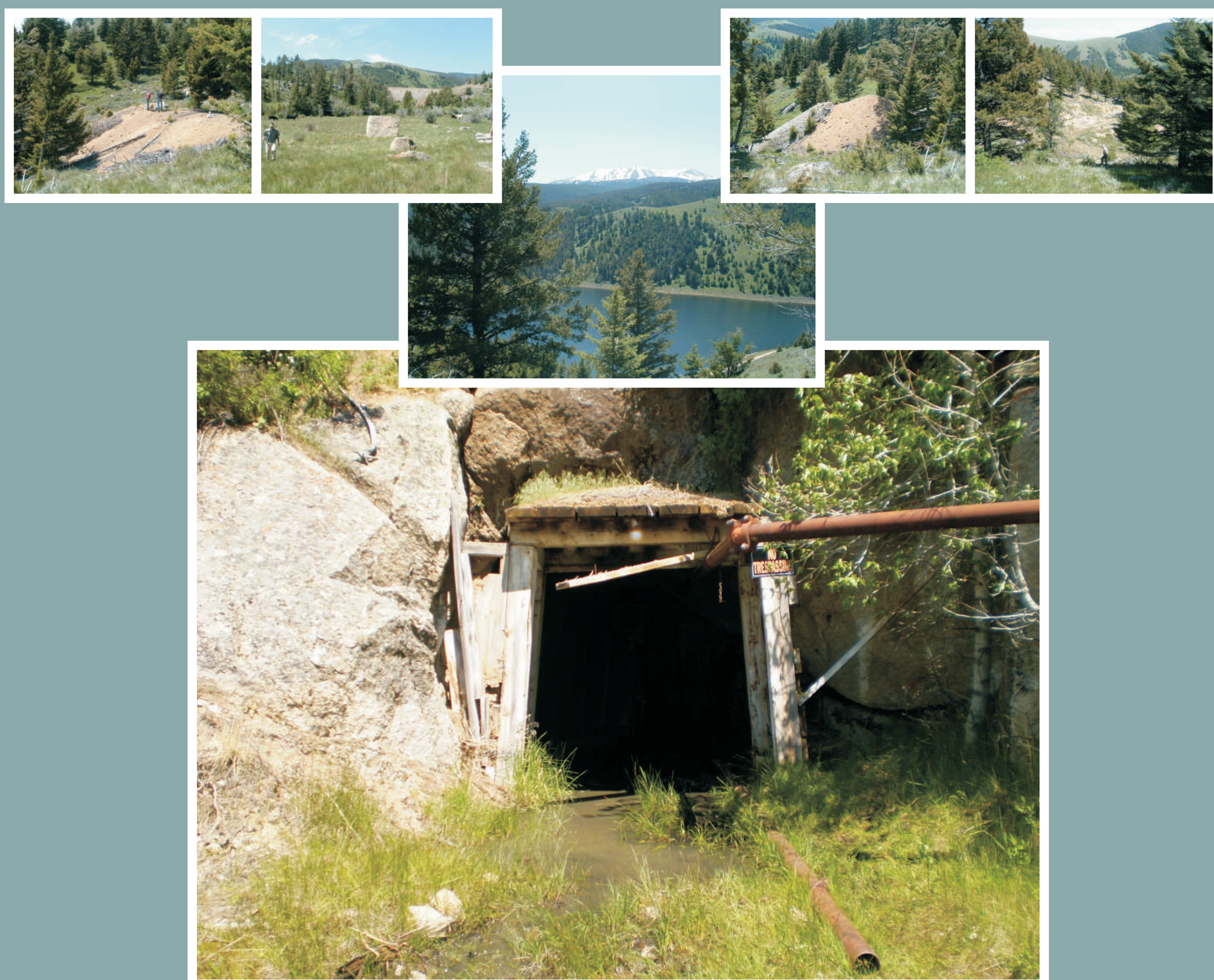
Final

EXPANDED ENGINEERING EVALUATION/COST ANALYSIS

Garnet Mine Area Reclamation Project



Prepared For:

Montana Department of Environmental Quality

January 2010

TETRA TECH

Final
Expanded Engineering Evaluation/Cost Analysis
Garnet Mine Area Reclamation Project

Mineral Hill Mining District, Madison County, Montana

Prepared for:

Montana Department of Environmental Quality
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LIST OF ACRONYMS AND ABBREVIATIONS

ABA	Acid Base Accounting
ABP	Acid Base Potential
AP	Acid Potential
ARARs	Applicable or Relevant and Appropriate Requirements
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
CFR	Code of Federal Regulations
cfs	cubic feet per second
CY	cubic yard
DEQ	Montana Department of Environmental Quality
District	Mineral Hill (Pony) Mining District
DTM	Digital Terrain Model
EEE/CA	Expanded Engineering Evaluation/Cost Assessment
EPA	U.S. Department of the Interior Environmental Protection Agency
FS	Feasibility Study
ft	foot or feet
GMBG	Garnet Mine Back-Ground
GMMW	Garnet Mine Monitor Well
GMPTG	Garnet Mine Preliminary Tailings Geochemistry
GMSW	Garnet Mine Surface Water
GMTG	Garnet Mine Tailings Geochemistry
GMWR	Garnet Mine Waste Rock
gpm	gallons per minute
HHS	Human Health Standard
kg	kilograms
kton	kiloton
MDEQ	Montana Department of Environmental Quality
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
μg/L	micrograms per liter
mg	milligrams
mg/L	milligrams per liter

MPDES	Montana Pollutant Discharge Elimination System
MWCB	Mine Waste Cleanup Bureau
NNP	Net Neutralizing Potential
NP	Neutralizing Potential
ppm	Parts per Million
RAOs	removal action objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SPLP	Synthetic Precipitate Leaching Procedure
s.u.	standard units
XRF	X-ray Fluorescence

1.0 INTRODUCTION

This report is an Expanded Engineering Evaluation/Cost Analysis prepared for the Garnet Mine area, which is listed as a Priority Abandoned Hard Rock Mine Site (PA No. 29-035) by the Montana Department of Environmental Quality (MDEQ). The Mine is located in the Mineral Hill (Pony) Mining District (District) of Madison County, Montana. In June of 2008, Tetra Tech entered into an agreement with the MDEQ (DEQ Contract 407036, Task Order 17) to prepare a Reclamation Work Plan, a Sampling and Analysis Plan, a Health and Safety Plan, conduct a Remedial Investigation, prepare a Remedial Investigation Report, and prepare an Expanded Engineering Evaluation / Cost Analysis (EEE/CA) for reclamation at the Garnet Mine site.

