Engineering Evaluation/Cost Analysis for:

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Draft Engineering Evaluation/Cost Analysis

Moran Tunnel Portal

Butte County, Idaho

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ACRONYMS AND ABBREVIATIONS

ABA	Acid-base accounting
AIT	iron-aluminum terrace
ALD	Anoxic limestone drains
AMD	Acid Mine Drainage
amsl	Above mean sea level
APC	aerobic polishing channel
APW	Aerobic polishing wetlands
ATV	All-terrain vehicle
ARARs	Applicable or relevant and appropriate requirements
ARD	Acid rock drainage
BCR	Biochemical Reactor
bgs	Below ground surface
BLM	Bureau of Land Management
BOM	United States Bureau of Mines
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic feet per second
COCs	Chemicals of Concern
COPCs	Constituents of potential concern
COPECs	constituents of potential ecological concern
CSM	Conceptual Site Model
cy	Cubic yards
DI	Deionized
ECM	Environmental Cost Management, Inc.
EE/CA	Engineering evaluation/cost analysis
EP	Extraction Procedure
EPA	Environmental Protection Agency
ESA	Environmental site assessment
EU	exposure unit
Fe^{+2}	Ferrous iron
Fe^{+3}	Ferric iron
ft	Feet
ft^2	Square feet
GFMC	Gold Fields Mining Corporation
gdm^2	Grams per day per square meter
gpm	Gallons per minute
HQ	hazard quotient
HRS	Hazard Ranking System
HRT	Hydraulic retention time
IC	Institutional Control
IDAPA	Idaho Administrative Procedure Act
IGC	Idaho Gold Corporation
LLDPE	Linear low-density polyethylene
MCL	Maximum contaminant level
McStay	SI McStay Corporation
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MOA	Memorandum of Agreement
MSL	Mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFRAP	No Further Remedial Action Proposed

NPL	National Priority List
NTCRA	Non-Time Critical Removal Action
OLC	Open limestone channels
OM&M	Operation, maintenance, and monitoring
OSHA	Occupational Safety and Health Administration
oz/yd^2	Ounce per square yard
PA	Preliminary Assessment
PCL	Proposed cleanup levels
PRGs	Preliminary remediation goals
PTS	Passive (wetland) treatment system
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
RAO	Removal Action Objective
RCRA	Resource Conservation and Recovery Act
RL	Reporting limit
RMC	Risk management criteria
RSI	Removal site inspection
SI	Site Investigation
STERA	Streamlined Ecological Risk Assessment
SRB	Sulfate reducing bacteria
s.u.	standard units
TBC	To-be-considered
TTLC	Total threshold limit concentration
µg/L	Micrograms per liter (parts per billion)
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USCS	Unified soil classification system
VFP	Vertical flow ponds
WET	Waste extraction test
WLCU	Water level control unit
XRF	X-ray fluorescence spectrometer
yd^2	Square yards

EXECUTIVE SUMMARY

The Moran Tunnel Site is an abandoned underground metal mine situated within Butte County, Idaho, approximately eight miles north of the Craters of the Moon National Monument. There are two sources of acid mine drainage (AMD) on the site that uncontrollably discharges to Champagne Creek: discharge from the Tunnel (at the portal) and a secondary source (referred to as the Secondary Seep) that is likely connected to the Tunnel workings through fractured bedrock. Isolated portions of a nearby surface mine, the "South Pit", may contribute to metal loading observed in the portal and the secondary source.

Five technologies were identified that warranted detailed consideration; however, none of the technologies could simultaneously address both the portal AMD and the secondary source:

A. Institutional controls,
B. Enhanced natural attenuation,
C. Source control,
D. Physical AMD management, and
E. Treatment of AMD including hybrid combinations of both passive and active technologies.

Three removal action alternatives in addition to the No Action Alternative (Alternative 1) were developed by combining the above technologies:

- Alternative 2 – Enhanced Natural Attenuation, Hybrid Treatment, Institutional Controls,
- Alternative 3 – Enhanced Natural Attenuation, Passive Treatment, Institutional Controls, and
- Alternative 4 – Enhanced Natural Attenuation, Passive Treatment, Source Control (South Pit Cap), Institutional Controls.

All these alternatives sequester arsenic, mercury, and cadmium either using natural attenuation, active, or passive treatment technologies.

Alternative 3, a combination of the enhanced natural attenuation of the Secondary Seep and passive treatment of the Moral Tunnel discharge, plus institutional controls in the form of signage is the preferred alternative. The *treatment* aspects of these technologies utilize natural processes without the use of chemicals, electricity, pumps, and are designed to function for decades between major maintenance. The processes rely on native bacteria and algae. In the case of the aluminum and iron terrace, the algae may be quite unique to the region if not the USA. The BCR technology, which uses common bacteria found in many animal's intestinal tracts, is a proven technology that has been found to be effective at numerous metal mine and coal mining sites with AMD. In fact, a mining company is implementing the BCR technology on a neighboring parcel in the Site vicinity. The aerobic polishing channel (APC) will mimic natural processes in Champagne Creek itself capitalizing on the beneficial traits of locally-harvested willows.

This alternative is implementable, has the potential to preserve existing natural attenuation conditions in the Champagne Creek alluvium, and reduces the potential for any risks to downstream users of Champagne Creek water.

The estimated construction costs for the preferred alternative is $481,000; the 30-year cost for implementing this alternative is $599,000. The 30-yr operation, maintenance, and

monitoring (OM&M) cost is approximately $118,000. This alternative relies on engineering natural processes whose mechanisms are currently not well known. Therefore, there are data gaps and technical uncertainties that will require evaluation prior to full scale design. The selected alternative cost includes $100,000 for related bench/pilot testing. Regardless, Alternative 3 still remains the least cost alternative.

1 INTRODUCTION

The United States Department of the Interior (USDOI) Bureau of Land Management (BLM) retained Environmental Cost Management, Inc. (ECM) to prepare an Engineering Evaluation/Cost Analysis Report (EE/CA) for the acid mine drainage (AMD) issuing from Moran Tunnel at Champagne Creek (Champagne Creek Site). Champagne Creek lies 17 miles west of Arco, Idaho in western Butte County (**Figure 1-1**). The Moran Tunnel is on public lands administered by the BLM in T.3N R.24E Section 15 SW1/4 SE1/4 NE1/4.

The Champagne Creek Site is an area of historical mining operations with abandoned mine workings. The Site consists of two main sources of acid mine drainage (AMD): the abandoned Moran Tunnel portal area; and the south unnamed tributary to Champagne Creek which flows from an AMD spring at the toe of a waste rock dump (**Figure 1-2**) that was placed on property leased by Idaho Gold Corporation (IGC). The Moran Tunnel portal area consists of the adit water, various seeps coming up into Champagne Creek approximately 125 feet southwest of the portal, and four treatment ponds, two berms and the imported materials underlying them. This area stretches between 500 and 600 feet along Champagne Creek (**Figure 1-2**). The portal of the Moran Tunnel is located approximately 100 feet east of Champagne Creek. The south unnamed tributary to Champagne Creek flows intermittently due to an AMD spring at the base of a waste rock pile and during heavy precipitation events. Through a Memorandum of Agreement (MOA), IGC will perform a separate study on the south, unnamed tributary to Champagne Creek for reducing impacts from this area. Therefore, the Moran Tunnel portal area will be the only source covered by BLM in this EE/CA.

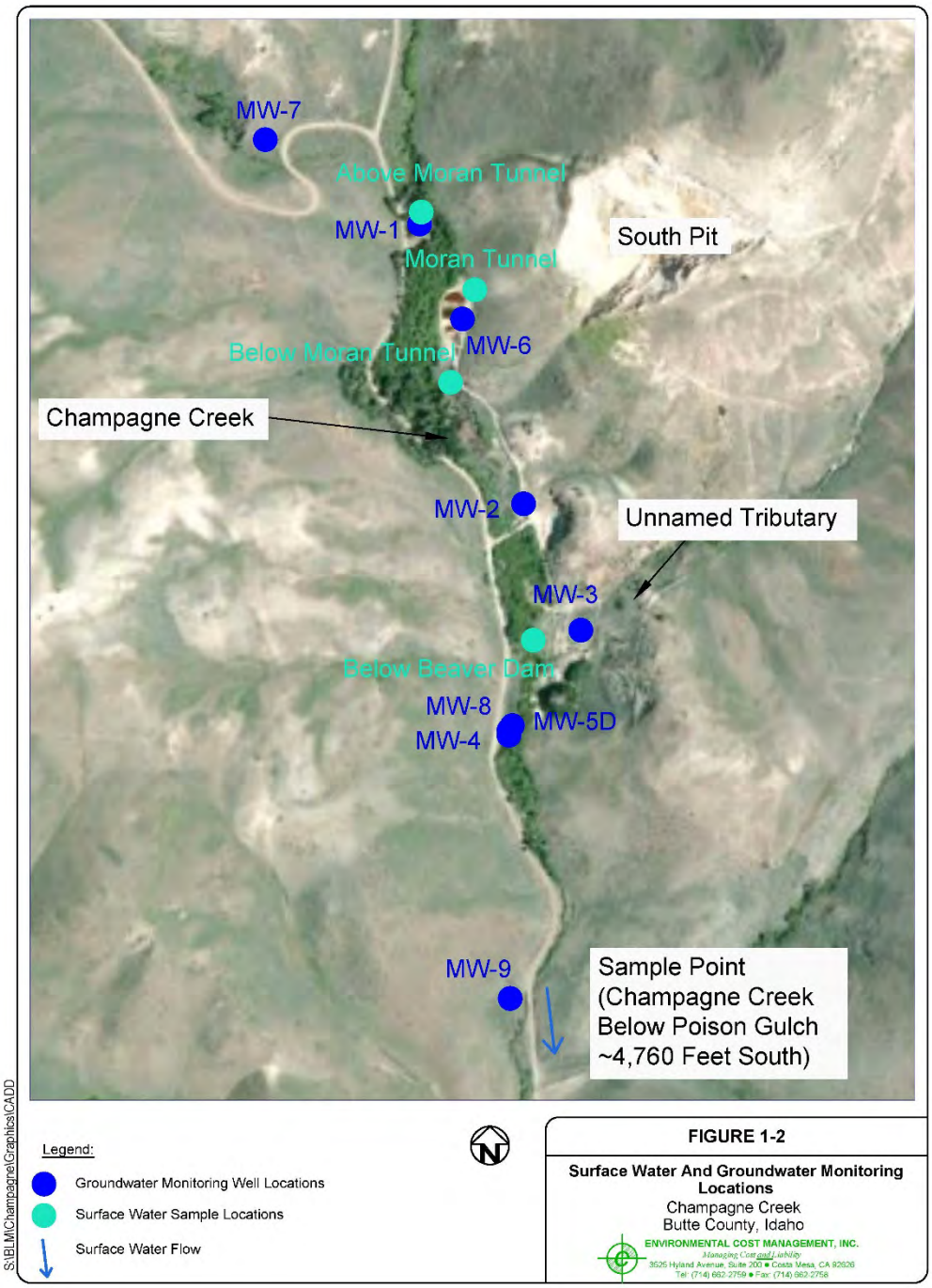
In 1986, a Preliminary Assessment (PA) for the Champagne Creek Site reported that mine spoil and AMD from two seeps containing levels of arsenic, cadmium, chromium, lead, and mercury above drinking water standards was impacting Champagne Creek. In 1988, a Site Investigation (SI) at the Champagne Creek Site concluded that there was no significant contamination migration from the abandoned mine sites by surface water, groundwater or air routes due to the buffering capacity of Champagne Creek. BLM received the first United States Environmental Protection Agency (USEPA) “No Further Remedial Action Proposed” (NFRAP) letter in June 1988, and a second letter in March of 2003. However, in 1993, BLM personnel noticed that the face of the Moran Tunnel portal had collapsed on the hill slope. This event flooded mine workings and greatly increased heavy metal concentrations. BLM has employed various remediation technologies to reduce metals concentrations and mitigate the impacts to Champagne Creek; however, complex water chemistry has rendered current remediation ineffective.

1.1 AUTHORITY

This EE/CA Report has been prepared in accordance with the criteria established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as sections of the National Contingency Plan (NCP) as applicable to removal actions (40 Code of Federal Regulations [CFR] §300.415 [b][4][I]). The BLM has been delegated CERCLA lead agency authority by the President of the United States and the Secretary of the Interior, and is exercising this authority at the Site (BLM, 2014). The EE/CA Report is consistent with the USEPA guidance document, *Guidance on Conducting Non-Time Critical Removal Actions under CERCLA* (USEPA, 1993).

Figure 1-1: Site Location Map

Figure 1-2: Surface Water and Groundwater Monitoring Locations



1.2 PURPOSE AND OBJECTIVES

Exposure to the chemicals of concern (COCs) at levels detected at the Site may pose unacceptable risks to human health and/or the environment. The BLM has determined that these threats to public health, welfare, and the environment at the Site necessitate a non-time critical removal action pursuant to CERCLA Section 104(a) and Section 300.415 of the NCP. The primary sources of COCs are from the Moran Tunnel portal area and the south, unnamed tributary to Champagne Creek[1]. The discharge from the Moran Tunnel is acidic and contains elevated concentrations of several metallic ions. The direct release from this discharge to Champagne Creek has caused an evident change in the chemical characteristics of Champagne Creek and has impacted riparian vegetation. The metallic deposits at the Site, located around the portal, present unacceptable risks to both human and ecological receptors due to high levels of arsenic, cadmium, chromium, lead, and mercury above drinking water standards (BLM, 2014a).

The goals for this EE/CA include:

- Evaluate the results of previous studies and historic site data, conduct a data quality review, and determine how and where to collect additional information to fill data gaps;
- Complete a Streamlined Risk Evaluation for the Site, including the south, unnamed tributary and Champagne Creek from above Moran Tunnel to Poison Gulch. Develop a human health and ecological conceptual site model (CSM),
- Using existing documents, including the Streamlined Risk Evaluation, identify and address potential data gaps, recommend and justify whether or not an additional removal action is needed at this Site, review applicable or relevant and appropriate requirements (ARARs), and document the need for removal actions to address contamination on-site,
- Identify the overall remedial action objectives of the removal action, and develop a list of ARARs for the Site,
- Evaluate the existing repository and recommend if it should be expanded, or if a new repository should be built, assuming that in the next 10 years that either the existing pond and berm materials will be removed, or that materials transported by the south tributary, both in the beaver dam and along Champagne Creek, will be placed in one,
- Recommend connectivity investigation techniques to determine whether there is connectivity between South Pit and Moran Tunnel,
- Evaluate appropriate removal actions and applicable technologies,
- Develop estimated construction costs, long-term maintenance intervals and costs, and relative water quality/environmental benefits for implementing each removal action alternative, and
- Satisfy CERCLA administrative record requirements for documenting the selected removal action.

[1] As stated in Section 1, under a MOA, Idaho Gold Corporation will perform a separate study on the south, unnamed tributary to Champagne Creek.

1.3 BACKGROUND

The Site is the location of former silver mining and milling operations dating from 1883 and 1887 held by various claimants. Within this region there are six abandoned mine sites within an area of less than two square miles. These abandoned sites are associated with historical operations of the Last Chance, Horn Silver, Oxide Lode, Ella, St. Louis and Reliant Mines[2].

In the 1920s, mining operations resumed with the construction of a crosscut tunnel called the Moran Tunnel. The Tunnel is connected to underground mine workings (stopes) associated with the Last Chance Mine, whose collapsed portal is just outside the South Pit boundary. In the 1930's various claimants performed more work at the numerous claims. Between 1943 and 1946, operations resumed producing silver, zinc, and lead ore. By 1946, the Moran Tunnel was 1,350 feet long (**Figure 1-3**).

BLM first detected water quality impacts at the Site in the late 1970's. BLM contacted the Idaho Department of Health and Welfare. In 1982, this water quality problem was identified in the Big Lost Management Framework Plan. In 1984, BLM received notification of a hazardous waste site classification for the Champagne Creek Site and it was listed on the Emergency Remediation and Response Information System (ERRIS) list. Since the late 1970's or early 1980's, BLM has observed seeps flowing into Champagne Creek adjacent to the former waste rock pile location (currently, the passive treatment system; see additional discussion below). Historically, the sources of the seeps were believed to be potential drainage from the Moran Tunnel system along intersecting fractures that flows beneath the former waste rock into Champagne Creek, and possible leakage from beneath the waste rock pile.

In 1986, the Preliminary Assessment (PA; AEPCO, 1986) for the Champagne Creek Site reported that approximately 7,500 cubic yards (cy) of mine spoil and AMD from two seeps contained levels of arsenic, cadmium, chromium, lead, and mercury above drinking water standards and was impacting Champagne Creek. The PA report scored the Site 17.90 with the Hazard Ranking System (HRS). Although this score did not qualify the site for the National Priority List (NPL), BLM ranked the site as Class III, containing sufficient concentrations of hazardous substances to be a potentially significant hazard to human health and/or the environment. Additional investigations were recommended to determine if groundwater was impacted and if other mining operations were also contributing contaminants to the surface water and groundwater resources of the area.

In 1988, BLM performed a Site Investigation (SI; EMS, 1988) at the Champagne Creek Site. This SI included the six abandoned mine sites in the immediate vicinity of the Moran Tunnel, and concluded that while there are several areas of potential contamination in the Champagne Creek region, the primary source is from the Moran Tunnel area of the Last Chance Mine. The SI concluded that contamination exists at the Moran Tunnel. The HRS score was 13.18, confirming the PA's conclusions that the site did not warrant listing on the NPL. BLM received the first EPA NFRAP letter in June 1988, and a second letter in March of 2003.

In the early 1990's, IGC mined the South Pit (**Figure 1-2**). The areal extent of disturbance of the South Pit has affected the ground surface overlying more than half of the length of Moran Tunnel (**Figure 1-3**). At the time, the South Pit floor was estimated to be 40 feet

[2] Environmental Management Services Company, 1988. *Site Investigation Report, Champagne Creek Site, Butte County, Idaho; BLM Site Code: 1DP141100012*.

above the Moran Tunnel (Section along Moran Tunnel (N74E)), Western Technologies Inc. (WTI), 1990). In July of 1990, WTI conducted a limited scope geologic assessment for IGC (WTI, 1990) and concluded that there is a reasonable probability that the planned mining activities could have a measurable impact on both the quantity and quality of water discharged from the Moran Tunnel.

In 1993, BLM personnel noticed that the face of the Moran Tunnel portal had collapsed on the hill slope. This event flooded mine workings and greatly increased heavy metal concentrations.

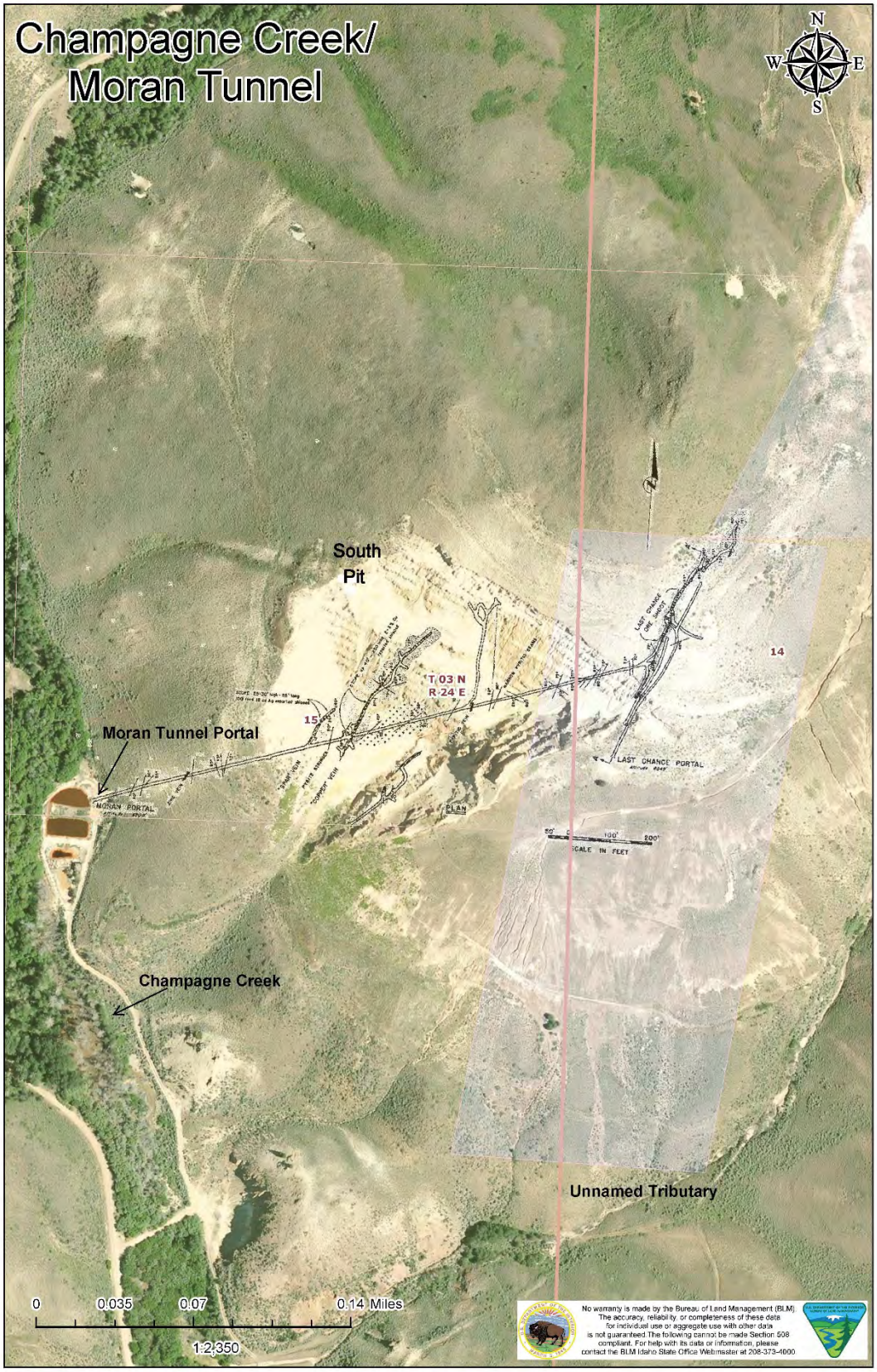
In 1999, the BLM began the initial phase of the Moran Tunnel cleanup project (McStay, 1999) under the Clean Water Action Plan. BLM first removed approximately 20,000 cubic yards of waste rock and spoil material in front of the tunnel and placed them into an engineered repository approximately one mile up valley. About 12,700 cubic yards of borrow soil for foundation materials were then placed on the ground after the waste rock was removed to allow for groundwater flow under the treatment area and to support pond construction with bentonite. Above this structure on the slope, BLM installed a passive treatment system to treat the AMD water draining from Moran Tunnel. The passive treatment system consisted of four treatment ponds adjacent to Champagne Creek. Periodic maintenance has occurred on uppermost pond since construction of the treatment ponds, including removal of precipitated material and the addition of more amendments both to the pond and to the first berm.

Between 2000 and 2013, BLM conducted an engineering review and several studies and investigations at this Site to assess the performance of the treatment system and how to improve it. Currently, no water is migrating from pond #1 to pond #2, likely a consequence of decreased permeability due to metal loading of the bioreactor between the ponds. Water may also be leaking from pond #1 as indicated by seeps in Champagne Creek located immediately downstream of the pond. BLM has diverted the tunnel discharge to pond #2. In July 2014, pond #1 contained no fluid. Only pond #2 had fluid.

1.4 MINING HISTORY

Mining activity began in the Lava Creek Mining District in 1883 with the discovery of silver ores in the Champagne Creek region in 1879. By the mid-1880s, several mines were in operation and the town of Era supported mining operations. These early operations only mined the easily accessible, shallow, oxidized silver ores. The shallow shafts used simply followed the veins of oxide ores. Typically these ores were mined to depths not exceeding 75 feet below the surface. Although the area was a very important silver producer in Idaho from 1884 to 1886, by 1887 most of the early operations had ceased.

Figure 1-3: Projected Location of Moran Tunnel Relative to South Pit



The area remained relatively inactive until the late 1920's, when the possibility of using the deeper base-metal sulfides as ores of lead and zinc regained interest. At this time, Hornsilver Consolidated Mines Company undertook a major underground exploration program. A key aspect of the program was driving a crosscut tunnel from the adit at the base of the mountain, uphill through the mountain in an attempt to intersect the Last Chance vein 450 feet below the surface. The intent of the crosscut tunnel was to intersect many of the older workings further up the mountain and to mine ore veins as they were reached. The Hornsilver Consolidated Mines Company produced silver ore from Moran Tunnel until 1930. The Moran Tunnel penetrated the vein at a barren point and the operations were soon terminated.

The Hornsilver Mine was reopened from 1937 to 1941 producing a total of 1,095 tons of ore. In 1941, the Era Mining and Development Company acquired control of many claims in the Champagne Creek region and mined sulfide ore from the Last Chance vein via the Moran Tunnel from 1941 to 1946. Since mining ceased in 1946, this area has been relatively inactive. Although an initial mill was used to produce concentrates, there was no fine milling process or refinery used. Ore from the Hornsilver Mine and most of the other mines that operated in this district was shipped to Salt Lake City to be processed; therefore, no tailings were produced at the Moran Tunnel.

Following a period of inactivity, IGC, a subsidiary of Bema Gold Inc. operated a heap leach-cyanide operation from 1988 to 1996. In an amendment to their mine plan, which originally included only the North Pit, IGC mined the South Pit in the early 1990's. The South Pit expansion removed an additional 2.25 million tons of ore, waste rock, and overburden, disturbing a surface area of approximately 24 additional acres. The South Pit is approximately 700 feet across in the north-south direction and 850 feet across in the east-west direction, with a maximum depth of 300 feet (IGC, 2010). Mining operations were suspended at the Champagne Mine for economic reasons in February 1992. Final reclamation of the site was completed in 1996.

2 SITE CHARACTERIZATION

2.1 LAND USE

The Champagne Creek site and most of the upper half of the Champagne Creek Drainage are located on federal lands administered by the BLM. The BLM lands are managed for multiple use by the Upper Snake Field Office, Idaho Falls District in accordance with the approved Big Lost Management Framework Plan (BLM, 1983). The Champagne Creek Site is located in the Big Lost Planning Unit of the Big Butte Resource Area. The only nonfederal lands in the upper region are five patented mining claims and other patented lands in Section 15 and Section 16, Township 3 North, Range 24 East. The five patented mining claims are associated with the Last Chance and Hornsilver mines and represent a total area of approximately 90 acres. Most of the valley below Poison Gulch is private land, some of which is Stock Raising and Homestead Land Act lands.

There are two grazing allotments in the Champagne Creek Basin: the Chicken Creek and the Champagne Creek Allotments. The Chicken Creek Allotment covers the upper reaches of the Champagne Creek Basin, including the areas historically mined. The Champagne Creek Allotment covers the federal lands in the lower reaches of the Champagne Creek Basin. In 1999, the Chicken Creek Allotment was determined to be meeting and/or making progress toward meeting all applicable rangeland health standards within the allotment. This progress has continued since 1999. In 2006, it was determined that the Champagne Creek Allotment was not meeting standards and livestock grazing was a causal factor in that determination. A management plan was implemented to remedy the problems identified at that time.

Although there has not been any significant mining in the Champagne Creek region since 1946, as discussed in Section 1.3.1, sporadic mineral exploration and development activities have continued in the area. In the early 1980's, Cash Industries conducted extensive exploration work on the Hornsilver Mine. Subsequently, Gold Fields Mining Corporation (GFMC) conducted exploration activities in the region including detailed geologic mapping and exploration drilling, including exploration work in the Champagne Creek area.

The Champagne Creek Basin is isolated and there are no developed recreation sites or facilities in the area. The primary recreational use of the area is hunting. Although the Champagne Creek Basin is not considered a favored or heavily used hunting area, the basin does receive some use by the residents of Arco (EMS, 1988).

Most of the private lands in the lower basin are used for grazing or as improved pasture for livestock or hay production. The nearest used private agricultural lands are associated with the Champagne Creek Ranch. This working ranch consists of approximately 1,800 acres and contains the only ranch house in the Champagne Creek valley. The Wisdom Ranch School, an alternative high school which supports approximately 30 students and adults, is also part of the Champagne Creek Ranch. The school has been in operation since about 2005 or 2006, prior to this the ranch contained a few seasonal residents. The ranch is located slightly less than three miles southeast of the site just off the county road along the Champagne Creek valley (**Figure 1-1**). Sufficient water to irrigate approximately 300 acres of this ranch is available, except during drought years. This land is irrigated with surface water from Champagne Creek. The diversion is located approximately 0.4 miles upstream of the ranch house and water is provided to a sprinkler system by gravity flow. The lands under irrigation are located immediately down-canyon from the ranch house.

2.2 SITE DESCRIPTION

The site is located at an elevation of approximately 6,200 feet in steeply rolling foothills of the White Knob and Pioneer Mountains about four miles north-northwest of the edge of the Snake River Plain.

Prominent geologic features in the area include Timbered Dome Mountain with an elevation of 8,356 feet, which is located less than two miles northeast of the Champagne Creek region; and the Craters of the Moon National Monument, which lies approximately six miles south of the region.

The Moran Tunnel portal entrance is about 50 feet up the hill forming the eastern edge of the valley of Champagne Creek. Slopes in the area are quite steep. The hill into which the mine shaft is driven rises at a slope of nearly 50% to an elevation of over 6,600 feet.

2.2.1 GeologY

The geology of Champagne Creek consists of Eocene Challis Volcanic rock overlying Mississippian Copper Basin and early Mississippian to early Permian White Knob limestones (Anderson 1929). There are Paleozoic, sedimentary rocks, and igneous intrusions found throughout the area. The United States Bureau of Mines (BOM) reported in 1948 that the mine area consists primarily of flows of andesite, latite, rhyolite, and tuff. No active faults have been mapped in the vicinity of the site. The BOM cites the presence of jointing systems, which provide low resistance pathways for groundwater movement.

Deposits at Moran Tunnel are fillings and replacements along zones of complexly faulted and fractured rock (Roby, 1948). At Moran Tunnel they are fundamentally base-metal deposits, but because of the considerable variation in the proportions of minerals deposits may be divided into several kinds based on the relative abundance of various metals. These metals are iron, zinc, lead, copper, tin, bismuth, silver, and gold, but because they are not equally distributed, the deposits may be classed respectively as zinc, copper, iron, lead-zinc, tin-bismuth and silver.

2.2.2 Hydrology

Surface water bodies in the site vicinity include Champagne Creek, the drainage flowing from the mine entrance and various seeps flowing into Champagne Creek below Moran Tunnel. The southern unnamed tributary to Champagne Creek is an intermittent stream that confluences with Champagne Creek 0.38 miles below Moran Tunnel.

Champagne Creek originates on the southeast flanks of Timbered Dome Mountain. From its headwaters, the stream flows to the south-southeast for a distance of approximately eight miles, at which point the stream flow is lost in the gravels near the edge of Snake River lava plain. Champagne Creek has a total drainage area of approximately 13 square miles, with nearly half of this area being drained by two principal tributaries, Poison Gulch and Slaughterhouse Canyon. Poison Gulch provides drainage for the northwest portion of the drainage basin and joins the main channel of Champagne Creek approximately 2.75 miles downstream of the headwaters. Once joined, the flows within Champagne Creek increase substantially. Slaughterhouse Canyon drains the southwestern portion of the drainage basin and joins the mainstream approximately one mile downstream of the confluence of Poison Gulch.

2.2.2.1 Surface Water

The Champagne Creek drainage basin ranges in elevation from approximately 7,500 feet above mean sea level (amsl) at its headwaters to near 5,500 feet amsl where flow is lost

to the Snake River Plain. The average gradient of Champagne Creek is nearly 250 feet per mile, with maximum gradient in the upper reaches exceeding 300 feet per mile. Side slopes in the basin are quite steep, ranging from 20 to over 50 percent. The Champagne Creek channel is incised into volcanic materials, and a significant quantity of alluvial materials have been deposited along the drainage bottom, especially in the lower reaches. This condition results in fairly unstable stream banks.

The upper 1.5 miles of Champagne Creek are ephemeral and flow in this segment occurs in direct response to surface runoff associated with snowmelt and heavy local rainstorms. A groundwater resurgence immediately downstream of the northeast corner of Section 15, Township 3 North, Range 24 East provides a baseflow to the stream and Champagne Creek is perennial from this point downstream to where the flow goes underground below the Moran Tunnel. Champagne Creek has limited surface expression in the area upstream and downstream of the confluence with the unnamed tributary. The creek is perennial below the Poison Gulch confluence, and the flows within Champagne Creek increase substantially at this point.

Surface water flows are seasonally variable, with the highest flows occurring in the spring as a result of snowmelt runoff. Stream flow tends to gradually decrease throughout the summer and early fall as water flow which is conveyed to the stream through the alluvium, soil and weathered bedrock decreases. During the late fall and winter, the stream is at baseflow conditions, with flows in the perennial segment being maintained from groundwater discharge to the stream. In 1980, the BLM monitored flow in Champagne Creek from April through September from five stations as part of a hydrological survey. The estimated flows near the Champagne Creek Site (Moran Tunnel) ranged from an average high of approximately 0.5 cubic feet per second (cfs), in late spring, to less than 0.1 cfs in the fall and early spring. Flows increased significantly downstream with flow rates being approximately three times higher at the BLM's most downstream station, located immediately downstream of the confluence of Poison Gulch, than that observed near the site.

Flow rates in Champagne Creek above the site varied from 0.02 to 0.65 cfs on selected dates between 1981 and 2013 (BLM, 2014c). The flow rate of the mine drainage from Moran Tunnel portal was found to vary between less than 1 gallon per minute (gpm) and 7.1 gpm during this same time period (BLM, 2014c). Based on a comparison of mine drainage and in-stream flows, mine drainage may represent up to14 percent of the total flow of Champagne Creek at the site (AEPCO, 1986).

2.2.2.2 Groundwater

No regional groundwater studies are known in the Champagne Creek area. It is assumed, based on topographic and geomorphic conditions, groundwater flow is from the White Knob and Pioneer Mountains to the east-southeast toward the Big Lost River and the Snake River Plain. Groundwater in the Champagne Creek drainage occurs in both bedrock and alluvium. No site-specific studies have been conducted to define the groundwater conditions or characteristics. Based on data collected by GFMC during exploratory drilling, groundwater occurs mainly in bedrock fissures and fracture zones, or through secondary permeability. The groundwater in the alluvium occurs through connection with both the bedrock fractures and as a result of seepage and channel losses of surface water from Champagne Creek. Based on topographic and geomorphic conditions, the site-specific groundwater flow direction appears to be down-canyon toward the southeast to the Snake River Plain.

In October 2012, BLM installed four shallow (<50 feet below ground surface [bgs])

groundwater monitoring wells (MW-1 through MW-4) and one deep (>50 feet bgs) groundwater monitoring well (MW-5D) to evaluate groundwater quality along Champagne Creek (FutureNet, 2012). BLM installed four additional groundwater monitoring wells at the Site with the assistance of USGS in September 2013 (**Figure 1-2**). The depth to groundwater in the alluvial wells adjacent to Champagne Creek varies from approximately 5 to 15 feet bgs. Well MW-3 is located near the confluence of the unnamed tributary and Champagne Creek. Depth to groundwater in this well fluctuates from 25 feet to 30 feet bgs.

According to Idaho Department of Water Resources records, the nearest drinking water wells include four wells owned by the Champagne Creek Ranch. One well is located southwest of the site in Slaughterhouse Canyon in Section 28, Township 3N, Range 24E. According to the driller's report, this well was completed fractured granite to a depth of 102 feet. Static groundwater at the time of completion was reported at 16 feet bgs. Three domestic wells are located southeast of the site in Section 26, Township 3N, Range 24E. Two well are located near the confluence of Slaughterhouse Canyon and Champagne Creek approximately three miles from the site. According to the driller's log, one well was completed in rhyolite at a depth of 150 feet. Static water in this well at the time of completion was 15 feet bgs. The second well in this Section was completed to a depth of 315 feet in black shale. The static water level at the time of completed was 35 feet bgs. The fourth well is located adjacent to Champagne Creek south of the Slaughterhouse Canyon confluence. This well was originally completed to a total depth of 240 feet in shale and was later deepened to 400 feet bgs. The static water level in this well is approximately 65 feet bgs. Well yields for these wells ranged from 10 to 30 gpm.

The Snake River aquifer, which lies about five miles to the southeast of the site is a major source for domestic, municipal, and irrigation water. Depth to static groundwater in one well in this aquifer located approximately six miles from the site is 108 feet bgs. Well yield is 12 gallons per minute.

2.2.3 Soils

Most of the Champagne Creek watershed is within the Jonda-Howcan-Hagenbarth soils complex (BLM, 1999). This unit is 30% Hagenbarth soils, 25% Howcan soils and 20% Jonda soils. These soils are located on the steep side slopes above Champagne Creek such as between the Moran Tunnel portal and the base of the South Pit and the tops of the hills undisturbed by mining and exploration activities.

The Jonda series consists of very deep, well-drained soils formed in slope alluvium and colluvium weathered from tuff. These soils are on mountains with slopes of 5% to 45%, and have a surface layer of gravelly loam. Permeability is moderately slow, with rapid runoff and moderate water erosion hazards.

The Howcan series are also very deep and well-drained soils that formed in slope alluvium and colluvium from extrusive igneous rocks, on 15% to 60% slopes. Permeability is moderate, with rapid runoff and moderate erosion hazard. This soil has a loamy surface layer.

The Hagenbarth series are deep and very deep, well-drained soils that have formed in mixed loess, residuum, colluvium and slope alluvium. Permeability is slow to moderately slow, with rapid runoff and moderate to severe water erosion hazard. This series is found on 1 % to 60% slopes, with a clay loam surface layer.

There are also two hydric soil series here, the Mooretown and the Borah. The Mooretown is a deep, loamy alluvium with moderate permeability. The Borah series is a very deep,

gravelly loam with high permeability. These soils are located within the valley of Champagne Creek and along the bottom of drainages of sufficient length to give the soils time to develop.

2.2.4 Climate

The Champagne Creek region has a continental climate, with wide ranges in seasonal and daily temperatures, wind direction and velocities, and precipitation. Winters are long and cold and summers are hot and dry. The region is classified as semi-arid. According to the weather station in Arco, ID (USC00100375), the latest 10-year precipitation average is 8.48 inches and the 30-year average is 9.01 inches (National Climatic Data Center, 2014). Precipitation occurs primarily as snow during December and January and as spring showers in May and June. Average snow depth for the month of February in nearby Craters of the Moon National Monument is 26 inches (U.S. climate data, 2014). Annual evaporation is about 40 inches per year, therefore, evaporation greatly exceeds rainfall.

2.2.5 Vegetation and Wildlife

The vegetation of the Champagne Creek region is typical of a semi-arid cold desert range community. The dominant plant community in the region is the Mountain big sagebrush (Artemisia tridentate vaseyana), Idaho fesue (Festuca idahoensis) community which is associated with the Champagne soil series. Bluebunch wheatgrass (Agropyron spicatum) replaces Idaho fescue on southern slopes with Howcan soil. The low sagebrush (Artemisia arbuscula) bluebunch wheatgrass community occurs on ridge tops in association with Jonda and Gabica soils. A narrow riparian zone, consisting primarily of Willow (Salix spp.) and Aspen (Populous tremloides), occurs along Champagne Creek. This riparian zone is discontinuous in the upper portions of the drainage where the creek is intermittent.

The BLM has prepared a list of wildlife likely to occur in the area and identifies species that are typically in a cold desert environment (BLM, 1983). The Champagne Creek Valley is used as a mule deer winter range, but is not considered a critical habitat. Elk are present in the Copper Basin area and may also move into the drainage for winter. There are no viable fish populations in Champagne Creek; however fish have been observed in Lower Champagne Creek below Poison Gulch. Except for the possibility of beaver ponds, the morphology of the stream channel is not really suitable for the establishment of a viable fishery. Also, Champagne Creek above Poison Gulch can lose all of it flow to bed loss. There is a series of active beaver dams on Champagne Creek immediately downstream of the mine spoil site at the Moran Tunnel and other evidence suggests that beaver activity goes on along the lower reaches of this stream. It is likely that these ponds are too shallow to support fish through winter. There are no threatened or endangered species of plants or animals in the Champagne Creek valley (Harvey, 2012). Some plant species identified as sensitive by the State may potentially occur in the area and sage grouse have been observed in the watershed.

2.2.6 Cultural Resources

Paleo-Indians visited the area near Craters of the Moon National Monument located 12 miles south of the Moran Tunnel about 12,000 years ago, but left very little archaeological evidence. Northern Shoshone created trails through the Craters of the Moon Lava Field during their summer migrations from the Snake River to the Camas Prairie, west of the lava field (NPS, 1981). Stone windbreaks at Indian Tunnel were used to protect campsites from the dry summer wind. The Northern Shoshone were a hunting and gathering culture. No evidence exists for permanent habitation by any Native

American group; therefore, the presence of artifacts is not anticipated.

The town of Era, located southwest of Mackay on Champagne Creek, was established with the discovery of the Hornsilver Mine in 1885 (Chenoweth, 2014). Initially, the ore from the mine was hauled by freight wagons to the smelter in Hailey. In 1886, a twenty stamp, dry crusher mill was built just south of Era. Era grew to approximately twelve hundred people. The mill operated until 1888 when the ore body pinched out. Milling resumed in 1893 for approximately three months and the mill operated intermittently until 1928. The rock foundations of the mill are still present (**Figure 2-1**).

Figure 2-1: Remaining Foundation of the St. Louis Mill Site

2.3 PREVIOUS SITE INVESTIGATIONS AND TREATMENT

BLM has monitored the Champagne Creek Site by collecting surface water quality samples since 1990. Although Moran Tunnel has elevated heavy metals associated with the AMD from the adit (average pH[3] = 3.15 (n = 31; n = sample size); average copper = 184 mg/L (n = 48); average iron = 1223 mg/L (n = 47); average zinc = 77 mg/L (n = 48)), the data has shown that the stream water quality characteristics are improved downstream beyond the confluence with Poison Gulch (average pH = 7.95 (n = 32); average copper = 0.05 mg/L (n = 52); average iron = 0.96 mg/L (n = 52); average zinc = 0.17 mg/L (n = 52)). Moran Tunnel's measured surface water flows vary from 0.6 to 7.1 gpm; however, considerable groundwater seepage flow in the form of seeps upwelling in Champagne Creek are observed. Past studies including a PA, SI, a groundwater investigation, and a vegetation assessment are summarized below.

2.3.1 Preliminary Assessment

Gannett Fleming Environmental Engineers acting as subcontractors to AEPCO, Inc. supplied personnel to make a preliminary assessment of the Champagne Creek site for the BLM in 1985 and 1986 (AEPCO, 1986). The work performed on the preliminary assessment of the Champagne Creek Site included acquisition of background data pertinent to the site history and operation, a site reconnaissance, and sampling and analysis of soils, waste material and liquids from the site. Field monitoring for various parameters was conducted coincident with sampling. Radiometer readings and organic vapor concentration levels at the sampling locations and in the headspace of the sample

[3] pH measurements throughout this document are referenced to standard units (s.u.)

containers were recorded for all soil and waste samples. Radiation and organic vapor measurements were within safe levels at all sampling locations. Field measurements estimated that the volume of mine waste was approximately 7,500 cubic yards.

The waste on the site consisted of soil and mine waste piles. These piles were unconfined and eroded into the channel of Champagne Creek. Mine waste was observed in direct contact with the creek. Acid drainage emanating from the portal (pH from 2.95 to 3.35) was observed to partially drain through the spoil piles before entering Champagne Creek, and a portion of the drainage also flowed directly into the creek. Concentrations of metals in water and sediment samples exceeded National Interim Primary and Secondary Drinking Water Standards for a number of parameters. Metals in the water sample exceeding standards included arsenic (153 mg/l), cadmium (0.48 mg/l), chromium (0.054 mg/l), lead (0.67 mg/l), and mercury (0.78 mg/l).

The PA indicated that the site, although contaminated, did not rank high enough to be on EPA's National Priority List (NPL), and the site was identified as one of many sites that may have been contributing contaminants to groundwater and surface water in Champagne Creek. Because the waste had migrated off site and is present in a water source used by transient populations in the area and for irrigation of rangeland used for grazing beef cattle, the site was ranked as a BLM Class III site. Additional investigation was recommended to determine if groundwater was impacted and if other mining operations were also contributing contaminants to the surface and groundwater resources of the area.

