rock consolidation area and placed with the waste rock. Reclamation in these reaches would consist primarily of streambank stabilization and revegetation.

Stream sediments in Subreaches 5, 6, and 7 would be reclaimed in place under this alternative. All visible tailings deposits would be excavated and hauled to the Subreach 3 waste consolidation areas. BRI classifies Subreaches 5 and 6 as Rosgen A3 stream type and Subreach 7 as an A4 stream type. Descriptions of these stream types (Rosgen 1996) indicate that the channel should be incised in the alluvium. These stream channels appear to have been unstable in the recent past, but now are becoming entrenched. However, the entrenchment is less than would be expected for a healthy A3 stream type. Entrenchment ratios (width of flood prone area divided by bank full width) are less than 1.4 for A type streams. Current entrenchment ratios measured by BRI range from 1.52 to 9.63. The goal of stream reclamation would be to restore the A3 stream type attributes to the injured reaches of creek, particularly depth to width ratios.

The floodplain on either side of the creek channel would be contoured so that water drains toward the creek. Restoration of the proper entrenchment ratio may require backfill to elevate the stream bank above the bankfull elevation along some reaches. Backfill would be placed over the floodplain as needed to achieve necessary floodplain elevations. Topsoil would then be placed over the floodplain. All disturbed areas would be seeded, fertilized, and mulched. Trees would also be planted across the floodplain. Establishing trees adjacent to the creek is necessary to limit channel migration in the reclaimed area.

Bank stabilization would be an important component of the channel construction. Stream banks are held in place by vegetation in the healthier reaches of the creek. Revegetation of the banks to hold the sediment in place would be the ultimate goal of bank stabilization. Placement of structures in the banks may be required at critical points to ensure channel stability until vegetation is established.

Alternative 3: Off-Site Disposal at the Eagle Creek Repository

All waste from the site would be excavated and hauled to the regional repository on the East Fork of Eagle Creek under this alternative.

Idora Mill

All tailings would be excavated from the Idora Mill site and placed in the regional repository on the East Fork of Eagle Creek under this alternative. Removal would include the waste on the hill side adjacent to the mill building. Reclamation would require construction of approximately 10,000 feet of road up Beaver Creek to the Idora Mill and include a minimum of two stream crossings. The road would have to be engineered to haul 3,500 cubic yards of waste from the Idora Mill and Subreach 3 waste rock dump to the existing road. Removal of the tailings from the floodplain at the mill would leave a surface that approximates the original ground surface. Backfill and topsoil would be placed over the removal area to bring the ground surface up to match the original surface.

Removal of the mill building will be required to remove the hill side waste. The building can be removed with disposal at a landfill or it may be possible to collapse the building in place and cover it with backfill. Backfill would be placed over the removal surface followed by topsoil. Erosion control mat would be placed over the disturbed hill side area to facilitate revegetation.

The main creek channel will not be disturbed in the vicinity of the Idora mill during reclamation. Tailings would be removed from the banks of the flood channel that flows across the tailings area. Banks of this channel would be shaped to a stable configuration. Removal may extend into the floodplain at the west end of the site. Floodplain stabilization will be accomplished primarily through establishing vegetation adjacent to the channel. Vegetation will match existing vegetation in healthy reaches of creek.

Subreach 3 Waste Rock

Under this alternative, all the Subreach 3 waste rock would be excavated and hauled to the Eagle Creek Repository. A minimum of 6 inches of underlying soil would also be removed. Further investigation would be required to determine the removal depth of underlying soil. The removal would not affect the creek channel, but would extend to the bank at some locations. Care would be exercised to ensure healthy riparian vegetation, where it exists, is not damaged. The cabin at this site may be built on waste rock. Removal of waste material under the cabin would require that the cabin be removed. Backfill would be placed over the removal area followed by topsoil. All disturbed areas would be seeded, fertilized, and mulched.

The floodplain above the cabin consists of a series of braided flood channels. Bank stabilization above the cabin might be appropriate to ensure flood waters are diverted back to the current creek channel and do not erode into the reclaimed area.