1.1 PURPOSE AND OBJECTIVES

This EEE/CA was developed using the "non-time-critical removal" process outlined in the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), as amended in 1986, the updated National Oil and Hazardous Substances Pollution Contingency Plan (NCP); and the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA). A non-time-critical removal action is implemented by the lead agency to respond to "the cleanup or removal of released hazardous substances from the environment… as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment…" (EPA, 1993). These programs are a part of a comprehensive reclamation procedure that streamline certain aspects of the process to meet the regulatory requirements to clean up abandoned mine land sites. The MDEQ has authority to conduct a removal action at the Garnet Mine site.

The purpose of this EEE/CA is to prepare a functional guide for conducting full scale reclamation activities that to the extent possible mitigate human health and environmental risks associated with the Garnet Mine Reclamation Area. The objective of the EEE/CA is to screen, develop and evaluate potential response alternatives that would be used to clean up mining wastes located within the Garnet Mine site.

The principal environmental issues at the Garnet Mine site are primarily related to either hazardous mine openings or elevated levels of metals present in mine waste piles, tailings, metal-laden water discharging from a mine opening, the transport and redeposition of contaminated mine tailings as in-stream sediments, and associated impacts to surface water.

1.2 REPORT ORGANIZATION

This EEE/CA is arranged in twelve sections. The contents of Sections 2 through 11 are summarized below. Appendices are included as the twelfth section.

Section 2.0: Site Background presents the history of the site including mining and milling activities; and general description of the site setting including a discussion of the location and topography, land use, ownership, climate, archeologically significant features, geology, hydrogeology and surface water hydrology and a discussion of the biological setting including vegetation, wildlife and fisheries.

Section 3.0: Waste Characteristics and Summary of Existing Site Data presents data pertinent to site characterization as outlined in the *Garnet Mine Remedial Investigation Report* (Tetra Tech, 2008). Describes pertinent data from previous investigations performed at the site

Section 4.0: Summary of Applicable or Relevant and Appropriate Requirements presents Montana State and Federal government requirements that are considered ARARs for the reclamation of this site.

Section 5.0: Summary of Risk Assessment summarizes the baseline human health and ecologic risks associated with the site.

Section 6.0: Reclamation Objectives and Goals outlines the removal action scope, removal action objectives (RAOs), and goals for the site. The RAOs were developed by the MDEQ and goals were identified based on both applicable or relevant and appropriate requirements (ARARs) and representative cleanup guidelines for mine waste sites.

Section 7.0: Development and Screening of Reclamation Alternatives response action technologies and process options are screened and potentially applicable removal alternatives are developed. Reclamation alternatives are initially screened for effectiveness, implementability, and cost.

Section 8.0: Detailed Analysis of Reclamation Alternatives presents a detailed analysis of alternatives using NCP evaluation criteria, and Section presents a comparative analysis of the alternatives.

Section 9.0: Comparative Analysis of Alternatives presents a comparative analysis of alternatives for consistency with the NCP criteria.

Section 10.0: Preferred Alternative presents the recommended preferred alternative to for the Garnet Mine Site and summarizes the rational for selecting the alternative.

Section 11.0: References provides a list of references cited in the report.

Figures and tables are incorporated into the text of the report. References cited in the document are listed at the end of the text. Appended information includes site maps and laboratory analytical data for samples collected during site characterization activities at the Garnet Mine site, spreadsheets used for calculating risk analysis metrics, and detailed cost estimates for alternatives.

2.0 SITE BACKGROUND

2.1 MINING HISTORY

The Garnet Mine began underground operations mining gold, silver, copper and lead in the late 1800s with most of the production occurring between 1897 and 1909 (Frontier, 2003). Mining continued intermittently through the 1930s. Milling operations were initially conducted in a 20-stamp amalgamation mill, and later a conventional floatation mill and tailings facility was added to produce a concentrate for shipping. Historical production has been estimated at as much as 175,000 tons of ore. The property has largely been used for grazing livestock since the late 1930's.

2.2 SITE SETTING

2.2.1 Location, Topography and Features

The Garnet Mine is located approximately 2.5 miles southwest of Pony, Montana in the Mineral Hill (Pony) Mining District of Madison County, Montana (**Site Map A-1**). The workings in the mine area occur on a steep south facing slope, along a tributary on the north side of Cataract Creek immediately northeast of Cataract Lake Dam. The elevation of Cataract Creek and the tailings impoundment is at approximately 6250-ft. The elevation of the highest workings (Collapsed Raise or stope, F-1) is at elevation 6950-ft on the south facing slope.