2.3.2 Site Investigation

In 1988, the Environmental Management Services Co. (EMS) prepared an SI detailing the old mining sites in the entire drainage, including the Last Chance, Hornsilver, Oxide Lode, Reliance, Ella and St. Louis Mines (EMS, 1988). EMS reviewed the laboratory analytical results from three samples of discharge from the Moran Tunnel, collected in May 1980, November 1985, and November 1987. This report found that although impacts are present near the Moran Tunnel discharge point, within about 100 yards downstream the metals returned to natural levels by the buffering capacity of Champagne Creek. EMS also confirmed, through coring and leach tests that the spoil pile between the portal and Champagne Creek (about 2 acres in size), was waste rock from the tunnel excavation and not tailings. Sample results from composite samples of soil and waste rock did not exceed the Extraction Procedure (EP) toxicity concentrations. The report concluded that there is no significant contamination migration from the abandoned mine sites by surface water, groundwater, or air routes. This study scored the site at 13.18 using HRS, classifying it as a Class I BLM site, not warranting any further action under CERCLA. EMS recommended solutions under BLM's own Clean Water Act initiatives.

2.3.3 Spoil Removal to Repository, Construction, and Upgrades of PTS

In 1999, BLM contracted SI McStay Corporation (McStay) to remove the spoil pile in front of Moran Tunnel to a repository up-valley from the tunnel portal, and to construct a passive wetland treatment system (PTS) for Moran Tunnel discharge to reclaim and rehabilitate the site under the 1998 Clean Water Action Plan Initiative (McStay, 1999). McStay moved twenty-thousand cubic yards of mine waste material into a designed repository approximately one mile up-valley, capped it with a clay/topsoil cover, and fenced and seeded the area.

The passive, flow-through treatment system was designed to address the metal-laden drainage that emanated from the portal of the Moran Tunnel. The PTS was designed to

be a two-stage process. Since the AMD contained a high concentration of dissolved and suspended iron, the wetland treatment system would first remove a substantial quantity of iron. The removal method oxidized the iron to the ferric state causing the iron to form ferric hydroxide and precipitate from solution. Because the hydrolysis which forms the ferric hydroxide lowers the pH of the solution, thus stopping the process of hydroxide formation and precipitation, the treatment system required a second action to raise the pH and allow the process of hydrolysis to continue. This was to be accomplished within the bioreactor relying on the actions of sulfate reducing bacteria (SRB).

Water quality monitoring data collected between system operation in 1999 and through the summer of 2001 revealed a decrease in pH buffering capacity by the system and a subsequent reduction in remediation capabilities for metals. BLM contracted North Wind Environmental (North Wind) to install an anaerobic pH buffering system for pretreatment of the adit discharge before its introduction to Pond 1 in November 2001. This system failed to function. North Wind performed an engineering review of the PTS in 2003 and concluded:

- Steady-state flow operations through the berms had never been achieved as indicated by declining pH buffering and aeration in the oxidizing cascade, and unsaturated, inconsistent flow through the bioreactors,
- The natural bentonite liner appeared to be leaking,
- The pH buffering with limestone would not be successful long-term because “gypsum” was encapsulating the limestone and filling the pore spaces,
- Maintenance operations for the PTS had not been properly designed, and
- Insufficient information regarding the geochemistry of the flows discharging from Moran Tunnel prevented design of an adequate treatment remedy.

BLM consulted SES, Inc. and Hedin Environmental (SES/HE) to provide options for the redesign of the PTS. In October 2004, a site investigation was conducted. An excavator was brought onsite to investigate soils in the Champagne Creek riparian zone and to open the collapsed Moran Tunnel portal. The tunnel was found to be competent for about 50 feet, but then partially blocked by a roof fall. Safety concerns prevented inspection of the tunnel at this time. BLM and SES/HE decided to further explore the mine tunnel's competency by hiring trained, MSHA-certified miners. Denver Grouting, a company that specializes in the inspection of abandoned mines was approved by BLM and contracted for the work. In November 2004, the tunnel was reopened and investigated. The miners dug through the visible partial blockage, but found that the tunnel was completely blocked 100 feet into the tunnel. Attempts to dig through the collapse by hand were unsuccessful. There was no assurance that additional work would yield an open tunnel. Instead, review of the mine map showed that the two collapsed areas correlated with faults (and mineral deposits) and several more faults existed in the tunnel before the Last Chance workings were reached. A likely outcome was that the mining activity would not result in substantial advancement of the in-mine treatment plan. Also, concerns were expressed that the inundation of the tunnel followed by its drainage likely resulted in added instability of the roof. The long-term competency of the tunnel was questioned.

North Wind returned to the site in 2005 to conduct PTS maintenance including removal of metal sludge material from an 80 foot section of PVC outlet pipe and replenished media material in Pond 1.

BLM contracted North Wind again in 2012 to perform PTS maintenance. Activities included:

- Excavation of sludge deposited in Pond 1 without contacting the bentonite liner, and transportation to the existing BLM repository approximately one mile away;
- Spreading mixture of manure, straw, 4 inch minus limestone rock in Pond 1;
- Scratching the upstream and downstream faces of Berm 1 to maintain flow and porosity ;
- Building up a 2-foot berm, using silt fence and soil, along the northwest corner of Pond 2 to prevent overflow into Champagne Creek during high water stages and replacing the silt fence along this alignment; and
- Installation of lengths of half culvert between the portal and Pond 1 to improve capture and conveyance of contaminated water.

2.3.4 Groundwater Investigation

BLM retained FutureNet Group. Inc. (FutureNet) to install groundwater monitoring wells and to collect and provide laboratory analysis of groundwater samples from the wells in 2012. FutureNet installed five groundwater monitoring wells and sampled them using low flow purging and sampling techniques. FutureNet concluded that MW-2 located in unconsolidated materials had low pH levels indicating impacted groundwater from AMD; however, the data from the four wells sampled did not provide enough data to delineate impacts of AMD to groundwater in the vicinity of Champagne Creek.

2.3.5 Vegetation Assessment

Because impacts to the vegetation within the riparian system below Moran Tunnel have been observed, K.C. Harvey Environmental, LLC collected soil and vegetation samples within this riparian system in 2012. The vegetation assessment found that AMD emanating from beneath the treatment pond system was entering Champagne Creek. The acidic water (~4.4 pH), contained elevated concentrations of metals including zinc, aluminum, copper, cadmium, iron and the metalloid arsenic. Soluble soil concentrations of these elements are phytotoxic and were negatively impacting the downstream vegetation, especially in the current creek channel. Mature aspen trees within the creek area were dead, while some younger trees did not appear to be impacted. Willow trees were impacted at the margins of the creek area. The low pH and elevated metal concentrations in soils were providing a phytotoxic environment. The trees were in an anoxic or hypoxic environment, which also limits growth and survival. A negative vegetation response to the AMD drainage was clearly exhibited.

2.3.6 Water Quality Assessment

In July 2013, USGS collected water samples in monitoring wells, seeps, tributaries, and points along the main stream channel to evaluate the presences and concentration of primary metals and major ions affecting the creek's water quality (USGS, 2014). Water quality parameters of pH, temperature, specific conductance, and dissolved oxygen were collected at the time of sampling. The USGS mapped sampling locations, seeps, tributaries, and outflows, comparing measured water quality parameters with location to evaluate changes along the reach. Eleven water samples from monitoring wells, seeps, and along the streambed were evaluated using stable isotope analysis to potentially determine the source of the water. The USGS installed four monitoring wells to provide additional data on groundwater quality. USGS provided maps, well logs, and water quality and isotopic analysis results to BLM. Water quality data from the assessment have been

incorporated in the streamlined risk evaluation (Section 2.5).

2.3.7 Data Quality Review and Data Gap Assessment

Although it was not anticipated that any additional studies or sampling would be necessary to achieve the objectives of this EE/CA, the results of previous studies at the Site were evaluated for data quality and completeness. Deficiencies in quality and gaps noted during the review of data presented in reports documenting previous site activities are described below.

2.3.7.1 Data Quality

Chemical data for surface water were of sufficient quality for purposes of completing the streamlined risk assessment for this EE/CA.

Chemical data for groundwater were of sufficient quality but of insufficient quantity for an evaluation of groundwater impacts. Initial groundwater monitoring wells were installed in 2012. Additional groundwater monitoring wells were installed in 2014; therefore limited data were available for these wells. It is understood that groundwater at the site is not used for drinking water. The nearest domestic drinking water wells are located downgradient of the site, approximately three miles to the southeast.

Chemical data were available for only two sediment samples. The data set is too small to fully evaluate risk to human health or to the environment from site-derived metals throughout the sediment substrate at Champagne Creek.

2.3.7.2 Data Gaps

Addressing the following data gaps could provide a more complete CSM for future phases of work:

- Additional sediment concentration data including samples from background locations;
- Additional dissolved metals concentrations in surface water to improve ecological PRGs;
- Source analysis and flow contribution from seeps;
- Additional groundwater data; and
- Data to identify and quantify hydrologic connectivity between the Moran Tunnel and the overlying South Pit.

2.4 CURRENT SITE CONDITIONS - SOURCE AND NATURE OF IMPACTS

2.4.1 Moran Tunnel

The Moran Tunnel (the Tunnel) has been a major source of dissolved metals loading to the watershed for over 40 years. It is unclear if the surface mining that occurred in the South Pit (immediately above the Tunnel) around 1990 contributes significantly to the loading.

A collapse of the portal face reportedly occurred in 1993, after which metal concentrations increased substantially in the drainage. The rock conditions in the tunnel appear to be inherently unstable as observed from outside the tunnel entrance. Roof collapses and other ground failures have resulted in fallen rock accumulating to a thickness of about four feet on the floor of the Tunnel at the entrance. From available photos, this situation has

endured since about 1980. Consequently, this roof fall material is completely saturated with acidic water that is likely being generated deeper in the underground workings.

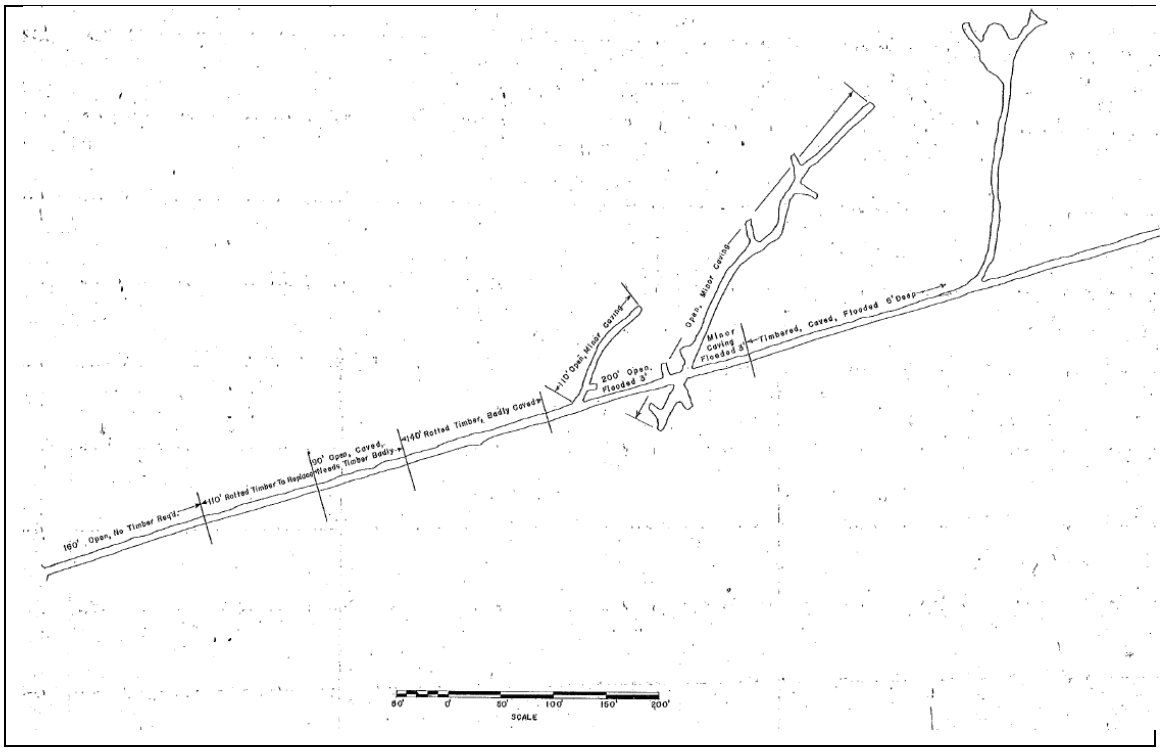


Figure 2-2: Tunnel Collapse Observations by Dahle, 1956

The roof collapse located 100 feet in from the portal was observed during a site investigation in 2004 (Hedin, 2005). Beyond this point, the underground workings were not accessible then and this condition persists. Mine maps (**Figure 2-2**) from Dahle, 1956 suggest that unstable roof conditions and impounded water behind roof falls have occurred historically. In typical underground mine openings, roof collapses tend to be associated with fault or fractured rock zones that are inherently unstable.

Water quality and flow data for the tunnel drainage has been collected periodically since 1989. Metal concentrations increased after a collapse of the portal face in 1993 (**Figure 2-3**). The pH is around 3 and copper and zinc concentrations since the sloughing of the portal average 194 and 83 mg/L, respectively. Flow from the Tunnel ranges from one to seven gpm (**Table 2-1**)

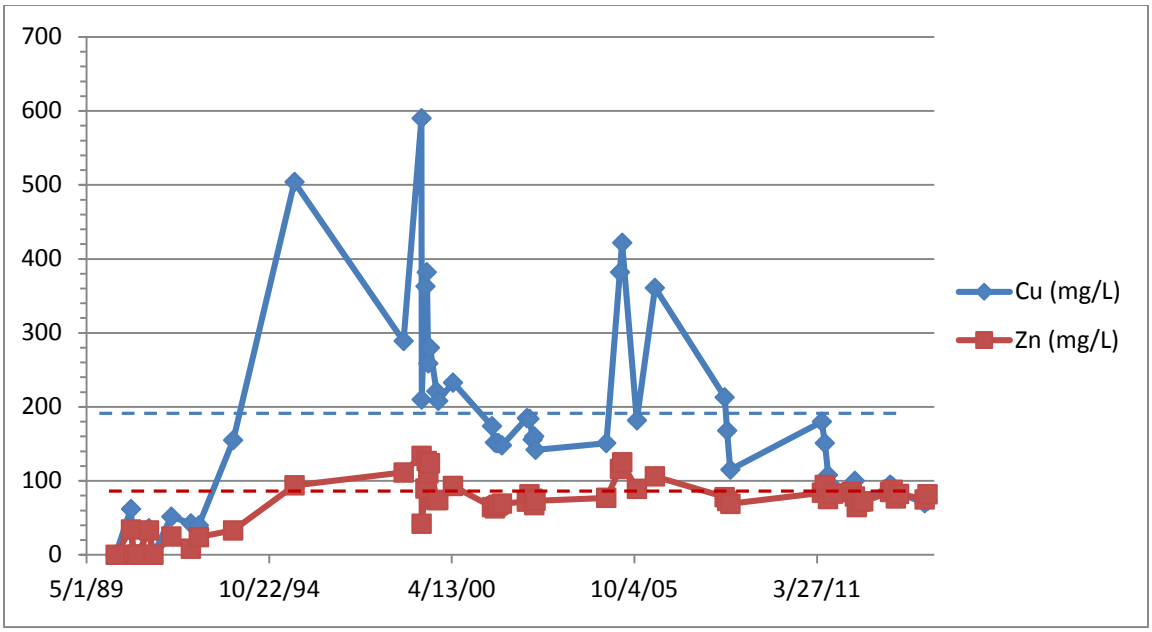


Figure 2-3: Moran Tunnel Copper and Zinc Concentration Trends

Note: Dotted lines represent average values.

Table 2-1: Moran Tunnel Summary Data; 1995-2014

Statistics	Flow (gpm)	pH (s.u.)	Al (mg/L)	Cu (mg/L)	Fe (mg/L)	Zn (mg/L)
Maximum	7.1	3.37	946	590	2460	134
Average	3.6	3.15	529	194	1321	83
Minimum	1.12	2.8	312	69	427	33
No. of Observations	32	25	39	44	44	44

Al – aluminum
Cu – copper
Fe – iron
s.u. – standard units
Zn - zinc

2.4.2 Secondary Source(s)

2.4.2.1 Secondary Seep

In a remedial action project in 1999, a waste rock stockpile outside the Tunnel portal was excavated and placed in an on-site repository. During this activity, acidic water was encountered at the base of the stockpile as reported by BLM staff and documented by photos. This was assumed to be additional seepage from the hillside and tunnel complex and a 15 foot bentonite barrier wall was built to try and stop the seepage. It was ineffective, in part, because it was completed to the maximum depth of the backhoe reach and did not extend to bedrock.

The exact source and quantity of this water is extremely important in the overall design of any treatment approach. Later work by Hedin (2005) interpreted this water as seepage

from the passive treatment system (PTS) and not an additional source. According to Hedin, the "secondary seepage" flow was less than the Tunnel flow and as a result it was assumed that there must be additional seepage to groundwater. Concentrations in the seepage were considerably less than the inflow from the portal and Hedin assumed that this was due to treatment. Based on flow estimates made during the study, Hedin projected that the total seepage loss from the ponds during high flow was on the order of three to five gpm. However, the observed seepage flow into Champagne Creek was substantially less than this value; leading Hedin to speculate that some seepage goes into the groundwater system.

Based on water samples collected in the aspen grove downstream of the treatment system, Hedin calculated an approximate flow contribution from the total seepage by using a mixing ratio calculation, assuming that copper and zinc were not removed due to the low pH in this area. When flows were low in April 2005, the dilution was about 3:1 (clean creek water to contaminated seep water), while under high flow conditions in May 2005, the dilution was about 8:1(see **Table 2-2**). Using these ratios and assuming that the measured berm seepage is representative of all the input, the total input flow ranges from 1.6 to 20 gpm.

Table 2-2: Groundwater Mixing Ratio Estimates (Hedin, 2005)

	Flow (gpm)	**Zn (mg/L)**	**Cu (mg/L)**
Low Flow Condition			
Champagne Creek above Moran Tunnel	6.5	0.11	0.01
Moran Tunnel	4.0	116	382
Berm Seep[(1)]	NA	59	97
Champagne Creek in aspen grove	NA	17	23
Dilution ratio	NA	*2.6*	*3.3*
Total Input Flow calculation (gpm)[(2)]	***1.6***	*59[(1)]*	*97[(1)]*
High Flow Condition			
Champagne Creek above Moran Tunnel	200	0.82	0.09
Moran Tunnel	6.5	125	422
Berm Seep[(1)]	>0.5	73	129
Champagne Creek in aspen grove	NA	9	14
Dilution ratio	NA	*7.9*	*8.5*
Total Input Flow calculation (gpm)[(2)]	***20***	*73[(1)]*	*129[(1)]*

Note 1: Used as representative concentration for Total Input Flow

Note 2: Based on measured creek flow and dilution ratio.

NA = Data not available

Data from a groundwater monitoring well later installed in the seepage area shows concentrations about twice the value in the berm seepage (**Table 2-3**) except for aluminum which is the same. If this water is used in the mixing ratio calculation the contributing flow rate is about half of what was estimated by Hedin.

Table 2-3: Groundwater Data

Sampling Point	Date	Al	Cu	Fe	Zn
MW-6	6/18/2014	312	119	738	82.0
MW-6	7/21/2014	384	127	923	94.6
Average		348	123	830	88.3
Berm seep (Hedin)	4/28/2005	266	97	225	59.0
Berm seep (Hedin)	5/23/2005	362	129	402	73.0
USGS below pond 1,2	7/17/2013	358	55.3	419	44.6
USGS adjacent berm from pond 3 to 4	7/17/2013	408	69.1	490	54.2

In a USGS study in July of 2013, two seepages were observed and sampled. The first was below Ponds 1 and 2 and the second was 25 feet downstream adjacent to the outflow berm of Pond 3. Concentrations in the seepage water were similar and substantially lower than the tunnel inflow. No flow estimates were made due to the low flow conditions at the time of sampling. When USGS sampled, there was essentially no difference in water quality between Ponds 1 and 2, so no treatment was occurring as water moved through the first treatment berm. Since some organic media had been placed in the bottom of Pond 1, it is possible that some treatment may occur for the water that leaks through Pond 1.

The total input flow to Champagne Creek is the sum of the seepage from the treatment ponds plus seepage directly from the mine workings (the secondary source or sources). Based on the limited data, it is assumed that the flow from the secondary source is in the same range as the Moran Tunnel flow and the water quality is comparable to MW-6.

Insufficient data are available to determine exactly how or where this secondary water is being generated; however, BLM staff believe it is an additional source approximately equal in load to the tunnel drainage. Therefore, the EE/CA removal action alternatives will assume that this secondary source of AMD needs to be managed and/or treated.

2.4.2.2 Champagne South Pit

From available data, it appears that the South Pit excavation never intersected underground workings associated with the tunnel or the Last Chance Mine; however, the floor of the South Pit was estimated to be located within 50 feet of the tunnel. A geologic assessment conducted for IGC (WTI, 1990) concluded that there was reasonable potential that the planned mining activities could have a measurable impact on both the quantity and quality of water discharged from the Moran Tunnel.

Since historical information and a site inspection indicated that the potential for connectivity between the South Pit and the Moran Tunnel existed, ECM recommended geophysical surveys to identify depth to bedrock, potential voids or collapses, and preferred groundwater transport pathways. The BLM performed a geophysical

investigation on the South Pit, near the Moran Tunnel in 2014 (**Appendix C**, BLM, 2014). The investigation sought two pieces of information:

- The location of the intersection of the surface location of an underground mine tunnel, and
- An estimate of the hydraulic connectivity between the floor of the south pit and the mine workings, if present.

BLM performed two surveys on the South Pit floor, a magnetic survey and an electrical resistivity survey.

The magnetic survey was conducted to identify metallic debris indicating the mine shaft (*e.g.*, ore car rails), and identified one magnetic anomaly on the South Pit floor, corresponding to the location of a holding berm. There was no other anomaly that would indicate metallic objects. BLM proposed two likely explanations for lack of metallic anomalies as either:

a) Highly acidic water corroded the ore cart rails away, or
b) The instrumentation was unable to resolve smaller objects with the context of the larger geological matrix.

The electrical resistivity survey was used to evaluate the subsurface structure, in an attempt to provide information on the location of the mine tunnel as well as the hydraulic conductivity. The electrical resistivity survey did not penetrate deep enough to provide information on the mine workings. Electrical anomalies were found in the subsurface structure. There appear to be several pockets of more-conductive material in the host rock. BLM proposed two possible explanations for the anomalies.

Scenario 1:

The highly-conductive anomalies represent pockets of clay that have been transported and deposited into sinkholes that have formed above collapsed structures. In the event this scenario is true, it is likely the clay has formed an effective hydraulic barrier by filling fractures and faults in the host rock.

Scenario 2:

The highly conductive anomalies represent perched water that exhibits elevated total dissolved solids (TDS) concentrations. If the perched water scenario is accurate, there is a possible connection between the South Pit (under the elevated bench) and the underground mine workings. There is not enough information to determine if water is moving past the perched layer or host rock. If it was moving past the host rock, there is an area on the South Pit floor (**Appendix C**) that may be a possible infiltration zone.

The BLM geophysical study concluded that there is no obvious indication that South Pit surface water was entering the underground mine workings. The results of the geophysical survey did not warrant further connectivity investigations. However, under Scenario 2, it is possible that the conductive anomalies might occur in response to recurring wetter conditions (periodic storm events or spring snow melt) that keep fine-grained soils beneath the elevated bench saturated with South Pit derived AMD. To expand on this hypothesis, a simple mass-balance model was developed to estimate the magnitude of a hypothetical infiltrating flow contribution from the South Pit to the Moran Tunnel that would be necessary to boost the metal loading for iron, copper, and zinc from pre-1993 (*i.e.*, pre-“collapse”) levels to the current (2014) loading values. Analytical data received from the BLM in November 2014 was used to develop the model (**Appendix D)**.

The model results suggest that one (1) gpm, on average, of South Pit AMD may be infiltrating into the Moran Tunnel from the South Pit. If this is true and this source can be diverted, iron and zinc loading may decrease. Although pre-1993 aluminum data is lacking, aluminum loading at the portal may decrease as well.

2.4.3 Natural Attenuation

2.4.3.1 Moran Tunnel Portal

As shown in the photos provided in **Figure 2-4**, iron and aluminum are being deposited at the mouth of the Moran Tunnel Portal and in the passive treatment system that was installed in 1999. The mechanisms are not fully understood but are believed to be related to processes observed in "iron terraces" (Burgos, 2005).

Figure 2-4: Iron (red) and Aluminum (white) Precipitation at the Moran Tunnel Portal

The estimated iron and aluminum removal rates (resulting in deposition) based on a single sampling event in November, 2014 were 34 and 35 grams per day per square meter (gdm^2), respectively. Manganese was being removed at a rate of 4 gdm^2 in the same reach of flow connecting the portal and Pond 2. These values are relatively high compared to expected removal rates (2 to 4 gdm^2) at the depressed pH exhibited by the Moran Tunnel AMD. Further site characterization is recommended to better quantify this natural attenuation phenomenon. It is suspected that two mechanisms contribute to metals precipitation: the activity of acid-tolerant algae and the oxidation of ferrous iron to ferric, which consumes hydrogen ions, thereby raising the pH. Uncontrolled, this process can reportedly clog pipelines carrying AMD very quickly, within two years of commissioning (BLM, 2014). This tendency will require consideration in the development of remediation/removal alternatives.

2.4.3.2 Champagne Creek

Natural attenuation of metals in Champagne Creek is likely due to the same or similar mechanisms observed at the Moran Tunnel portal, plus the adsorption of metals to manganese oxide deposits. This second mechanism should dominate in alluvial zones that are depleted of iron and aluminum and is subsequently described in more detail.

Iron removal is evident in where secondary seepage enters Champagne Creek as shown in **Figure 2-5** below. Aluminum removal in this area appears to be temperature dependent

and therefore seasonal. Iron removal is thought to be facilitated by the presence of leave litter from the nearby trees and willows.

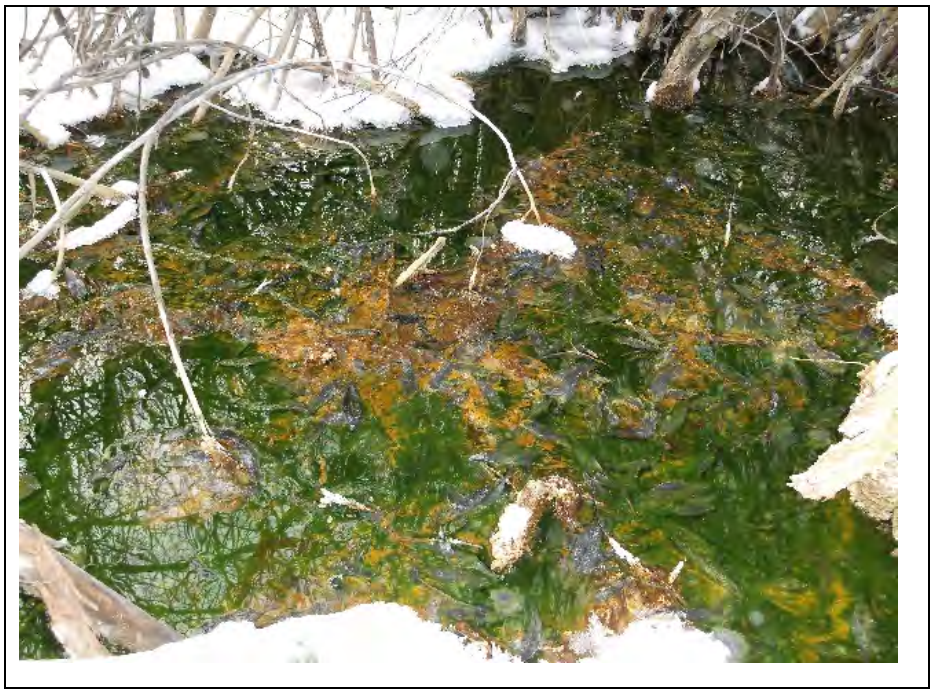


Figure 2-5: Iron Precipitation at the Secondary Seep (Berm Seep)

Evidence of previous aluminum removal in Champagne Creek was observed about 120 feet northwest of the beaver dam near the confluence of Champagne Creek and the un-named tributary as shown in **Figure 2-6**. This aluminum removal zone is just down-gradient from the reported "upwelling" zone observed in non-drought years by BLM personnel.

Figure 2-6: Aluminum Precipitation on Log 120 ft. NW of the Beaver Dam

Additional natural attenuation mechanisms may be assisting in pH improvement and metals attenuation in Champagne Creek. Acidic attack on potassium feldspar bearing rocks (*e.g.*, dacite) in the alluvium may be releasing potassium (K) and consuming hydrogen ions (H^+), which will raise the pH. This is a natural weathering process (Tulane University, 2014).

When aluminum and iron are absent, manganese oxide precipitation (facilitated by algae) is likely to occur. USGS data exhibit a decrease in manganese in groundwater as the sampling distance from the Moran Tunnel increases. This is a beneficial process, as the other heavy metals present will tend to adsorb to the manganese oxides. Over time, this process can cement alluvium particles together to form "manganocrete".

It is suspected that the alluvium materials in Champagne Creek are slowly being transformed to clay minerals in a natural weathering process which is capable of raising the pH through the consumption of hydrogen ions. Other metal attenuation processes may involve the precipitation of manganese oxide (MnO_2) on alluvium surfaces; the metals adsorb to the MnO_2. This process occurs in oxidizing conditions. If the AMD becomes anoxic, adsorbed metals can be remobilized.

In summary, there are a number of beneficial natural attenuation mechanisms in evidence at the Moran Tunnel site and in Champagne Creek. Response technologies should capitalize on these mechanisms and avoid creating conditions that could disrupt them.

2.5 STREAMLINED RISK ASSESSMENT AND CONCEPTUAL EXPOSURE PATHWAY ANALYSIS

EPA's guidance for producing an EE/CA (USEPA, 1993) requires a 'streamlined' or brief risk assessment to justify the need for a removal action. Consistent with EE/CA guidance, the streamlined risk assessment identifies the potential for risk, if no removal action is taken within the removal action boundary. The streamlined risk assessment approach identifies and addresses exposure pathways by evaluating potential ecological and human health risks. The assessment focuses on the human health and ecological risks associated with elevated concentrations of chemicals of potential concern (COPC) and focuses on the media that the removal action is intended to address (USEPA, 1993).

Mining activities from the Moran Tunnel have likely affected Champagne Creek since the 1940's or 1950's. Waste rock and AMD generated from the mining activity has contributed acidity and heavy metals into water, stream sediments and soils. The Moran Tunnel contaminated effluents impact natural resources on public lands. In addition, recreational demands are increasing in Butte County and potential exposure to relatively high metal concentrations in mine waste rock, sediments and surface waters exists.

The nature and extent of contamination associated with the Champagne Creek Site has been characterized in a collection of scientific studies as summarized in Section 2.3. Thus, the evaluation of COPCs was completed by relying on existing information gathered from key studies. COPCs were selected based on exceedances of water quality standards. Review of tables in the Human Health Risk Assessment (HHRA) for Champagne Creek, Idaho (**Appendix A**) and Streamlined Ecological Risk Assessment (STERA) for Champagne Creek/Moran Tunnel, Idaho (**Appendix B**) show that the principal COPCs are aluminum, iron, manganese, and zinc, with sporadic exceedances of cadmium and copper. Of these, iron, manganese, and zinc are most elevated. Manganese and zinc are elevated in Champagne Creek, but decrease in proportion to the sampling distance from the Moran Tunnel portal site. This observation suggests that metals are being naturally attenuated and sequestered in the Champagne Creek sediments.

The risk to exposed human and ecological receptors is evaluated in the HHRA and the STERA, respectively, by the comparison of measured water concentrations to promulgated protective standards including water quality standards, which are protective of human health and aquatic life. In addition, some of the referenced studies encompass direct measures of the on-site risk conditions to ecological receptors. These studies include evaluation of *in-situ* biometrics such as community composition and direct toxicity to exposed laboratory organisms. The results of these studies are direct measures of risk to ecological receptors from the Moran Tunnel's contaminated effluents and other sources. The subsections below summarize the HHRA and STERA.

2.5.1 Human Health Risk Assessment

To complete the data evaluation for the HHRA (**Appendix A**), all metal constituents in the BLM surface water data set, which consists of five sampling locations, were retained as COPCs. Champagne Creek was divided into four discrete exposure units (EUs) and a background area based on the locations at which BLM regularly collects surface water samples.

The exposure assessment process quantifies the magnitude, frequency, and duration of exposure for those populations and pathways selected for quantitative evaluation in the conceptual site model (CSM) (Figure 2 of the HHRA in **Appendix A**). To quantify exposures, where appropriate and sufficient data are available, maximum detected concentrations were identified for each relevant EU. The exposure assessment considers relevant populations and complete exposure pathways relevant in an assessment of surface water and sediment contact. The primary exposure routes associated with surface water contact include incidental ingestion and dermal contact attributable to recreational users, and ingestion of home-raised beef and milk from cattle watered in the Champagne Creek by an agricultural family. There is no use of shallow groundwater at the subject areas of the HHRA and future potential use of groundwater is unlikely; therefore, groundwater was excluded from the HHRA.

The concentrations of all target analytes detected in surface water from Moran Tunnel (EU 1) are greater than 10 times their respective background concentrations. In addition, the concentrations of aluminum, cadmium, copper, iron, nickel, and zinc detected in surface water in Champagne Creek immediately downstream from the Moran Tunnel discharge (EU 2) are greater than 10 times their respective background concentrations. This trend presents evidence that acid mine drainage from Moran Tunnel is impacting surface water in Champagne Creek and that risk/hazard estimates are not being unduly influenced by naturally-occurring conditions.

Based on the results of the HHRA, development of removal action alternatives is warranted to address risks and hazards associated with metals contamination identified at EU 1 and EU 2. No unacceptable risks or hazards were identified for EUs downstream of EU 2 for the subject receptor populations; therefore, no further action is warranted for these EUs.

2.5.2 Streamlined Ecological Risk Assessment

The STERA (**Appendix B**) quantifies to what extent exposure to mining-derived contaminants in aquatic habitats at the site may affect local community-level aquatic receptors (*e.g.* benthic invertebrates and fish) in Champagne Creek. Screening benchmarks were needed to assess the ecotoxicity of the metals measured in the various surface water and sediment samples collected from Champagne Creek.

Conservative chronic surface water screening benchmarks were selected from two

sources for use in selection of the constituents of potential ecological concern (COPECs), in the following order of preference: 1) Idaho's Surface Water Standards for chronic criteria, (Idaho Administrative Procedure Act [IDAPA] 58.01.02) and 2) USEPA National Recommended Water Quality Criteria (NRWQC). Both sources provided the screening benchmarks needed to evaluate all the metals assessed in the STERA. The NRWQC also provided a minimum acceptable surface water pH value (pH = 6.5), which was used in this evaluation as the screening threshold for acidity. Sediment screening benchmarks were taken from MacDonald, *et. al.* (2000) (see STERA, **Appendix B**).

The STERA made numerous simplifying assumptions discussed in Section 5 of the STERA, which created uncertainty. Most likely the STERA was overly conservative and therefore identified more COPCs and resulted in higher risk estimates than would be warranted if additional information regarding site-specific conditions were considered. However, even though the substantial hazard quotients (HQs) at EUs 1 through 3 could probably be reduced somewhat by considering site-specific information or a more extensive dataset, it appears unlikely that these adjustments would substantially reduce the risk described in this STERA.

The STERA concluded that site-related risk is present at EU 1, EU 2, and EU 3 from surface water and that this risk decreases down gradient from EU 1. All pH values were below the 6.5 benchmark. The HQs at EU 4 fell below the background, except for Zn (EU 4 HQ = 3.1 and background HQ = 2.3). The risk identified at EU 4 is comparable to the background risk.

2.5.3 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) for ecological and human receptors for surface water and sediment represent the concentrations of COPCs below which the human health and ecological risks are reduced to acceptable levels. As stated above, groundwater has been eliminated, since there is no current or planned future use for drinking water at the site. The screening benchmarks used in the ecological COPC selection process were retained as the PRGs for surface water. The selected PRGs for human receptors are based on the complete exposure pathways which underpin the HHRA. A comparison between PRGs for ecological receptors and human receptors indicates the PRGs for ecological receptors are more conservative (**Table 2-4**).

Table 2-4: Proposed PRGs for Surface Water and Sediment COPCs

Proposed PRG					
COPC	**Ecological Receptors (mg/L)**	**Human Recreator Non-carcinogenic Adjusted PRG HI=1 (mg/L)**	**Human Basis: Ingestion of Beef TR=1e-4 (mg/L water)**	**Human Basis: Ingestion of Milk HQ=1 (mg/L water)**	**Human Basis: Ingestion of Beef HQ=1 (mg/L water)**
Surface Water[a]					
Aluminum	0.087	-	-	-	-
Arsenic	0.150	-	1.16	-	-

Proposed PRG					
COPC	**Ecological Receptors (mg/L)**	**Human Recreator Non-carcinogenic Adjusted PRG HI=1 (mg/L)**	**Human Basis: Ingestion of Beef TR=1e-4 (mg/L water)**	**Human Basis: Ingestion of Milk HQ=1 (mg/L water)**	**Human Basis: Ingestion of Beef HQ=1 (mg/L water)**
Cadmium[b]	0.0006	0.561	-	-	-
Chromium[b]	0.074	-	-	-	-
Copper[b]	0.011	-	-	17.1	-
Iron	1.000	-	-	-	801
Mercury	0.00077	-	-	-	0.0146
Nickel[b]	0.052	-	-	-	-
Silver[b]	0.00032	-	-	0.16	-
Zinc[b]	0.120	-	-	-	68.6
Sediment[c]					
Arsenic	18 mg/Kg	-	-	-	-
Cadmium	2.2 mg/Kg	-	-	-	-
Copper	68.6 mg/Kg	-	-	-	-
Lead	67.7 mg/Kg	-	-	-	-
Zinc	236 mg/Kg	-	-	-	-

[a]As explained in Idaho's Surface Water Standards for chronic criteria, 58.01.02 the surface water PRGs for the hardness-dependent metals shown in this table are for dissolved metal and correspond to a total hardness of 100 mg/L and a water effect ratio of 1.0. These PRGs would likely change to some degree depending on the actual hardness measured at each impacted Champagne Creek EU.

[b]hardness-dependent metal

[c]Since no sediment target analytes contributed to risks in excess of 1E-04, nor hazard indices in excess of 1, no sediment PRGs were developed for the Champagne Creek investigation areas

COPC=constituent of potential concern

PRG=Preliminary remediation goal

TR=target cancer risk

HQ=hazard quotient

mg/L=milligrams per liter

2.6 BACKGROUND DATA FOR THE CHAMPAGNE CREEK SITE

Background surface water data were collected from a location above the Moran Tunnel discharge area to Champagne Creek. The selected sampling location was upgradient of Moran Tunnel with respect to surface water flow, prevailing wind direction and precipitation

overland/sheet flow and is understood to be predominately free of impacts due operations at the Moran Tunnel portal. However, data representative of the background location may be downgradient of other anthropogenic activities such as other mining operations and may receive inputs from these additional sources. As with the exposure point concentrations for each analyte in surface water, the maximum concentration of each analyte detected at the sample location above Moran Tunnel was selected from the combined BLM and USGS data sets for use as the background concentration and, when possible, only data collected in 2013 and 2014 were used to ensure the risk evaluation is based on current conditions. In some instances, no current *(i.e.*, 2013 or 2014) data were available for an analyte. In those cases, the most recently available data point was used. For example, the most recent mercury and silver data available are from 1999. Therefore, the concentrations of mercury and silver detected above Moran Tunnel in 1999 were used as the background concentrations. The background data set for Champagne Creek are presented in **Table 2-5** below (see also Table 3 of the HHRA, **Appendix A**).

Table 2-5: Background Concentrations of Target Analytes in Surface Water

Background Concentrations of Target Analytes in Surface Water											
Above Moran Tunnel	Sample Date	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Mercury	Nickel	Silver	Zinc
		mg/L									
BLM	6/6/2013	0.38	--	--	--	<0.01	0.46	--	--	--	<0.01
BLM	7/1/2013	6.35	--	--	--	<0.01	7.62	--	--	--	0.09
USGS	7/17/2013	14.5	0.012	0.00325	0.0256	0.0402	28.2	na	0.0419	na	0.281
BLM	8/8/2013	18	--	--	--	1.3	21.7	--	--	--	0.24
BLM	9/11/2013	18.7	--	--	--	0.03	22.4	--	--	--	0.23

Groundwater data for MW-1 and MW-7, which are both located upstream of the Moran Tunnel are presented in **Table 2-6** below. Three samples have been collected from well MW-1 and only one sample has been collected from well MW-7 as shown.

Table 2-6: Background Concentrations of Target Analytes in Groundwater

Background Concentrations of Target Analytes in Groundwater							
Well Location	Sample Date	Aluminum	Arsenic	Cadmium	Copper	Iron	Zinc
		mg/L					
MW-1 (Grab)	10/13/2012	20	0.0156	0.0032	0.167	36	0.217
MW-1 (total)	10/10/2012	4.8	<0.003	<0.002	0.11	7.36	0.0247
MW-1 (dissolved)	7/16/2013	0.0048	0.00023	0.000033	<0.0008	0.013	0.0065
MW-7 (dissolved)	9/13/2013	0.0188	0.0088	<0.000016	<0.0008	1.62	0.0029

Although two bulk sediment samples were collected from Champagne Creek below Moran Tunnel, background sediment data were not available for use in the streamlined risk evaluation.

2.6.1 Proposed Action Levels

The PRGs developed in the streamlined risk assessment represent conservative site-specific concentrations of COPCs developed to minimize risk to human and ecological receptors at the site. Under CERCLA (USEPA, 2002), concentrations of COPCs below the naturally occurring background levels are not generally subject to the removal action. Therefore, proposed action levels for the site are based on background levels established and presented in the streamlined risk assessment. The proposed action levels for the site

shown in **Table 2-7** below are the higher of the background concentration or the most conservative PRG.

Table 2-7: Proposed Action Levels for Surface Water and Sediment

COPC	Most Conservative PRG (Ecological Receptors)	Background Concentrations[a]
Surface Water		
Aluminum	0.087 mg/L	18.7 mg/L
Arsenic[c]	0.150 mg/L	0.012 mg/L
Cadmium[c]	0.0006 mg/L	0.00325 mg/L
Chromium[c]	0.074 mg/L	0.0256 mg/L
Copper	0.011 mg/L	1.3 mg/L
Iron	1.000 mg/L	28.2 mg/L
Mercury[d]	0.00077 mg/L	<0.0005 mg/L
Nickel[c]	0.052 mg/L	0.0419 mg/L
Silver[d]	0.00032 mg/L	<0.005 mg/L
Zinc	0.120 mg/L	0.281 mg/L

[a] Data from 2013 sampling events. Background is the highest value as described in the streamlined risk assessment.

[b] Concentrations below the reporting limit were included as half the reporting limit

[c] Data represent a single sampling event in 2013

[d] No data were available for 2013

NA – No background sediment data are available for the site

Highlighted cell represents proposed cleanup goal.

3 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES AND DOCUMENTATION OF ARARs

3.1 STATUTORY LIMITS ON NON-TIME-CRITICAL REMOVAL ACTIONS (NTCRA)

40 CFR Part 300.415(b)(5) and Section 104(c)(1) of CERCLA set limits of 12 months and $2 million for fund-financed removal actions. EPA can grant an exemption from the time and dollar limitations in the statutes if they determine that the proposed removal action is appropriate and consistent with the anticipated long-term remedial action. Implementation of any of the alternatives in this EE/CA could result in costs exceeding the NTCRA $2 million and 12-month statutory limits. Because BLM will not finance the NTCRA through Superfund, the statutory limits do not apply to this site. In addition, since the type of action and basis for action are consistent with any long-term remedial program, a consistency waiver is appropriate for each of the alternatives.