Beaver Creek

A few tailings deposits are visible along Beaver Creek from the Idora Mill to the confluence with Carbon Creek. Tailings deposits would be excavated and hauled to the Eagle Creek Repository. BRI estimates that 88,000 cubic yards of fine grained contaminated sediments are present in the floodplain of the investigation reach of Beaver Creek. Removal of the contaminated fine grained sediments would eliminate a source of lead to the lower reaches of the creek. Under this alternative, stream sediments from the floodplain of the more disturbed reaches would be screened, and all material less than ¼ inch would be placed in the Eagle Creek Repository. Sediment from the greater than ¼ inch fraction would be placed back in the floodplain. The creek channel would not be included in the removal. However, it may be necessary to deepen the channel in some locations to achieve the desired entrenchment ratio.

The floodplain would be graded after removal of the fines and placement of retained material. Backfill may be required to elevate the floodplain above the bank full stage in some areas. Some structures may be placed in the stream banks to reduce erosion potential at critical points. Top soil would be placed over the regraded floodplain. Riparian vegetation would be planted along the creek channel to stabilize the bank. The floodplain would be seeded, fertilized and mulched.

Items Necessary for All Reclamation Alternatives

A design quality survey of the site would be required of the site before detailed design work could begin. The survey would accurately delineate tailings deposits along the creek, the extent of waste rock in Subreach 3, extent of tailings at the Idora Mill, and placement of the creek channel. The survey would also include a possible access road route. Tailings depths at the Idora Mill and waste rock depths in Subreach 3 have not been accurately determined. The survey should include test pits to determine waste depths. A mini excavator could access the site on the ATV trail for the excavation of test pits.

A road would be required to the Idora Mill for reclamation. The road would likely follow the existing road to the site, but significant improvements would be required. A minimum of 2 creek crossings would be required. Crossing Carbon will require either a bridge or significant work on the approach.

The Idora Mill building is partially collapsed and in a dangerous state. The building will have to be removed as part of any reclamation. One possible option is removal of the debris to a landfill, provided the wood passes the necessary analytical requirements. A second option is to collapse the wood into the depression excavated into the mountain side for construction of the mill. Rock that forms the scree field adjacent to the building could then be placed over the wood. Removal of the building from the site would allow placement of tailings into the depression as a potential consolidation area.

The cabin at the Subreach 3 waste rock area may have to be removed. It appears that the cabin may be built on waste rock. If that is the case, the cabin will have to be demolished to access the underlying waste rock. Sampling of the wood at the cabin would be required to determine the appropriate disposal method..

RED MONARCH MINE RECLAMATION OPTIONS

The Red Monarch Mine is located on Missoula Gulch, a tributary of Dobson gulch that enters Beaver Creek at the base of Dobson Pass. The site consists of waste rock dump and adit/tunnel that is discharging an estimated 15 gallons of water per minute. The site is accessed by an overgrown road along the hillside above Dobson Gulch then follows Missoula Gulch to the waste rock dump. Improvements to the road would be required to access the site with heavy equipment.

Missoula Gulch is degraded from the waste rock dump to the confluence with Dobson Gulch. The creek channel has aggraded and a barren floodplain has been created. These reclamation options deal with the Red Monarch Mine and waste rock dump. Reclamation of Missoula Gulch is not included with these alternatives.

Reclamation Action Objectives

The following are proposed reclamation action objectives for the Red Monarch Mine.

- Reduce or Eliminate sedimentation to Missoula Gulch from the Red Monarch waste rock dump.
- Reduce human health risks associated with the site.
- Improve water quality of the mine drainage to reduce degradation of Missoula Gulch surface water

Alternative 1: No Action

No remedial actions would be taken at the site under this alternative. The site would remain as it is with natural attenuation the sole means of site reclamation.

Alternative 2: On-Site Reclamation

Waste rock at the site extends to the creek channel the entire length of the dump. Iron cemented waste rock creates a near vertical wall adjacent to the creek. Under this alternative waste rock at the site would be recontoured to a more stable configuration. Waste rock would be graded up to fill the flat area at the top of the dump. This would reduce the steepness of the waste and limit erosion of waste rock into Missoula Gulch. The stream channel of Missoula Gulch would not be included in the reclamation and the waste rock would still extend to the creek channel. The flat area opposite the tunnel appears to have been created during mine construction and is not waste rock. This area could be covered with waste rock or left as it is for a possible water treatment area.