The Garnet Mine site is comprised of adits, shafts, caved stopes, waste rock piles, tailings, and other hazardous and non-hazardous materials left from past mining and milling of the gold-silver ore. Mining related features and mine waste at the Garnet Mine site are depicted on **Site Map A-2** and are described below:

- F-1, an open raise or collapsed stope,
- F-2, a collapsed open stope or glory hole,
- F-3, a collapsed adit with a waste rock dump near the portal,
- F-3A, a waste rock pile,
- F-5, A collapsed adit and regraded waste rock pile,
- F-7, underground workings associated with the Oriole Adit (F-8),
- F-7A, a more modern open adit called the Tunnel No. 2 of the Oriole Lode, or the "Oriole Adit"
- F-8 Oriole Adit Waste Rock Pile
- F-4, F-6, F-9, F-10, F-11, and F-12 – are various buildings and mill facilities related to the mine

The Garnet Mine's earliest workings are located highest on the mountain on the Galena Lode patented mining claim (**Site Map A-2**) (RTI, 2004). These workings consist of an open raise (an underground shaft excavated from the bottom up; this feature may be a collapsed stope) (F-1), a collapsed open stope (underground mine working excavated so close to the surface that the overlying rocks collapse into the mine void, also called a “glory hole” if deliberately mined to the surface, F-2), and a collapsed adit (horizontal tunnel that has collapsed to surface, F-3A) with associated waste rock (F-3). There is speculation that this upper collapsed adit (F-3), extends beneath the glory hole or collapsed open stope (F-2) and collapsed open stope or raise (F-1). There are also reports that a winze (a shaft excavated from underground connecting different working levels) was mined, downward out of this adit, to access deeper underground ore zones.

A collapsed adit (F-5) and waste rock pile, and lower elevation underground workings (F-7) accessed by an open adit (horizontal mine tunnel that exits to the surface through a portal, F-7A), also with associated waste rock (F-8), are located on the Blue Jay and Oriole patented claims (RTI, 2004). This lower adit is called the Tunnel No. 2 of the Oriole Lode, or the “Oriole Adit”) and was likely driven to the north to mine ore beneath workings on the Blue Jay and Galena claims. This adit has recently been reopened to a cave-in at about 448 feet from the portal. There is approximately 440-feet of elevation difference between the upper adit (F-5) and lower Oriole Adit portal (F-8).

Ground water discharges from the Oriole adit and drains through waste rock at the portal and along the mine access road into the breached mine tailing facility in the valley bottom along Cataract Creek (**Site Map A-2**). Seepage from this adit is characterized by elevated metal concentrations and moderately acidic pH values that likely contribute to overall metal concentrations and degradation of receiving surface and groundwater. Remnants of two large tailings ponds and a breached dam also made of tailings lie downstream (east) of the mill remnants (F-9, **Site Map A-2**).

2.2.2 Vegetation

The project area is in the Foothill Sagebrush vegetation zone. Plant species include bluebunch, wheatgrass, sagebrush and cheat grass. Willow species are present along banks of Cataract Creek while cottonwood and pine trees grow at the sides of the valley and on hillsides above.

2.2.3 Land Use and Population

Mining at the Garnet Mine site was active beginning in 1884 and continued sporadically at some capacity until the late 1930’s (RTI, 2004). After that time, the land was used primarily for cattle grazing and in the late 1950’s an earthfill dam creating Cataract Reservoir was built by the Montana Water Conservation Board to store water for irrigation.

The mine site is currently uninhabited and is used for grazing cattle and recreation (i.e. fishing in the reservoir, ATV use, and presumably, hunting).

2.2.4 Land Ownership

Gary L. and Lisa A. Perry own the surface rights to the Garnet Mine’s patent claims at PA No. 29-035 as well as a presumed ½ interest in mineral rights (RTI 2004). They also hold the other lands at PA No. 29-035. Their address as of January 2010 was:

Gary L and Lisa A. Perry
3325 West Cedar Lane
Manhattan, MT 53741-8240

2.2.5 Historic and Archeologically Significant Features

A cultural resource inventory of the Garnet Mine and Mill site was prepared in 2003 (Frontier, 2003). The inventory determined that the integrity of the site has eroded due to natural and human forces, leaving only the foundations of the mill and collapsed structures. Other historic features have been removed or destroyed during recent operations. Because of its greatly diminished integrity, the Garnet Mine and Mill site does not qualify for the National Register of Historic Places.

2.2.6 Climate

The Garnet Mine is located approximately 3 miles west of Pony in southwestern Montana along the east side of the Tobacco Root Mountain range. The historic mining facilities are located between elevation 6,300 feet and 6,900 feet (above mean sea level) on a slope with a south facing aspect. A continental climate is characteristic of the site location. Average temperatures at Pony range from the mid-70s to low 30 degrees Fahrenheit with seasonal highs reaching into the 90s and lows below negative 20 degrees Fahrenheit. Precipitation is generally highest during the spring months with average rainfall depths around 3 inches in May. The lowest precipitation amounts occur during December and January with equivalent water depths just above 0.6 inches. The average annual precipitation for the site is 17.9 inches with and average annual snowfall of 85 inches.

2.2.7 Local and Regional Geology

The Garnet Mine is located at the northeastern end of the Tobacco Root Mountains of southwestern Montana. The core of the mountain range and the area in the vicinity of the Garnet Mine is underlain by the Cretaceous Tobacco Root batholith (Vuke and others, 2002). The intrusive rock of the batholith is comprised of a gray, coarse-grained to porphyritic, hornblende-biotite bearing, quartz monzonite or granodiorite. Because of glacial erosion, exposures of the intrusive complex typically result in rather steep, rounded outcrops exhibiting dominant fracture patterns that are etched out in negative relief. Highly weathered outcrops result in an infertile, weathered-in-place, pea-gravel (grus) type of soil material.