3.2 DETERMINATION OF REMOVAL ACTION SCOPE

3.2.1 Removal Action Objective

The NCP, 40 CFR Part 300.415 provides a framework for the removal action process. The process is a tool for accomplishing prompt risk reduction through implementation of an early action that is consistent with any final remedy that may be selected for site remediation. In some cases, the removal action itself becomes the final remedy. The removal action process is being applied to facilitate prompt risk reduction by reducing the potential for contaminant migration from the mine area.

The Removal Action Objectives (RAOs) have been developed based on analysis of the sources of contamination; the nature and extent of contamination; the results of the human health and ecological risk assessments; and the ARARs that have been identified. The RAOs have been developed to control the contamination sources, and to eliminate the potential for exposure of human and ecological receptors to site contamination. RAOs are the link from the site characterization, site conceptual model and risk assessment to the removal action alternatives. RAOs serve as a basis for selecting technologies and developing removal action alternatives and are written for each medium that is causing exposure and that needs exposure reduction. The RAOs for Moran Tunnel are as follows:

- Reduce or eliminate the release of acidity and heavy metals from the Moran Tunnel and “secondary seepage” to surface water, including the wetland, and groundwater in Champagne Creek and meet ARARs
- Minimize re-dissolving metals that have been previously attenuated by and/or deposited in the Champagne Creek alluvium
- Reduce or eliminate the potential for humans, aquatic and terrestrial biota exposure through ingestion or direct contact to AMD and heavy metals impacted surface water in Champagne Creek and by consumption of potentially contaminated aquatic life.

3.2.2 Removal Action Justification

According to 40 CFR 300.415(b), a removal action is justified, if there is a threat to human health or the environment based on one or a combination of any of the eight factors listed below:

Table 3-1: Removal Action Justification

Factor	Site Condition	Justified
(1) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants.	Public access to AMD-impacted surface water and soil containing concentrations of metals exists. Animal populations have access to the AMD-impacted surface water (**Section 2.5**).	Yes
(2) Actual or potential contamination of drinking water supplies or sensitive ecosystems.	No known population centers near the site derive potable water from site surface water sources. Drinking water aquifers do not appear impacted by site contaminants.	No
(3) Hazardous substances, pollutants, or contaminants in drums, barrels, tanks, or other bulk storage containers that may pose a threat of release.	No drums, barrels, tanks, or bulk storage containers on the Site.	No
(4) High levels of hazardous substances, pollutants, or contaminants in soils largely at, or near, the surface, that may migrate.	Concentrations of metals in reclaimed soils subject to erosion and migration.	Yes
(5) Weather conditions that may cause hazardous substances, pollutants, or contaminants to migrate or be released.	Sediment subject to erosion during wind, high flows, rain events, and snowmelt could cause waste material migration.	Yes
(6) Threat of fire or explosion.	No flammable materials on the Site.	No
(7) The availability of other appropriate federal or state response mechanisms to respond to the release.	The site is on BLM-administered land and is being addressed under BLM CERCLA authority.	Yes
(8) Other situations or factors that may pose threats to public health or the environment.	None.	No

3.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 300.415(j) of NCP requires removal actions pursuant to CERCLA Section 106, shall, to the extent practicable, considering the exigencies of the situation, attain ARARs under federal environmental or state environmental or facility siting laws". **Tables 3-2** through **3-4** lists all the ARARs for the Site.

An alternative that does not meet an ARAR under federal environmental or state environmental or facility siting laws may be selected under the following circumstances (40 CFR 300.430[f][1][ii][C]):

1. The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;
2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
3. Compliance with the requirement is technically impracticable from an engineering perspective;
4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirements, or limitation through use of another method or approach;
5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state; or
6. For fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment.

The interpretation of ARARs includes the inherent assumption that protection of human health and the environment must be ensured.

3.3.1 Terms and Definitions

Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (52 FR32496, August 27, 1987).

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (52 Federal Register [FR] 32496). For example, while the federal MCLs established under the Safe Drinking Water Act are applicable standards for public water supplies, MCLs are considered relevant and appropriate for use as groundwater cleanup levels when the groundwater is considered an actual or potential drinking water source. Requirements under federal or state law may be either applicable or relevant and appropriate to CERCLA cleanup actions, but not both. Requirements must be both relevant and appropriate for compliance

to be necessary. In the case where both a federal and a state ARAR are available, or where two potential ARARs address the same issue, the more stringent regulation must be selected. The final NCP states that a state standard must be legally enforceable and more stringent than a corresponding federal standard to be relevant and appropriate (55 FR 8756, March 8, 1990).

CERCLA on-site response actions must only comply with the substantive requirements of an ARAR and not the administrative requirements. “No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely onsite, where such remedial action is selected and carried out in compliance with this section” [CERCLA § 121(e) (1)]. As noted in the ARARs guidance (EPA, 1988):

> *The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion. Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements facilitate their implementation. The NCP defines on-site as "the area extent of contamination and all areas in very close proximity to the contamination necessary for implementation of the response action". EPA recognizes that certain administrative requirements, such as consultation with state agencies and reporting, are accomplished through the state involvement and public participation requirements of the NCP. Off-site response actions must comply with both the substantive and administrative requirements of an applicable (but not a relevant and appropriate) regulation.*

In the absence of federal- or state-promulgated regulations, many criteria, advisories, and guidance values are not legally binding but may serve as useful guidance for response actions. These are not potential ARARs but "to-be-considered" (TBC) guidance. These guidelines or advisory criteria should be identified if used to develop cleanup goals or if they provide important information needed to properly design or perform a response action. Three categories of TBC information are as follows:

1. Health effects information with a high degree of certainty (e.g., reference doses),
2. Technical information on how to perform or evaluate site investigations or response actions, and
3. Regulatory policy or proposed regulations. For example, EPA Region III Residential Risk Based Concentrations and Region IX Preliminary Remediation Goals (Residential) provide guidance to be considered to assess the health implications during site activities.

ARARs fall into the three categories listed below.

- Location-specific ARARs "set restrictions upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations" (53 FR 51394). In determining the use of location-specific ARARs for selected remedial actions at CERCLA sites, the jurisdictional prerequisites of each of the regulations must be investigated. In addition, basic definitions and exemptions must be analyzed on a site-specific basis to confirm the correct application of the requirements. For example, federal and state regulations concerning wetlands apply at a site where remedial activities may impact an existing wetland.

- Chemical-specific ARARs are usually health- or risk-based standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels or the basis for calculating such levels. Chemical-specific ARARs may also indicate acceptable levels of discharge in determining treatment and disposal requirements or the effectiveness of future remedial alternatives. For example, state water quality standards would apply as cleanup standards at a site where contaminated surface water is the subject of a cleanup.
- Action-specific ARARs set controls or restrictions on particular kinds of activities related to the management of hazardous waste (53 FR 51437). Selection of a particular response action at a site will invoke the appropriate action-specific ARARs that may specify particular performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals. For example, the federal and state air standards apply under many circumstances where a treatment technology involves air emissions. The Occupational Safety and Health Administration (OSHA) has promulgated standards for protection of workers who may be exposed to hazardous substances at Resource Conservation and Recovery Act (RCRA) or CERCLA sites (29 CFR Part 1910.120 and 1926.65). EPA requires compliance with the OSHA standards in the NCP (40 CFR 300.150), not through the ARAR process. Therefore, the OSHA standards are not considered ARARs. Although OSHA requirements, standards, and regulations are not ARARs, response activities must comply with them. Identification and evaluation of ARARs is an iterative process, which continues throughout the response process as a better understanding is gained of site conditions, contaminants, and response alternatives. Therefore, preliminary lists of ARARs and their relevance may change through time as more information is obtained and as the preferred alternative is chosen.

3.3.2 Chemical-Specific ARARs

Table 3-2: Chemical-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
CHEMICAL-SPECIFIC : FEDERAL				
EPA Ambient Water Quality Criteria (AWQC)	Surface Water	EPA Water Quality Standards Handbook, EPA-820-B-14-008, September 2014.	EPA's compilation of national recommended water quality criteria for the protection of aquatic life and human health in surface water for approximately 150 pollutants.	Applicable
Clean Water Act Water Quality Standards	Surface Water	33 USC 1251-1387, Section 303(c)(2)(B) 40 CFR Section 440.40-440.45 40 CFR Part 131, Quality Criteria for Water 1976, 1980, 1986	Chapter 26, Water Pollution Prevention and Control, sets criteria for water quality based on toxicity to aquatic organisms and human health.	Applicable
Safe Drinking Water Act National Primary Drinking Water Regulations and Maximum Contamination Goals National Secondary Drinking Water Regulations	Surface Water and groundwater	40 USC 300 40 CFR Part 141, Subpart B, pursuant to 42 USC 300(g)(1) and 300(j)(9) 40 CFR Part 141, Subpart F, pursuant to 42 USC 300(g)(1)	Establishes health-based standards for public water systems (maximum contaminant levels) and sets goals for contaminants. CERCLA Section 1211(d)(2)(B) provides that CERCLA response actions "shall require a level of standard or control which at least attains MCLGs established under the Safe Drinking Water Act." Section 300.430(f)(5) of the NCP provides that remedial actions must generally attain MCLs or non-zero MCLGs if water is a current or potential source of drinking water.	To be considered for drinking water quality downstream of the site. There are no wells used for drinking water at the site.
Safe Drinking Water Act National Primary Drinking Water Regulations and Maximum Contamination Goals National Secondary Drinking Water Regulations	Surface Water and groundwater	40 CFR Part 143, Subpart B pursuant to 42 USC 300(g)(1) and 300(j)(9)	Establishes welfare-based (non-enforceable) standards for public water systems (secondary maximum contaminant levels).	To be considered for possible public water system wells downstream of the site on private land.
EPA Region 3 Biological Technical Assistance Group (BTAG) Freshwater Screening Benchmarks and Freshwater Sediment Screening Benchmarks	Surface water and sediment	EPA Region 3, Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for Screening Contaminants of Potential Concern (ORNL, 1997)	The Region III BTAG Screening Benchmarks are values to be used for the evaluation of sampling data at Superfund sites. These values facilitate consistency in screening level ecological risk assessments.	To be considered
EPA Ecological Soil Screening Levels (Eco-SSL)	Soil	EPA Ecological Soil Screening Levels, OSWER Directive 9285.7-60 through 9285.7-76	Ecological Soil Screening Levels (Eco-SSLs) represent the collaborative effort of a workgroup consisting of federal, state, consulting, industry and academic participants led by the EPA.	To be considered
EPA Region 9 Regional Screening Levels - "Industrial Soil Supporting" and "Residential Soil Supporting"	Soil	EPA Region 9 Regional Screening Levels (RSL) Summary Table (TR=1E-6, HQ=0.1) November 2014	Combine current USEPA toxicity values with standard exposure factors to estimate acceptable contaminant concentrations in different environmental media (soil, air, and water) that are protective of human health."	To be considered
CHEMICAL-SPECIFIC : STATE/LOCAL				
Idaho Water Quality Standards (Antidegradation Policy)	Surface Water	IDAPA 58.01.02.050.02	Requires that existing water uses and water quality, high quality water, and Outstanding Resource Water (ORW) be maintained and protected	Applicable

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
Idaho Water Quality Standards (Violation of Water Quality Standards)	Surface Water	IDAPA 58.01.02.080	Prohibits discharges that violate water quality standards or injure beneficial uses. Allows the agency to authorize short-term exemptions	Applicable
Idaho Water Quality Standards (Analytical Procedures)	Surface Water	IDAPA 58.01.02.090	Establishes analytical procedures that must be used to determine compliance with water quality standards.	Applicable
Idaho Water Quality Standards (Surface Water Use Classifications)	Surface Water	IDAPA 58.01.02.100	Establishes specific beneficial use designations for surface water, which in turn determine applicable standards	Relevant and appropriate
Idaho Water Quality Standards (General Surface Water Use Designations)	Surface Water	IDAPA 58.01.02.101	Establishes general surface water use designations for waters not otherwise classified.	Applicable
Idaho Water Quality Standards (Designated Uses)	Surface Water	IDAPA 58.01.02.150 to 160	Designates uses for specific water bodies by hydrologic basin.	Relevant and appropriate. Currently, Champagne Creek has no designated uses.
Idaho Water Quality Standards (General Surface Water Quality Criteria)	Surface Water	IDAPA 58.01.02.200	Establishes narrative water quality criteria for hazardous, deleterious and radioactive material; floating, suspended or submerged matter; exceed nutrients; oxygen-demanding materials and sediment.	Relevant and appropriate, if remediation occurs with a potential to influence sediment loads.
Idaho Water Quality Standards (General Surface Water Quality Criteria)	Surface Water	IDAPA 58.01.02.210.1	Establishes water quality criteria (chronic) for toxic substances (metals)	Applicable
Idaho Water Quality Standards (Surface water Quality Criteria for Use Classifications)	Surface Water	IDAPA 58.01.02.250 to .253	Establishes numerical surface water quality criteria for beneficial use classifications.	Applicable
Idaho Water Quality Standards (Rules Governing Nonpoint Source Activities)	Surface Water	IDAPA 58.01.02.350	Provides for implementation of BMPs and water quality monitoring for nonpoint source activities.	Applicable
Idaho Groundwater Quality Rule (Groundwater Quality Standards)	Groundwater	IDAPA 58.01.11.200	Protects groundwater for beneficial uses including potable water supplies, establishes use classifications and establishes water quality criteria for groundwater.	Applicable
TMDLs, Guide to Selection of Sediment Targets for Use in Idaho	Sediment	Idaho Department of Environmental Quality, 2003. Guide to Selection of Sediment Targets for Use in Idaho TMDLs, June.	Suggests appropriate water column and streambed measures for gauging attainment of the narrative sediment goal.	To be considered. Currently, no specific TMDL has been established for Champagne Creek, located in the Lake Walcott Subbasin.
Sediment Quality Guidelines (SQGs)	Sediment	MacDonald, D.D., C.G. Ingersoll, and T.A.Berger. 2000 Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.	Develops numerical sediment quality guidelines (SQGs) for freshwater ecosystems based on consensus of previously developed guidelines.	To be considered

3.3.3 Location-Specific ARARs

Table 3-3: Location-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
LOCATION-SPECIFIC: FEDERAL				
Endangered Species Act	Wildlife and fisheries	316 USC § 1531 (h) through 1543 40 CFR Part 6.302 50 CFR Part 402	Act to protect habitat of endangered and threatened species. Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.	Applicable, if present
Fish and Wildlife Coordination Act	Wildlife and fisheries	16 USC 1251 661 et seq.; 40 CFR 6.302(g)	Requires consultation when Federal agency proposes or authorizes any modification of any stream or other water body to assure adequate protection of fish and wildlife resources.	Applicable
Historic Sites, Buildings, and Antiques Act and Executive Order 11593	Cultural resources	16 USC 461 et seq.; 40 CFR Part 6.301	EPA is subject to the requirements of the Historic Sites Act of 1935, 16 U.S.C. 461 et seq., the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq., the Archaeological and Historic Preservation Act of 1974, 16 U.S.C. 469 et seq., and Executive Order 11593, entitled Protection and Enhancement of the Cultural Environment.	Applicable
Migratory Bird Treaty Act	Birds	16 USC §§ 703 et seq.	Establishes federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the US Fish and Wildlife Service during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	Applicable, if present
National Environmental Policy Act	Wildlife, fisheries, cultural resources	7 CFR 799 (1969) http://www.epa.gov/region9/nepa/	Section (102)(2) of NEPA requires all Federal agencies to give appropriate consideration to the environmental effects of their proposed actions. The Council on Environmental Quality regulations at 40 CFR 1507.3(b) identify those items which must be addressed in agency procedures.	Applicable
Protection of Wetlands Order, Executive Order 11990	Wetlands	40 CFR Part 6	Requires minimizing and avoiding adverse impacts to wetlands	Applicable (if wetlands are present)
Floodplain Management, Executive Order 11988	Floodplains	42 USC 4321 et seq.; 42 USC 4001 et seq.	Requires evaluating the potential effects of actions that may take place in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	Applicable, if in floodplain
National Historic Preservation Act	Cultural resources	16 USC Section 470f 36 CFR Parts 60, 63, and 800 40 CFR Section 6.301	Section 106 of NHPA process balances needs of federal undertaking with effects the undertaking may have on historic properties	Relevant and appropriate

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
Archaeological Resources Protection Act	Cultural resources	16 USC Section 470 et. Seq. 40 CFR Part 7	ARPA and implementing regulations prohibit the unauthorized disturbance of archaeological resources on public and Indian Lands. Archaeological resources are any material remains of past human life and activities which are of archaeological interest. Removal of archaeological resources from public or Indian lands is prohibited and any archaeological investigations at a site must be performed by a professional archaeologist. ARPA and implementing regulations are applicable for the conduct of any elected response action that may result in ground disturbance.	Relevant and appropriate
American Indian Religious Freedom Act	Cultural resources	42 USC Section 1996 et seq.	Protects and preserves the traditional religious rights and cultural practices of Native Americans. These rights include, but are not limited to, access to sacred sites, freedom to worship through ceremonial and traditional rights, and use and possession of objects considered sacred.	Relevant and appropriate
Native American Graves Protection and Repatriation Act	Cultural resources	16 USC 1531 et seq. 50 CFM Parts 17, 402	Establishes the ownership of cultural items excavated or discovered on federal or tribal land.	Relevant and appropriate
LOCATION-SPECIFIC : STATE/LOCAL				
Idaho Classification and Protection of Wildlife Rule	Wildlife and fisheries	67-41 and 67-46, Idaho Code IDAPA 13.01.06	These regulations affect wildlife species protected by the state, including species listed by state regulation as endangered, threatened, species of special concern, and protected nongame.	Relevant and appropriate
Idaho Land Remediation Rules	Public Lands	IDAPA 58.01.18	The Idaho Land Remediation rules have been adopted with the purpose of fostering the remediation, transfer, reuse, or redevelopment of sites or groups of sites based on risk to human health and the environment.	Applicable
Idaho Comprehensive Wildlife Conservation Strategy (Challis Volcanic Section)	Wildlife and fisheries	Idaho Comprehensive Wildlife Conservation Strategy, Idaho Department of Fish and Game, September 2005	Idaho developed a Comprehensive Wildlife Conservation Strategy (CWCS) in October 2005 to provide a framework for conserving 'Species of Greatest Conservation Need' (SGCN) and the habitats upon which they depend. http://fishandgame.idaho.gov/public/wildlife/cwcs/	To be considered
Beneficial Use Reconnaissance Program (BURP)	Surface Water	Idaho Department of Environmental Quality, 2013. Idaho's Beneficial Use Reconnaissance Program, July.	The purpose of BURP is to help Idaho meet the requirements of the federal Clean Water Act by providing data to use in determining the existing uses and beneficial use support status of Idaho's water bodies.	To be considered for data below the Poison Gulch Confluence where Champagne Creek is perennial.
Small Stream Ecological Assessment Framework	Surface Water	Idaho Department of Environmental Quality, 2002. Idaho Small Stream Ecological Assessment Framework: An Integrated Approach, June.	Describes DEQ's ecological assessment approach to determine aquatic life use support in Idaho's small streams.	To be considered

3.3.4 Action-Specific ARARs

Table 3-4: Action-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
ACTION-SPECIFIC : FEDERAL				
Bevill Amendment	Waste	RCRA Section 3001 (a)(3)(A)(ii) 42 USC 6921 (a)(3)(A)(ii) 40 CFR Section 261.4(b)(7)	Exempts most mining wastes from regulation as hazardous waste. Exempted waste includes waste from the extraction and beneficiation of minerals, and some mineral processing waste.	To be considered
Federal Land Policy and Management Act of 1976	Public Lands	43 USC 1701 et seq.	Governs the way in which the public lands administered by the Bureau of Land Management are managed.	Applicable
Federal Watershed Restoration and Enhancement Agreement (Wyden Amendment)	Wildlife and fisheries	16 USC 1011	Allows the Secretary of the Interior for the purpose of entering into cooperative agreements with the heads of other Federal agencies, tribal, State, and local governments, private and nonprofit entities, and landowners for the protection, restoration, and enhancement of fish and wildlife habitat and other resources on public or private land and the reduction of risk from natural disaster where public safety is threatened that benefit these resources on public lands within the watershed	Relevant and appropriate
Surface Mining Control and Reclamation Act of 1977	Public Lands	30 USC 1201 et. seq.	Created an Abandoned Mine Land (AML) fund to pay for the cleanup of mine lands.	Applicable
Clean Air Act National Primary and Secondary Ambient Air Quality Standards National Emission Standards for Hazardous Air Pollutants	Air	42 USC 7409 40 CFR Part 50 40 CFR Part 61, Subparts N, O, P, pursuant to 42 USC 7412	Establish air quality levels that protect public health, sets standards for air emissions Regulates emissions of hazardous chemicals to the atmosphere	Relevant and Appropriate pertaining to disturbance of waste material during consolidation, removal, or treatment.
Clean Water Act (Section 404)	Surface Water	33 USC 1344 33 CFR Parts 320 - 330 40 CFR Part 230	Establishes dredge or fill requirements and are applicable to work in or near navigable waters. They establish requirements that limit the discharge of dredged or fill materials into navigable waters and associated wetlands.	Applicable, if action involves dredging or filling
Clean Water Act National Pollutant Discharge Elimination System (NPDES) Effluent Limitations	Surface Water	33 USC 1342 Section 404 40 CFR Parts 122, 125 33 USC 131140 CFR Part 440	Requires permits for the discharge of pollutants from any point source into waters of the United States. Sets standards for discharge of treated effluent to waters of the United States.	Applicable, if action involves direct discharge to Champagne Creek
Comprehensive Environmental Response, Compensation, and Liability Act	Waste	CERCLA Section 121	This section requires that all remedial actions which result in any hazardous substance, pollutants, or contaminants remaining on the Site be subject to Five-Year Review to evaluate the performance of the remedy.	Applicable

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
RCRA Subtitle D: Criteria for Classification of Solid Waste Disposal Facilities and Practices	Waste	40 CFR Part 257, Subpart A.	Written for non-municipal nonhazardous waste disposal units, the regulations require that facilities in floodplains not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, and not cause or contribute to the taking of any endangered or threatened species. Facilities must not cause a discharge of pollutants into waters of the US that violates the requirements of the National Pollutant Discharge Elimination System and must no contaminated an underground drinking water source beyond the solid waste boundary.	Applicable, if response action includes off-site disposal
BLM Abandoned Mine Land Program Policy Manual Section 3720	Public Lands	BLM Abandoned Mine Land Program Policy Manual Section (BLM MS-3720, 2013)	The BLM Abandoned Mine Land Program is administered pursuant to Abandoned Mine Land Program Manual, Section 3720. The Manual specifically identifies physical hazards at abandoned mine sites and how to identify environmental and ecological hazards. The manual lists and describes the statutes and regulations that authorize the BLM to address these issues.	To be considered
BLM Abandoned Mine Land Program Policy Handbook	Public Lands	BLM Abandoned Mine Land Policy Handbook (BLM H-3720-1, 2007)	The Abandoned Mine Land Program Policy Handbook is intended to provide options, tools, resources, and examples that can be considered when addressing significantly more complex remediation activities at Abandoned Mine Land Sites. The handbook provides basic information for identifying physical hazards; reducing environmental degradation caused by abandoned mines to ensure compliance with all standards and applicable Federal, State, Tribal, and local laws; and helps guide in identifying and prioritizing mines that most affect at-risk resources and functioning ecosystems.	To be considered
Best Management Practices for Soils Treatment Technologies	Soil	EPA OSWER, 1997	Provides technologies for controlling cross-media transfer of contaminants during materials handling activities.	To be considered
Design and Construction of RCRA/CERCLA Final Covers	Waste	EPA/625/4-91/025, May 1991	This publication provides guidelines for design and construction of covers.	To be considered
Closure Criteria for Municipal Solid Waste Landfills	Waste	40 CFR Part 258.60 (a)(1-3)	Establishes design for caps.	Applicable if material from bioreactors is relocated to alternate site
Hazardous Materials Transportation Act: Standards Applicable to Transport of Hazardous Materials	Waste	49 USC § 1801-1813 49 CFR Parts 10, 171-173 and 177	Requires placing, packaging, documentation for the movement of hazardous materials on public roadways.	Applicable if hazardous wastes are disposed of off site.
Resource Conservation and Recovery Act	Waste	40 CFR Part 261, Subpart D	Defines wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271	Applicable if hazardous wastes are disposed of off site.
Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act: Standards Applicable to Transporters of Hazardous Waste Standards for Owners and	Waste	42 USC 6901, et seq. 40 CFR Part 263, pursuant to 42 USC 6923 40 CFR Part 264, pursuant to 42 USC 6924, 6925	Establishes standards for persons transporting hazardous waste within the US if the transportation requires a manifest under 40 CFR Part 262. Defines general facility standards and acceptable management standards for owners and operators of facilities that treat, store, or dispose of hazardous waste.	Applicable if hazardous wastes are disposed of off site.

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities		40 CFR Part 265, pursuant to 42 USC 6936		
ACTION-SPECIFIC : STATE/LOCAL				
Idaho Solid Waste Management Rules	Waste	IDAPA 58.01.06.012-.013	Idaho regulations define the siting, design, operational, and closure requirements for solid waste management facilities. Tier II and Tier III facility include landfills for non-municipal solid wastes, with Tier III facilities generally for management of solid wastes where leachate or gas may be formed. These regulations explicitly do not apply to waste dumps. Tailings and other materials uniquely associated with mineral extraction, beneficiation or processing operation and are not applicable.	Tier II non-municipal solid waste landfill requirements are relevant and appropriate to the design, operation, and closure of mine waste rock piles and tailings impoundments. Sections of Tier III non-municipal solid waste landfill requirements may be relevant and appropriate to the design, operation, and closure of tailings impoundment and waste rock piles that include principal threat materials (e.g., metal concentrates).
Hazardous Waste Management Act of 1983	Waste	39-44, Idaho Code	The purpose of the act is to assure the safe and adequate management of hazardous wastes within the state of Idaho	Applicable if hazardous wastes are disposed of off site
Comprehensive State Water Plan Rules	Surface Water	Department of Water Resources; IDAPA 37.02.01	The purpose of these rules is to establish the procedures used by the Idaho Water Resource Board for designating a waterway as an interim protected river, adopting a comprehensive plan for a waterway, and providing adequate notice of any petitions filed or actions contemplated pursuant to the State Comprehensive Water Plan Act, 1988 Sess. Laws, ch. 370, p. 1090, codified as Sections 42-1730--1731 and 42-1734A--1734I, Idaho Code	Not applicable
Safety of Dams	Impoundments	42-1701 through 1721, Idaho Code and IDAPA 37.03.06	Regulates construction, enlargement, alteration, repair, maintenance, operation and removal of dams, reservoirs, mine tailings and impoundment structures including land and specification review and inspection.	Applicable
Stream Channel Alteration Rules	Surface Water, Fisheries	42-3801 through 3813, Idaho Code and IDAPA 37.03.07	Requires a permit or compliance with minimum stand for alteration of stream channel to protect fish and wildlife habitat, aquatic life, recreation, aesthetic beauty, or water quality. Authorizes the Board to adopt rules or set standards.	Applicable
Idaho Ground Water Quality Plan - Senate Bill 1269	Groundwater	Idaho Ground Water Quality Plan, December 1996	Presents Idaho's plan for protecting groundwater quality now and for future generations, with an emphasis on preventing groundwater contamination whenever possible, and provides agencies with direction to develop management programs and regulations and to implement groundwater quality protection strategies.	To be considered
Statistical Guidance for Determining Background Ground Water Quality and Degradation	Groundwater	State of Idaho, Division of Environmental Quality, March 2014.	Describes a process for DEQ to use when determining if groundwater quality is degraded.	To be considered

Standard, Requirement, Criteria, or Limitation	Medium	Citation	Description	Status
Idaho Non-Point Source Management Plan	Soil/Sediment	State of Idaho, Division of Environmental Quality, December 1999.	The plan requires activities to be consistent with the state's goal of restoration, maintenance, and protection of the beneficial uses of both surface water and groundwater. Long-term goals include design and implementation of BMPs for surface water and groundwater.	To be considered
Ground Water Quality Protection from storm water runoff	Groundwater	Idaho Department of Environmental Quality Policy Memorandum PM98-3. July 23.	The purpose is to clarify the Groundwater Quality Rule (IDAPA 16.01.11, 1997) implementation as it regards to the use of storm water management practices and methods for groundwater quality protection.	Applicable if action contains management of storm water to protect groundwater quality
Surface Water Ambient Monitoring Plan	Surface Water	State of Idaho, Division of Environmental Quality, Surface Water Ambient Monitoring Plan, Second Edition 2011-2020, January 2012.	Consists of a combination of random and targeted monitoring surveys to address statewide evaluation of Idaho's waters and support other surface water quality programs.	Applicable if action involves periodic surface water monitoring
Rules and Standards for Hazardous Waste	Waste	IDAPA 58.01.05	Identifies characteristic and listed hazardous waste including TCLP concentrations for metals.	Applicable if hazardous wastes are disposed of off site
Idaho Rules for Control of Fugitive Dust	Air	IDAPA 58.01.01.650-651	Requires reasonable precautions be taken to prevent particulate matter from becoming airborne, including using water or chemicals to control dust, covering trucks for transporting materials, and promptly removing excavated materials.	Applicable if action has the potential to create fugitive dust
Rules for the Control of Air Pollution in Idaho	Air	IDAPA 58.01.01.585-586	These regulations provide screening emission levels and acceptable ambient concentrations for designated noncarcinogens and for carcinogens. If a response action under CERCLA causes an emission exceeding the ACC, Best Available Control technology must be applied until the emission level falls below the AAC IDAPA 58.01.01.16.	Applicable if action has the potential to create air emissions

3.4 NON-TIME CRITICAL REMOVAL ACTION SCHEDULE

The BLM has determined that a non-time-critical removal action is appropriate at the Champagne Creek/Moran Tunnel Site. After completion of the EE/CA Report, BLM must complete an Action Memorandum. Following issuance of the Action Memorandum, BLM must secure congressional funding for the removal action. After receipt of funding, BLM will need to prepare a removal design and may need to contract the design implementation separately. A more detailed schedule can be developed once congressional funding has been secured.

4 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The goals and objectives of the NTCRA must be consistent with and supportive of BLM's remedial program goals and objectives.

4.1 STATUTORY AND POLICY CONSIDERATIONS

The following subsections summarize relevant statutes and policies identified and reviewed to help formulate the range of removal alternatives.

4.1.1 Statutory Considerations

The NCP (40 CFR 300.415(d)) provides that removal actions shall, to the extent practicable, contribute to the efficient performance of any anticipated long-term remedial action with respect to the release of concern. In addition, Section 121(b) of CERCLA expresses the preference for treatment over conventional containment or land disposal to address a principal threat at a site. This preference for treatment applies explicitly to remedial actions, but the overall strategy is also appropriate for removal actions.

Removal actions may satisfy goals and objectives by eliminating, reducing, or controlling risks and providing a basis for identifying specific removal technologies. Potentially applicable general response actions for a source control NTCRA may include the following:

- Implementing administrative measures to prevent, reduce, or control exposure;
- Removing contaminants to prevent, reduce, or control exposure or prevent a release; and
- Providing treatment to reduce the toxicity, mobility, or volume of contaminants.

The NCP (40 CFR 300.415 (e)) identifies appropriate removal actions that address risks to the public health or welfare, or the environment. Removal actions relevant to the Moran Tunnel portal site include, but are not limited to, the following:

1. Fences, warning signs, or other security or site control precautions - where humans or animals have access to waste sediments;
2. Drainage controls, (*e.g.*, run-off or run-on diversion), where needed, to reduce migration of hazardous substances, pollutants or contaminants off-site or to prevent precipitation or run-on from other sources (*e.g.*, flooding), from entering the release area from other areas;
3. Stabilization of berms, dikes, or impoundments or drainage/closing of lagoons, where needed, to maintain the integrity of the structures;
4. Capping of contaminated soils, where needed, to reduce migration of hazardous substances, pollutants, or contaminants into soil, ground, surface water, or air;
5. Using chemicals and other materials to retard the spread of the release or to mitigate its effects, where the use of such chemicals will reduce the spread of the release;
6. Excavation, consolidation, or removal of highly contaminated soils from drainage or other areas, where such actions will reduce the spread of or direct

contact with the contamination; and

7. Containment, treatment, or disposal of hazardous materials, where needed, to reduce the likelihood of human, animal, or food chain exposure.

4.1.2 Policy and Guidance Considerations

The principal guidance used for development of this EE/CA was the EPA guidance for NTCRAs: *Guidance for Conducting Non-Time-Critical Removal Actions under CERCLA* (EPA, 1993). The guidance document provides information and procedures/activities for performing NTCRAs.

4.2 EVALUATION OF OFF-SITE REPOSITORY

The existing one-acre off-site repository was created in 1999 when the passive treatment system was constructed. Originally the waste from the tunnel was stockpiled between the tunnel portal and Champagne Creek. This waste (~ 20,000 cy) was excavated and moved to the repository to minimize future impacts. The repository has a crushed limestone base and a 4-inch compacted bentonite cover with an 18-inch layer of topsoil. In 2012, about 200 cy of sludge from Pond 1 was added to the repository.

The repository could be expanded, if necessary, to receive wastes associated with the removal action alternatives considered in subsequent sections. For example, a new eight-foot lift of material would accommodate about 10,300 cubic yards of volume. It is assumed that the side slopes of the repository have an angle of 3 horizontal to 1 vertical (3H:1V) and the existing soil layer covering the repository would be salvaged and replaced after the new material is added. The bentonite cover would be replicated as well over the new eight-foot lift. The top area footprint of the repository would decrease to about 0.5 acres. Additional capacity could be gained if the southwest face of the repository were extended further to the southwest (down valley).

However, the volume of waste varies with the proposed alternative. For example, Alternative 2 would require the initial disposal of about 200 cy of metal precipitate and spent substrate in Pond 2 and 1,500 cy of metal precipitate per settling pond cleanout (3,000 cy total) every seven years. The repository would receive the spent contents of the BCR (400 cy) every 20 years.

Alternatives 3 and 4 would require the disposal of the BCR substrate (about 400 cy) in about 20 years and every 20 years thereafter. The existing contents of Pond 2 would be put to beneficial use as “seed” material in the Aluminum Terrace (see discussion in Section 5.1.5, below). Assuming an aluminum and iron oxyhydroxide accumulation rate of 1 inch per year (in the first 50% of the terrace) and a cleanout event when the metal precipitates there reach a thickness of 1.5 feet, the Aluminum Terrace would generate about 230 cy of sediment every 20 years. A conservative estimate of 300 cy is assumed.

Some portions of the precipitated material are likely to contain arsenic adsorbed to the iron oxyhydroxide, necessitating disposal in the repository. Other materials may be relatively metals-free and could be disposed of at a sanitary landfill.

In summary, the remaining capacity of the existing off-site repository appears to be sufficient to accept wastes for many decades before a new repository would be required.

4.3 IDENTIFICATION AND ASSESSMENT OF RESPONSE TECHNOLOGIES

Note that there is a substantial amount of iron, manganese and probably acidity stored in

the Champagne Creek sediments that has accumulated over the decades of discharges at the site. Meeting RAOs for this project will improve water quality in the surface water and groundwater downgradient of the site gradually. Removal alternatives must avoid reversing the beneficial effects of natural attenuation. For example, a treatment process that establishes a geochemically reducing zone could mobilize heavy metals suspected to be sequestered in the Champagne Creek alluvium.

Also, it may be difficult to overcome equilibrium shifts that would inevitably occur if relatively clean, treated water is re-introduced into the creek where metals are adsorbed to sediments. There may be a tendency for metals to re-dissolve until a new equilibrium condition is established. This could take decades to occur and ARARs would not be met beyond the mixing zone where treated Tunnel water is returned to Champagne Creek.

As a natural attenuation mechanism appears to have been present perhaps for decades (See Section 2.4.3), the simple diversion of Tunnel drainage (assumed to be through a buried pipeline or open channel) to any kind of treatment system may induce the same effect as if treated water were re-introduced into sediments that had been a metals "sink" during the attenuation process. That is, previously-deposited/attenuated metals could re-dissolve until the Champagne Creek sediments reach a new equilibrium condition in concert with the relatively cleaner pore water surrounding them.

Optimistically, the re-dissolved metals would only travel a short distance before encountering sediments and equilibrium conditions that favored re-deposition. Due to the complexity of the site, it is impossible to project if or when this could happen. However, if the effluent from a passive treatment system is oxidizing and contains excess alkalinity, re-dissolved metals would likely re-precipitate when they encounter this treated water.

The conclusions in the Hedin Report (2005) provide a solid foundation for eliminating in-situ *treatment* systems from further consideration. Hedin did not, however, consider *in-situ* source control technologies which are discussed in more detail in Section 4.3.3.1, below.

Within this restrictive context, the broad categories of potential removal action technologies include:

- Institutional Controls
- Enhanced Natural Attenuation
- Source Control
  - Surface Water Control (in the South Pit)
  - Underground Biological Controls (e.g., in the Last Chance Mine and/or stopes in the Moran Tunnel itself)
- Management of AMD, and
- Treatment of AMD
  - Active/Hybrid Treatment
  - Passive Treatment

4.3.1 Institutional Controls

Institutional controls include administrative land use restrictions, site access restrictions (such as signage and/or fencing), and/or relocation of potential receptors to attempt to minimize the potential for exposure to site contamination. Informational signage could

warn of potential hazards associated with abandoned mines and AMD, and could provide educational insights into natural attenuation processes that could become a part of a removal action alternative. Due to potential vandalism, signs must be inspected periodically. While institutional controls do not actively address the Moran Tunnel effluents, they can attempt to meet the RAOs by reducing the potential for human and ecological exposure to the waste. Institutional controls (*e.g.*, warning and/or educational signage) are retained as a removal action technology.

4.3.2 Enhanced Natural Attentuation

Enhanced natural attenuation may include reduction of vegetation overstory to allow better algal production, reconfiguring of existing stream channels with natural barriers/controls such as anchoring large tree trunks, chipping and shredding of timber slash from the site and distributing it upstream of natural barriers to create a terrace-like terrain in the stream bed and the importation, and placement of wood chips as a substitute or as a supplement to the timber slash produced from the site.

The addition of slash and wood chips is intended to reduce ferric iron [Fe^{+3}] to ferrous iron [Fe^{+2}], similar to the primary process in "traditional" vertical flow ponds (VFPs) that have been typically used in coal mine passive treatment systems in the Eastern USA. VFPs are designed to add alkalinity to AMD; they are lined excavations filled with a lower layer of crushed limestone (the alkalinity source) covered by a layer of organic matter (such as mushroom compost or whatever is locally plentiful). Ferric iron would armor the limestone but ferrous iron does not. The organic layer creates reducing conditions that transform the ferric iron to ferrous and thus prevent the limestone's armoring. In the case of Champagne Creek, the limestone is not deemed necessary due to other natural attenuation processes.

This process is already present at the site and the addition of more organic matter should enhance the situation further. When the ferrous iron oxidizes to ferric, hydrogen ions are consumed and the pH rises. This is the foundation of the iron removal mechanisms in iron terraces and is also a suspected mechanism in the formation of aluminum terraces.

Eliminating the vegetation over story would increase the amount of sunshine on algal zones; this easily-maintainable situation should encourage greater algal productivity and aluminum precipitation.

Adding additional zones of organic matter in losing portions of Champagne Creek that are typically dry could be beneficial. During high creek flows in the spring, these zones would become submerged and would also be configured to receive by-passed portal AMD. This design feature increases the flexibility of implementing the enhanced natural attenuation technology as it allows maintenance crews to accomplish meaningful work almost any time of the year.

Enhanced natural attenuation is appropriate for the Secondary Seep because this process is already established at the site. A minor amount of natural attenuation of Moran Tunnel AMD occurs in the portal area and it does not appear that enhancing it is practical. However, a minor amount of portal AMD attenuation may occur in the losing segment of Champagne Creek upstream of the upwelling zone near the beaver dam. This technology is therefore included in combination with other technologies.

4.3.3 Management of AMD

AMD management technologies may be categorized by source control or physical management. Source control means stopping or limiting the chemical reactions that

cause AMD (**Figure 4-1**). AMD management technologies work to eliminate or reduce AMD flow rates leaving the site through the underground placement of bulkheads, hydraulic controls, and grouting. Physical management methods do not require treatment of AMD, either at the surface or in the subsurface.

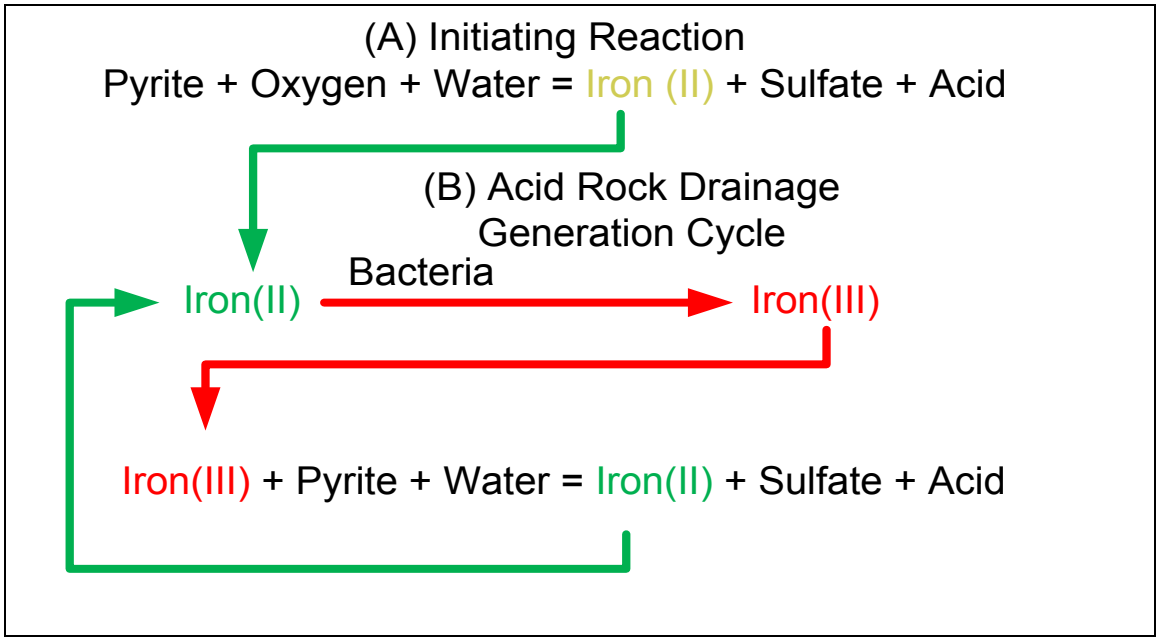


Figure 4-1: Acid Mine Drainage Generation Cycle

4.3.3.1 Source Control

Current state-of-the-art source control for AMD involves removing water and/or oxygen from the AMD chemical reaction. In addition, as the kinetics of AMD generation are primarily driven by bacterial activity, biotic suppression of AMD is a potential source control method (Olsen et al., 2006). AMD source control methods may be applied at the surface or underground within the mine workings.

Surface water run-on controls or storm water management structures include drainage channels, ditches, dams, trenches, grouting mine water infiltration areas, and other structures designed to prevent otherwise *uncontaminated* surface water from contacting the mine workings and mine wastes. By doing so, chemical reactions of water with acid producing minerals, erosion of contaminated surfaces, and subsequent off site transport of contamination via surface water or groundwater pathways is reduced. However, these controls do not address direct on site exposure of contaminants to human or ecological targets, nor the off-site transport via other exposure pathways, particularly the air pathways.

Underground controls include bulkheads that impound discharge within the mine workings thereby submerging the AMD-prone rocks and cutting off the oxygen supply; grouting to seal off groundwater flow into mine workings; adding neutralizing agents to impounded mine water (discussed in greater detail below); adding or applying bactericides to exposed mine wastes or pyrite-bearing wall rocks; and separating clean and contaminated mine inflows to minimize the volume of contaminated waters. The effectiveness of these methods is site-specific and depend on favorable mine geology and access to the underground mine workings. Bulkheading and mine flooding must be essentially permanent to be effective as an AMD source control method.