Recontoured waste rock would be covered with 1 foot of backfill followed by 6 inches of topsoil. All disturbed areas would be seeded, fertilized and mulched after topsoiling. Erosion control mat will be placed over the reclaimed waste rock dump to limit erosion.

Alternative 3 – Removal of Waste Rock to Eagle Creek Repository

Waste rock would be excavated, loaded, and hauled to the repository on the East Fork of Eagle Creek under this alternative. One foot of underlying soil would also be excavated and placed in the repository. Backfill and topsoil would be placed over the removal area. The disturbed areas would then be seeded, fertilized, and mulched. Erosion control mat would be placed over the reclaimed area to reduce potential erosion.

Removal of the waste rock will affect the creek channel at the west end of the dump. The creek flows under the waste rock at this location. After waste rock is removed, a new creek channel will be constructed from the lower part of Lobe 2 to the end of Lobe 3. It is unclear where the original creek channel was before mining activities. It is likely that the waste rock dump pushed the creek channel from the center of the valley to its present location at the valley edge. If this is the case, the creek channel may have to be reconstructed the entire length of the dump.

Mine Discharge

Discharge at the Red Monarch Mine is estimated at 15 gallons per minute of water containing 2.18 mg/L zinc, 0.07 mg/L lead, and 0.007 mg/L cadmium. This water flows into Missoula Gulch, mixes with the gulch water, then infiltrates into the sediments below the waste rock dump. Surface expression was not observed from about 100 yards below the waste rock to the confluence with Dobson Gulch. While the discharge contributes significant zinc to Missoula Gulch, groundwater samples were not collected from Missoula Gulch to determine the fate of zinc after surface water infiltrates.

Treatment alternatives for the Red Monarch discharge are limited by available space and lack of access to the site. The flat area opposite the tunnel is one possible location for passive or active treatment of the discharge water. This area appears to have been flattened prior to commencement of mining and does not contain waste rock.

Alternative 1 – No Action

Mine discharge water would not be treated under this alternative. The discharge would continue to flow into Missoula Gulch as currently occurs.

Alternative 2 – Chemical Precipitation

Under this alternative, water would be piped across Missoula gulch to the treatment area. Lime would be added to the discharge water to raise the pH and precipitate the metals as metal hydroxides. Water would then flow into a pond, or series of ponds, to allow the precipitated metals to settle. Water would flow from the settling pond back into the creek through a constructed channel. This system would be required to operate without any power and with minimal maintenance. The system may not be operational during the winter if water freezes in the settling ponds.

Alternative 2 – Constructed Wetland

The flat area across from the portal is the only available space for treating the water. Under this option, a wetland would be constructed that would remove the metals from the water through sulfide precipitation. The wetland would consist of a thick base high in organic matter such as a combination of sawdust and manure. Water would flow into the constructed wetland where reducing conditions in the subsurface would reduce the zinc and form zinc sulfide. After flowing through the wetland, the water would be diverted back to the creek in a constructed channel.

While this method of treatment could effectively remove the metals from the water, the system would probably freeze during the winter, limiting treatment to the warmer part of the year. Flow from the mine is estimated at 15 gallons per minute or 21,600 gallons per day. Water treatment with this method requires a residence time measured in days. A system that had a residence time of three days would have to hold 64,800 gallons of water. The area required would be 60 by 75 feet by 1.5 feet deep. Available space may limit the effectiveness of this option.

Mine Water Segregation

This method was used in Colorado at the Mary Murphy Mine in the Chalk Creek drainage (http://www.epa.gov/owow/NPS/Section319III/CO.htm). The Colorado Division of Minerals and Geology completed a hydrologic characterization at the mine and determined that 70 percent of the mine drainage volume was from unmineralized areas of the mine and did not contain significant metals. By segregating the contaminated water from the uncontaminated water in the mine they were able to reduce the volume of water needing treatment from 90 to 222 gpm (depending on seasonal flows) down to 5 to 20 gpm.

Mine discharge at the Red Monarch is estimated to be 15 gpm. This amount of water would be difficult to treat given the remote site and limited area to work with. Water sources within the mine have not been investigated. If some of the water sources in the mine are not contaminated, the clean water could be segregated from the contaminated water. This could reduce the volume of contaminated water to a more manageable amount and might increase the feasibility of passive treatment.


Possible consolidation area in center in back of people.


View of proposed consolidation area on hill slope at right.