The Tobacco Root batholith intrudes and domes Precambrian metamorphic rocks and Paleozoic sediments around the margin of the range. Precambrian metamorphic quartzo-feldspathic and amphibolite gneisses are exposed on the uppermost portion of the ridge above the Garnet Mine. The historic workings of the Garnet Mine area are associated with northeast-trending faults and shear zones within the Tobacco Root quartz-monzonite that range from one or two feet to as much as 20 feet in width. The mineralized rock exposed within the workings, both near the surface and underground in the Oriole adit (F-7), consist of parallel fractures or faults that have coalesced into shear zones that are variously silicified and locally clay-altered with abundant epidote (**Photo 2-1**). Mineralization occurs as sulfide veinlets along fractures, narrow replacement zones adjacent to fractures, and as dissemination within the shear zones. Gold, silver, copper, and lead were historically mined, and free gold and silver was initially processed in a stamp mill. Later ore was processed in a flotation mill that produced a metal-sulfide concentrate for shipping to a smelter, and left behind tailings as wastes stored behind impoundment(s) in the Cataract Creek drainage below the Garnet workings. The Oriole adit is discussed in greater detail below in the Mine Survey Section 3.6.

Photo 2-1. Oriole Adit mineralized shear zone with sulfides and epidote.

2.2.8 Hydrogeology

The hydrogeologic setting of the Garnet mine is typical of mountainous environments within this region. The general pattern of groundwater flow is from higher elevation areas, where bedrock groundwater is recharged by snowmelt and storm events to lower elevation areas along streams. In general the regional groundwater flow is easterly toward the town of Pony. Bedrock groundwater discharges from fractures as seeps and springs and to local stream drainages, recharging the alluvial groundwater system and ultimately sustaining base flow in Cataract Creek during periods of low precipitation. The recharge area of the Cataract Creek watershed is relatively small, and lies near topographic divides; therefore, annual precipitation amounts and timing significantly influence base flows in area streams.

Groundwater in the vicinity of the Garnet Mine has been studied only in areas of known mining impacts, predominantly along Cataract Creek and in the vicinity of Cataract Dam. There is a known seepage path through the south abutment of Cataract Reservoir Dam. Due to the limited amount and distribution of groundwater data, a potentiometric surface map for the entire study area cannot be compiled.

Bedrock permeability is considered to be low with groundwater flow occurring predominantly through fractures, joints, and fault zones. This conclusion is supported by relatively low base flow discharge (typically less than 10 gpm) from the 1,184 foot long Oriole Mine adit and other cross-cuts. Underground mapping further supports this observation with generally low flows from a very limited number of isolated fractures; the vast majority of underground fractures were dry at the time of mapping. Alluvium has a much higher permeability than bedrock due to the predominance of silt and sands with occasional gravels and cobbles in the Cataract Creek drainage.

Based on available data, local bedrock and alluvial groundwater discharge to Cataract Creek throughout the study area during the spring and summer seasons. During early fall groundwater contributes to Cataract Creek base flow in the vicinity of the Mill Site and adit; however, surface water appears to recharge groundwater in the vicinity of the historic tailings dam (F-13) with groundwater again supporting base flow downstream of the historic tailings dam.

The nearest groundwater supply well is GWIC ID# 122256 (Montana Bureau of Mines and Geology, 2008) located near the North Fork of Willow Creek about 3,500 feet downstream from the Garnet Mine site. This well had a static water level of 170 feet and an intended use of providing stock water when it was completed in September 1990. The nearest domestic water well is GWIC ID# 175123 located an additional 2,100 feet down-gradient with a static water level of 19 feet. This well was completed in October 1999.

2.2.9 Surface Water Hydrology

The mining facilities are located on a steep, south facing, wooded hillside above Cataract Creek. Cataract Creek is tributary to North Willow Creek which is tributary to the Jefferson River. The tailings impoundment is located in Cataract Creek downstream of the Cataract Creek Reservoir. Cataract Creek Reservoir is an 80-foot high, 775 foot long dam with a capacity of 1,480-ac-ft. Base flows in Cataract Creek are, in part, maintained by seepage from the reservoir through the glacial moraine material deposited along the south abutment of the dam (DNRC, 2005). The basin area upstream of the site is 6.1 square miles. Cataract Creek and the tributary basin flows from southwest to northeast through steep and mountainous terrain with elevations ranging from approximately 6,353 feet at the spillway crest to more than 10,000 feet at the upper reaches of the basin. The basin cover type is primarily forested with pine trees and includes some rock outcrops and grass/sagebrush fields. Soils in the basin are well drained and classified as being within Hydrologic Group B. Seasonal fluctuations in flow are primarily controlled by the releases from the reservoir. Peak flows from storm events in Cataract Creek are rare due to the attenuation of storm flows in the reservoir.

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3.0 WASTE CHARACTERISTICS AND SUMMARY OF EXISTING DATA

This section presents data that characterize the source, nature and extent of mining-related contaminants at the Garnet Mine site. Section 3.1 summarizes historic work conducted by Pioneer Technical Services during a hazardous material inventory site investigation in 1994. The remaining sections describe results of the remedial investigation activities conducted by Tetra Tech during summer and fall 2008. Methods employed during the remedial investigation are described by Tetra Tech (2008 and 2009).

3.1 PREVIOUS INVESTIGATIONS

Pioneer Technical Services (1994. Included as an appendix in RTI, 2004) conducted a hazardous materials inventory of the Garnet mine site for the Montana Department of State Lands Abandoned Mine Reclamation Bureau. Pioneer provided the original descriptions of the mine features F-1 through F-12 previously referred to in Section 2.2 of this report. Analytical data collected as part of the inventory included total metal concentrations in mine waste rock, tailings, creek sediments, and background soil samples measured with a portable XRF device. Surface water quality samples were also collected from Cataract Creek. Total metals and acid-base account analyses were reportedly conducted on mine wastes but data from these analyses have not been located.

3.2 MINE WASTE ROCK

Waste rock samples were collected for 1) acid-base accounting (ABA) to determine their potential to generate acidic leachate and 2) metal mobility testing using the Synthetic Precipitate Leaching Procedure (SPLP) to evaluate their potential to release metals in concentrations in excess of current DEQ-7 (MDEQ, 2008) surface water standards.