Rapid flooding of the mine workings with net alkaline water (pH of 7 or above) after bulkheads are installed may further reduce AMD generation. When successful, this measure yields several positive benefits. First, the alkaline water neutralizes residual AMD in the mine workings. It may suppress the pyrite oxidation process by eliminating ferric iron (whose presence can exacerbate AMD production) and raising the pH of the water to a level that suppresses pyrite-oxidizing bacterial activity. The submergence of pyrite-bearing rocks can cut off the oxygen supply required for pyrite-oxidizing bacterial activity. Lastly, by introducing net alkaline water (presumably using powdered limestone), the density of the water adjacent to the bulkhead would be similar to that in the upper zone of the mine pool and stratification may be suppressed.

Inundating the Moran Tunnel and Last Chance Mine with bulkheads is not practical due the near proximity of the South Pit. Most certainly, impounded water under static pressure would follow fractures and joints in the rock mass and a number of uncontrolled seeps would likely form in the walls and/or floor of the South Pit. Implementing this form of AMD source control is not feasible and it is eliminated from further consideration.

Injecting a combination of foamed bactericide mixed with powdered limestone into the Last Chance workings as per the emerging technology described by Gusek, et al. (2012) may provide an unknown improvement in the chemistry at the Moran Tunnel portal. This action would probably not suppress AMD generation in the stopes immediately above the Moran Tunnel (see map). Consequently, this primary effort would be followed by a similar effort initiated from the Moran Tunnel portal itself.

The magnitude of chemistry improvements in the Moran Tunnel and Secondary Seep that may be achieved using this emerging technology is unknown. While the concept may be feasible elsewhere, this uncertainty eliminates this technology from further consideration.

4.3.3.2 Physical Management of AMD

AMD management technologies are implemented within the underground workings and rely primarily on placement of bulkheads or hydraulic controls which redirect the flow of water. Bulkheads, with and without grouting, accomplish physical AMD management by acting as a plug to prevent discharge of drainage waters. Water tends to back up behind the bulkhead and rise to pre-existing natural levels in the subsurface.

The flooded mine workings are referred to as the “mine pool.” Water may be confined in the mine pool or, depending on the existence of faults, fractures and other directly-connected mine openings, water may seep out of these other geologic structures and mine openings in adjacent workings not directly connected to the primary site. Depending on conditions, this water may or may not be contaminated with AMD (*e.g*. by excluding oxygen, the formation of AMD is reduced [see Section 4.3.3.1, above] and the combined benefit of source control might be derived).

Regardless, the formation of a mine pool would probably decrease the size of the "cone of depression" or the "trough

of depression" which would prevent groundwater movement through the mined-out zones that are the sources of AMD (**Figure 4-2**). Ideally, physical AMD management actions would re-create "pre-mining" hydrogeological conditions. To properly accomplish this, multiple bulkheads may be required.

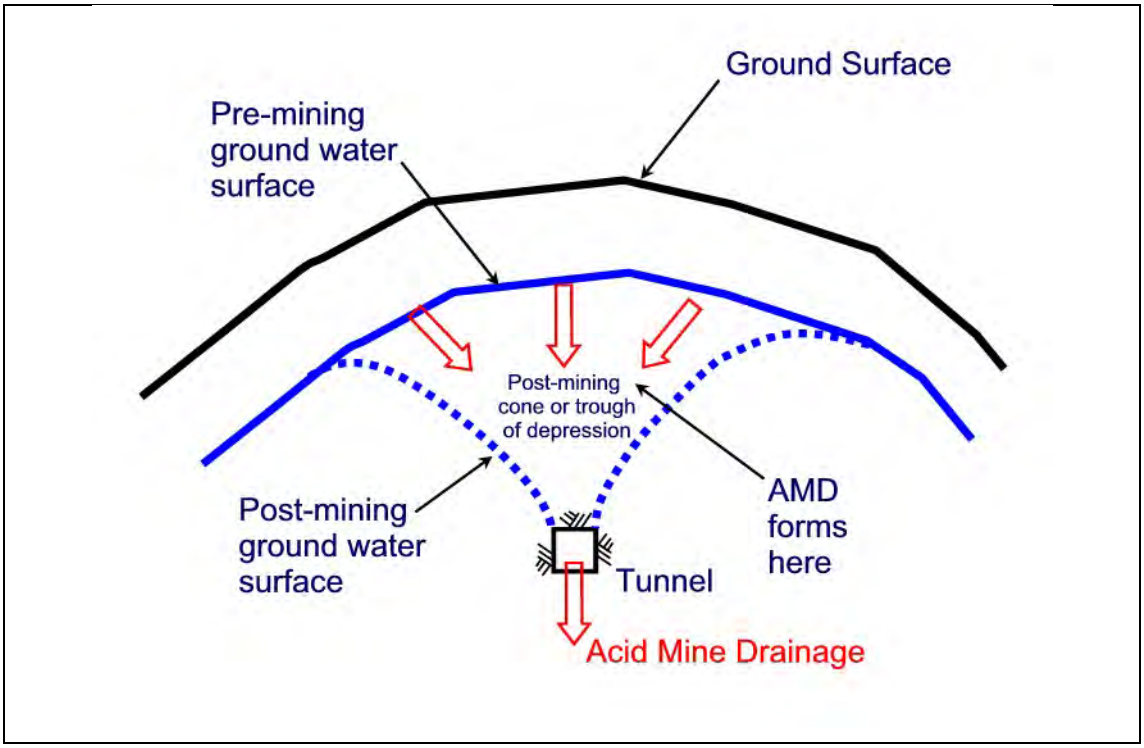


Figure 4-2: Pre- and Post-Mining Groundwater Conditions

Hydraulic controls may be used to segregate clean water in the mine workings from AMD water. Clean water can be collected and discharged separately from the AMD, thus reducing the amount of water that needs to be treated.

Once the mine pool forms, any AMD generated in the upper portion of the mine pool tends to migrate (through small differences in water density) to the bottom of the mine pool where the bulkhead would be installed. This mine pool "stratification" process may take several years to complete. No bulkhead system is totally efficient at controlling mine seepage; minor leakage around the bulkhead through natural factures may occur. In practice, fracture grouting in the vicinity of the bulkhead can limit seepage but not eliminate it.

Due to the proximity of the Moran Tunnel to South Pit surface workings and the poor ground conditions (caving, *etc*.) in the Tunnel, physical management of AMD alternatives are not considered further.

4.3.4 Treatment of AMD

AMD treatment technologies can be either "active" or "passive" and may include the use of both technologies together as a hybrid treatment.

4.3.4.1 Active Treatment

Active systems use machinery, pumps, reagents, power, buildings and operators, while passive systems use none of the above, blend into the landscape and do not require as much maintenance. The addition of acid-neutralizing lime is typically implemented in an active treatment system, although some acid neutralizing reagent delivery systems operate without power and only require periodic reagent re-supply (*e.g.* the Aquafix™ and Wheeltreater™ "semi-active" technologies).

Active systems can consume large quantities of neutralizing reagents on a continuous basis and produce a sludge waste stream.

Because of close management controls (*e.g.*, on-site personnel and extensive process instrumentation), conventional active treatment systems can typically meet water quality standards.

Active treatment as defined above is extremely sensitive to the availability of at least several feet of gravity/hydraulic head to drive the water wheel. The Moran Tunnel and available topography adjacent to the tunnel portal allow this, so this technology is retained for inclusion in a removal action; however, this technology is not appropriate for addressing secondary seepage at the site. The Secondary Seep is expressed as a spring on the bank or in the channel bed of Champagne Creek (see **Figure 2-5**). There is inadequate hydraulic head to capture without extensive excavation with no guarantee of success, so active treatment of secondary seepage with water wheel-driven units is not considered further.

As the active technology is a critical step in hybrid treatments, hybrid methods are not practical for the Secondary Seep and are also eliminated from further consideration.

4.3.4.2 Passive Treatment

Passive systems may include the use of open limestone channels (OLCs), anaerobic bioreactors using sulfate reducing bacteria (*i.e.,* biochemical reactors or BCRs), vertical flow ponds (VFPs), anoxic limestone drains (ALDs), aerobic polishing wetlands (APWs), and combinations of these general types of systems. Passive treatment systems may not achieve the same level of treatment as an active system on a continuous basis, particularly in systems which are poorly designed (*e.g.*, bench and/or pilot test data are lacking) or poorly maintained. While passive treatment may be considered a low-maintenance technology, it is not a "no-maintenance" technology.

However, the aluminum terrace concept, which appears to be a natural tendency for the site's AMD, is retained as a potential process in passive treatment system designs. However, an aluminum terrace at this site should be considered an innovative and unique process that has not been implemented elsewhere. The "volunteer" aluminum deposits at the site are not configured in a manner that allows an easy understanding of the design parameters required to replicate/mimic them on a larger scale in an engineered passive treatment system. Pilot scale testing in advance of detailed engineering design is required.

Passive system media (in some process components) is continuously but slowly consumed, and typically is designed to be replaced on a 20 to 30 year schedule. The depleted media will contain the metals removed from the AMD in solid form. However, the volume of residue from a passive system should be less than the volume of sludge that would have been generated if an active treatment technology had been implemented. This would be expected due to metal precipitate density differences and water contents of residues from the two processes.

The passive treatment technology is not appropriate for addressing the secondary seepage at the site. Collecting AMD from the Secondary Seep and diverting it to a fully passive treatment system would be difficult. First, as evidenced by the deposition of iron oxyhydroxide at the seep, the chemistry of the Secondary Seepage is prone to cause plugging in pipelines; conveying the AMD to an alternative site downstream would pose a significant maintenance burden. Second, there is insufficient space immediately adjacent to the Secondary Seep to accommodate a passive treatment system (PTS) without encroaching into the floodplain of Champagne Creek. The passive treatment technology is not considered appropriate for the Secondary Seep AMD and it is excluded from further consideration. Some passive treatment components are prone to plugging or armoring when the AMD contains even small amounts of aluminum. These are OLCs and ALDs and others. Because the Moran Tunnel AMD contains elevated aluminum, these process components are not considered further.

5 REMOVAL ACTION ALTERNATIVES

Previous studies indicate that the Moran Tunnel and Secondary Seep discharges represent the primary sources of metals loading and acidity to Champagne Creek. The Champagne Creek alluvium has also been shown to serve as an important sink for metals year-round, achieving sequestration through natural attenuation processes that are believed common, but also complex and not well understood. The longevity of this presumed attenuation is also not well known. Integrating the technologies selected in Section 4 into removal action alternatives must preserve the existing metals-attenuated deposits in the Champagne Creek alluvium, improve the pH, and remove the COCs in the AMD.

This section presents and evaluates potential removal alternatives for the AMD discharges from both the Moran Tunnel and the Secondary Seep which, though similar, involve different physical and chemical properties that require independent consideration. To adequately consider the complexity of the site, the potential to leverage and extend existing natural attenuation processes, and the unique properties of the two discharges, the retained technologies were first evaluated in terms of the individual AMD source(s) they were retained to address (Section 5.1). In some cases, this evaluation included a conceptual design and assumptions regarding design details. Following this assessment, technologies were combined, where appropriate, into site-wide removal action alternatives (Section 5.2). In Section 5.3, removal action alternatives were then individually evaluated for effectiveness, implementability, and cost both in terms of their independent component technologies/designs and as complete removal alternatives.

5.1 RETAINED TECHNOLOGY ASSESSMENTS

In some cases, technologies described in Section 4 where not applicable to both the Moran Tunnel discharge and the Secondary Seep, and in no case was a single technology applicable as a complete removal alternative. This section further details the potential application of the retained technologies at the site including the AMD discharge(s) to which they apply and a discussion of the application strategy. Where chemical treatment or related processes are involved, a conceptual design is presented including a discussion of assumptions, advantages, limitations, and data gaps involved with implementing the technology, as applicable.

5.1.1 Institutional Controls (Moran Tunnel & Secondary Seep)

Institutional controls in the form of signage would apply to both the Moran Tunnel and the Secondary Seep discharge and would be combined with other technologies as part of a removal action alternative. In application, institutional controls are assumed to include five informational/educational signs installed at the following locations with content depending on the final alternative chosen:

- At the entrance to BLM-controlled land near the confluence of Champagne Creek and Poison Gulch (warning about AMD toxicity),
- At the locked gate at the fenced tunnel portal area (warning about AMD toxicity, corrosion hazards with active treatment, and possible educational information about aluminum terrace passive treatment),
- At the portal itself (assumes trespassers did not see the warning sign at the gate),
- At the BCR– educational information about the BCR treatment process, and

- At the beaver pond area (up-welling), educational information discussing natural attenuation.

5.1.2 Enhanced natural attentuation (Secondary seep)

Enhanced natural attenuation would apply to the Secondary Seep discharge (**Figure 5-1**). There are four suspected natural attenuation processes at the Champagne Creek site to consider:

a) Algal precipitation of aluminum in terraces,

b) Iron terrace deposition in concert with or independent of aluminum terraces (iron terraces effectively sequester arsenic),

c) Feldspathic alteration to clay (raises the pH) in Champagne Creek sediments, and

d) Adsorption of metals (*e.g.*, arsenic, copper, lead, zinc, cadmium, cobalt, chromium) to manganese oxide.

Enhancing process technologies a and b (algal aluminum terraces and iron terraces, respectively) are potentially implementable for the Secondary Seep without disrupting existing conditions and form the process basis for this technology application.

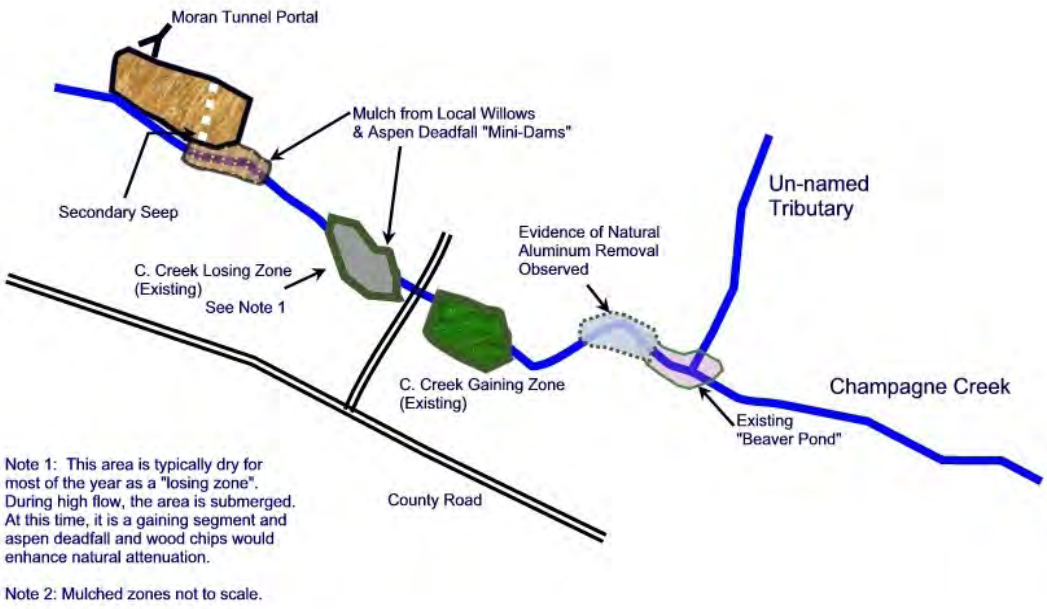


Figure 5-1: Secondary Seepage Enhanced Natural Attenuation

Implementing enhanced natural attenuation would involve positioning downed trees perpendicular to the creek flow direction and placing chipped slash on the up-gradient side. The chipped zone will be field-fit, depending on the extent of iron staining, indications of high water marks along the creek banks, the volume of chipped slash, or wood chip

availability from off-site sources. Straw or other locally-sourced agricultural wastes may also be used. Algae from other parts of the site may be harvested and placed on the chips/slash to facilitate colonization.

5.1.3 Physical AMD Management (Moran Tunnel & Secondary Seep)

Installing an impermeable cap over a potential AMD infiltration zone in the South Pit could significantly reduce metals loading and/or flow at both the Moran Tunnel and the Secondary Seep. It is uncertain if this technology would divert all the AMD presumed infiltrating at the South Pit or just a portion of it. Additional study would be needed to verify the effectiveness of this technology to reduce flow and/or metals loading in the Moran Tunnel and/or the Secondary Seep.

The conceptual AMD diversion design includes:

- Backfilling a depression/small basin on a bench on the north side of the South Pit so that it slopes to drain toward the floor of the pit,
- Installing a 60 mil (0.060-inch) linear low-density polyethylene (LLDPE) geomembrane sandwiched between two cushioning/protective layers of 12 ounce per square yard (oz/yd^2) geotextile,
- Covering the geomembrane with 18 inches of plant growth medium and re-vegetating,
- Installing 315 linear feet of a riprap-lined diversion channel (2 feet bottom width) adjacent to the pit walls that would drain diverted acidic runoff to the wood chip covered pit floor.

5.1.4 Active/Passive (Hybrid) Treatment (Moran Tunnel)

Hybrid AMD treatment combines the best aspects of active treatment technology (small system footprints) for acidity management (raising the pH to circumneutral and precipitating aluminum and iron as hydroxides) and passive treatment (precipitating heavy metals such as copper, lead, zinc, cadmium, and cobalt as sulfides in a BCR without additional chemical reagents or pH change).

Hybrid treatment would be applicable only to the Moran Tunnel discharge. To implement this technology, an active, water-powered reagent delivery/dosing unit would be installed down-gradient of the (Moran Tunnel) portal to treat the discharge near its source. Existing ponds would be retrofitted to settle and temporarily store the precipitated aluminum and iron solids in sludge form.

The neutral pH effluent (virtually iron and aluminum free) from the settling ponds would be treated in a BCR, likely located downstream near the confluence of Champagne Creek and the un-named tributary. The BCR effluent would then be discharged through an unlined aerobic polishing channel (APC) that would be aligned with the main channel of Champagne Creek. The APC would be within the flood plain and could be submerged during high flows. A sketch of this conceptual layout is provided in **Figure 5-2.**

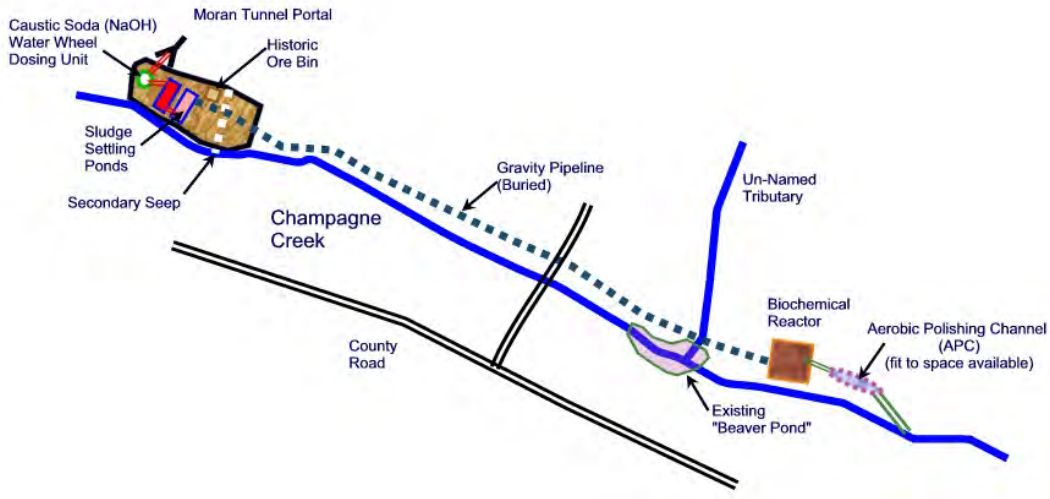


Figure 5-2: Hybrid Treatment Technology Schematic Layout

Three types of chemicals were considered for the active reagent dosing system:

1) pebble lime (calcium oxide),
2) caustic soda (NaOH),
3) MBS (a proprietary product that was tested by Dr. Martin Foote).

For this conceptual level design, caustic soda was assumed for cost estimating purposes. This was because intermittent to zero flows are problematic for pebble lime dosing units; the screw feeder tends to seize if the pebble lime cakes during periods of inactivity. Moran Tunnel flows can drop to near-zero for prolonged periods (BLM, 2014).

The dosing unit (a water-wheel driven peristaltic pump) would be sized for the specific AMD chemistry and 3.6 gpm average flow from the portal. It would dispense caustic soda into the discharge flow which would then be directed to settling ponds for the precipitated metals to settle out. The primary purpose of the pH adjustment is to remove the bulk of the acidity (contributed by the iron and aluminum) so that the size of the BCR can be reduced. Raising the pH to approximately 4 will remove most of the iron and increasing it to approximately 5 will remove most of the aluminum. Arsenic and copper are likely to co-precipitate with the iron and aluminum solids. Sulfate will not be affected.

Caustic soda freezing will be a design issue. The tank will need to be buried and well insulated to mitigate against anticipated extended periods of wintry weather.

The sludge settling ponds (the beginning of the passive portion of the treatment technology) were sized for a retention time of 24 hours after allowing for five year accumulation of sludge volume. The ponds will accumulate sludge that will eventually be removed and properly disposed. This clean out event can be accomplished through by-passing half of the ponds for a summer, and drying the sludge for excavation and hauling it to a repository. A clean out event is anticipated to be needed every five years.

Following settlement, the effluent will require transport to the BCR. Due to severe winter conditions inherent to the site, open channel flow delivery would likely approach ambient outside temperatures and the channel would freeze solid. Bulky insulation could impact aesthetics, be susceptible to damage from wildlife, and could consume much of the

channel's right of way. Considering these complications, transport of pond effluent to the BCR was assumed to require construction of a buried pipeline.

While a buried pipeline resolves the winter-related issues, it creates the potential for plugging (primarily by iron and aluminum) and related maintenance issues. By design however, the AMD constituents most likely to cause pipeline plugging would be removed in the settling ponds. Nonetheless, delivering neutral pH, clarified iron- and aluminum-free settling pond effluent to the BCR via buried pipeline may not be able to avoid plugging issues as some constituents may be near saturation. For this reason, the pipeline would be fitted with cleanouts to allow periodic removal of metals accumulation including an assumed potential for non-iron, non-aluminum scale. Cleanout events every decade are assumed. Additional design testing would be necessary to verify these assumptions and evaluate whether plugging would be a significant maintenance issue.

The size of the BCR required (discussed below) would be about the same size as the passive treatment BCR (discussed in Section 5.1.5) because the majority of the metals load is removed with the caustic soda and aluminum/iron terrace components, respectively. The BCR effluent would be further treated in an APC. Manganese would not be treated; its natural attenuation would be expected in the Champagne Creek sediments.

The design chemistry and flow rates for this technology are provided in **Table 5-1**. Note that some water is expected to be retained in the post-caustic dosing sludge and/or lost to evapotranspiration (especially during the hot summer months), so the average flow rates to be treated in the BCR will be slightly lower than those measured at the portal.

Table 5-1: Assumed Moran Tunnel Chemistry for Hybrid Conceptual Design

Parameter	Moran Tunnel	Post-NaOH Dosing
Peak Flow	7 gpm	6.8 gpm
Steady State Flow	3.6 gpm	3.4 gpm
pH (s.u.)	3.15	6.5
Aluminum (mg/L)	529	<1
Arsenic (mg/L)	0.28	0
Iron (mg/L)	1320	<1
Copper (mg/L)	194	80
Cadmium (mg/L)	1.09	1
Cobalt (mg/L)	2.7	2.7
Chromium (mg/L)	0.41	0.3
Nickel (mg/L)	2.2	2.6
Manganese (mg/L)	44	44
Lead (mg/L)	0.45	0.45
Sulfate (mg/L)	4,565	4,560
Zinc (mg/L)	83	85

Concentrations for most constituents at Moran Tunnel are based on the average values

from 1995-2014.

Component Design Assumptions

Implementing this technology would require:

- A water-wheel driven peristaltic pump installed in an insulated concrete vault,
- Seven interconnected and buried 2,000 gallon plastic tanks filled with 20% caustic soda which would be refilled every four months,
- Two LLDPE-lined settling ponds (1.2 acres total footprint) with individual HRTs of 24 hours each, allowing for seven years of sludge storage,
- A 1,300 ft. long buried four-inch diameter pipeline from the settling ponds to a BCR located near the beaver pond; the pipeline would be fitted with cleanouts every 100 feet,
- A BCR filled with 400 cy of an organic media/substrate, and
- A 300 ft. long by 2 ft. wide (600 ft^2) unlined aerobic polishing channel (APC) filled with locally-harvested willow cuttings.

Water Wheel Dosing Unit

The water wheel driven peristaltic pump will be used to dose the AMD with caustic soda. The unit would be installed in a concrete vault to protect it from precipitation and freeze events. The dosing unit design includes:

- Installing the water-wheel peristaltic pump in a small concrete vault,
- A chain of polyethylene tanks with a total volume of 12,500 gallons for storing the 20% caustic soda solution to be dosed. Tanks will be buried at least to the frost depth of 4 feet, and
- An estimated dosing of 49,100 gallons of 20% caustic soda per year.

Settling Ponds

Two settling ponds with 24 hour retention times will collect solids before the AMD is conveyed to the BCR. The design includes:

- Excavating two 1,550 cy ponds,
- Lining the ponds with a combined 4,000 yd^2 of 60 mil LLDPE geomembrane liner,
- Dredging and disposing of sludge, generated at approximately 200 cy per year per pond at 5% solids, every two years, and
- Cleanouts would be accomplished with commercial vacuum trucks used to clean septic tanks or with a small floating suction dredge that would discharge the sludge to geotextile fabric tubes contained in standard roll-off dumpsters. Over the span of several months, the iron precipitates consolidate and create room for additional solids. Synthetic polymers can be used to facilitate the process by increasing the density of the solids.

BCR Cell

The BCR will be buried and covered to protect it from extreme rainfall and snowmelt events. The BCR top footprint will be approximately 117 ft. by 117 ft. (including berms) and about 6.2 ft. deep. The BCR substrate will consist of woodchips, hay, sawdust, and manure. The standing water level in the BCR will be adjustable using an inline water level control unit (WLCU). This design feature can be procured from Agridrain, Inc. (www.agridrain.com). The BCR design includes:

- BCR cell excavation,
- Installing a 60 mil LLDPE geomembrane sandwiched between two layers of 12 oz/yd^2 geotextile,
- Installation of the drainage layer, substrate, and BCR cover, and
- Installing the water level control unit.

APC

A 300 ft. long and 2 ft. wide (600 ft^2) unlined aerobic polishing channel (APC) filled with locally-harvested willow cuttings. The design includes:

- Channel excavation,
- Channel filling with top soil, and
- Harvesting of willow cutting and planting them in the channel.

The goal of this process feature is to re-aerate the anoxic effluent from the BCR. As previously discussed, infiltrating BCR effluent directly into the Champagne Creek sediments has the potential to remobilize (at least temporarily) some metals that may be adsorbed to manganese oxide, one of the natural attenuation processes suspected to be present on site. The willows will facilitate this during the growing season and natural algae should do the same (even through ice or snow cover) during the winter months.

Technology Summary

There appears to be adequate hydraulic head for a water wheel driven dosing unit at the Tunnel portal. There is sufficient area for implementation of the caustic soda dosing and settling pond portion of this technology in the vicinity of the Tunnel portal.

A BCR, located near the Beaver Pond, but out of the flood plain, would remove remaining heavy metals. The manganese levels in the BCR influent would remain unchanged in the BCR effluent. Minor BCR effluent polishing would occur in an unlined aerobic polishing channel (APC) which would return the final PTS effluent to Champagne Creek where additional manganese oxide deposition (a natural attenuation process presumed to be present) would occur.

This technology does not conflict with the processes included in the Enhancement of Natural Attenuation technology.

5.1.5 Passive Treatment (Moran Tunnel)

Passive treatment is applicable only to the Moran Tunnel discharge. This technology involves an aluminum/iron terrace, a limestone-free vertical flow pond, a BCR, and an aerobic polishing channel (APC). Brief discussions of these passive processes follow.

The aluminum and iron terrace concept (0.18 acres) uses the available space the most efficiently. The terrace portion of this technology was conservatively sized on an initial iron and aluminum removal rate of 34 gdm^2 with the removal rate dropping to 50% of this value for every 50% drop in aluminum or iron concentration. For example, a 34 gdm^2 value at 620 aluminum mg/L would drop to 17 gdm^2 when the aluminum concentration approaches 310 mg/L and the removal rate would drop to 8.5 gdm^2 when the aluminum concentration dropped to 155 mg/L, and so on. Actual gdm^2 values in final design would be based on bench or pilot test results.

The VFP technology background was provided in Section 4.3.4.2. The purpose of the VFP is to convert any remaining ferric iron [Fe^{+3}] to ferrous iron [Fe^{+2}] (*without* raising the pH of the AMD) to avoid pipeline scaling. To recap, a VFP is a geomembrane lined pond filled with a layer of crushed limestone on the bottom that is covered with a layer of organic matter (typically mushroom compost). Because of the elevated aluminum levels in the Moran Tunnel AMD discharge, the limestone component of a "standard" VFP has been eliminated due to the potential for plugging.

The limestone-free VFP for converting ferric iron to ferrous is sized for a hydraulic retention time (HRT) of 32 hours; this is double the HRT for a typical VFP. Actual design HRT should be based on laboratory testing results.

The BCR technology was demonstrated on a bench scale at a nearby passive treatment project, with AMD that is similar to the Moran Tunnel. This suggests that a BCR could accept raw Moran Tunnel AMD directly as well. However, there is insufficient area in the vicinity of the Moran Tunnel portal to construct a properly-sized BCR for the anticipated loading and certainly not enough area for an accompanying APC.

For comparison, a BCR accepting raw AMD would require 6,200 cy of organic substrate and cover 2 acres compared to 400 cy of substrate and 0.3 acres required for this BCR which is sized to receive AMD that is relatively free of iron and aluminum.

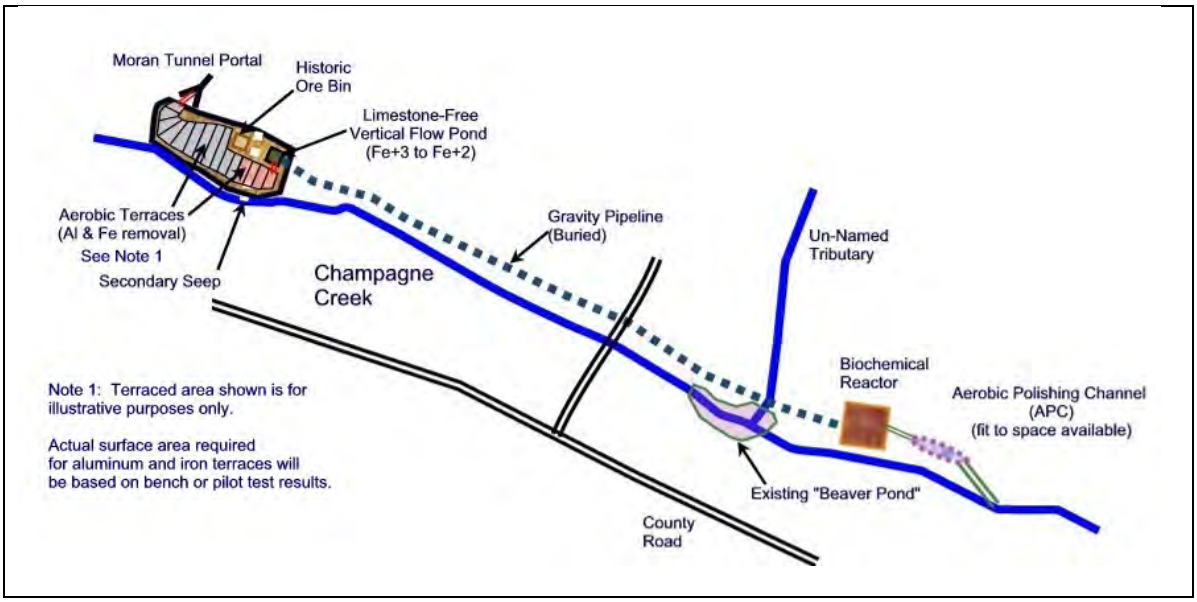


Figure 5-3: Passive Treatment Technology Schematic Layout

The primary differences between the hybrid and full passive treatment technologies are the absence/presence of the caustic dosing unit and the settling ponds and aluminum/iron terraces, respectively. The sizes of the BCRs are similar, but not identical. While the effluent from the aluminum and iron terrace will be designed to be low in aluminum and iron (95% to 100% removal of iron), the pH is expected to be about 3.5.

The size of the BCR will be somewhat sensitive to the assumed iron removal efficiency of the aluminum terrace. If it is assumed that 95% of the iron were removed, the final iron concentration of water delivered to the BCR would be about 66 mg/L. If 100% of the iron were assumed removed, the BCR footprint would be about 0.31 acres; at 95% iron removal efficiency, the BCR footprint would increase to about 0.36 acres, or about 2,200 square feet larger. Under the 95% assumption, there is adequate space for the BCR near the beaver pond site.

The industry standard BCR typically consists of a below-ground level lined cell that is filled with a media/substrate mixture of crushed limestone and organic matter (e.g. wood chips, spoiled hay, sawdust, manure, *etc.*). Ponded water on the surface of the BCR distributes the AMD water evenly across the top of the cell. The AMD is treated as it flows vertically toward a drainage layer comprised of inert gravel and perforated plastic pipes. BCRs operate on the principle that cellulose and hemi-cellulose degrading bacteria break down the wood chips and other organic materials into soluble organic compounds that sulfate reducing bacteria use to reduce the sulfate to sulfide in an anaerobic environment. These conditions precipitate metals and neutralize acidity. Limestone dissolution also contributes to acidity neutralization.

BCR design criteria developed in the last decade predominantly by Gusek and Wildeman has expanded on the initial BOM research work (Gusek, 2002, 2004, 2005). The required volume of organic/limestone media required is based on a loading factor of 0.3 moles of metal loading per day per cubic meter of media. The bottom area of the BCR is governed by acidity loading; the higher the mineral acidity the larger the area. The BOM acidity loading criteria (50 gdm^2) is not as conservative as that typically assumed by Gusek and Wildeman but it would be refined to a site-specific value typically based on bench or pilot scale testing. For initial design sizing, a value of about 25 gdm^2 is appropriate. Passive technology design chemistry and flow rates are provided in **Table 5-2**.

Table 5-2: Assumed Moran Tunnel Raw AMD and Post Terrace Chemistry

Parameter	Moran Tunnel	Post-Aluminum and Iron Terrace (for BCR sizing)
Peak Flow	7 gpm	6.5 gpm
Steady State Flow	3.6 gpm	3.1 gpm
pH (s.u)	3.15	3.5
Aluminum (mg/L)	529	1
Arsenic (mg/L)	0.28	0
Iron (mg/L)	1,320	1 to 66
Copper (mg/L)	194	150
Cadmium (mg/L)	1.09	0.75
Cobalt (mg/L)	2.7	2.0

Parameter	Moran Tunnel	Post-Aluminum and Iron Terrace (for BCR sizing)
Chromium (mg/L)	0.41	0.3
Nickel (mg/L)	2.2	2.2
Manganese (mg/L)	44	30
Lead (mg/L)	0.45	0.3
Sulfate (mg/L)	4,565	4,565
Zinc (mg/L)	83	60

The design flow to the system is 3.6 gpm but some evaporation losses are expected in the initial terrace zone. Evaporation losses are estimated to be about 0.5 gpm on the average but will vary seasonally.

Some metals removal other than aluminum and iron are expected to occur in the terrace zone, mostly through adsorption to manganese oxide. The effects of this process as indicated in **Table 5-2** are preliminary estimates that will require validation for final design.

To avoid the adverse consequences of overloading, and to take advantage of natural attenuation, portal flows greater than 3.6 gpm will be diverted around the terrace zone and into the mulched area of Champagne Creek near the losing zone as shown in **Figure 5-1**. The bypass design feature greatly reduces not only the area required for the passive treatment system but also the capital cost.

Diverting higher-than-design tunnel flows to the creek is assumed to only occur during the spring runoff, when flows in Champagne Creek are elevated and can average 0.5 cfs. The minor flow contribution of the by-passed flow (say under five gpm) would be a trace fraction of the creek flow and the by-pass effects would be mitigated by dilution and enhanced natural attenuation as discussed above. By-passing would be accomplished passively with a compound weir and monitored with an H-flume or similar device fitted with a data logger.

The APC for the hybrid and passive technologies are identically sized. See Section 5.1.4.

A description and conceptual design of the passive technology's components follows.

<u>Aluminum and Iron Terrace</u>

Implementing this unproven technology would divert about 3.6 gpm of very acidic and metal-laden AMD away from the portal discharge and into a terraced zone of one-foot thick layer of wood chips on a regarded portion of the floor (8,000 sf) of the bermed and fenced area now occupied by ponds 1 and 2. The terrace design (see **Figure 5-4**) includes:

- Backfilling the ponds and constructing a terrace with one foot drop so it slopes to drain toward a limestone-free VFP,
- Installing a 60 mil LLDPE geomembrane sandwiched between two layers of 12 oz/yd^2 geotextile,
- Placing one foot of woodchips mixed with the iron-laden materials harvested from Pond 2 on top of the geomembrane and placing an Enkamat® for algae to attach and grow. Similar harvested materials at other sites have shown to

exhibit a catalytic effect when commissioning similar passive treatment components (Dempsey, et al., 2002), and

- Anchoring the Enkamat® by placing sand bags on top of it.

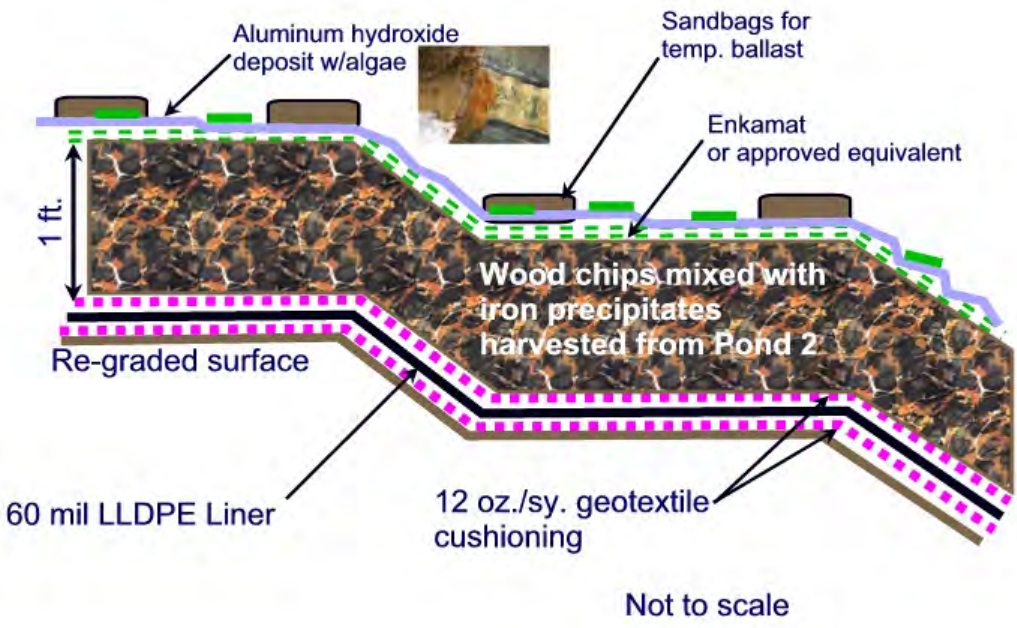


Figure 5-4: Aluminum Terrace Schematic Cross Section

The design area (8,000 ft^2) in the fenced portion of the site near the Moran Tunnel portal was predicated on the results of one sampling event. While portions of the site near the beaver pond exhibit natural aluminum terrace behavior, the loading conditions that allowed this to occur are unknown. If the algae-facilitated aluminum removal efficiency is contingent on sunshine, removal efficiency may wane in the nighttime hours. However, the pH gains from ferrous iron oxidation should be independent of sunshine. The relative contributions of these two pH-raising processes need to be verified in bench and/or pilot testing in order to maximize the utilization of space for the aluminum and iron terrace component of the passive treatment alternative.

The flow losses due to evaporation from this much additional exposure of the AMD also needs to be considered. The flow to the BCR during the dry hot summer months could be quite low. However, low (even zero) flows are not detrimental to BCR operation.

The longevity of the effects of implementing the terrace portion of this technology should be relatively permanent but some periodic maintenance will be required.

The one-foot wood chip layer on the floor of the terraces is assumed only for system commissioning and does not require periodic replacement. However, aluminum and iron precipitates will be excavated and disposed of off-site on an approximate once-a-decade schedule.

The costs associated with implementing this technology are summarized in **Table 5-5**. They include the cost of conducting a data gap analysis and aluminum and iron terrace bench/pilot test verify and refine design assumptions.

Limestone-Free Vertical Flow Pond (VFP)

The VFP will be buried and covered to protect it from extreme rainfall and snowmelt events. The VFP top footprint will be approximately 46 ft. by 46 ft. (including berms) and about 5.8 ft. deep. The VFP substrate will consist of only woodchips. The design includes:

- VFP cell excavation,
- Installing a 60 mil LLDPE geomembrane sandwiched between two layers of 12 oz/yd^2 geotextile, and
- Installation of the drainage layer, substrate, and VFP cover.

Delivery Pipeline

One 4-inch HDPE SDR17 delivery pipeline will be installed from the limestone-free VFP to the BCR. The length of the pipeline would be approximately 1,600 ft. and will be buried 4 ft. deep, which may be within the frost depth zone. The delivery pipe includes:

- Excavating a 3 ft. wide by 4 ft. deep trench,
- Installation of the pipeline, and
- Trench filling.

Biochemical Reactor (BCR) Cell

The BCR will be buried and covered to protect it from extreme rainfall and snowmelt events. The BCR top footprint will be approximately 117 ft. by 117 ft. (including berms) and about 6.2 ft. deep. The BCR substrate will consist of woodchips, hay, sawdust, crushed limestone, and manure based on the mixture used by IGC at a similar site nearby. The standing water level in the BCR will be adjustable using an inline water level control unit (WLCU). This design feature can be procured from Agridrain, Inc. (www.agridrain.com). The BCR design includes:

- BCR cell excavation,
- Installing a 60 mil LLDPE geomembrane sandwiched between two layers of 12 oz/yd^2 geotextile,
- Installation of the drainage layer, substrate, and BCR cover, and
- Installing the water level control unit.

APC

A 300 ft. long by 2 ft. wide (600 ft^2) unlined aerobic polishing channel (APC) filled with locally-harvested willow cuttings. The design includes:

- Channel excavation
- Channel filling with top soil
- Harvesting of willow cutting and planting them in the channel

Technology Summary

There appears to be sufficient area for the aluminum/iron terrace portion of this technology to be sited in the vicinity of the Tunnel portal. The terrace effluent would be “conditioned” for conveyance via a buried pipeline by a limestone-free vertical flow pond. A BCR, located near the Beaver Pond but up out the flood plain, would remove remaining heavy

metals. The manganese levels in the BCR influent would remain unchanged. Minor BCR effluent polishing would occur in an unlined APC which would return the final PTS effluent to Champagne Creek where additional manganese oxide deposition (a natural attenuation process presumed to be present) would occur. This technology does not conflict with the processes included in the enhancement of natural attenuation technology (**Section 5.1.2**).

5.2 DEVELOPMENT OF REMOVAL ALTERNATIVES

The five removal action technologies discussed in Section 5.1 were combined in three variations to generate removal alternatives expected to meet RAOs for the site. These removal alternatives are designated Alternatives 2, 3, and 4, with Alternative 1 being No Action. A summary of the technology combinations and the applicable discharge(s) addressed by alternative are presented in **Table 5-3** below. A brief description of the rationale behind the development of the removal alternatives are presented in the sections below.

Table 5-3: Summary of Removal Alternatives by Technology

Retained Technology	Applicable Discharge	Removal Alternative			
		1	2	3	4
Institutional Controls (Signage)	Tunnel & Seep		●	●	●
Enhanced Natural Attenuation	Seep		●	●	●
Physical AMD Mgmt. (South Pit Cap)	Tunnel & Seep				●
Active & Passive (Hybrid) Treatment	Tunnel		●		
Passive Treatment	Tunnel			●	●

5.2.1 Alternative 1: No Action

Alternative 1 is the No Action alternative. Under this alternative, there is no removal action proposed for Moran Tunnel nor the Secondary Seep. No response activities would occur at the site to control COC loading, nor to reduce toxicity or AMD volume. The existing site conditions would remain unchanged.