Six composite waste rock samples were collected from four historic waste dumps and a collapsed raise/stope in the project area (**Site Map A-3**). Geologic descriptions of these samples are provided in the Remedial Investigation Report (Tetra Tech, 2009). Samples GMWR-F1-A and GMWR-F1-B were each collected at the collapsed raise/stope labeled F1 in **Site Map A-2**. Sample GMWR-F1-A was representative of the most commonly observed rock exposed within the perimeter of the collapsed feature while sample GMWR-F1-B was a "high-graded" sample consisting of a greater proportion material rich in visible sulfides. Samples GMWR-F3 and GMWR-F3-A were collected from the waste piles respectively labeled F-3 and F-3A on **Site Map A-2**. Samples GMWR-F5 and GMWR-F8 were collected from waste piles respectively located downhill of the collapsed adits F5 and F8 (i.e. the Oriole Adit) shown in **Site Map A-2**.

Each of the four waste piles was surveyed in the field to provide data to calculate the total volume of waste in each pile. The waste pile volumes were calculated utilizing AutoCAD Civil 3D computer software, which developed a native ground digital terrain model (DTM) using contour data surrounding the waste pile and an existing waste pile DTM using the waste pile survey contour data. The waste rock pile volumes were then calculated by comparing the native ground DTM and the existing waste pile DTM. The volume estimates are preliminary and will be further refined for the EEE/CA. The estimated waste rock pile volumes are summarized in **Table 3-1**.

TABLE 3-1
Preliminary Waste Rock Volume Estimate
Garnet Mine Reclamation Area

Waste Rock Pile	Volume Estimate (CY)
F-1	100
F-3	500
F-3A	1,000
F-5	4,000
F-8	8,000

Acid-base account testing determines the Acidification Potential (AP) and Neutralization Potential (NP) of a sample (Sobek et al., 1978). The test uses relatively complete digestion of finely ground rock, and therefore conservatively estimates the reactivity of available sulfide. AP and NP are reported in units of tons $CaCO_3$ / kiloton of rock. The ratio of these values, along with Net Neutralization Potential (NNP = NP-AP. Also known as Acid Base Potential, ABP), are used by regulatory agencies to assess the acid generation potential of rock samples based on the generally accepted criteria shown in **Table 3-2**. Samples falling in the "uncertain" category require kinetic testing using humidity cells to evaluate their potential to generate acidic leachate over an extended period of weathering.

Acid-base account data for the six waste rock samples collected from the Garnet project area are summarized in **Table 3-3**. All waste rock data, including sulfur fractionation and metal mobility test data, are reported in **Table B-1** (**Appendix B**). These data show all samples to have uncertain acid generation potential indicated by NNP values between +20 and -20 $CaCO_3$ / kiloton of rock. Three samples (i.e. GMWR-F1-B, GMWR-F3, and GMWR-F8) have somewhat greater potential to generate acid based on NP:AP values below 1.

TABLE 3-2
Acid-Base Account Criteria for Classifying Acid Generation Potential of Rock Samples
Garnet Mine Reclamation Area

Classification	Criteria for Classification[1]
Potentially Acid Generating	NP:AP < 1 and NNP < -20 tons/kton
Uncertain Acid Generation Potential	NP:AP between 1 and 3 and/or NNP between -20 and +20 tons/kton
Unlikely to Generate Acid	NP:AP > 3 and NNP > +20 tons/kton

[1] From BLM (1996) and USEPA (1994).

TABLE 3-3
Summary of Acid-Base Account Data for Garnet Waste Rock Samples Garnet Mine Reclamation Area

Criteria	GMWR-F1-A	GMWR-F1-B	GMWR-F3	GMWR-F3-A	GMWR-F5	GMWR-F8
NP:AP[1]	6.0	0.3	0.6	2.2	2.6	0.7
NNP[2]	6	-6	-2	3	4	-1

[1] NP:AP is the ratio of neutralization potential to acid generation potential.
[2] NNP is net neutralization potential in units of tons $CaCO_3$ / kiloton of rock.

Results of SPLP metal mobility testing are reported in **Table B-1** in **Appendix B**. Test extracts from all six waste rock samples exceeded DEQ-7 acute aquatic life, chronic aquatic life, and/or human health standards for surface water for at least one of the analyzed metals. Lead was the most commonly detected constituent and was measured at concentrations above the human health standard in extracts from all six samples. The acute aquatic life standard for copper was exceeded in extracts from five of the six samples and secondary standards for iron and manganese were exceeded in extracts from four and five samples, respectively. Standards for arsenic, cadmium, mercury, or zinc were exceeded in three or fewer samples.

3.3 TAILINGS DEPOSITS

3.3.1 Tailings Geochemistry

Five tailings samples were collected for geochemical characterization. Analytical data for these samples (**Table B-1** in **Appendix B**) indicate that their environmental geochemical behavior is similar to that of waste rock samples. All five tailings samples have “uncertain” acid generating potential based on acid-base accounting results (**Table 3-4**).

TABLE 3-4
Summary of Acid-Base Account Data for Garnet Tailings Samples Garnet Mine Reclamation Area

Criteria	GMTG-1	GMTG-2	GMTG-3	GMTG-4	GMTG-5
NP:AP[1]	0.0	3.8	1.6	0.0	1.2
NNP[2]	-5	3	0	-2	0

[1] NP:AP is the ratio of neutralization potential to acid generation potential.
[2] NNP is net neutralization potential in units of tons $CaCO_3$ / kiloton of rock.

Data from SPLP metal mobility testing showed that extracts from all five samples exceeded the human health standard for lead as well as acute aquatic life standards for copper and zinc (**Table B-1** in **Appendix B**). Human health, acute aquatic life, or chronic aquatic life standards for cadmium were also exceeded by extracts from all five samples. Three samples produced extracts that exceeded the chronic aquatic life standard for iron and the human health standard for mercury.

3.3.2 Tailings Delineation

The results of XRF analysis were used to determine depth of tailings, or impacted soils underlying tailings, present in Cataract Creek floodplain by comparing tailings metal concentrations to concentrations in background soil samples (**Tables B-2** and **B-3** in **Appendix B**) as described in the Remedial Investigation Report (Tetra Tech 2009). In some locations a depth of tailings could not be determined because of 1) unsafe sampling conditions or 2) deeper samples could not be obtained due to groundwater or refusal. **Site Map A-4** displays the locations of the test pits as well as the depth of tailings at each sampling location. Additional XRF metals data (**Table B-4** in **Appendix B**) were collected for use in the risk analysis presented in Section 5 of this report.

Based on field observations, tailings were likely discharged into Cataract Creek and the adjacent wetland marsh **(Photo 3-1**) from the mill site (F-9 to 12) to be impounded upstream of two structures. The first structure is an old headwall constructed of wood approximately 500-ft downstream of the mill site as shown on **Site Map, A-2**. A second, larger earth dam was constructed 1,400-ft downstream of the mill, also shown on **Site Map, A-2**. The second structure has since been breached (**Photo 3-2**), presumably when the Cataract Creek Reservoir spillway discharged in 1975 and 1995 according to Department of Natural Resource project records. It is assumed that tailings were more uniformly distributed behind the dams prior to spillway flows from Cataract Creek Reservoir and breaching of the lower dam. As a result of these events, thicker tailings deposits remain in mounds along the existing creek alignment where thick vegetation (pines and willows) stabilized the tailings. Tailings in the adjacent marsh area either never existed to any substantial thickness or eroded as a result of flood events or seasonal runoff. The valley narrows near the breached dam and the thickness of the tailing mounds increase with respect to the height of the dam above the creek invert (**Photo 3-2**). Vegetation is very dense from approximately 100-ft to 500-ft upstream of the dam. In portions of this lower vegetated area near the breached dam, mounds of tailings were found to extend further north from the existing creek alignment compared to tailings in upstream areas, with little remaining tailings near the dam.

Photo 3-1. Wetland/Marsh Area.

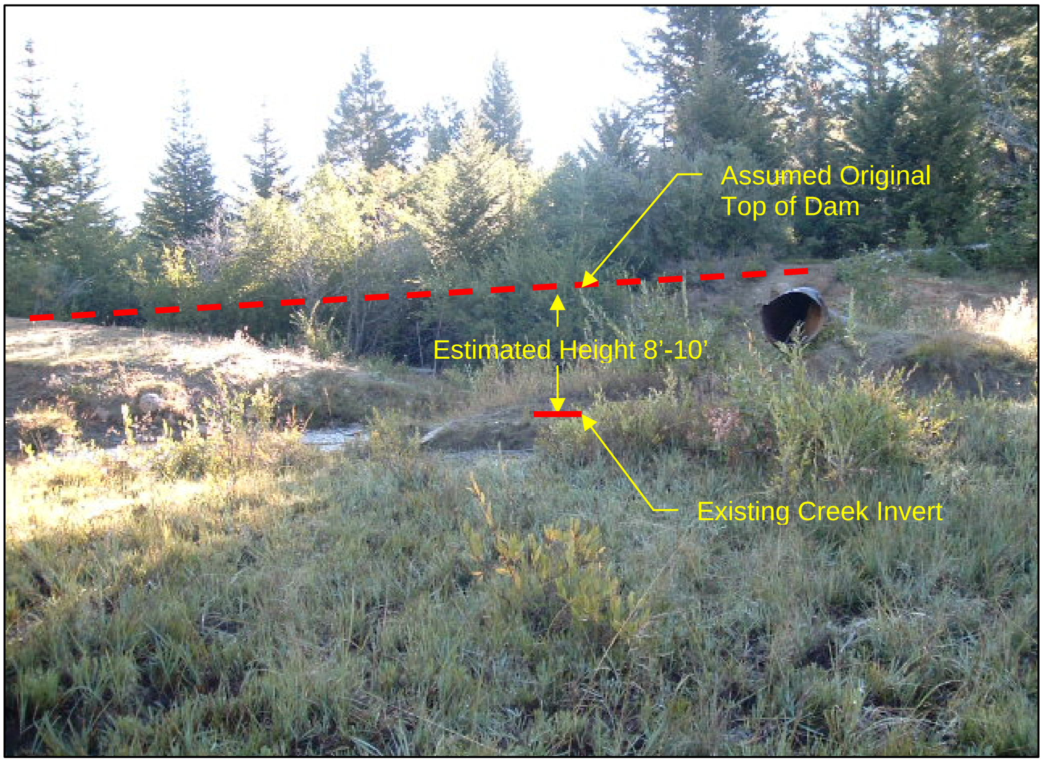

Photo 3-2. Breached Earthen Dam.

Test pits were excavated throughout the tailings deposit area as described *Final Remedial Investigation Report* (Tetra Tech, 2009). Test pit locations and depth of tailings/impacted soil at each pit are shown on **Site Map A-4**. General tailing depositional patterns observed during the tailings investigation are discussed further below by location:

- South Side of Cataract Creek

The channel of Cataract Creek is located along the southern edge of the floodplain, close to bedrock outcrops forming the south valley wall or slope, and minimal tailings were observed south of the creek upstream of the unvegetated tailings piles near the breached tailings dam (F-13, **Site Map A-2**).