5.2.2 Alternative 2: Enhanced Natural Attenuation, Hybrid Treatment, Institutional Controls

Alternative 2 involves implementing enhanced natural attenuation for the Secondary Seep, hybrid treatment for the Moran Tunnel, and includes institutional controls for the site in the form of signage. This alternative combines the best features of the simplicity of enhanced natural attenuation technology to address the Secondary Seep impacts and the small footprint and reduced effectiveness uncertainty of hybrid treatment technology to address the Moran Tunnel impacts. High operation, maintenance, and monitoring (OM&M) costs are a trade-off for the small footprint and reduced uncertainty relative to a fully passive strategy.

5.2.3 Alternative 3: Enhanced Natural Attenuation, Passive Treatment, Institutional Controls

Alternative 3 involves implementing enhanced natural attenuation for the Secondary Seep, passive treatment for the Moran Tunnel, and includes institutional controls for the site in the form of signage. This alternative combines the best features of the simplicity of enhanced natural attenuation technology to address the Secondary Seep impacts and the low OM&M costs of passive treatment to address the portal AMD impacts. The tradeoffs of this alternative are increased uncertainty in effectiveness relative to an active or hybrid approach.

5.2.4 Alternative 4: Enhanced Natural Attenuation, Passive Treatment, South Pit Cap, Institutional Controls

Alternative 4 involves implementing enhanced natural attenuation for the Secondary Seep, passive treatment for the Moran Tunnel, physical AMD control measures in the form of partial capping in the South Pit, and institutional controls for the site in the form of signage. This alternative combines the best features of the simplicity of enhanced natural attenuation technology and the low OM&M costs of passive treatment with a relatively permanent diversion of South Pit AMD away from the tunnel. Similar to Alternative 3, the tradeoffs of this alternative are increased uncertainty in effectiveness relative to an active or hybrid approach.

5.3 ALTERNATIVE EFFECTIVENESS, IMPLEMENTABILITY, AND COST

In this section, each removal alternative is assessed in terms of its effectiveness, implementability, and cost (USEPA, 1993). For alternatives that involve combinations of technologies, each individual technology is assessed independently followed by an assessment of the alternative as a whole.

Estimated costs relied on several assumptions regarding site conditions and are based on conceptual design only. The estimated costs are intended for alternative comparison only and are not suitable for construction bidding purposes in the absence of an approved design. The approved design will likely be based on a preliminary assessment or pilot test of the performance of the alternative under site-specific conditions and may require the collection of additional site data specific to the performance of the alternative.

5.3.1 Alternative 1: No Action

A no action alternative would rely on natural attenuation processes to maintain the current conditions in the Champagne Creek.

Alternative Effectiveness: Natural attenuation processes/conditions may not be sustainable without human assistance, particularly if the conditions regarding quantity, acidity or metals concentrations of the AMD changes. Due to impact of AMD to the Champagne Creek watershed and potentially to downstream (agricultural) users in particular, the No Action Alternative would not be protective of human health or the environment. This option would not be effective in meeting ARARs because it does not address a number of human health, ecological, historical, and archaeological requirements. The No Action Alternative would not achieve the RAOs, since it would not prevent or reduce human or ecological exposure to metals in soil. Human health and ecological risks would persist.

Alternative Implementability: The No Action alternative is technically implementable, requiring no onsite equipment, onsite personnel or services, or laboratory testing. It is

administratively feasible, and the availability of resources would not be an issue. There are no processes involved in the performance of the alternative rendering it easy to implement.

Alternative Cost: There are no capital costs or operation and maintenance costs associated with the No Further Action Alternative. However, there may be significant long-term costs associated with future impacts or releases. There may also be non-monetary costs associated with impacts to ecological receptors.

5.3.2 Alternative 2: Enhanced Natural Attenuation, Hybrid Treatment, Institutional Controls

5.3.2.1 Enhanced Natural Attenuation of Secondary Seep

Technology Effectiveness: Implementing this technology would improve the natural attenuation processes adjacent to the Secondary Seep and at the upwelling zone upstream of the beaver dam where a "volunteer" aluminum terrace would likely form. Harvesting the willows in this area would increase sunshine penetration in the summer and encourage algae growth. The harvested willows could also be used in constructing the aerobic polishing channel.

Evidence of aluminum terracing in the upwelling zone is shown in **Figure 2-6**. As shown in **Figure 5-1**, iron removal would also occur in an aluminum terrace. RAOs associated with the Secondary Seep would be achieved.

Once aluminum and iron are removed (the benefits of enhanced natural attenuation activities), manganese oxide formation and its associated adsorption of heavy metals is likely. Slow kinetic weathering/alteration of dacite rock in the Champagne Creek alluvium and algal activity will raise the pH.

Technology Implementability: This technology is technically implementable and could probably be accomplished by BLM personnel skilled in fuel-reduction projects without any special equipment other than chain saws, wood chippers and other similar vegetation management tools. The work would be scheduled to coincide with low creek flow in the fall season.

Technology Cost: The cost of implementing this technology follows.

Table 5-4: Enhanced Natural Attenuation of Secondary Seep Cost

Construction Costs		
Cost Item	**Cost**	**% of Total**
Mobilization/Demobilization	$4,600	4%
Thin Dead Trees/ Chip Slash - Seep	$32,340	30%
Anchor/Lay Down Trees By Seep	$9,240	9%
Thin Willows/Chip Slash - Upwelling Zone	$18,480	17%
Procure and Deliver Off Site Wood Chips	$19,500	18%
Place Slash and Woodchips	$9,240	9%
Engineering	$5,000	5%

Construction Costs		
Cost Item	**Cost**	**% of Total**
Construction Management/Contingency	$8,500	8%
Total Construction Cost (Rounded)	**$107,000**	**100%**
Periodic OM&M Costs		
Cost Item	**Cost**	**Frequency**
Replenish Woodchips	$19,500	5 Years

The 30-year total cost of this technology is about $185,000.

5.3.2.2 Hybrid Treatment of Moran Tunnel Discharge

Technology Effectiveness: This technology has proven to be effective when operated correctly. The treated AMD the APC receives is expected to meet RAOs and the willows will further reduce the volume of water returned to the environment via evapotranspiration.

Technology Implementability: The installation is relatively simple and could be completed in about a month. The technology involves the storage of a corrosive solution (20% strength caustic soda). This strength is required to prevent freezing.

Sludge drying can be facilitated with large bags fabricated with permeable geotextile such as geotubes™.

Given governmental budgeting challenges, allocating the annual OM&M costs would be difficult and there may be periods where the active portion of the hybrid treatment system is inadequately maintained and it would fail to be effective.

Technology Cost: The economics of a hypothetical hybrid AMD treatment system are discussed in Gusek (2006); the results of this analysis show that the life cycle cost of a hybrid is similar to the life cycle cost of a purely passive system but the hybrid system footprint is a fraction of the size of a purely passive system designed to treat the same AMD load. As shown in **Table 5-5**, the cost of construction is about $300,000. The annual cost of 20% caustic soda alone is $122,800 and the cost of a cleanout event (every seven years) is $20,000.

Table 5-5: Hybrid Treatment of Moral Tunnel Cost

Construction Costs		
Cost Item	**Cost**	**% of Total**
Mobilization/Demobilization	$25,000	8%
Clear, Grub, Topsoil Harvest	$11,000	4%
Water Wheel Dosing Unit	$25,900	9%

Settling Pond Conversions	$86,500	29%
Biochemical Reactor	$65,400	22%
Conveyance Piping and APC	$16,500	6%
Engineering	$21,000	7%
Contingency	$22,000	7%
Construction Management	$24,500	8%
Total Construction Cost (Rounded)	**$300,000**	**100%**
Periodic OM&M Costs		
Cost Item	**Cost**	**Frequency**
20% Caustic soda solution (delivered)	$30,700	3 Months
Settling pond cleanout & dispose precipitates	$20,000	7 Years
Pipeline cleanout	$5,000	Annually
BCR Substrate refurbishment	$17,700	20 Years

The 30-year present value cost of this technology is about $2,487,000 or $2.5 million.

5.3.2.3 Institutional Controls

Technology Effectiveness: Signs will be protective of public health and the community and increase community understanding of the hazards associated with the Site. Educational signs could lessen the tendency for site visitors to vandalize removal alternative features.

Technology Implementability: Signs are easy to install as access to the five proposed locations is good. The signs could be installed almost any time of the year and would be easy to inspect and maintain.

Technology Cost: Signs are relatively inexpensive. A 6 ft. x 4 ft. wooden sign with 6-inch diameter treated timber fence posts with concrete anchors is assumed to cost approximately $4,000 installed. This price applies for a group of five similar signs located in close proximity to each other for a total cost of $20,000. Total maintenance would be about five percent (5%) per annum or $19,000 over 30 years.

5.3.2.4 Combined Technology Assessment of Alternative 2

Alternative Effectiveness: This alternative is protective of public health and the community as well as being protective of the environment. It achieves the RAOs for both the Moran Tunnel AMD and Secondary Seep and is compliant with the ARARs. The enhanced natural attenuation technology reduces residual concerns but the sludge from the hybrid treatment technology increases these concerns.

Alternative Implementability: Technically, the construction effort associated with these combined technologies could be implemented simultaneously or sequentially. Site accessibility is good almost year round; no additional easements or rights of way are needed. The alternative could be implemented within a one-year window. The alternative

would not impact adjoining properties.

Implementing this alternative involves handling of corrosive chemicals and the frequent excavation and disposal of sludge. The existing repository would reach full capacity faster with this alternative.

The alternative is not likely to receive regulatory and community acceptance due to its high cost (see below), the use of caustic soda which is a corrosive chemical, and the frequent disposal of sludge.

Alternative Cost: The costs of the combined technologies are cumulative and does not yield savings or additional costs associated with combined implementation. The construction cost of this alternative is $427,000, the second lowest of the alternatives evaluated. The 30-year present value cost of this alternative is $2.7 million. It is the highest present value cost among the alternatives evaluated. These costs break down by technology as follows:

Alternative 2 Cost Breakdown by Technology			
Technology	**Construction Cost**	**30-year Operation Cost**	**Total Cost**
Enhanced Natural Attenuation of Secondary Seep	$ 107,000	$ 78,000	$ 185,000
Hybrid Treatment of Moral Tunnel	$ 300,000	$ 2,187,000	$ 2,487,000
Institutional Controls	$ 20,000	$ 19,000	$ 39,000
Totals	$ 427,000	$ 2,284,000	$ 2,711,000

5.3.3 Alternative 3: Enhanced Natural Attenuation, Passive Treatment, Institutional Controls

5.3.3.1 Enhanced Natural Attenuation Assessment of Secondary Seep

Refer to Section 5.3.2.1

5.3.3.2 Passive Treatment of Moral Tunnel Discharge

Technology Effectiveness: The effluent from this technology's implementation should meet RAOs year-round. During the spring runoff, some of the acidity and metals loading from the tunnel may be diverted to Champagne Creek through a compound weir. This by-passed water should be mitigated by its mixing with Champagne Creek water and through natural attenuation.

The BCR-treated AMD the APC receives is expected to meet RAOs and the willows will further reduce the volume of water returned to the environment via evapotranspiration.

Technology Implementability: This technology is technically implementable with the caveat that the sizing criteria for the aluminum and iron terrace portion of the technology is not well defined as this technology has not been implemented elsewhere. The conservative sizing criteria used to develop the technology costs needs to be validated.

The aluminum terrace construction could be accomplished by a small earthmoving contractor without any special equipment over a span of several weeks. VFPs are similar in construction to BCRs and with the use of just wood chips as media, the VFP would be simpler to construct than typical VFPs that involve two different media layers (organic compost over limestone rock). IGC has constructed a BCR to treat waste rock seepage that is affecting the unnamed tributary. The BCR design was based on bench test results; the system is expected to come on line in the spring of 2015. The construction effort for the IGC system spanned several months as was accomplished by a qualified earthmoving contractor.

Technology Cost: A cost analysis was performed for the implementation of a full-scale passive water treatment system (**Table 5-6**). The cost analysis included generation of construction cost estimates, which were calculated from unit costs specific to passive treatment system construction. These unit costs were derived from experience on previous passive treatment system projects, such as the biochemical reactor being constructed at the adjacent unnamed tributary to Champagne Creek site. The cost estimate was developed with the following assumptions:

- The effective design life of the system used for cost estimation was 30 years,
- Substrate for the passive elements can be refurbished at the end of their effective lives, and
- The Iron and Aluminum Terrace needs to be cleaned out every 20 years.

Table 5-6: Passive Treatment of Moran Tunnel Cost

Construction Costs		
Cost Item	**Cost**	**% of Total**
Mobilization/Demobilization	$25,000	7%
Clear, Grub, Topsoil Harvest	$12,500	4%
Aluminum and Iron Terrace	$53,371	15%
Vertical Flow Pond	$18,800	5%
Biochemical Reactor	$65,400	18%
Conveyance Piping and APC	$16,500	5%
Engineering	$22,500	6%
Bench/Pilot Testing On-Site	$100,000	28%
Contingency	$18,500	5%

Construction Costs		
Cost Item	**Cost**	**% of Total**
Construction Management	$21,000	6%
Total Construction Cost (Rounded)	**$354,000**	**100%**
Periodic OM&M Costs		
Cost Item	**Cost**	**Frequency**
Aluminum and Iron Terrace Clean out	$12,000	20 years
VFP Substrate Refurbishment	$7,800	20 Years
BCR Substrate Refurbishment	$17,700	20 Years
Total Cost (Construction and OM&M) (Rounded)	**$375,000**	

From **Table 5-6**, the 30-year implementation cost for this technology is estimated to have a present value of about $375,000.

5.3.3.3 Institutional Controls

Refer to Section 5.3.2.3

5.3.3.4 Combined Technology Assessment of Alternative 3

Alternative Effectiveness: This alternative is protective of public health and the community as well as being protective of the environment. It achieves the RAOs for both the Tunnel AMD and Secondary Seepage and is compliant with the ARARs. The enhanced natural attenuation technology reduces residual concerns. The aluminum and iron accumulations in the terrace segment of the alternative also should reduce residual concerns.

Alternative Implementability: Technically, the construction effort associated with these combined technologies could be implemented simultaneously or sequentially. Site accessibility is good almost year round; no additional easements or rights of way are needed. The alternative could not be implemented within a one-year window because additional time would be required to collect data associated with bench/pilot scale aluminum terrace testing. Bench and/or pilot studies are required to better understand the sizing criteria for the aluminum/iron terrace design. The alternative would not impact adjoining property (ies). Institutional controls (signage) would be easy to install and maintain.

The existing repository would not reach full capacity (10,300 cy) for about 300 years at a combined filling rate of 700 cy (300 cy of aluminum precipitates and 400 cy of depleted BCR residue) every 20 years.

The alternative is likely to receive regulatory and community acceptance due to its low cost, nature-friendly technology that requires no chemicals, and the infrequent disposal of residuals.

Alternative Cost: The costs of the two technologies are cumulative; implementing either of the two does not yield savings or additional costs associated with implementing the other. The construction cost of this alternative is $481,000. The 30-year present value cost

of this alternative is 599,000. These costs break down by technology as follows:

Alternative 3 Cost Breakdown by Technology			
Technology	**Construction Cost**	**30-year Operation Cost**	**Total Cost**
Enhanced Natural Attenuation of Secondary Seep	$ 107,000	$ 78,000	$ 185,000
Passive Treatment of Moran Tunnel	$ 354,000	$ 21,000	$ 375,000
Institutional Controls	$ 20,000	$ 19,000	$ 39,000
Totals	$ 481,000	$ 118,000	$ 599,000

5.3.4 Alternative 4: Enhanced Natural Attenuation, Passive Treatment, South Pit Partial Cap, Institutional Controls

5.3.4.1 Enhanced Natural Attenuation of Secondary Seep

Refer to Section 5.3.2.1

5.3.4.2 Passive Treatment of Moran Tunnel Discharge

Refer to Section 5.3.3.2

5.3.4.3 Institutional Controls

Refer to Section 5.3.2.3

5.3.4.4 South Pit Partial Cap

Technology Effectiveness: Implementing this technology would divert about one (1) gpm of very acidic and metal-laden AMD away from the Moran Portal discharge and into a one-foot thick zone of wood chips on the floor (20,600 ft^2) of the South Pit. It would likely improve the tunnel chemistry, but to what extent is unknown. The diverted flow would be attenuated in South Pit which would function like portions of Champagne Creek itself, with zones of aluminum and iron deposition and metals attenuation via adsorption to manganese oxide coatings. The longevity of the effects of implementing this technology should be relatively permanent. Some sloughing of sediments may clog the diversion channel and some periodic maintenance (excavation) may be required if ponding causes surface water to by-pass the LLDPE geomembrane and infiltrate into the Tunnel (the presumed current condition).

The one-foot wood chip layer on the floor of the South Pit is assumed to naturally mature to a vegetative layer that will be self-sustaining. No maintenance is expected.

This technology would not be effective in eliminating all the metal loading from the Tunnel. Its implementation may not address all the AMD infiltrating into the Moran Tunnel from the South Pit (there may be other source/infiltration areas that are inaccessible). Its implementation could improve the longevity or treatment capacity of passive or active treatment technologies.

Further study would be required to determine whether this technology would provide any

benefit. The study might include monitoring the effects of a temporary geomembrane cover installed over the suspected infiltration zone.

Technology Implementability: This technology is technically implementable and could be accomplished by a small earthworks contractor in about one to two weeks of construction effort. No specialized equipment would be required. The work would be scheduled to coincide with the drier seasons (summer and fall).

Technology Cost: The costs associated with implementing this technology are summarized in **Table 5-7**.

Table 5-7: South Pit Partial Cap Estimated Implementation Costs

Construction Costs		
Pay Item	**Cost**	**% of Total**
Mobilization/Demobilization	$15,900	9%
Clear, Grub, Topsoil Harvest	$7,500	4%
South Pit Earthwork and Lining	$45,100	24%
South Pit Gravel Layer	$42,800	23%
Rip-Rap Drainage Channel	$11,300	6%
Wood Chip/ Mulch Layer	$21,700	12%
Engineering	$12,500	7%
Contingency	$19,500	10%
Construction Management	$10,500	6%
Total Construction Cost (Rounded)	**$187,000**	**100%**

Assuming a diversion channel clean-out is assumed once a decade, that cost is estimated to be $1,300 per event.

The 30-year total cost of this technology is about $190,000.

The economic or effectiveness benefits of implementing this technology could be realized in several ways: the size and construction cost of treatment technologies could be less; the peak treatment capacities (gpm) could be increased proportionately to the reduction in metals/acidity concentrations; the reagent cost of the active treatment technology could be less than projected, and/or the longevity of the aluminum terrace, VFP, and BCR components of the passive treatment technology would be extended.

5.3.4.5 Combined Technology Assessment of Alternative 4

Alternative Effectiveness: This alternative is just as effective as Alternative 3 alone discussed above. It is additionally protective of the environment because it sequesters more metals and acidity in the South Pit where it originates. It reduces residual concerns because it should lessen the contaminant levels in the tunnel AMD but to what extent is uncertain.

Alternative Implementability: Technically, the construction effort associated with these

combined technologies could be implemented simultaneously or sequentially. Site accessibility is good almost year round; no additional easements or rights of way are needed.

The alternative could not be implemented within a one-year window because additional time would be required to collect data associated with bench/pilot scale aluminum terrace testing. Implementing the partial cap technology would necessitate additional study to confirm that a significant metal and acidity load originating in the South Pit could be diverted away from the tunnel. Bench and/or pilot studies are required to better understand the sizing criteria for the aluminum/iron terrace design. The alternative would not impact adjoining property (ies). Institutional controls (signs) would be easy to install and maintain.

The existing repository would not reach full capacity (10,300 cy) for more than 300 years. Lower metal loading would extend the longevity of the repository and the BCR but to what extent is uncertain.

The alternative is likely to receive regulatory and community acceptance due to its low cost, nature-friendly technology that requires no chemicals, and the infrequent disposal of residuals. However the additional capital cost compared to Alternative 3 may not be as attractive in a restricted budgetary environment.

Alternative Cost: The costs of the four technologies are assumed to be cumulative. Implementing the partial cap technology in the South Pit would prolong the interval between aluminum terrace cleanouts or BCR refurbishing events. As the economic effects of these benefits are incurred many years into the future, the cumulative 30-year present value OM&M costs are appreciably different from Alternative 3 due to the discounting factor. The construction cost of this alternative is $668,000. The 30-year present value cost of this alternative is $1,008,000. These costs break down by technology as follows:

Alternative 4 Cost Breakdown by Technology			
Technology	**Construction Cost**	**30-year Operation Cost**	**Total Cost**
Enhanced Natural Attenuation of Secondary Seep	$ 107,000	$ 78,000	$ 185,000
Passive Treatment of Moran Tunnel	$ 354,000	$ 240,000	$ 594,000
Institutional Controls	$ 20,000	$ 19,000	$ 39,000
South Pit Cap	$ 187,000	$ 3,000	$ 190,000
Totals	$ 668,000	$ 340,000	$ 1,008,000

6 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

While Section 5.3 evaluated each removal action alternative independently in terms of its effectiveness, implementability, and cost, this section compares the alternatives relative to one another in terms these criteria including an additional criterion of safety. As part of this analysis, alternatives are also ranked relative to one another in terms of these criteria for direct comparison.

Table 6-1 summarizes the comparative analysis and indicates the relative ranking by criterion. A discussion of the numeral ranking definitions is included at the end of this section and a discussion of the comparative analysis of the three alternatives retained (not including No Action) are presented below.

Alternative 2 (enhanced natural attenuation, hybrid treatment, and institutional controls) meets RAOs for the site. It is an effective alternative and could be implemented in less than a year. However, unlike the fully passive technologies, it is expensive to operate and maintain and involves handling a corrosive chemical and the generation of significant sludge.

As with the other alternatives, it incorporates standard technologies that are flexible. That is, if the tunnel flow changes, the water wheel rotation would change with it to maintain the proper chemical dosage. However, if the tunnel discharge chemistry changes, over-dosing or under-dosing could occur. The consequences of large chemistry variations on the downstream BCR vary as this technologic component has been observed to be fairly resilient to short term chemistry changes. Nonetheless, over-dosing the BCR with caustic soda could harm the bacterial suite in the organic substrate. Short term caustic under-dosing (which would result in a greater acidity load on the BCR) is less problematic as the limestone component of the BCR substrate is included as “insurance” for this situation. Under-dosing of the tunnel discharge with caustic could cause pipeline scaling issues since the majority of the aluminum and iron may not be removed in the settling ponds. Metals might even be remobilized in this situation. As a result, it receives an effectiveness ranking score of [7], on the higher end of the “moderate” ranking level.

There is less chemical/biochemical design uncertainty with this alternative relative to the passive technology, and therefore very little design testing would be required to implement it. Laboratory jar/titration tests and settling tests would be required to size the caustic dosing system and settling ponds. These could be accomplished in about a month. The BCR substrate mixture from the nearby BCR constructed by ICG is assumed to be suitable for the Moran Tunnel’s BCR unit.

In contrast to the passive technology, this alternative will require frequent attention by BLM employees or contractors to keep the caustic soda tank filled, to remove accumulated sludge and dispose of it in the repository. Funding interruptions may result in OM&M operations being suspended and treatment could stop. The BCR might be difficult to restart if the stoppage is prolonged. As a result, the implementability score of this alternative is low [3].

The natural attenuation aspect of this alternative is easy to implement and maintain; likewise with the institutional warning and educational signs.

This alternative has the second most expensive construction cost but the most expensive OM&M cost which results in its exhibiting the highest 30-year net present value cost, $2.7 million. It receives a low score for cost criteria [2] compared to the other alternatives.

Due to the usage of corrosive caustic soda, the safety ranking of implementing is low [3].

Alternative 3 (enhanced natural attenuation and passive treatment, and signs) meets RAOs for the site, is relatively inexpensive, and is easy to maintain. It would take longer to implement than Alternative 2 because of required pilot testing.

As with the other alternatives, it too incorporates standard technologies that are flexible, That is, if the tunnel flow changes, the iron-aluminum terrace (AIT) component (which would be conservatively over-sized based on pilot test results) would probably accommodate the situation. If not, excessive flow could be diverted to an existing enhanced natural attenuation zone. Under dosing or over-dosing is impossible with the IAT as the BCR will be designed to accept mildly acidic AMD. If the natural accumulations of aluminum near the beaver pond are any indication of geochemical stability, it is unlikely that already precipitated aluminum and/or iron would be remobilized if the AIT is temporarily overloaded. Evaporation losses in the summer may reduce AIT effluent flow rates to near-zero.

In the unlikely event that the AIT technology cannot be adequately developed, a larger sized BCR would be required which would increase the cost of this alternative. As discussed earlier, there is insufficient room near the beaver pond to site a larger BCR. A larger treatment unit would have to be located further downstream so the AMD delivery pipeline would be longer, further increasing the construction cost. The VFP would need to be sized larger to accommodate the increased iron load to prevent pipeline scaling. Bench testing would be necessary to properly size the VFP for this new situation. In short, if the AIT technology is not implementable, Alternative 3 would still be effective but would be larger and more costly. As a result, Alternative 3 receives an effectiveness ranking score of [8], on the lower end of the “excellent” ranking level.

Assuming the AIT technology is proved feasible through bench/pilot testing, the VFP component should reduce pipeline scaling problems to manageable levels. This low-tech treatment unit that mimics natural processes present in Champagne Creek, would be designed to be refurbished every two decades.

As stated throughout this document, significant design testing for the AIT component would be required to implement this alternative. Doing so is estimated to add $50,000 to the construction cost and delay full-scale construction for a year, until 2017. VFP testing to validate its sizing criteria would be conducted at the same time as the AIT testing with little additional effort. This testing program could be completed over the spring and summer of 2015 and continued at a less intensive sampling schedule through the winter of 2015-2016 to validate AIT wintertime functionality. As with Alternative 2, the BCR substrate mixture from the nearby BCR constructed by ICG is assumed to be suitable for the Moran Tunnel’s BCR unit.

This alternative will require infrequent attention by BLM employees. Quarterly inspections and 20-year major retrofitting events should be the norm. The functionality of the alternative would not suffer from OM&M funding interruptions. There is sufficient room for residuals disposal in the repository for several centuries of operation. As a result, the implementability score of this alternative is moderately high [7].

The natural attenuation aspect of this alternative is easy to implement and maintain; likewise with the institutional warning and educational signs.

This alternative has the least expensive construction cost and the least expensive OM&M cost which results in its exhibiting the lowest 30-year net present value cost of $599,000. It receives a high score for cost criteria [8] compared to the other alternatives.

Due to the lack of any chemical usage and infrequent major refitting schedule, the safety ranking of implementing Alternative 3 is high [9].

Alternative 4 (Alternative 3 with South Pit partial cap) meets RAOs for the site, but the future OM&M cost savings may not justify the up-front capital cost of implementing it.

For convenience, the advantages and disadvantages of Alternative 3 will not be repeated and the comparison of this alternative to the others will focus on the aspects of the partial cover (physical management of AMD) in the South Pit.

The overall effectiveness of adding the partial cover is difficult to predict and would require infiltration testing or pre-construction and time to realize the effect. The partial cover may reduce the seep and/or portal flows significantly and therefore extend the life of the treatment system and/or lower the maintenance relative to Alternative 3. Furthermore, if tested prior to design, the cover may indicate a smaller, less expensive treatment design is needed. Although there is potential for benefit of adding the partial cap, the performance uncertainty is high, therefore Alternative 4 receives a ranking score of [8], which is identical to Alternative 3.

Similar to Alternative 3, this alternative will require infrequent attention by BLM employees. Quarterly inspections of the partial cover and 10-year runoff diversion channel maintenance events (coupled with OM&M for the enhanced natural attenuation and passive treatment components) should be the norm. The functionality of the alternative would not suffer from funding interruptions. There is sufficient room for residuals disposal in the repository for several centuries of passive treatment operation. As a result, the implementability score of this alternative is moderately high [7].

This alternative has the second-most expensive construction cost (with the addition of the partial cap in the South Pit to the “baseline” Alternative 3 cost) and the second most expensive OM&M cost which results in its exhibiting the 30-year net present value cost of $1,008,000. Most of the additional cost for the partial cap is a “present value” expenditure and the benefits/payback of implementing it may never be recouped. It receives a moderate score for cost criteria [5] compared to the other alternatives.

As with Alternative 3, the safety ranking of implementing Alternative 4 is high [9].

Numerical Ranking Criteria Discussion

The ranking criteria adopted is appropriate for comparing relatively few (only three) alternatives and it allows some increased sensitivity in addressing alternatives that are similar (e.g., Alternatives 3 and 4).

- **Values of 0-3** allow a range of low ratings – screening elements receiving these scores are not favorable.
- **Values of 4-7** are moderate ratings – screening elements are favorable or acceptable but there may be other alternatives that provide a better remedy.
- **Values of 8-10** are excellent – alternative screening elements receiving these high scores should be viewed very favorably with little or no adverse issues.

Table 6-1: Screening Comparison of Alternatives

Alternative	Effectiveness	Implementability	Cost	Safety
1	Not effective	Implementable	**none**	N/A
2	Will meet RAOs & ARARs but AMD chemistry and caustic dosing variations could damage BCR [7]	OM&M is subject to funding cuts & potential loss of Alt. functionality [3]	**$**2.7 million (present value) over 30 years [2] this is mostly OM&M cost	Caustic soda is corrosive [3]
3	Will meet RAOs & ARARs, even if AIT is not utilized – PTS would be then be larger and more expensive [8]	Easy to construct, infrequent OM&M; will take longer to implement – must wait for pilot test results; OM&M relatively immune to funding cuts [7]	**$**599,000 (present value) over 30 years; still least cost with AIT testing [8]	Not hazardous [9]
4	Will meet RAOs & ARARs; addition of Phys. Mgt. in South Pit would not change or improve this. [8]	Easy to construct, infrequent OM&M; will take longer to implement – must wait for pilot test results; OM&M relatively immune to funding cuts; little OM&M on Phys. Mgt. in South Pit [7]	**$**1,008,000 (present value) over 30 years – might not recoup Phys. Mgt. investment due to uncertain long term benefits [5]	Not hazardous [9]

7 RECOMMENDED REMOVAL ACTION ALTERNATIVE

7.1 RECOMMENDATION AND RATIONALE

Alternative 3 is the recommended removal action alternative. This alternative involves passive treatment of the Moran Tunnel discharge, enhanced natural attenuation of the Secondary Seep, and installing institutional controls at the site in the form of warning and educational signage. This alternative was recommended based on the following considerations:

- Ease of construction and installation in the space available
- Involves exclusively passive and natural processes
- Utilizes predominantly proven, standard technologies
- Relatively low capital cost
- Low maintenance and long useful life
- Generally safe with properly maintained controls

As detailed previously, this alternative entails numerous design assumptions that will require field and/or bench scale evaluation prior to final design and implementation. Implementation considerations, upon which this recommended alternative is contingent, are discussed in Section 7.2.

7.2 IMPLEMENTATION CONSIDERATIONS

With the numerous advantages that come with this relatively inexpensive and exclusively passive alternative comes tradeoffs in certainty and sensitivity to design assumptions. As detailed in this document, there are several data gaps and technical uncertainties in application that will require further evaluation and testing, some critical.

In treating the Moral Tunnel discharge, for example, the proper sizing and functioning of the aluminum and iron terrace in particular is critical to successful performance and achievement of RAOs. The conceptual terrace design for this alternative was based on an iron and aluminum removal rate derived from a single field sample result, a removal rate considerably higher than would be expected in a low pH environment like the Moran Tunnel (Section 2.4.3.1). Adding to the criticality, the functioning of the terrace consequently affects the sizing and function of the downstream VFP and the BCR, and could considerably impact scaling and plugging of the buried pipeline component of the technology.

With such considerations in mind, it is critical that a comprehensive data gap analysis and bench/pilot test workplan be developed and performed prior to finalizing a design for this alternative. Depending on the findings of the workplan, other alternatives or components of alternatives may need to be revisited.

8 REFERENCES

AEPCO, Inc. 1986. *Preliminary Assessment (PA) Report For Champagne Creek Site, Arco, Butte County, Idaho*, July 8. (**AEPCO, 1986**)

Anderson, A.L., August, 1929. *Geology and Ore Deposits of the Lava Creek District, Idaho*, University of Idaho, Moscow, Idaho. (**Anderson, 1929**)

Burgos, William, Yizhi Sheng, Brad Kaley 2005. *Bioreactors for low-pH Fe (II) oxidation also remove remarkable amounts of total Fe*, Applied Geochemistry, 20:1320-1356. (**Burgos, 2005**)

Chenoweth, 2014 in www.ghosttowns.com/states/id/id.html (**Chenoweth, 2014)**

Dahle, Donald G., 1956. Transmittal of an Application for Aid in an Exploration Project, Pursuant to DMEA Order 1, Under the Defense Production Act of 1950, as Amended. (**Dahle, 1956**)

Environmental Management Services Company, 1988. *Site Investigation Report, Champagne Creek Site, Butte County, Idaho*, May 1988. (**EMS, 1988**)

FutureNet Group, Inc., 2012. *Champagne Creek Ground Water Investigation, Arco, Idaho*, December 2012. (**FutureNet, 2012**)

Gusek, J.J., 2002. Sulfate-Reducing Bioreactor Design and Operating Issues: Is This the Passive Treatment Technology for Your Mine Drainage, presented at the National Association of Abandoned Mine Land Programs, Park City, Utah, September 15-18, 2002. (**Gusek, 2002**)

Gusek, J.J., 2004. Scaling Up Design Challenges for Large Scale Sulfate Reducing Bioreactors, presented at the 2004 Joint Conference of the 21st Annual Meeting of the American Society for Mining and Reclamation, and the 25th West Virginia Surface Mine Drainage Task Force Symposium, Morgantown, WV, April 18-22, 2004. (**Gusek, 2004**)

Gusek, J.J., 2005. Design and Operation of Bioreactors and Case Studies of Bioreactors, 2005 Mine Water Treatment Technology Conference, Office of Surface Mining Pittsburgh, PA, August 15-16, 2005. (**Gusek, 2005**)

Gusek J. and K. Conroy. 2007. Hybrid Treatment Systems for Very Acidic Mining Influenced Water. 2007 Annual Meeting of the American Society for Mining and Reclamation, June. Gillette, WY. (**Gusek, 2007**)

Gusek, James, B. Masloff, and J. Fodor. 2012. Engineered Pumpable pHoamTM: An Innovative Method for Mitigating ARD. 2012 Annual Meeting of the American Society for Mining and Reclamation, June. Tupelo, MS. (**Gusek, 2012**)

Idaho Gold Corporation, 2010. *Champagne Mine Work Plan for Waste Dump Stabilization, Butte County, Idaho*, October 15. (**IGC, 2010**)

KC Harvey Environmental, LLC., 2012. *Champagne Creek Vegetation Assessment, Final Report*, September 5. (**Harvey, 2012**)

National Climatic Data Center, National Oceanic and Atmospheric Administration, Climate Data Online, Station USC00100375, http://www.ncdc.noaa.gov/cdo-web/, accessed January 2015. (National Climatic Data Center, 2014)

North Wind Environmental, 2001. *Completion Report for Construction at the Moran Tunnel*, November 5. (**North Wind, 2001**)

North Wind Environmental, 2003. *Completion Report for Construction at the Moran Tunnel*, November 5. (**North Wind, 2003**)

North Wind Environmental, 2005. *Final Report For the 2005 Moran Tunnel Treatment System Maintenance Actions*, December. (**North Wind, 2005**)

North Wind Environmental, 2012. *Final Report for the 2012 Moran Tunnel Maintenance Activities*, December. (**North Wind, 2012**)

Olson, G. J., T. R. Clark, T. I. Mudder, M. Logsdon, 2006. Toward Source Control of Acid Rock Drainage. Paper presented at the 7th International Conference on Acid Rock Drainage (ICARD), March 26-30, 2006, St. Louis MO. R.I. Barnhisel (ed.) Published by the American Society for Mining and Reclamation. pp 2170–2187. (**Olsen et al., 2006**)

Roby, R.N., 1948. *Investigation of the Hornsilver Lead-Zinc Property, Butte County, Idaho*, U.S. Department of Interior, Bureau of Mines. (**Roby, 1948**)

S.I. McStay, 1999. Moran Tunnel Water Treatment Wetland Design, July 14. (**McStay, 1999**)

SES, Inc. and Hedin Environmental, 2005. *Remediation of Acid Mine Drainage From the Moran Tunnel*, September 30. (**Hedin, 2005**)

Tulane Univ. Website, 2014. Weathering and Clay Minerals. http://www.tulane.edu/~sanelson/eens211/weathering&clayminerals.htm (**Tulane, 2014**)

U.S. Department of Interior, Bureau of Land Management, June 1981. *Preliminary Soils Series Classification, Idaho Falls, Idaho*. (**BLM, 1981**)

U.S. Department of Interior, Bureau of Land Management, 1983. *Big Lost Management Framework Plan,* Idaho Falls District, Idaho Falls, Idaho. (**BLM, 1983**)

U.S. Department of Interior, Bureau of Land Management, June 1981. *Environmental Assessment for Champagne Creek – Moran Tunnel, Abandoned Mined Lands Remediation*. (**BLM, 1999**)

U.S. Department of Interior, Bureau of Land Management, April 2014, *CERCLA Engineering Evaluation/Cost Analysis, Approval Memorandum, Champagne Creek/Moran Tunnel, Butte County, Idaho*. (**BLM, 2014a**)

U.S. Department of Interior, Bureau of Land Management, 2014. *Summary of the geophysical investigation of the South Pit/Champagne Creek Site, Idaho*, October 2. (**BLM, 2014b**)

U.S. Department of Interior, Bureau of Land Management, 2014. *Unpublished Surface Water, Groundwater and Soil Data for the Champagne Creek Site, Idaho*, July. (**BLM, 2014c**)

U.S. Department of Interior, National Park Service, 1981. *Craters of the Moon: National Park Handbook (139)*. Washington D.C.: National Park Service Division of Publications. ISBN 978-0-912627-44-1. (**NPS, 1981**)

U.S. Environmental Protection Agency, *Role of Background in the CERCLA Cleanup Program*, OSWER 9285.6-07P, April 26, 2002. (**USEPA, 2002**)

U.S. Geological Survey (USGS), 2014. *Data Summary Report, Champagne Creek, Idaho*, USGS – Idaho Water Science Center, February 12. (**USGS, 2014**)

Western Technologies, Inc. 1990. Limited Geologic Assessment of the South Zone Pit, July. (**WTI, 1990**)

www.usclimatedata.com/climate/arco/idaho/united-states/usid0007/2014/1 (U.S. climate data, 2014)

APPENDIX A

HUMAN HEALTH RISK ASSESSMENT

DRAFT HUMAN HEALTH RISK ASSESSMENT FOR CHAMPAGNE CREEK, IDAHO

December 2014

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ACRONYMS

ABSGI	Gastrointestinal Absorption Value
ADAF	Age-Dependent Adjustment Factors
ATSDR	Agency for Toxic Substances and Disease Registry
BLM	Bureau of Land Management
COPC	Contaminant of Potential Concern
Cr	Chromium
Cr(III)	Trivalent Chromium
Cr(VI)	Hexavalent Chromium
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
EFH	Exposure Factors Handbook
EPC	Exposure Point Concentration
ET	Exposure Time
EU	Exposure Unit
EV	Event Frequency
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
GI	Gastrointestinal
ILCR	Incremental Lifetime Cancer Risk
IRB	Ingestion Rate of Beef
IRM	Ingestion Rate of Milk
IRS	Ingestion Rate of Sediment
IRW	Ingestion Rate of Water
IUR	Inhalation Unit Risk
MMOA	Mutagenic Mode of Action
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ORNL	Oak Ridge National Laboratories
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
REL	Reference Exposure Level
RfC	Reference Concentration
RfD	Reference Dose
RSL	Regional Screening Level
SDEF	Standard Default Exposure Factors
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
XRF	X-ray Fluorescence Spectrophotometry

1.0 INTRODUCTION

Champagne Creek is located approximately 17 miles west of Arco, Idaho, and has been impacted by acid mine drainage from Moran Tunnel, an abandoned tunnel which was built in the 1920s. As part of the acid mine drainage, heavy metal constituents are being released to the Champagne Creek (USGS, 2014). The United States Department of Interior, Bureau of Land Management (BLM) conducts period monitoring of surface water in Champagne Creek, and has tasked the ECM Team with preparation of a human health risk assessment (HHRA) to evaluate potential health risks and hazards to current and future populations who may access Champagne Creek.

This HHRA is considered a *focused* assessment, as its purview is constrained with respect to target constituents and receptor populations specified by BLM. It is limited in focus to metal contaminants identified by BLM as part of their surface water monitoring effort. In addition, a BLM sediment data set was considered in the HHRA (KC Harvey, 2012). The scope of this HHRA has been previously approved by BLM in correspondence dated October 15, 2013, Client Contract GS-10F-0335R.

This HHRA follows generally accepted United States Environmental Protection Agency (USEPA) risk assessment policies, procedures and guidance documents, and has been performed in accordance with *Risk Assessment Guidance for Superfund* (RAGS) (USEPA, 1989, 2001, 2002a, and 2004). Due to the focused nature of the HHRA, it does not explicitly follow RAGS, Part D (USEPA, 2001) in presentation format. To the greatest extent practicable, the exposure assessment considers exposure parameter values underpinning the most recent version of the USEPA Regional Screening Levels (RSLs) (May 2014) or generally accepted values as referenced in *Exposure Factors Handbook* (USEPA, 1997, 2011 and updates) and the 2014 updates to USEPA's Standard Default Exposure Factors (SDEF) guidance (EPA, 2014a).

The data evaluation and process for selecting contaminants of potential concern for the risk assessment are discussed in Section 2.0. The exposure assessment and the conceptual site model are explained in Section 3.0. Section 4.0 presents the toxicity assessment. The characterization of risk and hazard is presented in Section 5.0. The Uncertainty Analysis is presented in Section 6.0 and the HHRA Conclusions are presented in Section 7.0. References are provided in Section 8.0.

2.0 DATA EVALUATION

All metal constituents in the BLM surface water data set, which consists of five sampling locations, were retained as constituents of potential concern (COPCs) in the HHRA. The target analyte list includes the following metals: aluminum, arsenic, cadmium, chromium, copper, iron, mercury, nickel, silver, and zinc. In addition, it is noted that BLM provided the ECM Team with surface water data collected from Champagne Creek by the United States Geological Survey (USGS) in 2013 (USGS, 2014). Of the USGS locations sampled, four sample locations correspond to four (of the five) BLM surface water sample locations. This additional surface water data set, consisting of four sample locations, was used in conjunction with the BLM data set in the HHRA. See Table 1 for additional information regarding the surface water sample locations which make up the data set.

In addition, a sediment data set provided by BLM was evaluated in the HHRA (KC Harvey, 2012). Two samples, corresponding to a single exposure unit (EU) (i.e., EU 2, described further in Section 3.0), were collected and analyzed for five metals by BLM: arsenic, cadmium, copper, lead, and zinc. As such, the sediment data set consists of these five metals only. All metal constituents in the sediment data set were retained as COPCs. It is noted that additional sediment sample locations along Champagne Creek were field screened for metals contaminants using X-ray fluorescence spectrophotometry (XRF) by BLM in December 2013 (BLM provided the ECM Team with this raw data); however, given that these data were field-screened only (i.e., XRF data has neither the sensitivity, accuracy, nor reproducibility needed for a risk assessment), they were excluded from the quantitative assessment.

No COPCs were eliminated from the risk characterization based on comparison to non-anthropogenic, naturally-occurring (background) concentrations. In the event that background-related COPCs are determined to be risk and/or hazard drivers, the risk and/or hazard attributable to background will be evaluated and discussed as part of the Uncertainty Analysis of the HHRA.

2.1 DEVELOPMENT OF EXPOSURE POINT CONCENTRATIONS

Champagne Creek was divided into four discrete EUs and a background area based on the locations at which BLM regularly collects surface water samples. These EUs are described in Section 3.0. The exposure point concentration (EPC) for each analyte in surface water is the maximum concentration detected at each EU. The maximum concentration was selected from the combined BLM and USGS data sets and, when possible, only data collected in 2013 and 2014 were used to ensure the HHRA is based on current conditions. In some instances, no current (i.e., 2013 or 2014) data were available for an analyte. In those cases, the most recently available data point was used. For example, the most recent mercury and silver data available are from 1999. Therefore, the concentrations of mercury and silver detected at each EU in 1999 were used as the EPCs. The ECM Team recognizes the uncertainty inherent in the use of historical data, and notes these data were incorporated into the HHRA at the request of BLM. The EPCs for surface water are presented in Table 1.