- North Bank of Cataract Creek

The north bank of the Cataract Creek channel consists largely of mounded tailings which form a levee-like feature between the creek and the marsh area that extends northward to the access road along the northern edge of the valley (**Site Map A-4**). Exposed tailings were observed in numerous locations along the north embankment. Typical mounded tailings conditions along the north bank of Cataract Creek are shown in **Photos 3-3, 3-4** and **3-7**.

Photo 3-3. Typical streamside tailings.

Photo 3-4. Typical streamside tailings.

- Wetland/Marsh Area

Typical of the marsh area (**Photo 3-1**), a minor volume of tailings were visually identified in the area extending north from the northern creek embankment. Tailings in this area consisted of thin lenses of tailings just below the vegetative mat as shown in **Photos 3-5** and **3-6**. Generally, tailings deposits appeared to extend part way into the marsh area toward the road with the thickest deposits near the creek and tapering out approaching the road (**Site Map A-4** in **Appendix A**). XRF metals data greater than screening levels also occurred in some areas where no tailings were visible; indicating that metal-rich tailings are locally intermixed with underlying natural soils in these areas.

Photo 3-5. Typical marsh area tailings.

Photo 3-6. Typical marsh area tailings.

- Breached Dam and Area Immediately Upstream

Larger mounds of exposed and vegetated tailings occur along the creek immediately upstream of the breached historic tailings dam as shown on **Photo 3-7**. Thick willow vegetation limited the number of test pits that could be excavated in these areas; however, test pits were excavated on most of the larger mound-shaped deposits. The valley narrows toward the dam (**Site Map A-4**) and tailings deposits were observed to become more confined in width in this area. Crests of the tailings mounds described above are at similar elevations as the breached tailings dam crest, suggesting that at one time tailings were impounded to this elevation behind the dam. If this is true the mounds are erosional remnants of a much larger tailing deposit, and a considerable amount of tailings must have washed downstream since the dam was breached.

Photo 3-7. Exposed tailings at GMTG-0.5L30 (looking upstream).

The inferred lateral extent of the tailings deposit is shown in plan view on **Site-Map A-4.** Two tailings deposit boundaries, and the depth of tailings/impacted soil at each test pit are depicted. A Surficial Tailings Deposit Boundary, where tailings depths are 2 feet or less, mainly encompasses the wetland/marsh areas. A second, Primary Tailings Deposits Boundary is also shown where tailings deposits were found at depths greater that 2-ft to over 8ft deep. Test pits deeper than 8-ft were not excavated due to safety concerns. Areas where impacted tailings are greater that 8ft are concentrated to a few mounded areas within several hundred feet of the dam. One of these areas is shown in **Photo 3-7**. The locally dispersed nature of the tailings deposits, the undulating character of the of the lower tailings deposit contact surface, and the commingling of tailings or leaching of metals from the tailings into the underlying native soil material results in a range of calculated tailings/impacted soil volumes of 30,000 to 50,000 cubic yards.

3.4 SURFACE WATER

Surface water quality data are reported in **Table B-5** in **Appendix B**. Water collected from Cataract creek monitoring stations during all monitoring events exhibited near-neutral pH values ranging from 5.85 to 7.25 as measured in the field. Metals concentrations were typically low with the exceptions of lead and copper at stations below GMSW-1 (i.e. the Cataract Reservoir dam outfall) (**Figures 3-1** and **3-2**). Concentrations of both metals increased with distance downstream with lead exceeding the chronic aquatic life standard at GMSW-2, -3, and -4 during both July sample events.

Copper concentrations exceeded acute aquatic life standards below the breached tailings dam at GMSW-4 during both July sampling events. The acute standard for copper was exceeded at GMSW-2 during the second July monitoring event. It should be noted that this was the only instance of an upstream location having a greater metal concentration compared to downstream locations above the breached tailings dam. The dissolved copper concentration for the GMSW-2 sample was below detection suggesting that sampling bias (i.e. unintentional inclusion of suspended sediment in the sample container) may influence these data. The chronic aquatic life standard for copper was exceeded at GMSW-3 during the first monitoring event.

Water quality improved slightly during the October monitoring event, likely in response to diminished flow entering the creek from the adjoining marshy tailings depositional area. Copper concentrations met applicable standards at all stations monitored in October and lead concentrations were roughly half of those measured in late July although chronic aquatic life standards were still exceeded. October monitoring data also indicates improvements in water quality occurs between GMSW-4 (i.e. below the tailings dam) and GMSW-4/1 (i.e. at the farthest downstream edge of the flat meadow area below the tailings dam). Concentrations of iron, lead, and manganese were all less at GMSW-4/1 compared to GMSW-4.

Despite having near neutral pH (6.09 and 7.06), seepage from the Oriole Adit (GMSW-5) had high concentrations of metals (**Table B-5**). Human health standards were exceeded for lead during all three monitoring events, cadmium during both July monitoring events and for copper and zinc during the first July event. Acute aquatic life standards for copper and zinc were exceeded during late July and October monitoring events. Secondary or chronic aquatic life standards were also exceeded for iron and manganese.