The sediment data set consists of two sediment samples collected from the same EU. The EPC for each analyte in sediment is the maximum concentration detected. The EPCs for sediment are presented in Table 2.

2.2 BACKGROUND EVALUATION

Background surface water data were collected from a location above the Moran Tunnel discharge area to Champagne Creek. The selected sampling location is upgradient of Moran Tunnel (with respect to surface water flow, prevailing wind direction and precipitation overland/sheet flow) and is understood to be predominately free of impacts due to site operations at the Moran Tunnel Adit. Data representative of background locations may be downgradient of other anthropogenic activities and may receive inputs from these additional sources. It appears the background area is downgradient from the Hornsilver Mine, as well as Idaho Gold Corporation's Champagne Mine and other anthropogenic activities. As with the EPCs for each

analyte in surface water, the maximum concentration of each analyte detected at the sample location above Moran Tunnel was selected from the combined BLM and USGS data sets for use as the *de facto* background concentration and, when possible, only data collected in 2013 and 2014 were used to ensure the HHRA is based on current conditions. In some instances, no current (i.e., 2013 or 2014) data were available for an analyte. In those cases, the most recently available data point was used. For example, as with the EPCs discussed above, the most recent mercury and silver data available are from 1999. Therefore, the concentrations of mercury and silver detected above Moran Tunnel in 1999 were used as the background concentrations. The background data set for Champagne Creek is presented in Table 3.

3.0 EXPOSURE ASSESSMENT

The exposure assessment process quantifies the magnitude, frequency, and duration of exposure for those populations and pathways selected for quantitative evaluation in the conceptual site model (CSM) (See Figure 2). To quantify exposures, where appropriate and sufficient data are available, maximum detected concentrations were identified for each relevant EU. The exposure assessment considers relevant populations and complete exposure pathways relevant in an assessment of surface water and sediment contact.

3.1 CONCEPTUAL SITE MODEL

An evaluation of the potential human health risks posed by a site requires the identification of populations that may be exposed to site-related chemicals and to determine the routes by which these exposures may occur. The human health CSM provides the basis for a comprehensive evaluation of the potential risks to human health by identifying the mechanisms through which receptors may be exposed to residual COPCs at a site. The CSM traces the COPCs identified at a site in a logical migration from their source(s) through various release mechanisms and exposure routes to potentially affected receptors.

This section describes the generic current and future potential conditions at the Champagne Creek EUs, as defined below, including the current and potential future land use, human receptor populations and the complete exposure pathways.

3.1.1 Land Use and Receptor Populations

Current and future land uses have been specified by direction from BLM and include the following:

- EU1: Current/future recreational adult and child; agricultural family, adult and child.
- EU2: Current/future recreational adult and child.
- EU3: Current/future recreational adult and child; agricultural family, adult and child.
- EU4: Current/future recreational adult and child; agricultural family, adult and child.

Land uses are considered to remain consistent for the foreseeable future. Because the target analytes are metals and characterization of exposure is heavily weighted by the use of default exposure parameter values, and based on the use of the maximum detected concentration as the

effective EPC, current and future potential land uses are assumed to be equivalent. The Risk Characterization (Section 5) will present one set of quantitative point estimates of risk and hazard for each current/future exposure condition. The HHRA does not evaluate future residential redevelopment as a pragmatic option for the subject site and its environs, based on direction provided by BLM.

3.1.2 Exposure Units

The site has been divided into four discrete EUs and a background area (BKG). The EUs are defined below:

- EU1: Moran Tunnel Effluent – Moran Tunnel drainage area, prior to confluence with Champagne Creek.
- EU2: Moran Tunnel – Champagne Creek immediately downstream from the Moran Tunnel discharge point.
- EU3: Beaver Pond Discharge – Champagne Creek immediately downstream from the beaver pond.
- EU4: Poison Gulch – Champagne Creek immediately downstream of the Poison Gulch discharge point.

In point of fact, each EU actually represents a BLM sampling point or indicator area within Champagne Creek that is used to evaluate exposures to receptor populations originating from areas adjacent to the EU. These areas are not specifically defined for the purposes of the HHRA with respect to size or boundary.

The background area, BKG, represents the sampling location upstream from the Moran Tunnel discharge point(s).

Each EU and the BKG are depicted on Figure 1.

3.2 SOURCES AND TRANSPORT MECHANISMS

Primary, secondary, and tertiary sources of contaminants are listed in the CSM (Figure 2). Sources include the Moran Tunnel discharge to environmental matrices (e.g., soil, sediment, surface water) where COPCs can be found. COPCs may migrate from their primary source to secondary and tertiary sources. This HHRA evaluates COPCs that may be associated with residual metals from mine operations and fugitive waste rock resulting from historical operations at the Moran Tunnel Adit. The original constituent release mechanism is overland runoff from the Moran Tunnel surfaces and infiltrating shallow groundwater impacted through a compromised passive treatment system. Secondary release mechanisms include leaching and progressive erosion/overland flow suspension/resuspension of mine tailing particles by the erosive action of wind or water. Tertiary release mechanisms include resuspension as well as discharge of groundwater at the groundwater/surface water interface. The primary contact media for consideration within the HHRA are surface water in Champagne Creek and bank sediments.

3.2.1 Surface Water and Sediment

Evaluation of chronic exposure to contaminated surface water is the primary focus of the HHRA; however, a limited evaluation of exposure to contaminated sediment at EU 2 is also included. Considerations for exposure to surface water include incidental ingestion and dermal exposure for recreational users of the discharge environs as well as exposures to agricultural families via downstream ranching activities, where beef and milk cattle may be allowed watering access to Champagne Creek. The inclusion of home-raised milk ingestion by an agricultural farm family is a conservative assessment which is not a complete exposure pathway under current land use conditions and may be an unlikely consideration for future potential land use. Nevertheless, the HRA has invoked conservative bias in this assessment and considered the possibility that a dairy cow could be kept by a local farm family. It has been further presumed that this dairy cow would be allowed grazing along Champagne Creek.

Considerations for exposure to (predominantly dry) bank sediment include incidental ingestion, dermal exposure, and particulate inhalation for recreational users of the discharge environs.

Additional concerns related to contaminated groundwater will be addressed within the context of the HHRA as contributing/additional media.

3.2.2 Groundwater

There is no use of shallow groundwater at the subject areas of the HHRA. Consequently, use of groundwater as drinking water has not been evaluated within the HHRA. Future potential use of groundwater is unlikely and has been excluded from the HHRA based on direction from BLM.

Fate and transport considerations related to discharge of shallow groundwater at the groundwater-surface water interface will be addressed within the context of the Uncertainty Analysis (Section 6.0).

3.3 COMPLETE EXPOSURE PATHWAYS

The CSM, presented in Figure 2 is a graphical representation of the complete, incomplete, and potentially complete exposure pathways associated with the site under current conditions and future potential land use options. The quantitative components of the HHRA are focused on a subset of exposure conditions, targeting the most relevant and significant populations and complete exposure pathways, as dictated by BLM. The HHRA does not establish a baseline assessment in consideration of uncontrolled land use (e.g., residential development).

The primary exposure routes associated with surface water contact include incidental ingestion and dermal contact attributable to recreational users, and ingestion of home-raised beef and milk from cattle watered in the Champagne Creek by an agricultural family.

The receptor populations under current land use include:

- Recreational Users (Adult and Child).
- Agricultural Farm Family (Adult and Child).

Future potential receptor populations are the same as the current scenario.

Recreational users (adult and child) are assumed to have routine exposure to surface water while recreating in Champagne Creek. The complete exposure pathways include incidental ingestion and dermal contact with surface water while engaging in activities such as wading and similar activities. Incidental ingestion of and dermal contact with submerged sediment is not expected to contribute materially to overall exposure. The potential exists for contact to occur with bank sediments, especially as water levels ebb seasonally. Potential contact with bank sediments is addressed within EU2 and in the context of the Uncertainty Analysis. The HHRA does not evaluate fishing or fish/shellfish ingestion exposures based on direction from BLM.

An agricultural farm family, represented by an adult and child are assumed to ingest farm- or home-raised beef and milk from cattle watered in Champagne Creek. These populations are not assumed to have routine contact with surface water in Champagne Creek.

The inclusion of home-raised milk ingestion by an agricultural farm family is a conservative assessment which is not a complete exposure pathway under current land use conditions and may be an unlikely consideration for future potential land use. Nevertheless, the HRA has invoked conservative bias in this assessment and considered the possibility that a dairy cow could be kept by a local farm family. It has been further presumed that this dairy cow would be allowed grazing along Champagne Creek.

3.4 EXPOSURE QUANTIFICATION

The equations, exposure parameters, and parameter values used in the HHRA were taken from USEPA's RAGS (USEPA, 1989 and 2004); USEPA's *Supplemental Guidance for Developing Soil Screening Levels at Superfund Sites* (USEPA, 2002b); the USEPA's Exposure Factors Handbooks (EFH) (USEPA, 2008 and 2011); and, OSWER Directive 9200.1-120: *Update of Standard Default Exposure Factors* (SDEF) (USEPA, 2014a). ECM will utilize the Oak Ridge National Laboratories (ORNL) default parameter and intake values, consistent with agreements with BLM (ECM, 2014). The receptor-specific exposure parameters and values are presented in Tables 4, 9 and 13 and discussed further in subsections under Section 3.4.1.

3.4.1 Receptor-Specific Exposure Parameters

Receptor-specific exposure parameters were identified from activity studies in the USEPA Exposure Factor Handbook (USEPA, 2011) and are reflected in the ORNL databases.

Intake equations are taken from the Oak Ridge National Laboratory Risk Assessment Information System (RAIS) website (www.rais.ornl.gov) and are consistent with USEPA risk assessment policy. The presentation of these intake approaches includes consideration of adjustments to address mutagenic mode of action (MMOA). No COPCs associated with MMOA are among the COPCs at the Champagne Creek investigation areas.

Common pathway intake parameters for the adult and child recreational users and agricultural

farm family are listed in Sections 3.4.1.1 and 3.4.1.2 below. All receptor-specific exposure parameters and values are presented in Tables 4, 9 and 13.

3.4.1.1 Adult and Child Recreational Users

Exposure parameters for active recreational users generally follow USEPA guidance for residential exposures, with some modifications based on child activity studies reported in the Exposure Factor Handbook (USEPA, 2011) that reflect frequent outdoor activity and best-professional judgment. The active recreational use evaluation provides a more health protective exposure scenario for children playing in creek surface water than the traditional residential use scenario, but overall, these receptors have a significantly lessened degree of exposure when compared with future potential residents based on reduced exposure frequency. Active recreational users (adult and child) are assumed to have direct contact (dermal and ingestion) with COPCs in surface water. Common pathway intake parameters include:

Exposure Frequency: Recreational users are assumed to be exposed continuously for 45 days per year. This exposure frequency equates to slightly less than two days/week for the most attractive six months of the year. The degree of conservatism in this parameter is significant and is expected to represent the maximum frequency which can be reasonably attributed to a recreator.

Exposure Duration: Exposure assumptions for recreational users are assumed to be similar to those for residents. Therefore, recreational users are assumed to be exposed continuously for a period of 20 years for adults and six years for children. Twenty-six years is an upper-bound (90th percentile) estimate for residency at one address, allowing for routine access to Champagne Creek (USEPA, 2014a) and a child is defined as an individual between one and six years of age (USEPA, 2011).

Body Weight: A body weight of 80 kg was assumed for adults while 15 kg was assumed for children (USEPA, 2014a).

Averaging Time: The carcinogenic and noncarcinogenic averaging times for adults are assumed to be 25,550 days and 9,490 days, respectively. The carcinogenic and noncarcinogenic averaging times for children are assumed to be 25,550 days and 2,190 days, respectively. The averaging time for noncarcinogens was calculated by multiplying the exposure duration by 365 days per year (USEPA, 1989).

Skin Surface Area: The skin surface area available for contact with surface water is given as 20,900 cm^2 for an adult and 6,378 cm^2 for a child. These estimates reflect swimming exposures which are anticipated to overestimate routine surface water contact more pragmatically believed to represent wading activities (USEPA, 2011).

Ingestion Rate of Water (IRW): The IRW is given as 0.05L/hr, and reflects incidental ingestion of surface water while swimming. This estimate, utilized for both adult and child exposures, is anticipated to overestimate routine surface water contact more pragmatically believed to represent wading activities (USEPA, 2011).

Exposure Time (ET): Exposure time is conservatively assumed to represent 1 hour per event, consistent with ORNL recommendations. This value is utilized for both adult and child exposures.

Event Frequency (EV): Event frequency is conservatively assumed to represent one event per day, consistent with ORNL recommendations. This value is utilized for both adult and child exposures.

The ages associated with a child recreational user are 0-6 years which would incorporate age-dependent adjustment factors (ADAF) of 10 and 3 for constituents which act via a mutagenic mode of action (MMOA) over this time period, if any were associated with the site. This age period is assumed to be conservative for routine access to Champagne Creek, as child exposures, if any, are more likely to occur to children over 6 years of age given the remote nature of the site.

3.4.1.2 Adult and Child Agricultural Farm Family

Exposure parameters for an agricultural farm family (adult and child) largely reflect USEPA guidance for residential exposures. Adult and child farmers are assumed to have direct contact (ingestion) with farm-raised beef and milk from cattle which have been watered in Champagne Creek. Common pathway intake parameters include the following:

Exposure Frequency: Farmers are assumed to be/eat at their place of residence daily, with the exception of a single two-week vacation (i.e., 350 days per year) (USEPA, 2014a).

Exposure Duration: Residents are assumed to be exposed continuously for a period of 20 years for adults and six years for children (USEPA, 2014a). Twenty-six years is an upper-bound (90th percentile) estimate for residency at one address (USEPA, 2011) and a child is defined as an individual between one and six years of age (USEPA, 2011).

Body Weight: A body weight of 80 kilograms (kg) was assumed for adults while 15 kg was assumed for children (USEPA, 1989 and 2011).

Averaging Time: The carcinogenic and noncarcinogenic averaging times for adults were assumed to be 25,550 days and 9,490 days, respectively. The carcinogenic and noncarcinogenic averaging times for children were assumed to be 25,550 days and 2,190 days, respectively. The averaging time for noncarcinogens was calculated by multiplying the receptor-specific exposure duration by 365 days per year (USEPA, 1989).

Ingestion Rate of Milk (IRM): The adult ingestion rate for milk is given as 615,000 mg/day. The child ingestion rate for milk is given as 265,000 mg/day (ORNL, 2014).

Ingestion Rate for Beef (IRB): The adult ingestion rate for beef is given as 138,000 mg/day. The child ingestion rate for beef is given as 12,900 mg/day (ORNL, 2014).

4.0 TOXICITY ASSESSMENT

This section provides information regarding the potential for health risks from exposure to target

COPCs detected at Champagne Creek. Specifically, this section provides a quantitative estimate of the relationship between exposure and severity or probability of human biological effects for the COPCs identified in Section 2.0. Section 4.1 identifies carcinogenic toxicity values for potentially carcinogenic COPCs evaluated in the risk assessment. Section 4.2 describes how dose-response, or toxicity values, are established and used to assess exposure to noncarcinogenic COPCs.

In accordance with USEPA's Superfund guidance hierarchy of sources to identify dose-response values (USEPA, 2003), and consistent with the development of the May 2014 RSLs (USEPA, 2014b), relevant carcinogenic and noncarcinogenic dose-response values for this HHRA were obtained from the following sources (in descending order of preference):

a. Tier 1 – USEPA's Integrated Risk Information System (USEPA, 2014c);
b. Tier 2 – USEPA's Provisional Peer Reviewed Toxicity Values (USEPA, 2014d);
c. Tier 3 – Other Toxicity Values: This includes additional USEPA and non-USEPA sources of toxicity information. Priority is given to those sources of information that are the most current, transparent and peer-reviewed. Since the 2003 guidance does not rank the Tier 3 sources, the USEPA created a hierarchy among these sources in development of the RSLs (USEPA, 2014b) as follows:

    i. The Agency for Toxic Substances and Disease Registry (ATSDR),
    ii. The Cal/EPA OEHHA's Chronic Reference Exposure Levels (RELs),
    iii. PPRTV Appendix Screening Toxicity Values, and
    iv. Health Effects Assessment Summary Tables (HEAST) Toxicity Values.

4.1 CARCINOGENIC CONSTITUENTS

The incremental lifetime cancer risk (ILCR) attributed to a carcinogen is calculated as a product of the daily intake and the cancer slope factor (CSF) ($(mg/kg\text{-}d)^{-1}$) for oral and dermal exposure and the inhalation unit risk (IUR) expressed in units of $(ug/m^3)^{-1}$. USEPA's model of carcinogenesis assumes the relationship between exposure to a carcinogen and cancer risk is linear over the entire dose range, except at very high doses (USEPA, 1989). This linearity assumes there is no threshold-of-exposure dose below which harmful effects will not occur.

Because of this, carcinogenic effects are considered to be cumulative within and across all relevant pathways and within age groups when considering lifetime exposures. The CSFs and IURs for the COPCs evaluated in this report are presented in Tables 18, 20, and 22. Although no dermal CSFs are available from the sources identified above, the USEPA has devised a method for making route-to-route (oral-to-dermal) extrapolations for systemic effects (USEPA, 2004), as described in Section 4.3 below.

4.1.1 Carcinogens with a Mutagenic Mode of Action

There are no COPCs associated with a MMOA.

4.2 NONCARCINOGENIC CONSTITUENTS

For the noncarcinogenic effects of specific constituents, USEPA assumes a dose exists below which no adverse health effects will be seen (USEPA, 1989). Below this "threshold" it is believed that exposure to a chemical can be tolerated without adverse effects. Adverse effects manifest only when physiologic protective mechanisms are overcome by exposure to doses above the threshold. For assessment of hazard, a chemical-specific reference value dose (RfD) (mg/kg/day) is derived for use in assessing oral and dermal exposures and a reference concentration (RfC) (ug/m^3) is derived for use in assessing inhalation exposures. The RfD, expressed in units of milligrams per kilogram-day (mg/kg-d), represents the daily oral intake of a constituent (averaged over a year) per kilogram of body weight that is below the effect threshold for the constituent. The RfC represents a concentration expected to be without appreciable risk of adverse health effects if inhaled over the course of a lifetime, accounting for sensitive subpopulations. The reference doses and reference concentrations for the COPCs evaluated in this report are presented in Tables 18, 20, and 22. While hazard is assumed to be additive within and across pathways in the baseline assessment, hazard indices may be segregated by target organ system effect/endpoint. The USEPA assumes noncarcinogenic exposure doses are not cumulative from age group to age group over a lifetime of exposure (USEPA, 1989). Dermal RfDs are derived from oral RfDs, as described in Section 4.3.

4.3 ROUTE-TO-ROUTE EXTRAPOLATION

Ideally, route-specific toxicity factors account for dosimetry information on the dose-response relationship for systemic effects from the absorbed dose. In the absence of dermal toxicity factors, USEPA has devised a method for making route-to-route (oral-to-dermal) extrapolations for systemic effects (USEPA, 2004). Using absorption efficiency information from oral administration studies, toxicity factors are adjusted to represent the absorbed dose rather than the administered dose. When gastrointestinal absorption of a chemical in the critical study is poor (e.g., 10%), the absorbed dose is much smaller than the administered dose. To account for this, the RfDs and CSFs are multiplied or divided, respectively, by the recommended gastrointestinal (GI) absorption values (ABSGI). The ECM Team has followed the procedures for dermal risk assessment as outlined in USEPA, 2004.

5.0 RISK CHARACTERIZATION

The following receptor populations were evaluated in the HHRA: current and future adult and child recreational users and a current and future agricultural farm family composed of an adult and child. A summary of the carcinogenic risks and non-carcinogenic hazards for each receptor population are summarized in Tables 5 through 8 (for recreators exposed to surface water), Tables 10 through 12 (for an agricultural farm family exposed to surface water), and Table 14 (for recreators exposed to sediment at EU 2), respectively.

5.1 RECREATIONAL USERS

The cumulative excess carcinogenic risk for a recreational user attributable to surface water exposure in the Moran Tunnel EU (EU 1) is 1.56E-04, which is based on age-adjusted exposure

durations of 6 years for a child and 20 years for an adult. This risk estimate lies at the high end of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) target risk range of 1E-04 and 1E-06. Carcinogenic risk is driven by exposure to arsenic via the ingestion exposure pathway, with contributions due to exposure to arsenic via the dermal exposure pathway.

The cumulative excess carcinogenic risks for a recreational user attributable to surface water exposure in the Below Moran Tunnel EU (EU 2), Below Beaver Pond EU (EU 3), and Below Poison Gulch EU (EU 4) are all less than 1.0E-06.

The total non-carcinogenic hazard indices (HI) for an adult recreational user (3.23) and a child recreational user (9.52) attributable to surface water exposure in EU 1 exceed unity. Non-carcinogenic hazard in EU 1 is driven by exposure to arsenic and cadmium. In addition, the total HIs for an adult recreational user (1.04) and a child recreational user (2.62) attributable to surface water exposure in EU 2 exceed unity. Non-carcinogenic hazard in EU2 is driven by exposure to cadmium.

The total non-carcinogenic HIs for a recreational user attributable to surface water exposure in EU 3 and EU 4 are less than 1.

In addition, the cumulative excess carcinogenic risk for an age-adjusted recreational user attributable to sediment exposure in the Below Moran Tunnel EU (EU 2) is 2.65E-05, which falls at the mid-point of the NCP target risk range. Carcinogenic risk is driven by exposure to arsenic via the ingestion and dermal exposure pathways. The total non-carcinogenic HIs for an adult and child recreational user attributable to sediment exposure in EU 2 are less than 1. In addition, it is noted that the maximum detected concentration of lead is below the residential soil standard of 400 milligrams per kilogram.

5.2 AGRICUTURAL FARM FAMILY

The cumulative excess carcinogenic risk for an agricultural farm family attributable to ingestion of beef and milk from cattle watered in Champagne Creek at the Moran Tunnel EU (EU 1) is 1.70E-04. This risk estimate lies at the high end of the NCP target risk range of 1E-04 and 1E-06. Carcinogenic risk is driven by exposure to arsenic via ingestion of beef and milk.

The cumulative excess carcinogenic risks for an agricultural farm family attributable to ingestion of beef and milk from cattle watered in Champagne Creek in the Below Beaver Pond EU (EU 3) and Below Poison Gulch EU (EU 4) are all less than 1.0E-06.

The total non-carcinogenic HI for an agricultural farm family (35.3) attributable to ingestion of beef and milk from cattle watered in Champagne Creek at EU 1 exceeds unity. Non-carcinogenic hazard is driven by exposure to mercury.

The total non-carcinogenic HIs attributable to an agricultural farm family based on ingestion of beef and milk from cattle watered at Champagne at EU 3 and EU 4 are less than 1.

6.0 UNCERTAINTY ANALYSIS

Overall, the HHRA follows a conservative approach in the assessment of current and future potential risk and hazard. The EPCs represent the maximum detected concentrations and the intake parameter values predominately represent the USEPA default values currently utilized in the May 2014 version of the RSLs and those promulgated by ORNL.

Generally, the combination of default exposure parameter values, which largely reflect upper-bound estimates of potential exposure, and an EPC predicated on a maximum detected concentration will lead to a conservative assessment of reasonable maximum exposure which is appropriately biased in the face of uncertainty. This inherent bias is compulsory given the uncertainty associated with human behavior patterns, the basis of the toxicity criteria, and the absence of current data to underpin a more current assessment of contaminant concentrations at the subject EUs.

6.1 EXPOSURE ASSESSMENT

An agricultural farm family, represented by an adult and child, are assumed to ingest farm- or home-raised beef and milk from cattle watered in Champagne Creek. These populations are not assumed to have routine contact with surface water in Champagne Creek. However, it is noted that if they did have routine contact with contaminated surface water, their exposures would be equivalent to the recreational user's exposures and consequently the risks/hazards from these two populations would be considered cumulative.

The inclusion of home-raised milk ingestion by an agricultural farm family is a conservative assessment which is not a complete exposure pathway under current land use conditions and may be an unlikely consideration for future potential land use. Nevertheless, the HRA has invoked conservative bias in this assessment and considered the possibility that a dairy cow could be kept by a local farm family. It has been further presumed that this dairy cow would be allowed grazing along Champagne Creek. Milk ingestion, generally, results in associated risk which is roughly an order of magnitude less than risks associated with beef ingestion. Thus, milk ingestion does not substantively contribute to overall risks for a farm family consuming home-raised beef which has been watered at Champagne Creek. Milk risks are above the *de minimis* level (1E-06) at EU-1; however, they are approximately an order of magnitude less than risks associated with beef ingestion and so do not materially impact risk-based decision making with regard to the watering of any cattle in Champagne Creek.

Total Risk to a Farm Family Assuming Routine Contact with Surface Water

	EU 1	EU 3	EU 4
Risk – Ingestion of Beef and Milk	1.70E-04	2.32E-07	2.32E-07
Risk – Direct Contact with Surface Water*	1.56E-04	2.13E-07	2.13E-07
Total Risk to Farm Family Assuming Routine Contact with Surface Water	3.26E-04	4.45E-07	4.45E-07

*Value presented is total risk to an age-adjusted recreator exposed to surface water.

As shown in the table above, assuming that these risks are additive does result in an effective doubling of carcinogenic risk to a farm family; however, it is important to note that this overall increase in total risk is not likely substantive from a risk management perspective in that individual relevant populations at EU 1 are already associated with contaminant risks above the upper-brightline of the NCP relative risk range (i.e., 1E-04). Individual and combined exposure scenarios at EU 3 and EU 4 are associated with contaminant risks which fall outside the NCP relative risk range (i.e., are less than 1E-06). This presumes the data reflecting current conditions is defensible for effective risk management.

Recreational users were assumed to be exposed continuously for 45 days per year. This exposure frequency equates to slightly less than two days/week for the most attractive six months of the year. This exposure frequency is likely overestimated given the remote location and altitude of Champagne Creek.

The skin surface area available for contact with surface water is given as 20,900 cm^2 for an adult and 6,378 cm^2 for a child. These estimates reflect swimming exposures which are anticipated to overestimate routine surface water contact, more pragmatically believed to represent wading activities, if and when they actually occur.

The assumed IRW was 0.05L/hr, and reflects incidental ingestion of surface water while swimming. This estimate, utilized for both adult and child exposures, is anticipated to overestimate routine surface water contact, more pragmatically believed to represent wading activities which would not be expected to result in incidental ingestion.

The assumed sediment ingestion rate (IRS) for adult and child recreational users at EU 2 was 100 mg/day and 200 mg/day, respectively. These ingestion rates are based on routine exposure to soil and likely overestimate bank sediment contact. Based on information provided by BLM, the sediment sampling locations are predominantly dry, but may be periodically inundated (i.e., submerged). As a result, exposures to sediment may be limited. Exposure to submerged sediment would not be expected to contribute materially to overall exposure.

6.2 BACKGROUND DATASET

Background surface water data were collected from a location above Moran Tunnel. As discussed in Section 2.2, the selected sampling location is predominately upgradient of Moran Tunnel (with respect to prevailing wind direction and precipitation overland/sheet flow); however variation in wind direction could contribute to some suspension and subsequent dispersion of surface material that could in turn llead to deposition within the background area. In addition, the background area may be impacted by other upgradient sources such as the Hornsilver Mine and the Champagne Mine. Surface water data from this location may represent elevated aluminum, iron, and zinc and groundwater (MW-1) may be impacted by aluminum and iron.

The concentrations of all target analytes detected in surface water in EU 1 are greater than 10 times their respective background concentrations. In addition, the concentrations of aluminum, cadmium, copper, iron, nickel, and zinc detected in surface water in EU 2 are greater than 10

times their respective background concentrations. This trend tends to indicate that acid mine drainage from Moran Tunnel is impacting surface water in Champagne Creek and that risk/hazard estimates are not being unduly influenced by naturally-occurring conditions.

6.3 GROUNDWATER DATA

Based on input from BLM, ECM understands that groundwater, impacted by infiltrating surface water and a compromised passive treatment system, discharges to surface water in Champagne Creek; as such, metals detections in Champagne Creek may reflect both direct mine drainage to surface water and contaminant loading from groundwater. BLM provided ECM with groundwater data collected in 2013 and 2014 from nine monitoring wells located in the vicinity of Champagne Creek (See Table 15). Groundwater samples were analyzed for aluminum, copper, iron, and zinc. The ECM Team compared the concentrations of contaminants detected in groundwater samples collected from monitoring wells located upgradient from each EU to the surface water detections at those EUs:

- Monitoring Well (MW) 1 is located northwest (upstream) of EU 1. The maximum concentrations of aluminum, copper, iron, and zinc detected in surface water at EU 1 are approximately three orders of magnitude greater than those detected in groundwater at MW 1. It is noted that MW 1 is also located north of Moran Tunnel itself; as such, concentrations in groundwater are more likely representative of background conditions.
- Monitoring well MW 6 is located north (upstream) of EU 2. The maximum concentrations of the four metals detected in surface water at EU 2 are approximately the same as those detected in groundwater at MW 6.
- Monitoring well MW 2 is located north (upstream) of EU 3. The maximum concentrations of the four metals detected in surface water at EU 3 are approximately one to two orders of magnitude less than those detected in groundwater at MW 2.
- Monitoring well MW 9 is located north (upstream) of EU 4. The maximum concentrations of the four metals detected in surface water at EU 4 are approximately one order of magnitude greater than those detected in groundwater at MW 9.

Based on the comparison of surface water and groundwater data in the vicinity of Champagne Creek, it appears that groundwater discharge *may be* contributing contamination to surface water at EU 2 and EU 3. This is based on the observation that concentrations in groundwater detected in wells upstream are the same or greater than those detected in surface water at these EUs. A detailed review of groundwater-surface water discharge points, rates, and a mixing zone analysis are beyond the scope of the HHRA. However, differentiating between inputs is important in an evaluation of contributing sources to groundwater and surface water. It is also an important consideration in the overall management of the site.

6.4 CHROMIUM

Chromium (Cr) is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases (ATSDR, 1998). Cr exists in two possible oxidation states in soil: trivalent (Cr(III)) and hexavalent (Cr(VI)) forms (Deverel et. al., 2012). As discussed below,

CrIII is the form of this metal at issue at this site. The respiratory tract is the major target organ for chromium (III) toxicity. Chromium (III) is an essential element in humans. The body can detoxify some amount of chromium (VI) to chromium (III).

The average concentration of Cr in the earth's crust is about 100 mg/kg. Chromium concentrations are higher in basaltic and ultramafic rocks, which have average concentrations of about 200 mg/kg and 2400 mg/kg, respectively, than in granitic rocks, which have an average concentration of 10 mg/kg (Krauskopf, 1967). Chromium is most likely to be found in chromite ($FeCr_2O_4$) ore and exists in the trivalent oxidation state (Izbicki et. al., 2008). The solubility of Cr(III) in soil solution and groundwater is affected primarily by its interaction with mineral surfaces and co-precipitation with iron oxide type minerals. Trivalent Cr oxidizes to the hexavalent form under oxidizing conditions prevalent in some soils. Organic material and manganese oxides are important electron acceptor for this reaction (ASCE, 2012). Cr(III) is the predominant form in most minerals and is favored by reducing and strongly acidic conditions, while Cr(VI) occurs under oxidizing and alkaline conditions. Typical geogenic sources of Cr(VI) are ultramafic rocks and serpentinites. When Cr(III) is oxidized to Cr(VI), typically in the presence of manganese oxides, it adsorbs on iron oxides under neutral to acidic conditions (Izbicki et al., 2008). Mobilization of Cr(VI) can occur when the pH is increased beyond the pH of zero-charge of iron oxides, which is in the range 7.5 to 9 (Dimitris et.al., 2012). However pH levels below 10 in soil are not conducive to the formation/stability of Cr(VI).

The ECM Team reviewed the pH for the sediment data set provided by BLM (KC Harvey, 2012). Values for pH for the two sediment samples were 4.4 and 4.3. Neutral to slightly acidic pH levels in soil favor Cr(III), and Cr(III) is the most stable from under reducing conditions at pH values from 4 to 8 (Fendorf, 1994). Therefore it is highly likely that Cr(III) is the predominant (if not entire) form of Cr at Champagne Creek rather than Cr(VI). In the absence of speciation data for Cr, the HHRA has assumed that all detected Cr is representative of the Cr(III) form. This assumption is not anticipated to confer significant underestimation of hazard which could materially impact defensible site management decision-making. However, The ECM Team suggests that future site investigations either characterize the form of Cr or collect defensible estimates of surface water/sediment pH to refine future risk assessment efforts.

7.0 CONCLUSIONS

The cumulative excess carcinogenic risk for a recreational user attributable to surface water exposure in the Moran Tunnel EU (EU 1) is 1.56E-04. Similarly, the cumulative excess carcinogenic risk for an agricultural farm family attributable to ingestion of beef and milk from cattle watered in Champagne Creek at EU 1 is 1.70E-04. These risk estimates lie at the high end of the NCP target risk range and are driven by exposure to arsenic via the ingestion exposure pathway. In addition, total non-carcinogenic HIs for an adult and child recreational user attributable to surface water exposure in EU 1 exceed unity; these HIs are driven by exposure to arsenic and cadmium. Similarly, the total non-carcinogenic HI for an agricultural farm family attributable to ingestion of beef and milk from cattle watered in Champagne Creek at EU 1 exceeds unity; this HI is driven by exposure to mercury.

It is noted that for the recreational user receptor population, the risk and hazard estimates are based on an assumed surface water ingestion rate of 0.05L/hr, and exposed skin surface areas of 20,900 cm^2 for an adult and 6,378 cm^2 for a child. These exposure parameter values are anticipated to overestimate routine surface water contact, which is more pragmatically believed to represent wading activities, if and when they actually occur. Similarly, recreational users were assumed to be exposed continuously for 45 days per year; this exposure frequency is likely overestimated given the remote location and altitude of Champagne Creek. Nonetheless, the concentrations of all target analytes detected in surface water in EU 1 are greater than 10 times their respective background concentrations, indicating that acid mine drainage from Moran Tunnel is likely impacting surface water in Champagne Creek at EU 1.

The cumulative excess carcinogenic risks for a recreational user attributable to surface water exposure in the Below Moran Tunnel EU (EU 2) was less than 1.0E-06; however, the total HIs for an adult and child recreational user attributable to surface water exposure in EU 2 exceed unity. These HIs are driven by exposure to cadmium. Risks and hazards to an agricultural farm family were not evaluated at EU 2. As with EU 1, risks to the recreational user population are likely overestimated; however, the concentrations of aluminum, cadmium, copper, iron, nickel, and zinc detected in surface water in EU 2 are greater than 10 times their respective background concentrations, indicating that acid mine drainage from Moran Tunnel is impacting surface water in Champagne Creek at EU 2.

No unacceptable risks or hazards were identified for EU 3 or EU 4 for the subject receptor populations.

8.0 RECOMMENDATIONS

Based on the results of the HHRA, it appears that development of remedial action alternatives is warranted to address risks and hazards associated with metals contamination identified at EU 1 and EU 2. No unacceptable risks or hazards were identified for EU 3 or EU 4 for the subject receptor populations; therefore, no further action appears to be warranted for these EUs.

9.0 REFERENCES

Agency for Toxic Substances & Disease Registry (ATSDR) (1998). T*oxicological Profile for Chromium*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

American Society of Civil Engineers (ASCE) (2012). Agricultural Salinity Assessment and Management.

Deverel, S.J., Goldberg, S. and R. Fujii (2012). *Chemistry of Trace Elements in Soils and Groundwater. In: W.W. Wallender and K.K. Tanji (eds) ASCE Manual and Reports on Engineering Practice No. 71 Agriculture Salinity Assessment and management (2nd Edition).* ASCE, Reston, VA. Chapter 4 pp:89-137. http://www.ars.usda.gov/SP2UserFiles/Place/53102000/pdf_pubs/P2199.pdf

Dimitris Dermatasa , Christos Vatseris , Iraklis Panagiotakis, Maria Chrysochoou (2012). *Potential Contribution of Geogenic Chromium in Groundwater Contamination of a Greek Heavily Industrialized Area*.

ECM (2014). Scoping Teleconference with BLM. June 30.

Fendorf, Scott E (1994). *Surface Reaction of Chromium in Soils and Waters*.

Izbicki, John A., Ball, James W., Bullen, Thomas, D., and Sutley, Stephen J (2008). *Chromium, Chromium Isotopes and Selected Trace Elements, Western Mojave Desert, USA.*

Krauskopf, Konrad B. Introduction to Geochemistry. McGraw-Hill Book Company, 1967, Chapter 20 pp 588-593 and Appendix III.

KC Harvey Environmental, LLC (KC Harvey) (2012). *Champagne Creek Vegetation Assessment Final Report*. September 5.

Oak Ridge National Laboratory (ORNL) (2014). The Risk Assessment Information System. Rais.ornl.gov. October.

USEPA (1989). Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC.

USEPA (1997). Exposure Factors Handbook. Volume I General Factors. Office of Research and Development, Washington, D.C. EPA/600/P-95/002Fa. August 1997.

USEPA (2001). Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part D), Final, Publication 9285.7-47, Office of Emergency and Remedial Response, Washington, DC. December.

USEPA (2002a). Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites, EPA 540-R-01-003, OSWER Directive 9285.7-41, Washington, DC.

USEPA (2002b). Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24, December.

USEPA (2003). Human Health Toxicity Values in Superfund Risk Assessments. OSWER Directive 9285.7-53. Memo from Michael B. Cook. December 5, 2003.

USEPA (2004). Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R/99/005. July.

USEPA (2008). Child-Specific Exposure Factors Handbook (Final Report) 2008. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-06/096F.

USEPA (2011). Exposure Factors Handbook. 2011 Edition. Office of Research and Development, Washington, D.C. EPA/600/R-09/052F. September.

USEPA (2014a). Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120. February 6, 2014.

USEPA (2014b). Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites. U.S. Environmental Protection Agency, May.

USEPA (2014c). Integrated Risk Information System. http://www.epa.gov/IRIS/

USEPA (2014d). Provisional Peer Reviewed Toxicity Values for Superfund. http://hhpprtv.ornl.gov/

U.S. Geological Survey (USGS) (2014). *Data Summary Report, Champagne Creek, Idaho*. February 12.

TABLES

Table 1
Exposure Point Concentrations (Maximum Detected Concentrations) for Target Analytes in Surface Water

	Aluminum		Arsenic		Cadmium		Chromium		Copper		Iron		Mercury		Nickel		Silver		Zinc	
Sample Location	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**
EU 1: Moran Tunnel	738.000	9/11/2013	1.470	7/17/2013	1.280	7/17/2013	0.457	7/17/2013	95.000	6/6/2013	1520.000	6/6/2013	0.275	8/18/1999	2.770	7/17/2013	0.193	8/18/1999	88.100	7/1/2013
EU 2: Below Moran Tunnel	375.000	7/21/2014	0.007	7/17/2013	0.555	7/17/2013	0.029	7/17/2013	42.300	7/14/2014	323.000	7/21/2014	ND	8/18/1999	0.771	7/17/2013	ND	8/18/1999	54.900	7/14/2014
EU 3: Below Beaver Pond	3.640	6/6/2013	0.002	7/17/2013	0.024	7/17/2013	0.003	7/17/2013	3.600	7/1/2013	19.700	7/17/2013	NA	N/A	0.057	7/17/2013	NA	N/A	10.200	6/6/2013
EU 4: Below Poison Gulch	4.190	8/8/2013	0.002	8/18/1999	0.002	5/18/2000	ND	3/11/2000	0.120	8/8/2013	7.370	8/8/2013	ND	8/18/1999	0.016	8/18/1999	ND	8/18/1999	0.370	8/8/2013

Notes

Data sources include (1) Bureau of Land Management surface water data collected in 2013 and 2014 and (2) United States Geological Survey (USGS) data collected in 2013 (as presented in the *Data Summary Report, Champagne Creek, Idaho* , dated February 12, 2014).
USGS data points 4, 11, and 16 (as presented in their *Data Summary Report*) correspond to BLM sampling locations Moran Tunnel, Below Moran Tunnel, and Below Beaver Pond, respectively. No USGS data point corresponds to BLM sampling location Below Poison Gulch.
Data presented are the maximum concentrations of each analyte detected in the last two years (i.e., 2013 and 2014) except where noted.
Light blue shading indicates the maximum detected concentration was identified in the Bureau of Land Management data set from 2013 and 2014.
Light orange shading indicates the maximum detected concentration was identified in the United States Geological Survey data set from 2013.
Light green shading indicates no current (i.e., 2013 or 2014) data are available for this analyte. The concentration listed for the analyte is that of the most recent available from the Bureau of Land Management data set.

Definitions

EU: Exposure unit
mg/L: milligrams per Liter
NA: None available
N/A: Not applicable
ND: Not detected

Table 2 Exposure Point Concentrations (Maximum Detected Concentrations) for Target Analytes in Sediment					
Sample Location	**Arsenic**	**Cadmium**	**Copper**	**Lead**	**Zinc**
EU 2: Below Moran Tunnel - Sample 1	22.30	6.14	1100.00	38.60	107.00
EU 2: Below Moran Tunnel - Sample 2	**87.60**	**10.60**	**1710.00**	**62.20**	**146.00**

Notes

Data source: *Champagne Creek Vegetation Assessment Final Report* , prepared by KC Harvey Environmental, September 15, 2012.
Data collected in June 2012.
Concentrations reported in milligrams per kilogram dry weight.
The sample with the highest reported concentration is bolded and shaded.

Definitions

EU: Exposure Unit

Table 3
Background Concentrations of Target Analytes in Surface Water

	Aluminum		Arsenic		Cadmium		Chromium		Copper		Iron		Mercury		Nickel		Silver		Zinc	
Sample Location	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**	**Max Detect (mg/L)**	**Date Sampled**
Above Moran Tunnel	18.700	9/11/2013	0.001	7/17/2013	0.003	7/17/2013	0.026	7/17/2013	1.300	8/8/2013	22.400	9/11/2013	ND	8/18/1999	0.042	7/17/2013	ND	8/18/1999	0.281	7/17/2013

Notes

Data sources include (1) Bureau of Land Management surface water data collected in 2013 and 2014 and (2) United States Geological Survey (USGS) data collected in 2013 (as presented in the *Data Summary Report, Champagne Creek, Idaho* , dated February 12, 2014).
USGS data point 1 (as presented in their Data Summary Report) corresponds to BLM sampling location Above Moran Tunnel.
Data presented are the maximum concentrations of each analyte detected in the last two years (i.e., 2013 and 2014) except where noted.
Light blue shading indicates the maximum detected concentration was identified in the Bureau of Land Management data set from 2013 and 2014.
Light orange shading indicates the maximum detected concentration was identified in the United States Geological Survey data set from 2013.
Light green shading indicates no current (i.e., 2013 or 2014) data are available for this analyte. The concentration listed for the analyte is that of the most recent available from the Bureau of Land Management data set.

Definitions

mg/L: milligrams per Liter
ND: Not detected

Table 4 Recreator Equation Inputs for Surface Water	
Variable	**Value**
TR (target cancer risk) unitless	0.000001
ED_{rec} (exposure duration - recreator) years	26
THQ (target hazard quotient) unitless	1
LT (lifetime - recreator) yr	70
EF_{rec-w} (exposure frequency) d/yr	45
ET_{rec} (exposure time) hours/day	1
Apparent thickness of stratum corneum (cm)	0.001
BW_a (body weight - adult) kg	80
SA_{rec} (skin surface area - adult) cm^2	20900
IRW_{rec} (water intake rate - adult) L/day	0.05
$ET_{recw-adj}$ (age-adjusted exposure time) hour/event	1
$ET_{recw-madj}$ (mutagenic age-adjusted exposure time) hour/event	1
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	1.4625
$IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg	5.925
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	349929
$DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	1082538
BW_{0-2} (body weight) kg	15
BW_{2-6} (body weight) kg	15
BW_{6-16} (body weight) kg	80
BW_{16-30} (body weight) kg	80
ED_{0-2} (exposure duration) year	2
ED_{2-6} (exposure duration) year	4
ED_{6-16} (exposure duration) year	10
ED_{16-30} (exposure duration) year	10
EF_{0-2} (exposure frequency) day/year	45
EF_{2-6} (exposure frequency) day/year	45
EF_{6-16} (exposure frequency) day/year	45
EF_{16-30} (exposure frequency) day/year	45
$ET_{recw0-2}$ (exposure time) hour/event	1
$ET_{recw2-6}$ (exposure time) hour/event	1
$ET_{recw6-16}$ (exposure time) hour/event	1
$ET_{recw16-30}$ (exposure time) hour/event	1
EV_{0-2} (events) events/day	1
EV_{2-6} (events) events/day	1
EV_{6-16} (events) events/day	1
EV_{16-30} (events) events/day	1
IRW_{0-2} (water intake rate) L/hour	0.05
IRW_{2-6} (water intake rate) L/hour	0.05
IRW_{6-16} (water intake rate) L/hour	0.05
IRW_{16-30} (water intake rate) L/hour	0.05
SA_{0-2} (skin surface area) cm^2	6378
SA_{2-6} (skin surface area) cm^2	6378
SA_{6-16} (skin surface area) cm^2	20900
SA_{16-30} (skin surface area) cm^2	20900
ED_{recwa} (exposure duration - adult) year	20
EF_{recwa} (adult exposure frequency) day/year	45
ET_{recwa} (adult exposure time) hour/event	1
EV_{recwa} (adult) events/day	1
BW_{recwa} (body weight - adult) kg	80
SA_{recwa} (skin surface area - adult) cm^2	20900
IRW_{recwa} (water intake rate - adult) L/hr	0.05

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Table 5
Exposure Unit 1: Moran Tunnel
Summary of Risks and Hazards for Adult and Child Recreators Exposed to Surface Water

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Concentration (ug/L)	Child Ingestion HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Dermal Risk	Total Risk
Aluminum	No	No	738	738000	3.03E-01	3.87E-02	3.42E-01	5.69E-02	2.38E-02	8.06E-02	1.14E-01	2.72E-02	1.41E-01	-	-	-
Arsenic, Inorganic	No	No	1.47	1470	2.01E+00	2.57E-01	2.27E+00	3.78E-01	1.58E-01	5.35E-01	7.55E-01	1.81E-01	9.36E-01	**1.26E-04**	**3.02E-05**	**1.56E-04**
Cadmium (Water)	No	No	1.28	1280	1.05E+00	2.68E+00	3.74E+00	1.97E-01	1.65E+00	1.85E+00	3.95E-01	1.89E+00	2.28E+00	-	-	-
Chromium(III), Insoluble Salts	No	No	0.457	457	1.25E-04	1.23E-03	1.35E-03	2.35E-05	7.55E-04	7.78E-04	4.70E-05	8.64E-04	9.11E-04	-	-	-
Copper	No	No	95	95000	9.76E-01	1.25E-01	1.10E+00	1.83E-01	7.65E-02	2.60E-01	3.66E-01	8.76E-02	4.54E-01	-	-	-
Iron	No	No	1520	1520000	8.92E-01	1.14E-01	1.01E+00	1.67E-01	6.99E-02	2.37E-01	3.35E-01	8.01E-02	4.15E-01	-	-	-
Mercury (elemental)	No	Yes	0.275	275	7.06E-01	9.01E-02	7.96E-01	1.32E-01	5.54E-02	1.88E-01	2.65E-01	6.34E-02	3.28E-01	-	-	-
Nickel Soluble Salts	No	No	2.77	2770	5.69E-02	3.63E-02	9.32E-02	1.07E-02	2.23E-02	3.30E-02	2.13E-02	2.55E-02	4.69E-02	-	-	-
Silver	No	No	0.193	193	1.59E-02	3.04E-02	4.62E-02	2.97E-03	1.86E-02	2.16E-02	5.95E-03	2.13E-02	2.73E-02	-	-	-
Zinc and Compounds	No	No	88.1	88100	1.21E-01	9.24E-03	1.30E-01	2.26E-02	5.68E-03	2.83E-02	4.53E-02	6.50E-03	5.18E-02	-	-	-
**Total Risk/HI*			-	-	*6.14E+00*	*3.39E+00*	*9.52E+00*	*1.15E+00*	*2.08E+00*	*3.23E+00*	*2.30E+00*	*2.38E+00*	*4.68E+00*	***1.26E-04***	***3.02E-05***	***1.56E-04***

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Table 6
Exposure Unit 2: Below Moran Tunnel
Summary of Risks and Hazards for Adult and Child Recreators Exposed to Surface Water

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Concentration (ug/L)	Child Ingestion HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Dermal Risk	Total Risk
Aluminum	No	No	375	375000	1.54E-01	1.97E-02	1.74E-01	2.89E-02	1.21E-02	4.10E-02	5.78E-02	1.38E-02	7.16E-02	-	-	-
Arsenic, Inorganic	No	No	0.0072	7.2	9.86E-03	1.26E-03	1.11E-02	1.85E-03	7.73E-04	2.62E-03	3.70E-03	8.85E-04	4.58E-03	6.18E-07	1.48E-07	7.66E-07
Cadmium (Water)	No	No	0.555	555	4.56E-01	1.16E+00	1.62E+00	8.55E-02	7.15E-01	8.01E-01	1.71E-01	8.19E-01	9.90E-01	-	-	-
Chromium(III), Insoluble Salts	No	No	0.0286	28.6	7.84E-06	7.69E-05	8.47E-05	1.47E-06	4.72E-05	4.87E-05	2.94E-06	5.41E-05	5.70E-05	-	-	-
Copper	No	No	42.3	42300	4.35E-01	5.54E-02	4.90E-01	8.15E-02	3.41E-02	1.16E-01	1.63E-01	3.90E-02	2.02E-01	-	-	-
Iron	No	No	323	323000	1.90E-01	2.42E-02	2.14E-01	3.56E-02	1.49E-02	5.04E-02	7.11E-02	1.70E-02	8.81E-02	-	-	-
Mercury (elemental)	No	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel Soluble Salts	No	No	0.771	771	1.58E-02	1.01E-02	2.59E-02	2.97E-03	6.21E-03	9.18E-03	5.94E-03	7.11E-03	1.30E-02	-	-	-
Silver	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc and Compounds	No	No	54.9	54900	7.52E-02	5.76E-03	8.10E-02	1.41E-02	3.54E-03	1.76E-02	2.82E-02	4.05E-03	3.23E-02	-	-	-
**Total Risk/HI*			-	-	*1.34E+00*	*1.28E+00*	*2.62E+00*	*2.50E-01*	*7.87E-01*	*1.04E+00*	*5.01E-01*	*9.01E-01*	*1.40E+00*	*6.18E-07*	*1.48E-07*	*7.66E-07*

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Table 7
Exposure Unit 3: Below Beaver Pond
Summary of Risks and Hazards for Adult and Child Recreators Exposed to Surface Water

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Concentration (ug/L)	Child Ingestion HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Dermal Risk	Total Risk
Aluminum	No	No	3.64	3640	0.0015	1.91E-04	1.69E-03	2.80E-04	1.17E-04	3.98E-04	5.61E-04	1.34E-04	6.95E-04	-	-	-
Arsenic, Inorganic	No	No	0.002	2	0.00274	3.49E-04	3.09E-03	5.14E-04	2.15E-04	7.28E-04	1.03E-03	2.46E-04	1.27E-03	1.72E-07	4.11E-08	2.13E-07
Cadmium (Water)	No	No	0.0237	23.7	0.0195	4.97E-02	6.92E-02	3.65E-03	3.05E-02	3.42E-02	7.30E-03	3.50E-02	4.23E-02	-	-	-
Chromium(III), Insoluble Salts	No	No	0.0028	2.8	0.000000767	7.53E-06	8.29E-06	1.44E-07	4.62E-06	4.77E-06	2.88E-07	5.29E-06	5.58E-06	-	-	-
Copper	No	No	3.6	3600	0.085	4.72E-03	4.17E-02	6.93E-03	2.90E-03	9.83E-03	1.39E-01	3.32E-03	1.72E-02	-	-	-
Iron	No	No	19.7	19700	0.0116	1.48E-03	1.30E-02	2.17E-03	9.06E-04	3.07E-03	4.34E-03	1.04E-03	5.37E-03	-	-	-
Mercury (elemental)	No	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel Soluble Salts	No	No	0.0571	57.1	0.00117	7.48E-04	1.92E-03	2.20E-04	4.60E-04	6.80E-04	4.40E-04	5.26E-04	9.66E-04	-	-	-
Silver	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc and Compounds	No	No	10.2	10200	0.014	1.07E-03	1.50E-02	2.62E-03	6.57E-04	3.28E-03	5.24E-03	7.52E-04	5.99E-03	-	-	-
**Total Risk/HI*			-	-	*0.136*	*5.83E-02*	*1.46E-01*	*1.64E-02*	*3.58E-02*	*5.22E-02*	*1.58E-01*	*4.10E-02*	*7.38E-02*	*1.72E-07*	*4.11E-08*	*2.13E-07*

Output generated 01OCT2014:16:23:46

Table 8
Exposure Unit 4: Below Poison Gulch
Summary of Risks and Hazards for Adult and Child Recreators Exposed to Surface Water

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Concentration (ug/L)	Child Ingestion HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Dermal Risk	Total Risk
Aluminum	No	No	4.19	4190	1.72E-03	2.20E-04	1.94E-03	3.23E-04	1.35E-04	4.58E-04	6.46E-04	1.54E-04	8.00E-04	-	-	-
Arsenic, Inorganic	No	No	0.002	2	2.74E-03	3.49E-04	3.09E-03	5.14E-04	2.15E-04	7.28E-04	1.03E-03	2.46E-04	1.27E-03	1.72E-07	4.11E-08	2.13E-07
Cadmium (Water)	No	No	0.002	2	1.64E-03	4.19E-03	5.84E-03	3.08E-04	2.58E-03	2.88E-03	6.16E-04	2.95E-03	3.57E-03	-	-	-
Chromium(III), Insoluble Salts	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	No	No	0.12	120	1.23E-03	1.57E-04	1.39E-03	2.31E-04	9.66E-05	3.28E-04	4.62E-04	1.11E-04	5.73E-04	-	-	-
Iron	No	No	7.37	7370	4.33E-03	5.52E-04	4.88E-03	8.11E-04	3.39E-04	1.15E-03	1.62E-03	3.88E-04	2.01E-03	-	-	-
Mercury (elemental)	No	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel Soluble Salts	No	No	0.016	16	3.29E-04	2.10E-04	5.38E-04	6.16E-05	1.29E-04	1.90E-04	1.23E-04	1.47E-04	2.71E-04	-	-	-
Silver	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc and Compounds	No	No	0.37	370	5.07E-04	3.88E-05	5.46E-04	9.50E-05	2.38E-05	1.19E-04	1.90E-04	2.73E-05	2.17E-04	-	-	-
**Total Risk/HI*			-	-	*1.25E-02*	*5.72E-03*	*1.82E-02*	*2.34E-03*	*3.51E-03*	*5.86E-03*	*4.69E-03*	*4.02E-03*	*8.71E-03*	*1.72E-07*	*4.11E-08*	*2.13E-07*

Output generated 01OCT2014:16:32:27

Table 9 Farmer Equation Inputs for Contaminated Water	
Variable	**Value**
EF_c (exposure frequency - child) day/yr	350
EF_a (exposure frequency - adult) day/yr	350
ED_{ag} (exposure duration - resident) yr	26
LT (lifetime - resident) yr	70
CF_m (contaminated intake fraction - milk) unitless	1
CF_b (contaminated intake fraction - beef) unitless	1
BW_a (body weight - adult) kg	80
BW_c (body weight - child) kg	15
ED_c (exposure duration - child) yr	6
IRM_a (milk intake rate - adult) mg/day	615000
IRM_a (milk inake rate - child) mg/day	265000
IRB_a (beef intake rate - adult) mg/day	138000
IRB_c (beef intake rate - child) mg/day	12900
IRM_{adj} (age-adjusted milk intake rate) mg-year/kg-day	90912500
IRB_{adj} (age-adjusted beef intake rate) mg-year/kg-day	13881000
$Q_{w\text{-}dairy}$ (dairy water intake rate) L/day	92
$Q_{w\text{-}beef}$ (beef water intake rate) L/day	53

Output generated 01OCT2014:15:36:04

Table 10
Exposure Unit 1: Moran Tunnel
Summary of Risks and Hazards to an Agricultural Farm Family (via Cattle Exposed to Surface Water)

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Beef Ingestion HQ	Milk Ingestion HQ	Beef and Milk Total HQ	Beef Ingestion Risk	Milk Ingestion Risk	Beef and Milk Total Risk
Aluminum	No	No	738	4.84E-02	2.30E-01	2.78E-01	-	-	-
Arsenic, Inorganic	No	No	1.47	4.28E-01	4.58E-01	8.86E-01	1.27E-04	4.33E-05	1.70E-04
Cadmium (Diet)	No	No	1.28	3.08E-02	1.99E+00	2.02E+00	-	-	-
Chromium(III), Insoluble Salts	No	No	0.457	7.32E-05	7.12E-04	7.85E-04	-	-	-
Copper	No	No	95	1.04E+00	5.55E+00	6.59E+00	-	-	-
Iron	No	No	1520	1.90E+00	8.46E-01	2.75E+00	-	-	-
Mercury (elemental)	No	Yes	0.275	1.88E+01	1.21E+00	2.00E+01	-	-	-
Nickel Soluble Salts	No	No	2.77	3.63E-02	2.16E-01	2.52E-01	-	-	-
Silver	No	No	0.193	5.06E-03	1.20E+00	1.21E+00	-	-	-
Zinc and Compounds	No	No	88.1	1.28E+00	-	1.28E+00	-	-	-
**Total Risk/HI*			-	*2.36E+01*	*1.17E+01*	*3.53E+01*	*1.27E-04*	*4.33E-05*	*1.70E-04*

Output generated 01OCT2014:15:36:04

Table 11
Exposure Unit 3: Below Beaver Pond
Summary of Risks and Hazards to an Agricultural Farm Family (via Cattle Exposed to Surface Water)

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Beef Ingestion HQ	Milk Ingestion HQ	Beef and Milk Total HQ	Beef Ingestion Risk	Milk Ingestion Risk	Beef and Milk Total Risk
Aluminum	No	No	3.64	2.39E-04	1.13E-03	1.37E-03	-	-	-
Arsenic, Inorganic	No	No	0.002	5.83E-04	6.23E-04	1.21E-03	1.73E-07	5.89E-08	2.32E-07
Cadmium (Diet)	No	No	0.024	5.77E-04	3.74E-02	3.80E-02	-	-	-
Chromium(III), Insoluble Salts	No	No	0.003	4.81E-07	4.68E-06	5.16E-06	-	-	-
Copper	No	No	3.6	3.93E-02	2.10E-01	2.49E-01	-	-	-
Iron	No	No	19.7	2.46E-02	1.10E-02	3.56E-02	-	-	-
Mercury (elemental)	No	Yes	-	-	-	-	-	-	-
Nickel Soluble Salts	No	No	0.057	7.47E-04	4.44E-03	5.19E-03	-	-	-
Silver	No	No	-	-	-	-	-	-	-
Zinc and Compounds	No	No	10.2	1.49E-01	-	1.49E-01	-	-	-
**Total Risk/HI*			-	*2.15E-01*	*2.65E-01*	*4.80E-01*	*1.73E-07*	*5.89E-08*	*2.32E-07*

Output generated 01OCT2014:16:28:29

Table 12
Exposure Unit 4: Below Poison Gulch
Summary of Risks and Hazards to an Agricultural Farm Family (via Cattle Exposed to Surface Water)

Chemical	Mutagen?	VOC?	Concentration (mg/L)	Beef Ingestion HQ	Milk Ingestion HQ	Beef and Milk Total HQ	Beef Ingestion Risk	Milk Ingestion Risk	Beef and Milk Total Risk
Aluminum	No	No	4.19	2.75E-04	1.31E-03	1.59E-03	-	-	-
Arsenic, Inorganic	No	No	0.002	5.83E-04	6.23E-04	1.21E-03	1.73E-07	5.89E-08	2.32E-07
Cadmium (Diet)	No	No	0.002	4.81E-05	3.12E-03	3.17E-03	-	-	-
Chromium(III), Insoluble Salts	No	No	-	-	-	-	-	-	-
Copper	No	No	0.12	1.31E-03	7.01E-03	8.32E-03	-	-	-
Iron	No	No	7.37	9.20E-03	4.10E-03	1.33E-02	-	-	-
Mercury (elemental)	No	Yes	-	-	-	-	-	-	-
Nickel Soluble Salts	No	No	0.016	2.10E-04	1.25E-03	1.46E-03	-	-	-
Silver	No	No	-	-	-	-	-	-	-
Zinc and Compounds	No	No	0.37	5.39E-03	-	5.39E-03	-	-	-
**Total Risk/HI*			-	*1.70E-02*	*1.74E-02*	*3.44E-02*	*1.73E-07*	*5.89E-08*	*2.32E-07*

Output generated 01OCT2014:16:37:06

Table 13 Recreator Equation Inputs for Soil/Sediment	
Variable	**Value**
TR (target cancer risk) unitless	0.000001
ED_r (exposure duration - recreator) years	26
ET_r (exposure time - recreator) hours	1
ED_c (exposure duration - child) years	6
BW_a (body weight - adult) kg	80
BW_c (body weight - child) kg	15
SA_a (skin surface area - adult) cm^2/day	6032
SA_c (skin surface area - child) cm^2/day	2690
THQ (target hazard quotient) unitless	1
LT (lifetime - recreator) yr	70
EF_r (exposure frequency) d/yr	45
IRS_a (soil intake rate - adult) mg/day	100
IRS_c (soil intake rate - child) mg/day	200
AF_a (skin adherence factor - adult) mg/cm^2	0.07
AF_c (skin adherence factor - child) mg/cm^2	0.2
IFS_{adj} (age-adjusted soil ingestion factor) mg/kg	4725
DFS_{adj} (age-adjusted soil dermal factor) mg/kg	14434.2
$IFSM_{adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	21450
$DFSM_{adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	61148.4
AF_{0-2} (skin adherence factor) mg/cm^2	0.2
AF_{2-6} (skin adherence factor) mg/cm^2	0.2
AF_{6-16} (skin adherence factor) mg/cm^2	0.07
AF_{16-30} (skin adherence factor) mg/cm^2	0.07
BW_{0-2} (body weight) kg	15
BW_{2-6} (body weight) kg	15
BW_{6-16} (body weight) kg	80
BW_{16-30} (body weight) kg	80
ED_{0-2} (exposure duration) year	2
ED_{2-6} (exposure duration) year	4
ED_{6-16} (exposure duration) year	10
ED_{16-30} (exposure duration) year	10
EF_{0-2} (exposure frequency) day/year	45
EF_{2-6} (exposure frequency) day/year	45
EF_{6-16} (exposure frequency) day/year	45
EF_{16-30} (exposure frequency) day/year	45
ET_{0-2} (exposure time) hour/day	1
ET_{2-6} (exposure time) hour/day	1
ET_{6-16} (exposure time) hour/day	1
ET_{16-30} (exposure time) hour/day	1
IRS_{0-2} (soil intake rate) mg/day	200
IRS_{2-6} (soil intake rate) mg/day	200
IRS_{6-16} (soil intake rate) mg/day	100
IRS_{16-30} (soil intake rate) mg/day	100
SA_{0-2} (skin surface area) cm^2/day	2690
SA_{2-6} (skin surface area) cm^2/day	2690
SA_{6-16} (skin surface area) cm^2/day	6032
SA_{16-30} (skin surface area) cm^2/day	6032
City (Climate Zone) PEF Selection	Boise, ID (4)
A_s (acres) PEF Selection	0.5
Q/C_{wp} (g/m^2-s per kg/m^3) PEF Selection	71.22808
PEF (particulate emission factor) m^3/kg	6621648129
A (PEF Dispersion Constant)	11.3161
B (PEF Dispersion Constant)	19.6437
C (PEF Dispersion Constant)	224.8172
V (fraction of vegetative cover) unitless	0.5
U_m (mean annual wind speed) m/s	3.98
U_t (equivalent threshold value)	11.32
F(x) (function dependant on U_m/U_t) unitless	0.0495
City (Climate Zone) VF Selection	Default
A_s (acres) VF Selection	0.5
A (VF Dispersion Constant)	11.911
B (VF Dispersion Constant)	18.4385
C (VF Dispersion Constant)	209.7845
Q/C_{wp} (g/m^2-s per kg/m^3) VF Selection	68.18
foc (fraction organic carbon in soil) g/g	0.006
ρ_b (dry soil bulk density) g/cm^3	1.5
ρ_s (soil particle density) g/cm^3	2.65
θ_w (water-filled soil porosity) L_{water}/L_{soil}	0.15
T (exposure interval) s	819936000

Output generated 01OCT2014:16:18:05

Table 14
Exposure Unit 2: Below Moran Tunnel
Summary of Risks and Hazards for Adult and Child Recreators Exposed to Sediment

Chemical	Mutagen?	VOC?	Volatilization Factor (m^3/kg)	Particulate Emission Factor (m^3/kg)	Soil Saturation Concentration (mg/kg)	Concentration (mg/kg)	Child Ingestion HQ	Child Inhalation HQ	Child Dermal HQ	Child Total HI	Adult Ingestion HQ	Adult Inhalation HQ	Adult Dermal HQ	Adult Total HI	Adjusted Ingestion HQ	Adjusted Inhalation HQ	Adjusted Dermal HQ	Adjusted Total HI	Ingestion Risk	Inhalation Risk	Dermal Risk	Total Risk
Arsenic, Inorganic	No	No	-	6.62E+09	-	87.6	4.80E-01	4.53E-06	3.87E-02	5.19E-01	4.50E-02	4.53E-06	5.70E-03	5.07E-02	1.45E-01	4.53E-06	1.33E-02	1.59E-01	2.43E-05	1.09E-10	2.23E-06	2.65E-05
Cadmium (Diet)	No	No	-	6.62E+09	-	10.6	1.74E-02	8.22E-07	1.87E-03	1.93E-02	1.63E-03	8.22E-07	2.76E-04	1.91E-03	5.28E-03	8.22E-07	6.45E-04	5.92E-03	-	5.50E-12	-	5.50E-12
Copper	No	No	-	6.62E+09	-	1710	7.03E-02	-	-	7.03E-02	6.59E-03	-	-	6.59E-03	2.13E-02	-	-	2.13E-02	-	-	-	-
Lead and Compounds	No	No	-	6.62E+09	-	62.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc and Compounds	No	No	-	6.62E+09	-	146	8.00E-04	-	-	8.00E-04	7.50E-05	-	-	7.50E-05	2.42E-04	-	-	2.42E-04	-	-	-	-
**Total Risk/HI*			-	-	-	-	*5.68E-01*	*5.35E-06*	*4.06E-02*	*6.09E-01*	*5.33E-02*	*5.35E-06*	*5.98E-03*	*5.93E-02*	*1.72E-01*	*5.35E-06*	*1.40E-02*	*1.86E-01*	*2.43E-05*	*1.15E-10*	*2.23E-06*	*2.65E-05*

Output generated 01OCT2014:16:18:05

Table 15
Groundwater Data Collected from Wells Located Near Champagne Creek

Groundwater Sample	Date	Aluminum	Copper	Iron	Zinc
Well #1	6/26/2013	NS	NS	NS	NS
Well #1	7/11/2013	4.90	0.00	6.24	0.02
Well #1	8/8/2013	2.70	0.02	3.37	0.02
Well #1	9/11/2013	1.80	0.00	2.30	0.01
Well #1	5/22/2014	NS	NS	NS	NS
Well #1	6/18/2014	1.62	<0.01	1.65	<0.01
Well #1	7/21/2014	2.10	<0.01	2.62	<0.01
Well #2	6/26/2014	NS	NS	NS	NS
Well #2	7/11/2013	202.00	18.40	265.00	21.00
Well #2	8/8/2013	213.00	19.20	306.00	20.10
Well #2	9/11/2013	191.00	17.80	277.00	18.50
Well #2	5/22/2014	NS	NS	NS	NS
Well #2	6/18/2014	133.00	18.80	109.00	20.50
Well #2	7/21/2014	203.00	19.60	190.00	23.70
Well #3	6/26/2013	65.20	0.12	1.15	3.48
Well #3	7/11/2013	NS	NS	NS	NS
Well #3	8/8/2013	8.51	0.02	7.65	0.33
Well #3	9/11/2013	160.00	0.27	56.00	5.74
Well #3	5/22/2014	75.90	0.16	0.49	3.80
Well #3	6/18/2014	65.40	0.19	0.91	3.27
Well #3	7/21/2014	56.70	0.22	1.48	3.47
Well #4	6/26/2013	NS	NS	NS	NS
Well #4	7/11/2013	42.70	0.05	50.30	0.00
Well #4	8/8/2013	23.30	0.02	24.40	7.47
Well #4	9/11/2013	8.43	0.00	0.15	0.09
Well #4	5/22/2014	NS	NS	NS	NS
Well #4	6/18/2014	14.40	0.01	13.50	0.12
Well #4	7/21/2014	35.50	0.03	35.90	0.24
Well #6	6/26/2013	NS	NS	NS	NS
Well #6	7/11/2013	NS	NS	NS	NS
Well #6	8/8/2013	NS	NS	NS	NS
Well #6	9/11/2013	NS	NS	NS	NS
Well #6	5/22/2014	NS	NS	NS	NS
Well #6	6/18/2014	312.00	119.00	738.00	82.00
Well #6	7/21/2014	384.00	127.00	923.00	94.60
Well #7	6/26/2013	NS	NS	NS	NS
Well #7	7/11/2013	NS	NS	NS	NS
Well #7	8/8/2013	NS	NS	NS	NS
Well #7	9/11/2013	NS	NS	NS	NS
Well #7	5/22/2014	NS	NS	NS	NS
Well #7	6/18/2014	1.48	<0.01	5.44	<0.01
Well #7	7/21/2014	0.90	<0.01	5.14	<0.01
Well #8	6/26/2013	NS	NS	NS	NS
Well #8	7/11/2013	NS	NS	NS	NS
Well #8	8/8/2013	NS	NS	NS	NS
Well #8	9/11/2013	NS	NS	NS	NS
Well #8	5/22/2014	NS	NS	NS	NS
Well #8	6/18/2014	8.26	<0.01	7.23	0.04
Well #8	7/21/2014	44.60	0.05	45.50	0.14
Well #9	6/26/2013	NS	NS	NS	NS
Well #9	7/11/2013	NS	NS	NS	NS
Well #9	8/8/2013	NS	NS	NS	NS
Well #9	9/11/2013	NS	NS	NS	NS
Well #9	5/22/2014	NS	NS	NS	NS
Well #9	6/18/2014	0.62	<0.01	0.30	<0.01
Well #9	7/21/2014	0.78	<0.01	0.53	<0.01

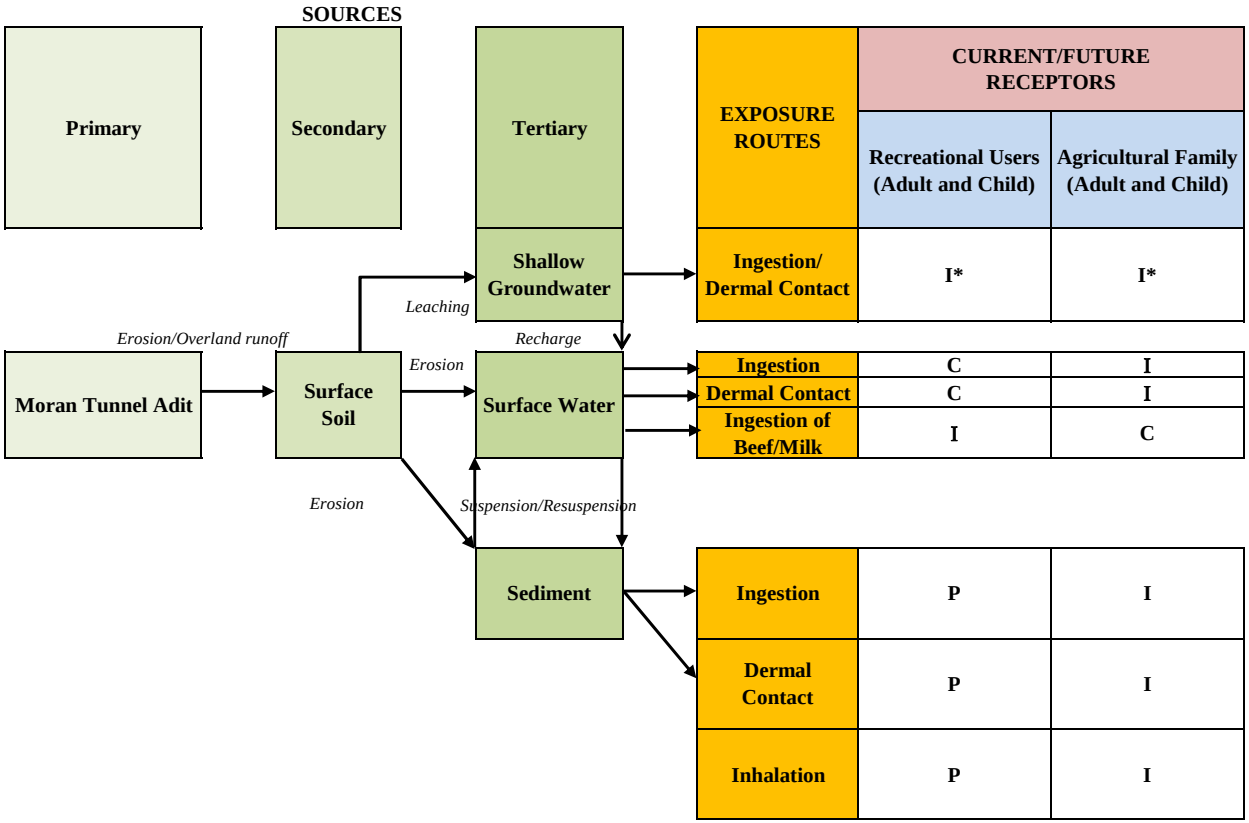
Notes

NS: Not sampled

FIGURES

Champagne Creek Surface Water Sample Locations
Above Moran Tunnel
South Pit
Moran Tunnel
Pond Seeps
Below Treatment Ponds
AMD Spring
possible natural seep
Below Beaver Dam
Champagne Creek Below Poison Gulch
Legend
Surface Samples

Figure 2
Human Health Conceptual Site Model



I = Incomplete exposure pathway
C = Complete exposure pathway quantitatively assessed in the HHRA
P = Potential complete exposure pathway, addressed qualitatively within the HHRA
* = Addressed qualitaitively in the Uncertainty Analysis

Notes:
1) Direct contact with contaminated surface soil is not a component of the HHRA.
2) Shallow groundwater is not currently used to support the spectrum of domestic water usage and is considerd an unrealistic future potential use. The contaminant contribution/relationship to surface water is addressed within the context of the Uncertainty Analysis.
3) Recreational user direct contact with sediments is addressed quantitatively within the HHRA on a limited basis at EU 2 only. Otherwise, recreational user direct contact with sediments is addressed qualitatively within the HHRA given the quality of the available data.
4) Inhalation of periodically inundated sediment (as a function of suspension by wind) is unlikely to contribute substantively to risk or hazard and expectant risk levels are 1 to 2 orders of magnitude below the direct contact-based ingestion risks. With a severely limited data set, the inclusion of this pathway in the quantitative risk assessment would incorporate an unacceptable level of additional uncertainty and convey little information to underpin effective risk management decision making.

APPENDIX B

STREAMLINED ECOLOGICAL RISK ASSESSMENT

Draft

Streamlined Ecological Risk Evaluation
For
Champagne Creek/ Moran Tunnel, Idaho

December 2014

Prepared for:

Bureau of Land Management
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Table 2 Sediment Hazard Quotient/ COPEC Selection
Table 3 Surface Water Background Hazard Quotient/ COPEC Selection

FIGURES

Figure 1: Champagne Creek/Moran Tunnel Water Sampling Locations

ACRONYMS

Ag	Silver
Al	Aluminum
As	Arsenic
BLM	Bureau of Land Management
COPEC	Contaminant of Potential Ecological Concern
Cd	Cadmium
Cr	Chromium
Cu	Copper
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
EU	Exposure Unit
Fe	Iron
Hg	Mercury
HQ	Hazard Quotient
ND	Not Detected
Ni	Nickel
NRWQC	National Recommended Water Quality Criteria
Pb	Lead
PEC	Probably Effect Concentration
PRG	Preliminary Remediation Goal
STERA	Streamlined Ecological Risk Assessment
TEC	Threshold Effect Concentration
USGS	United States Geological Survey
Zn	Zinc

1.0 INTRODUCTION

This Streamlined Ecological Risk Evaluation (STERA) measures to what extent exposure to mining-derived contaminants in aquatic habitats at the Champagne Creek/Moran Tunnel Site (the Site) may affect local community-level aquatic receptors (e.g. benthic invertebrates and fish) in Champagne Creek. The outcome of this simplified evaluation will help risk and site managers determine if conditions warrant cleanup action or if more site-specific data are needed to support defensible and cost-effective remedial decision-making.

This report is organized as follows: Section 2.0 discusses the STERA process, data evaluation and steps for selecting Contaminants of Potential Ecological Concern (COPECs); Section 3.0 explains the risk interpretation; Section 4.0 develops the Preliminary Remediation Goals (PRGs); Section 5.0 discusses some of the major uncertainties inherent in the STERA; Section 6.0 presents a Summary and Conclusions; and Section 7.0 provides the references.

2.0 STERA PROCESS

The STERA used existing analytical data to assess four Exposure Units (EUs) of Champagne Creek. The EUs are listed below, together with a brief description of their locations.

- **EU1**: Moran Tunnel Effluent – Moran Tunnel drainage area, prior to confluence with Champagne Creek.
- **EU2**: Below Moran Tunnel – Champagne Creek immediately downstream from the Moran Tunnel discharge point.
- **EU3**: Below Beaver Pond – Champagne Creek immediately downstream from the beaver pond discharge point.
- **EU4**: Below Poison Gulch – Champagne Creek immediately downstream of the Poison Gulch discharge point.

Each EU represents a Bureau of Land Management (BLM) sampling point or indicator area within Champagne Creek used to evaluate exposure to receptors inhabiting areas adjacent to the EU.

A background location up gradient of the Moran Tunnel (with respect to prevailing wind direction and precipitation overland/sheet flow) was also sampled for surface water. This location is considered free of impacts from Site operations, but may be influenced by other anthropogenic activities, such as operations at the Hornsilver Mine as well as the Idaho Gold Corp.'s Champagne Mine. Surface water at this background location may be impacted by aluminum, iron and zinc, and the ground water (MW-1) by aluminum and iron.

The four EUs and the background location along Champagne Creek are identified on **Figure 1**.

2.1 Analytical Data

Only analytical data collected in 2012, 2013 and 2014 were used in the STERA, unless otherwise noted. The decision was made to focus on more recent data in order to assess current environmental conditions.

The surface water analytical data used in the STERA came from two sources, as follows:

- BLM provided analytical data collected in 2013 and 2014 from the four EUs on Champagne Creek, plus the background area. These samples were not filtered and were analyzed for total aluminum (Al), total copper (Cu), total iron (Fe), and total zinc (Zn). Surface water pH readings were also obtained from each sample location.

- The United States Geological Survey (USGS) collected one sample in 2013 from each of three locations on Champagne Creek (namely, EU 1, EU 2, and EU 3), plus the background location above Moran Tunnel. These samples were not filtered and were analyzed for total Al, As, Cd, Cr, Cu, Fe, Ni, and Zn. The analytical data are provided in *Data Summary Report, Champagne Creek, Idaho* prepared by the U.S. Geological Survey- Idaho Water Science Center Appendix 1 (Water quality data, summary table, Champagne Creek, ID).

In addition to these two surface water datasets, a small sediment dataset was published by the BLM in *Champagne Creek Vegetation Assessment*, Final Report, prepared by KC Harvey Environmental (September 15, 2012). Two bulk sediment samples were collected from Champagne Creek Below Moran Tunnel (EU 2) and were analyzed for As, Cd, Cu, Pb, and Zn.

2.2 Screening Benchmarks

Screening benchmarks were needed to assess the ecotoxicity of the metals measured in the various surface water and sediment samples collected from Champagne Creek. The benchmarks selected for use in the STERA are protective of sensitive aquatic community-level receptors, such as aquatic plants, benthic invertebrates, water column invertebrates, fish, and embryo-larval stages of amphibians.

<u>Surface water</u>

Conservative chronic surface water screening benchmarks were selected from two sources for use in the COPEC-selection process, in the following order of preference: 1) *Idaho's Surface Water Standards for chronic criteria, 58.01.02 available at: http://adminrules.idaho.gov/rules/current/58/0102.pdf* and 2*) U.S. Environmental Protection Agency (EPA) National Recommended Water Quality Criteria (NRWQC), latest version available at:* http://www.epa.gov/scitech/swguidance/standards/current/. Both sources provided the screening benchmarks needed to evaluate all the metals assessed in the STERA. The NRWQC also provided a minimum acceptable surface water pH value (pH = 6.5) which was used in this evaluation as the screening threshold for acidity.

Sediment

The STERA used one source of published sediment screening benchmarks, as follows: *MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000 Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31*. This publication provided all the required benchmarks for the five metals analyzed in the sediment samples.

2.3 Exposure Point Concentrations

The Exposure Point Concentrations (EPCs) used in the STERA represent contaminant levels in surface water and sediment used as "worst-case" exposures experienced by the local aquatic community. The EPCs are the maximum-detected concentration for total metals in the surface water and sediment samples collected at the Champagne Creek EUs and the background location. **Tables 1 and 3** present the Site and background surface water EPCs, respectively.

Neither the 2013 USGS nor the BLM surface water datasets provided data for Hg or Ag. The STERA filled this data gap by using older BLM Hg and Ag data collected on August 8, 1999 at EU1, EU2, and EU4. The Hg and Ag levels measured at EU1 (Hg = 275 µg/L and Ag = 193 µg/L) were used as the EPCs. Neither metal was present above its detection limit in the surface water samples collected from EU 2 and EU 4 on that date. Note also that Hg and Ag were not analyzed in any of the surface water samples collected from EU 3 and could therefore not be evaluated at this location.

Neither the 2013 USGS nor the BLM surface water dataset from 2013/2014 provided data for Cd at EU4 (Below Poison Gulch). Cd was analyzed in surface water collected by BLM from EU4 on the May 18, 2000. The result (2 µg/L) was used as the EPC for this metal.

An explanation of the data used to select EPCs is also footnoted in **Table 1**.

Table 2 summarizes the EPCs for the five metals measured in the two sediment samples collected from EU 3. Note that background sediment data were not available for use in the STERA.

2.4 Hazard Quotient and COPEC Selection

The STERA identified surface water and sediment COPECs by calculating a Hazard Quotient (HQ) based on dividing the EPCs discussed in Section 2.3 by the screening benchmarks identified in Section 2.2. A compound was retained as a surface water or sediment COPEC if its HQ exceeded 1.0 (i.e., the exposure concentration exceeded the screening benchmark). Conversely, a compound was not retained as COPECs if its HQ fell below 1.0.

Tables 1 and 2 summarize the surface water and sediment analytical data, respectively, used in the COPEC-selection process, as follows:

- frequency of detection,

- maximum detected concentration,
- minimum detected concentration,
- EPC,
- screening benchmark,
- screening benchmark source,
- HQ,
- Whether a contaminant is retained as a COPEC or not.

3.0 RISK INTERPRETATION

3.1 Surface Water

Table 1 summarizes the data discussed in this section for each EU.

<u>EU 1 (Moran Tunnel Effluent)</u>

All metals were retained as COPECs at EU 1 because their HQs exceeded 1.0, most by several orders of magnitude. Al, Cd, Cu, and Fe had the highest HQs, ranging from 1520 to 8636. The HQs for Hg, Ag, and Zn were also substantial, ranging from 357 to 734. As, Cr and Ni had the lowest HQs, which ranged from 5.3 to 9.8.

The only surface water pH measured at EU 1 in 2013 and 2014 equaled 3.1. HQs cannot be calculated for pH because these measurements represent logarithmic values. However, a pH of 3.1 is close to three orders of magnitude lower (i.e., more acidic) than the NRWQC screening benchmark of 6.5 and therefore has an HQ much above 1.0.

Based on this information, the STERA identified unacceptable risk to the aquatic community at EU 1 due to high metal levels and low pH in the surface water.

<u>EU 2 (Below Moran Tunnel)</u>

Al, Cd, Cu, Fe, Ni, and Zn were all retained as COPECs at EU 2. Al and Cu had the highest HQ, equal to 4310 and 3845, respectively. The HQs for Cd, Fe, and Zn ranged from 323 to 925. Ni had the lowest HQ at 14.8. As, Cr, Hg, and Ag were not retained as COPECs because (a) the maximum detected value for As and Cr did not exceed their screening benchmarks and (b) Hg and Ag were reported as ND during the August 18, 1999 sampling at EU 2.

The lowest surface water pH measured at EU 2 in 2013 and 2014 equaled 2.7. This value was close to four orders of magnitude lower than the NRWQC screening benchmark of 6.5 and therefore had an HQ much above 1.0.

Based on this information, the STERA identified unacceptable risk to the aquatic community at EU 2 due to high metal levels and low pH in the surface water.

EU 3 (Below Beaver Pond)

The same metals identified as COPECs at EU 2 were also retained as COPECs at EU 3, even though they showed much lower HQs. Cu had the highest HQ (327), followed by Al, Cd, and Zn, which had HQs ranging from 39.5 to 85.0. Fe and Ni were also retained as COPECs, with HQs of 19.7 and 1.1, respectively.

As and Cr had HQs below 1.0, whereas Hg and Ag were not analyzed for in any of the surface water samples collected from EU 3 in 2013 and 2014.

The lowest surface water pH measured at EU 3 in 2013 and 2014 equaled 5.61. This pH is close to one order of magnitude lower than that the NRWQC screening benchmark of 6.5 and therefore had an HQ much above 1.0.

Based on this information, the STERA identified unacceptable risk to the aquatic community at EU 3 due to high metal levels and low pH in the surface water.

EU 4 (Below Poison Gulch)

The same metals identified as COPECs at EU 2 and EU 3 were also retained as COPECs at EU 4, except for Ni. However, all the HQs dropped substantially at this EU. Al had the highest HQ (48.2). The HQs for Cd, Cu, Fe, and Zn ranged from 3.1 to 10.9. As and Ni were not retained as COPECs because their HQs fell below 1.0. No data were available for Cr (ND), or Hg and Ag (not analyzed). Therefore these three metals could not be assessed at this EU.

The lowest surface water pH measured at EU 4 in 2013 and 2014 equaled 7.8. This value fell well within the NRWQC acceptable range of 6.5-9.

The background HQs presented in **Table 3** indicated that the HQs at EU 4 were no worse than the local background conditions. Hence, it was concluded that the surface water chemistry at EU 4 did not require further evaluation.

3.2 Sediment

Table 2 provides the data discussed in this section. Only two sediment samples were collected from EU 2. No sediment chemistry data were available for the other EUs or the background location.

All five metals had maximum-detected levels that exceeded their screening benchmarks and were thus retained as COPECs. Cu had the highest HQ (54.1). As and Cd had HQs of 8.9 and 10.7, respectively. Pb and Zn had HQs of 1.7 and 1.2, respectively.

Based on this information, the STERA identified unacceptable risk to the benthic community in Champagne Creek due to high metal levels in bulk sediment samples collected from EU2.

4.0 DERIVING PRELIMINARY REMEDIATION GOALS

The risk interpretation identified unacceptable screening-level ecological risk in surface water (EUs 1, 2, and 3) and sediment (EU 2) collected from Champagne Creek. The final step in the STERA consisted of deriving Preliminary Remediation Goals (PRGs) for the selected surface water and sediment COPECs in those EUs.

The screening benchmarks used in the COPEC selection process were retained as the PRGs for the surface water COPECs. These benchmarks are chronic values that represent concentrations above which a non-lethal but toxic response is possible over long-term exposure periods.

The PRGs for the five sediment COPECs were calculated as the geometric mean of the screening (no effect, or Threshold Effect Concentration [TEC]) benchmark and the affect (Probable Effect Concentration [PEC]) benchmark presented in Tables 2 and 3 in MacDonald *et al*., 2000. These PRGs exceed the screening sediment benchmarks but are still protective of the benthic invertebrate community because they fall well below their corresponding effect benchmarks.

Exhibit 1 summarizes the surface water and sediment COPECs and their proposed PRGs.

Exhibit 1: Proposed PRG's for surface water and sediment COPECs

COPEC	Proposed PRG
Surface Water[a]	
Aluminum	87 ug/L
Arsenic	150 ug/L
Cadmium[b]	0.6 ug/L
Chromium[b]	74 ug/L
Copper[b]	11 ug/L
Iron	1000 ug/L
Mercury	0.77 ug/L
Nickel[b]	52 ug/L
Silver[b]	0.32 ug/L
Zinc[b]	120 ug/L
Sediment	
Arsenic	18 mg/Kg
Cadmium	2.2 mg/Kg
Copper	68.6 mg/Kg
Lead	67.7 mg/Kg
Zinc	236 mg/Kg

[a]As explained in Idaho's Surface Water Standards for chronic criteria, 58.01.02 the surface water PRGs for the hardness-dependent metals shown in this table are for dissolved metal and correspond to a total hardness of 100 mg/L and a water effect ratio of 1.0. These PRGs would likely change to some degree depending on the actual hardness measured at each impacted Champagne Creek EU.
[b]hardness-dependent metal

5.0 UNCERTAINTY ANALYSIS

The STERA was highly conservative and made numerous simplifying assumptions, which created uncertainty. Some of these major uncertainties are discussed below.

- The surface water and sediment HQs were calculated by dividing maximum concentrations by their corresponding screening benchmarks. Those HQs are, by definition, quite conservative since they are derived using “worst-case” exposures and conservative benchmarks.

- The surface water data used in the evaluation corresponded to total metals instead of dissolved metals. Total metals represent all metal fractions in surface water, including those associated with particulates. Dissolved metals represent only the bioavailable portion of the total metals, which are toxic to aquatic receptors. As such, using total metals as the EPCs represents a “worst case” exposure scenario, leading to more-conservative HQs.

- The STERA did not account for Site-specific conditions that could reduce metals bioavailability to aquatic community-level receptor groups. These conditions include acid volatile sulfides and organic carbon in sediment, and surface water hardness. These factors can limit the bioavailability of the COPECs and render them less toxic than assumed in the STERA.

- The Idaho and US EPA surface water screening benchmarks represent a generic surface water hardness of 100 mg/L. No site-specific hardness values for Champagne Creek were available for adjusting these benchmarks to reflect actual Site conditions. Risk could be underestimated if surface water hardness at the Site is less than100 mg/L or overestimated if surface water hardness at the Site exceeds 100 mg/L. The surface water data used in the STERA were only collected in the summer months. Hence, they only reflect "summer flow" conditions and may not fully represent conditions at other times in the year, such as during high-flow events associated with snowmelt.

- Only two sediment samples were collected from one EU and analyzed for a five metals. This dataset is too small to fully evaluate the risk from Site-derived metals throughout the substrate of Champagne Creek.

- Several metals at the Site EUs were only analyzed in a small number of samples. Basing the potential risk at an EU on limited data results in much uncertainty regarding the overall conditions present at each EU and the true potential risk.

- The surface water analytical data used in the STERA represent total metals, whereas both the Idaho and EPA chronic surface water criteria represent dissolved metals.
  The dissolved metals criteria are slightly more conservative (from 0% to about 15%) compared to their corresponding total metals criteria, as represented by the "Conversion Factors for Dissolved Metals" in Appendix A of the EPA National Recommended Water

Quality Criteria document. As a result, the HQs for some of the metals are slightly more conservative than required. These relatively small differences do not materially change the current risk conclusions as described in the STERA.

Most likely the STERA was overly conservative and therefore identified more COPECs and resulted in higher risk estimates than would be warranted if Site- specific conditions were considered. Note, however, that even though the substantial HQs at EUs 1 through 3 could probably be reduced somewhat by considering Site-specific information or a more extensive dataset, it appears unlikely that these adjustments would substantially reduce the risk described in this STERA.

6.0 SUMMARY AND CONCLUSIONS

This report summarized a STERA for surface water and sediment collected primarily in 2012, 2013 and 2014 at the Champagne Creek/Moran Tunnel Site in Idaho. The analytical data consisted of up to 22 surface water samples and two sediment samples collected from four EUs for surface water and one EU for sediment. Not all samples were analyzed for the full list of metals. A background location (above EU 1) was also sampled for surface water. No background sediment samples were collected.

The STERA was conservative and simplistic by design. The risks were estimated using "worst-case" exposure assumptions and published screening benchmarks that did not necessarily reflect site-specific exposures or toxicity conditions.

<u>Surface Water</u>

All metals analyzed for at EU 1 were retained as COPECs. Al, Cd, Cu, and Fe were the main risk drivers with HQs well above 1000. The pH at EU 1 was also extremely low (pH = 3.1) and would, by itself, inhibit all aquatic invertebrate and vertebrate species.

EU 2, EU 3, and EU 4 generally identified the same surface water COPECs but HQs decreased sequentially the more downstream the EU was from Moran Tunnel (EU 1). Al, Cd, Cu, Fe, and Zn were the main risk drivers with HQs well above 1.0. However, the HQs above 1.0 at EU 4 were all lower than the background surface water HQs. The pH of these three EUs also increased the further they were from EU 1. Only the pH at EU 4 fell within an acceptable range. It is not known from the available information if the surface water chemistry at EU 4, which was no worse than that measured at the background location but still exceeded several surface water benchmarks, could support a healthy aquatic community.

The STERA concluded that Site-Related risk is present at EU 1, EU 2, and EU 3 from surface water and that this risk decreases down gradient from EU 1. All pH values were well under the 6.5 benchmark. The HQs at EU 4 fell below the background, except for Zn (EU 4 HQ = 3.1 and background HQ = 2.3). The risk identified at EU 4 is comparable to the background risk.

It is deemed unlikely that refining the exposure assumptions (e.g., measuring dissolved metals, adjusting the screening benchmarks of the hardness-dependent metals to site-specific harness

values, collecting more data during different seasons, performing additional sampling) would substantially change the current conclusion of high Sire-related risk at EUs through 3.

Sediment

Only two sediment samples were collected from EU 2 and analyzed for five metals (As, Cd, Cu, Pb, and Zn). This dataset was too small to assess the potential risk to the benthic invertebrate community throughout Champagne Creek. However, the metal levels measured in these two samples identified risk, mainly from As, Cd, and Cu. A more robust dataset is needed to evaluate the overall risk from sediment to receptors elsewhere in Champagne Creek below EU 2. Obtaining a Site-specific background sediment data set would also be beneficial to determine if any Site risks reflect background sediment conditions or Moran Tunnel influences.

7.0 REFERENCES

Data Summary Report, Champagne Creek, Idaho prepared by the U.S. Geological Survey- Idaho Water Science Center, February 12, 2014.

Idaho's Surface Water Standards for chronic criteria, 58.01.02 available at: http://adminrules.idaho.gov/rules/current/58/0102.pdf

U.S. Environmental Protection Agency (EPA) National Recommended Water Quality Criteria (NRWQC), 2009 available at: http://www.epa.gov/scitech/swguidance/standards/current/.

MacDonald, D.D., C.G. Ingersoll, and T.A.Berger. 2000 Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31

TABLES

Table 1
Surface Water Hazard Quotient/ COPEC Selection
Streamlined Ecological Risk Assessment
Champagne Creek/Moran Tunnel , Idaho

Metals	Frequency of Detection	Maximum detect (µg/L)	Minimum detect (µg/L)	Exposure Point Concentration (EPC) (µg/L)	Screening Benchmark (µg/L)	Screening Benchmark source	Hazard Quotient (HQ)	COPEC? (y/n)
Moran Tunnel (Exposure Unit 1)								
Aluminum	7 / 7	738000	614000	738000	87	b	**8483**	Y
Arsenic	1 / 1	1470	1470	1470	150	a	**9.8**	Y
Cadmium	1 / 1	1280	1280	1280	0.6	a	**2133**	Y
Chromium	1 / 1	457	457	457	74	a	**6.2**	Y
Copper	7 / 7	95000	95000	95000	11	a	**8636**	Y
Iron	7 / 7	1520000	1270000	1520000	1000	b	**1520**	Y
Mercury *	1 / 1	275	--	275	0.77	b	**357**	Y
Nickel	1 / 1	277	277	277	52	a	**5.3**	Y
Silver *	1 / 1	193	--	193	0.32	b	**603**	Y
Zinc	7 / 7	88100	75100	88100	120	a	**734**	Y
pH- 3.1 (9/9/2013)					6.5	b	**>1.0**	Y
Champagne Creek Below Moran Tunnel (Exposure Unit 2)								
Aluminum	7 / 7	375000	82000	375000	87	b	**4310**	Y
Arsenic	1 / 1	7.2	7.2	7.2	150	a	0.05	N
Cadmium	1 / 1	555	555	555	0.6	a	**925**	Y
Chromium	1 / 1	28.6	28.6	28.6	74	a	0.39	N
Copper	7 / 7	42300	14100	42300	11	a	**3845**	Y
Iron	7 / 7	323000	72200	323000	1000	b	**323**	N
Mercury *	0 / 1	ND	ND	ND	0.77	b	NC	N
Nickel	1 / 1	771	771	771	52	a	**15**	Y
Silver *	0 / 1	ND	ND	ND	0.32	b	NC	N
Zinc	7 / 7	54900	12600	54900	120	a	**458**	Y
pH 2.7 (6/6/2013)					6.5	b	**>1.0**	Y
Champagne Creek Below Beaver Pond (Exposure Unit 3)								
Aluminum	3 / 3	3640	450	3640	87	b	**42**	Y
Arsenic	1 / 1	2	2	2	150	a	0.01	N
Cadmium	1 / 1	23.7	23.7	23.7	0.6	a	**40**	Y
Chromium	1 / 1	2.8	2.8	2.8	74	a	0.04	N
Copper	3 / 3	3600	176	3600	11	a	**327**	Y
Iron	3 / 3	19700	940	19700	1000	b	**20**	Y
Mercury	0 / 0	NA	NA	NA	0.77	b	NC	N
Nickel	1 / 1	57.1	57.1	57.1	52	a	**1.10**	Y
Silver	0 / 0	NA	NA	NA	0.32	b	NC	N
Zinc	3 / 3	10200	969	10200	120	a	**85**	Y
pH 5.61 (6/6/2013)					6.5	b	**>1.0**	Y
Champagne Creek Below Poison Gulch (Exposure Unit 4)								
Aluminum	4 / 5	4190	110	4190	87	b	**48**	Y
Arsenic *	1 / 1	2	--	2	150	a	0.01	N
Cadmium *	1 / 1	2	--	2	0.6	a	**3.3**	Y
Chromium *	0 / 1	ND	--	ND	74	a	NC	N
Copper	1 / 5	120	120	120	11	a	**11**	Y
Iron	5 / 5	7370	230	7370	1000	b	**7.4**	Y
Mercury *	0 / 1	ND	--	ND	0.77	b	NC	N
Nickel*	1 / 1	16	--	16	52	a	0.31	N
Silver *	0 / 1	ND	--	ND	0.32	b	NC	N
Zinc	5 / 5	370	0.01	370	120	a	**3.1**	Y
pH 7.8 (5/17/2006)					6.5	b	<1.0	N

Definitions
µg/L = micrograms per liter
COPEC = Contaminant of Potential Ecological Concern
ND = Not detected
NA = Not analyzed
NC = Not calculated
HQ = hazard quotient (Maximum-detected value divided by the screening benchmark).
bold = HQs greater than 1.0
Y= Yes, a chemical is retained as a COPEC because the maximum-detected value exceeds the screening benchmark
N= No, a chemcial is not retained as a COPEC because the maximum-detected value does not exceed the screening benchmark

Notes
The most recent sampling event with a reported value was selected (1999 or later) if a reported value for an analyte was not available in 2013 and 2014, see specific notes below:
*** Moran Tunnel**: The mercury conc. of 275 µg/L is from 8/18/1999 -the most recent sampling event with a Hg value.
The silver conc. of 193 µg/L is from 8/18/1999 which is the most recent sampling event with a Ag value.
*** Below Moran Tunnel**: A mercury conc. was not available for Below Moran Tunnel. The most recent sampling event in which Hg was detected occurred in 8/18/1999
A silver conc. was not available for Below Moran Tunnel. The most recent sampling event in which Ag was detected occurred in 8/18/1999
*** Below Poison Gulch**: The arsenic conc. of 2 µg/L is from 8/18/1999 which is the most recent sample event with a As value.
The cadmium conc. of 2 µg/L is from 5/18/2000 which is the most recent sample event with a Cd value.
The nickel conc. of 16 µg/L is from 8/18/1999 which is the most recent sample event with a Ni value.
Mercury, Silver, and Chromium were reported as ND during the most recent sampling event (8/18/1999- Hg and Ag 3/11/2000- Cr).

Surface water data sources: (1) Bureau of Land Management surface water data collected in 2013 and 2014 (unless otherwise noted) and (2) United States Geological Survey data collected in 2013 (as presented in the Data Summary Report, Champagne Creek, Idaho, dated February 12, 2014).

Data presented are the maximum concentrations of each analyte detected in 2013 and 2014, except where noted.

The inorganic values represent total metals
The hardness-sensitive metals (Cd, Cr, Cu, Ni, Ag, and Zn) were not hardness adjusted because the surface water data sets did not include site specific hardness values.
The screening benchmarks for the hardness-sensitive metals are based on a default hardness of 100 mg/L

Benchmark Sources:
a- Idaho surface water quality standard for chronic criteria, 58.01.02. Available at http://adminrules.idaho.gov/rules/current/58/0102.pdf
b- US EPA National Recommended Water Quality Criteria. Available at http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable

Table 2
Sediment Hazard Quotient/ COPEC Selection
Streamlined Ecological Risk Assessment
Champagne Creek/ Moran Tunnel, Idaho

Metals	Frequency of Detection	Maximum detect (mg/kg, dw)	Minimum detect (mg/kg, dw)	Exposure Point Concentration (EPC) (mg/kg, dw)	Screening Benchmark (mg/kg, dw)	Screening Benchmark Source	Hazard Quotient (HQ)	COPEC ? (y/n)
Below Moran Tunnel (Exposure Unit 2)								
Arsenic	2 / 2	87.6	22.3	87.6	9.79	a	**8.9**	Y
Cadmium	2 / 2	10.6	6.14	10.6	0.99	a	**10.7**	Y
Copper	2 / 2	1710	1100	1710	31.6	a	**54.1**	Y
Lead	2 / 2	62.2	38.6	62.2	35.8	a	**1.7**	Y
Zinc	2 / 2	146	107	146	121	a	**1.2**	Y

Definitions

mg/kg dw= microgram per kilogram dry weight

HQ= Hazard Quotient (maximum value divided by the screening benchmark).

COPEC= Chemical of Potential Ecological Concern

Y= Yes, a chemical is retained as a COPEC because the maximum-detected value exceeds the screening benchmark

N= No, a chemcial is not retained as a COPEC because the maximum-detected value does not exceed the screening benchmark

Notes:
Sediment data source: see Table 2 in *Champagne Creek Vegetation Assessment Final Report* , prepared by KC Harvey Environmental, September 15, 2012.
Data collected in June 2012.
no recent sediment samples were collected from any of the other exposure units
bold = HQs greater than 1.0

Sediment benchmark source:
a- MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.

Table 3
Background Surface Water Hazard Quotient/ COPEC Selection
Streamlined Ecological Risk Assessment
Champagne Creek/Moran Tunnel, Idaho

Metals	Frequency of Detection	Maximum detect (µg/L)	Minimum detect (µg/L)	Exposure Point Concentration (EPC) (µg/L)	Screening Benchmark (µg/L)	Benchmark source	Hazard Quotient (HQ)
Aluminum	5 / 5	18700	380	18700	87	b	**215**
Arsenic	1 / 5	12	12	12	150	a	0.08
Cadmium	1 / 5	3.25	3.25	3.25	0.6	a	**5.4**
Chromium	1 / 5	25.6	25.6	25.6	74	a	0.35
Copper	3 / 5	1300	30	1300	11	a	**118**
Iron	5 / 5	28200	460	28200	1000	b	**28**
Mercury*	0 / 6	ND	--	ND	0.77	b	NC
Nickel	1 / 5	41.9	41.9	41.9	52	a	0.81
Silver*	0 / 6	ND	--	ND	0.32	b	NC
Zinc	4 / 5	281	90	281	120	a	**2.3**

Definitions
µg/L = micrograms per liter
ND = Not detected
NC = Not calculated
HQ= Hazard Quotient (maximum value divided by the screening benchmark).
bold = HQs greater than 1.0

Notes
Data sources include (1) Bureau of Land Management surface water data collected in 2013 and 2014 and
(2) United States Geological Survey data collected in 2013 (as presented in the Data Summary Report, Champagne Creek, Idaho, dated February 12, 2014).
Data presented are the maximum concentrations of each analyte detected in the last two years (i.e., 2013 and 2014) except where noted.

* Mercury and silver were not analyzed for in 2013 and 2014. The most recent sample date where Hg and Ag were analyzed was 8/18/1999 with both reported as ND.

Benchmark Sources:
a- Idaho surface water quality standard for chronic criteria, 58.01.02. Available at http://adminrules.idaho.gov/rules/current/58/0102.pdf
b- US EPA National Recommended Water Quality Criteria. Available at http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable

FIGURES

Figure 1: Surface Water Sampling Locations
Champagne Creek/ Moran Tunnel, Idaho

APPENDIX C

SUMMARY OF GEOPHYSICAL INVESTIGATION OF THE SOUTH PIT/CHAMPAGNE CREEK SITE, IDAHO

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Subject: Summary of the geophysical investigation of the South Pit/Champagne Creek Site, Idaho

The Bureau of Land Management (BLM) National Operations Center (NOC), in cooperation with the BLM Idaho Falls District Office (IFDO), performed a surface geophysical investigation at the South Pit near the Moran Tunnel in southeast Idaho on September 15th, 16th, and 17th . The goal of the investigation was to identify the intersection of the surface location of an underground mine tunnel and the South Pit floor and also to gain an understanding of subsurface conditions that would indicate hydraulic connectivity between the pit floor and the tunnel. Non-invasive surface geophysical methods were used to evaluate the subsurface conditions, including magnetic and direct-current (DC) resistivity methods. While the tunnel itself was not imaged, the DC profiles present two scenarios for surface water/groundwater (and subsequently the Moran tunnel) connectivity.

Magnetic surveys were conducted on the main pit floor and on two of the benches to assess the lateral extent of metallic debris. A Geometrics G858 gradiometer was used to collect magnetic data. Data were collected in a sub-meter accuracy GPS-referenced grid format with predominately northwest-to-southeast oriented lines spaced approximately 3 meters apart. Tie lines, oriented northeast-to-southwest, were collected at variable spacing. Magnetic data were processed, gridded, and analyzed for strong gradients that would indicate the presence of buried metals. Other than one anomaly in the main pit floor, corresponding to the location of the holding berm, there is no anomaly identifiable in the mag data outside the regional gradient that would indicate metallic objects (e.g., ore car rails) (Figure 1). Likely explanations for the lack of expected anomalies include either a) corrosion of the rails due to highly acidic water or b) the instrumentation is unable to resolve smaller objects (with smaller geophysical footprints) at deeper depths.

The DC resistivity method was used to evaluate the subsurface structure. Resistivity of geologic materials is primarily controlled by general mineralogy (clay/mineral content), groundwater quality, and water content. Due to topographic constraints, resistivity data were collected over three 2-D profiles from the available space in the floor of the main pit and on the second bench using an Advanced Geosciences SuperSting R8 resistivity meter with 112, 56, and 56 electrodes [per line] at 1.25m, 2m, and 1.33m spacing. Data were processed and inverted with topographic correction, resulting in cross sections representing the resistivity structure of the subsurface to depths of 25m, 18m, and 15m. Figure 2 presents the line locations of the DC profiles and magnetic survey; Figure 3 presents the inverted DC profiles.

Based on the expected location and depth of the tunnel and suitable and available space for data collection, it is unlikely that the tunnel was imaged directly. GPS data indicate that the opening of the tunnel is a maximum 39 meters +/- 2 m (due to radio lock loss) below the lowest elevation of the pit. A 5% slope along the tunnel to the Last Chance workings decreases the distance to about 35 meters beneath the pit's main floor, but still at least 10 meters deeper than any of the resistivity profiles.

There are however subsurface structures visible in the geophysical data that correspond to the expected locations directly over the "copper" vein stope and tunnel. Generally, the fairly resistive (70-150 Ohm-m) material in each of the profiles represents host rock (weathered igneous extrusives). In profile 1 (Fig 3a), the transition from host rock to the clays in the pit is visible based on the lower (<15 Ohm-m) values. This base rock layer, assumed to be the bottom of the pit prior to deposition of the finer-grained material now at the surface, extends westward and northwestward and intersects the other two profiles at approximately the same elevation (Fig 3). The highly conductive anomalies (Fig 3b, Anomalies A) represent pockets of clay that have been transported and deposited into sinkholes that have formed above collapsed structures. Based on the conductivity values, it is likely that these are saturated clays as their values correspond to the conductive anomaly (Figs 3b, 3c, Anomaly B) that correlates to the observable shallow clay pit/pond at the surface near the intersections of profiles 2 and 3 (orange pond in Figure 1); the pit was saturated at the time of data collection.

This subsurface structure can also be explained by a continuous impermeable and resistive layer (e.g., ferricrete) that is perching water rich in total dissolved solids (picked up as surface water travels over exposed mineral-rich rock), clays, or both, resulting in the visible conductive anomalies along a continuous layer. This TDS-rich water exhibits conductivity values similar to the water measurements taken at the Moran Tunnel (~2 Ohm-m).The impermeable layer, however, would effectively prohibit any transfer of water into the subsurface directly into the stoped area/tunnel unless compromised (e.g., drilled to introduce a pathway).

In the event that scenario 1 (clay pockets) holds true, in a highly fractured and clay rich area like the south pit, it is likely the clay has formed an effective barrier by filling in any available fracture or fault zone in the subsurface where water might be able to penetrate, preventing any direct hydraulic connectivity between the pit and the mine workings. If scenario 2 (perched water) holds true, there is a possible connection between the South Pit (under the elevated bench) and the underground workings. Based on available data, there is not enough information to reliably determine whether water is currently moving deeper than either the perching layer or host rock. However, if water were moving deeper into the subsurface, there is an area along profile 2 that could allow infiltration (Figure 4).

Ground truthing the anomalies in profile 2 (Fig 3b, Anomalies A) through augering or geoprobe would identify actual subsurface conditions at this area and facilitate interpretation. If a dye tracer study is performed without ground truthing the data, Figure 4 presents a recommended location for injecting a tracer.

In summary, based on available data, there is no indication that water is moving from the pit directly into the mine workings. However, it is possible that under the middle bench there is a conduit for water to directly move into the mine workings. These two scenarios are not intended to exhaust the possibilities but to highlight subsurface conditions that honor the available data.

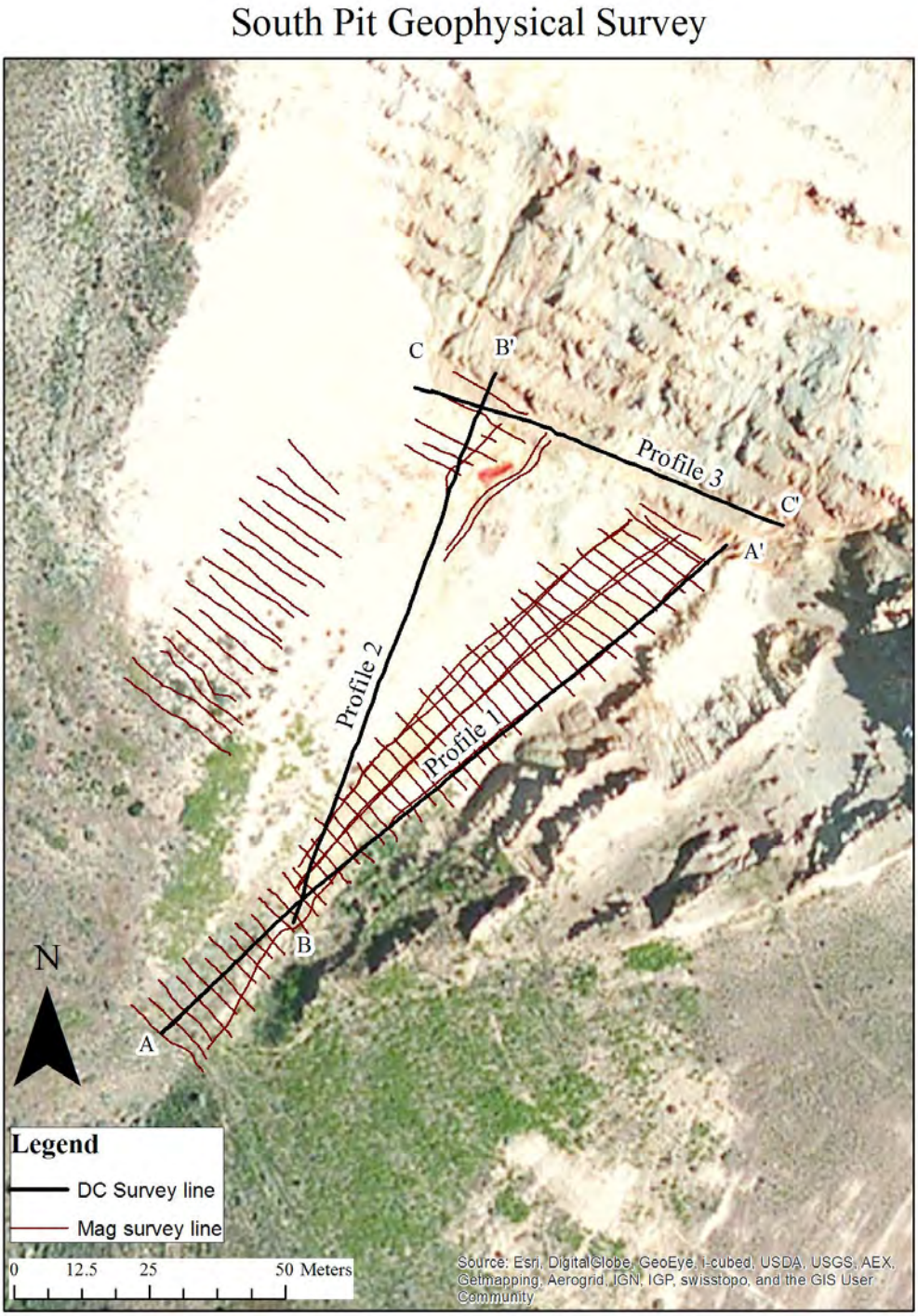


Figure 1. Map of the South Pit site showing the locations of the magnetic and direct current resistivity survey lines. Letters indicate transects (profiles) seen in Figure 3.

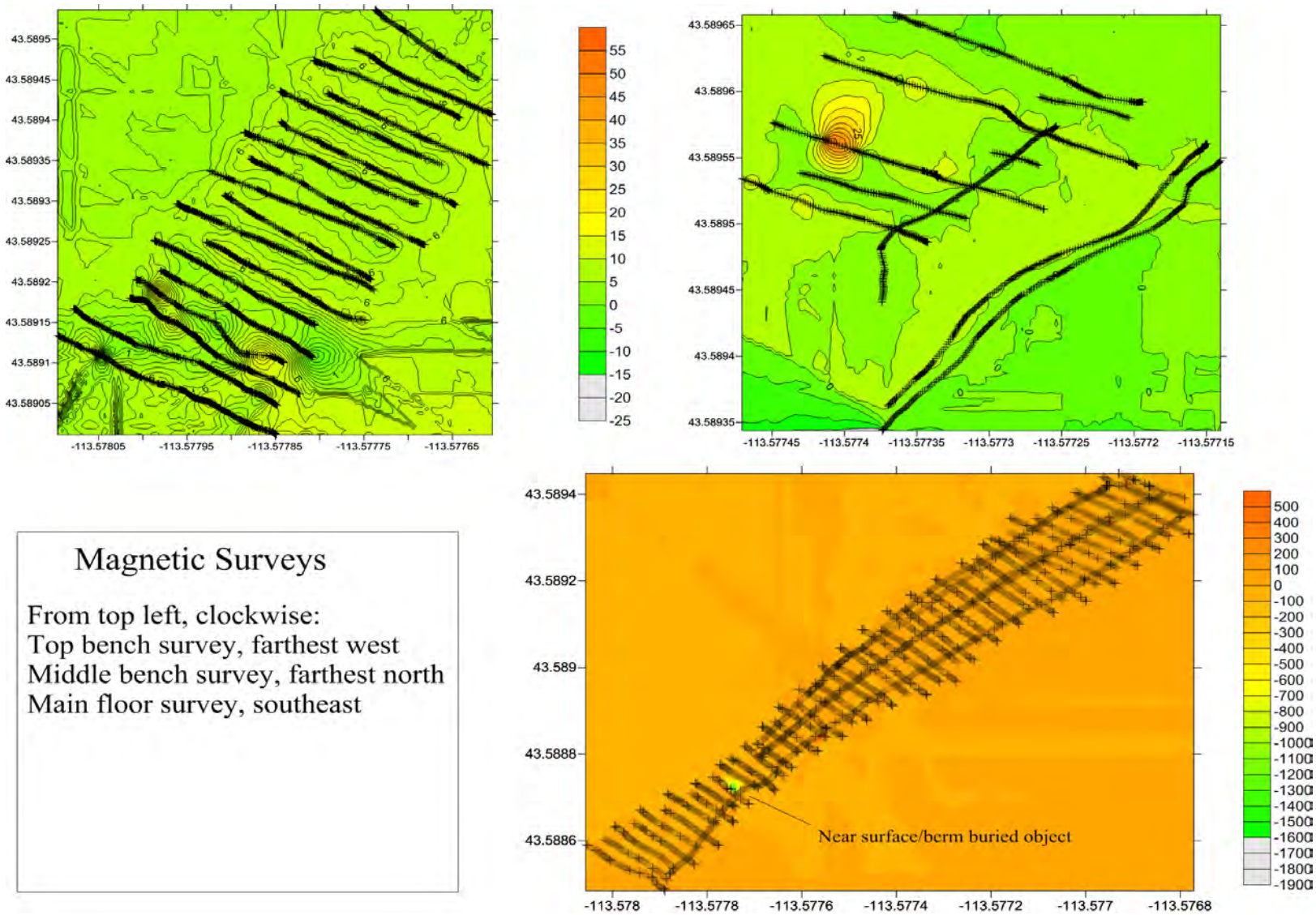


Figure 2. Magnetic survey results. Refer to Figure 1 for line locations against aerial imagery of the South Pit.

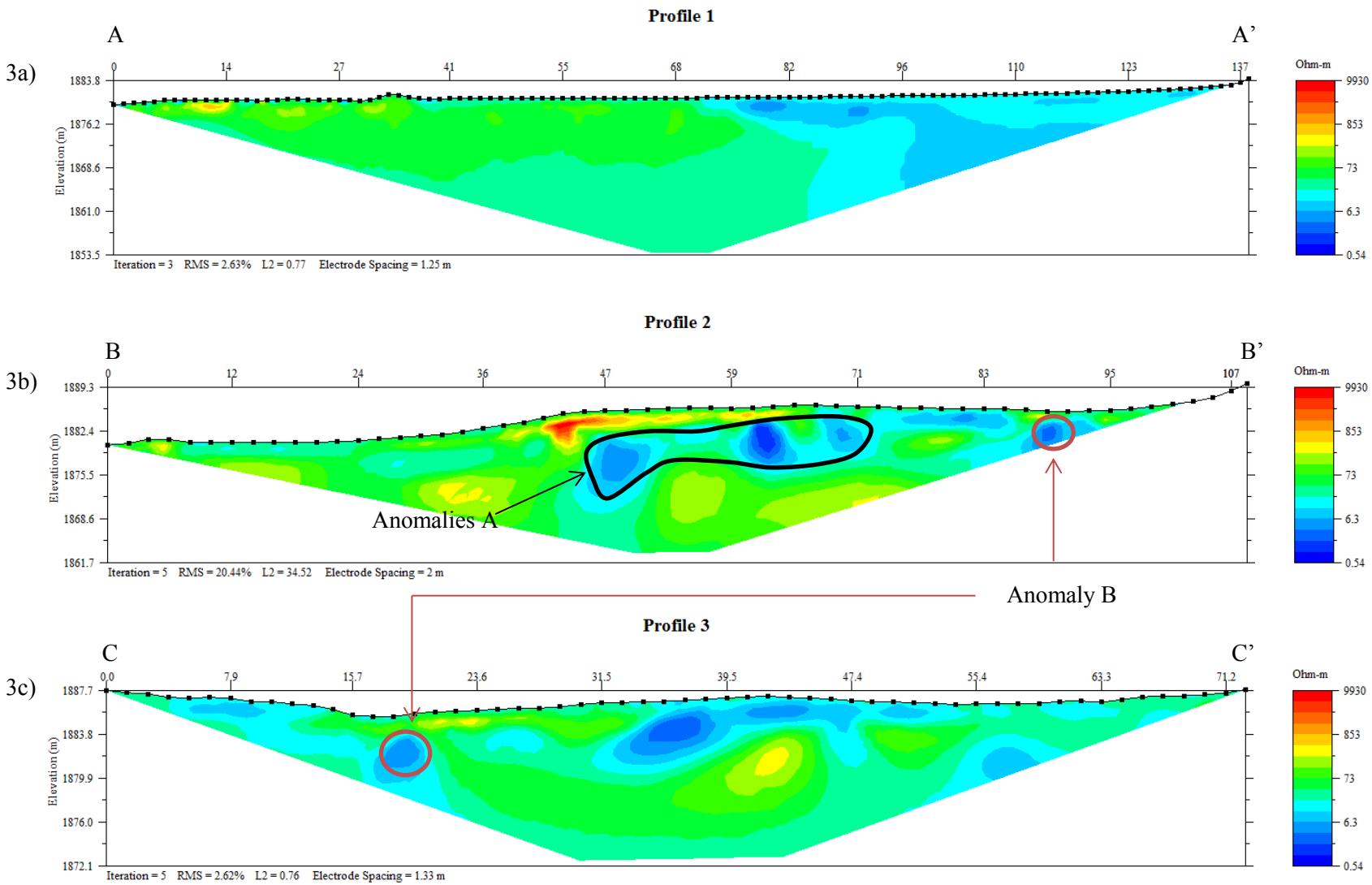


Figure 3. Inverted Direct Current (DC) Resistivity Sections from the South Pit, Idaho. Letters above each profile indicate transect sections from Figure 1.

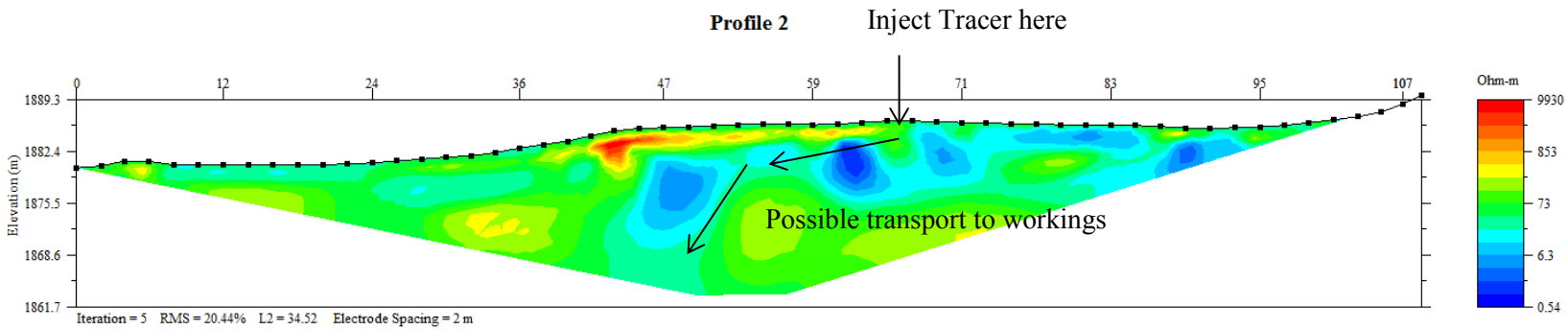


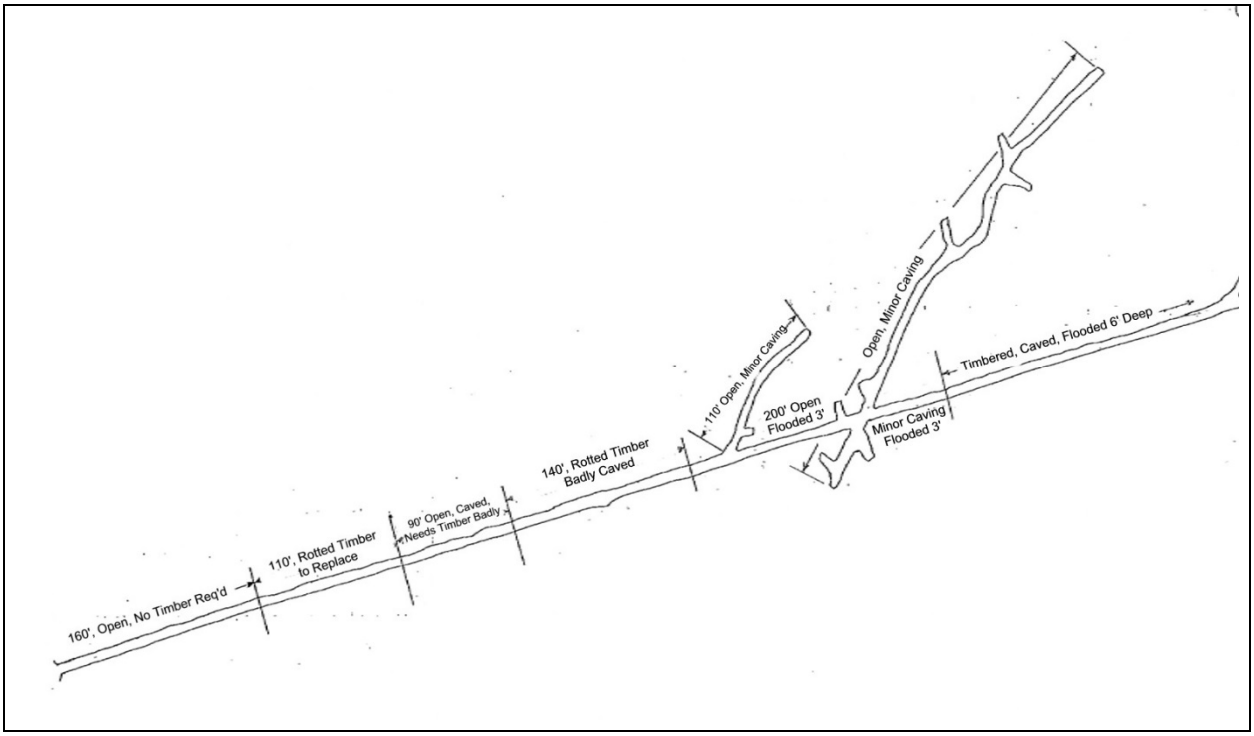
Figure 4. Recommended location for tracer injection and possible flow path into subsurface. Coordinates for injection location are: 291933, 4829487 UTM 12N.

APPENDIX D

SOUTH PIT FLOOR ARD SOURCE EVALUATION

Appendix D
South Pit Floor ARD Source Evaluation
Potential for South Pit Floor Seepage Influence on Moran Tunnel Portal Seep

The change in water chemistry and flow rate coming from the Moran Tunnel portal after a collapse of portions of the tunnel portal in 1993 could be partially explained by a new source of mining influence water (MIW) seeping into the tunnel. While the collapse was primarily observed at the portal in 1993, other simultaneous collapses further underground could have created fractures in the rock above allowing MIW to infiltrate from a pond in the South Pit, located directly above the tunnel. A mine map from Dahle (1956) *with the notes on the roof and flooding conditions enhanced*, shows how unstable the mine workings were almost 60 years ago. The map scale and certain deeper mapped areas are omitted to improve readability.



Data on flow rate and MIW chemistry at the tunnel portal from 1989 to present was used to evaluate this possibility. The MIW chemistry of the South Pit pond water was based off a single sampling event on 8/21/2014.

Table D1 below summarizes average values of a few key parameters for the time periods before and after the "theoretical" collapse in the Moran Tunnel.

Table D1: Mining Influenced Water Chemistry Summary

	Q avg (gpm)	Al avg (mg/L)	Cu avg (mg/L)	Fe avg (mg/L)	Zn avg (mg/L)
Pre-Theoretical Collapse	1.4	No Data	46	201	25
Post-Theoretical Collapse	3.6	535	191	1320	83
South Pit		1370	21	4150	130
Ratio of South Pit Concentrations to Pre Theoretical Collapse Concentrations		No Data	0.46	20.61	5.21
Ratio of South Pit Concentrations to Post Theoretical Collapse Concentrations		2.56	0.11	3.14	1.57

Metals loading was used as the primary indicator to quantify the theoretical MIW seepage from the floor of the South Pit into the tunnel below. The surface copper loading data points to the possibility that a "copper reservoir" was created/exposed to tunnel base flow at the time of the theoretical collapse, and this reservoir has been steadily leached away since then. The low level of copper in the South Pit MIW, coupled with the copper leaching theory, precluded copper as a good candidate for estimating metals loading from the South Pit. There is no pre-theoretical collapse data for aluminum, so that leaves zinc and iron as the potential candidates for mass-balance modeling.

The flow rate appears to have jumped from an average of 1.4 gpm to 3.6 gpm after the tunnel theoretically collapsed. The size of the pond in the South Pit and the water chemistry both refute the possibility that the entire additional 2.2 gpm of flow is seeping from the South Pit pond. Assuming the MIW chemistry and flow rate in the original tunnel would be unchanged without the influence of South Pit seepage, the zinc and iron concentrations would be as follows if all additional flow came from the South Pit:

$$Projected\ Zn\ Conc.@2.2\ gpm = \frac{[(1.4gpm * 25mg/L) + (2.2gpm * 130mg/L)]}{3.6\ gpm} = 60.5\ mg/L$$

$$Projected\ Fe\ Conc.@2.2\ gpm\ = \frac{\left[\left(1.4gpm * \frac{201mg}{L}\right) + \left(2.2gpm * \frac{4150mg}{L}\right)\right]}{3.6\ gpm} = 2{,}614\ mg/L$$

In this scenario, the theoretical zinc loading would be less than what currently is measured, and the theoretical iron would be nearly double what is currently being measured. A more likely scenario is that a lower MIW flow rate from the South Pit is seeping into the tunnel from the floor of the South Pit. Again assuming flow rate and water chemistry of the tunnel would have remained unchanged if the tunnel had not collapsed (in theory) allowing South Pit seepage in, the theoretical seepage based on iron concentration is 1.0 gpm.

$$Actual\ Fe\ Conc. = 1320\frac{mg}{L} = \frac{\left[(3.6gpm - Q) * 25\frac{mg}{L} + \left(Q * 4150\frac{mg}{L}\right)\right]}{3.6\ gpm} ==>$$

$$Solve\ for\ Q = 1.0\ gpm$$

At a flow rate of 1.0 gpm, the expected zinc concentration would be 41.1 mg/L, assuming the remaining 2.6 gpm of flow maintained pre-theoretical collapse MIW chemistry.

$$Projected\ Zn\ Concentration = \frac{[(2.6gpm * 25mg/L) + (1.0gpm * 130mg/L)]}{3.6\ gpm} = 41.1\ mg/L$$

The actual zinc concentration is 83 mg/L at the portal. This difference suggests that the South Pit MIW is leaching additional zinc between the seepage zone on the pit floor (that was sampled in August 2014) and a mixing point/zone with existing tunnel flow. Zinc bearing minerals, possibly *sphalerite*, exposed in the seepage pathways are the likely source of the increase.

The actual gain in average flow of 2.2 gpm suggests that the tunnel may be collecting other seepage sources that may not be as concentrated as the South Pit seepage. Regardless, preventing the infiltration of 1 gpm of concentrated MIW from the South Pit may result in some decrease in metal loading in the Moran Tunnel, perhaps to pre-1993 levels.