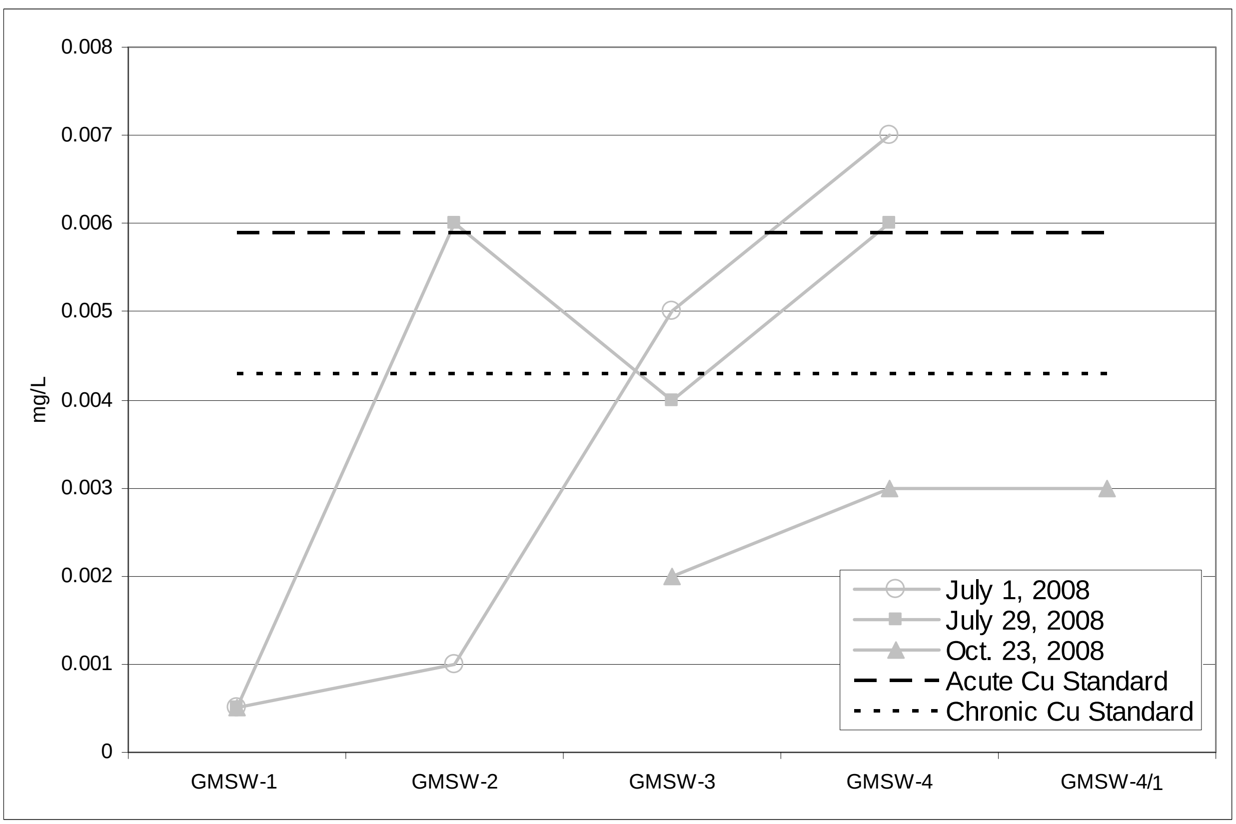

Figure 3-1. Total recoverable copper concentrations in Cataract creek surface water.

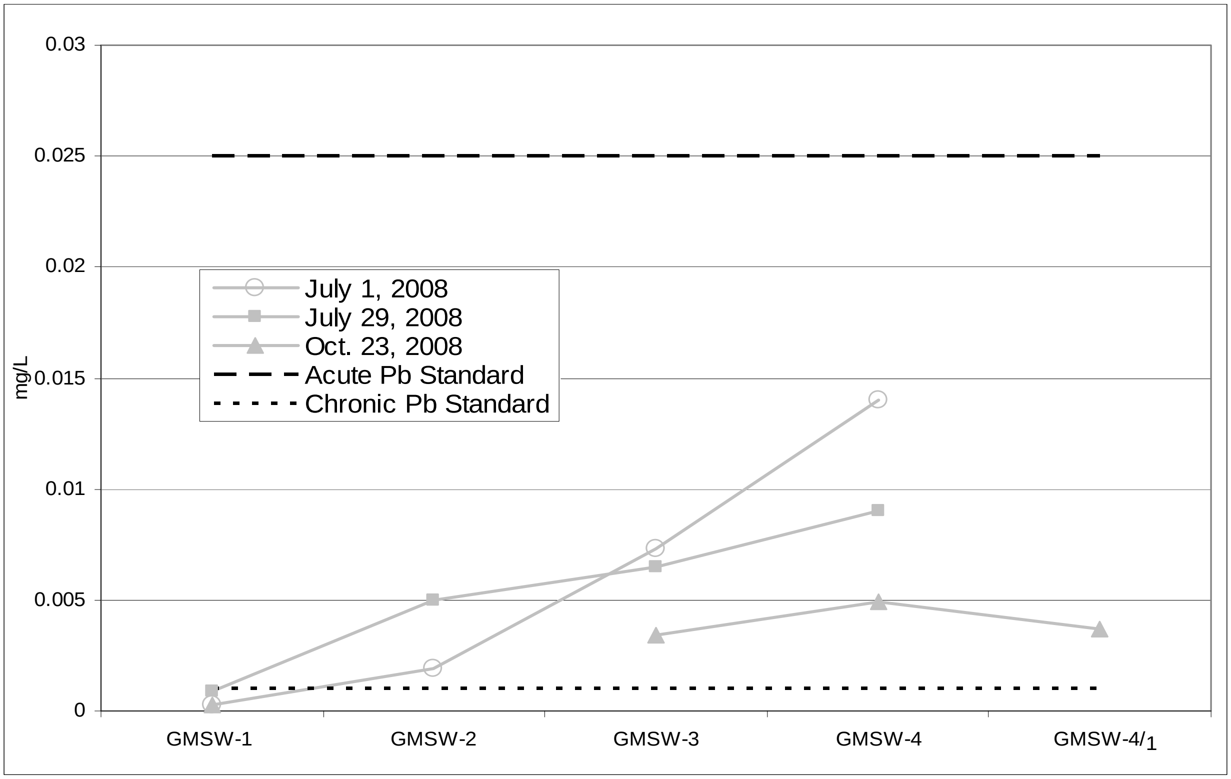

Figure 3-2. Total recoverable lead concentrations in Cataract creek surface water.

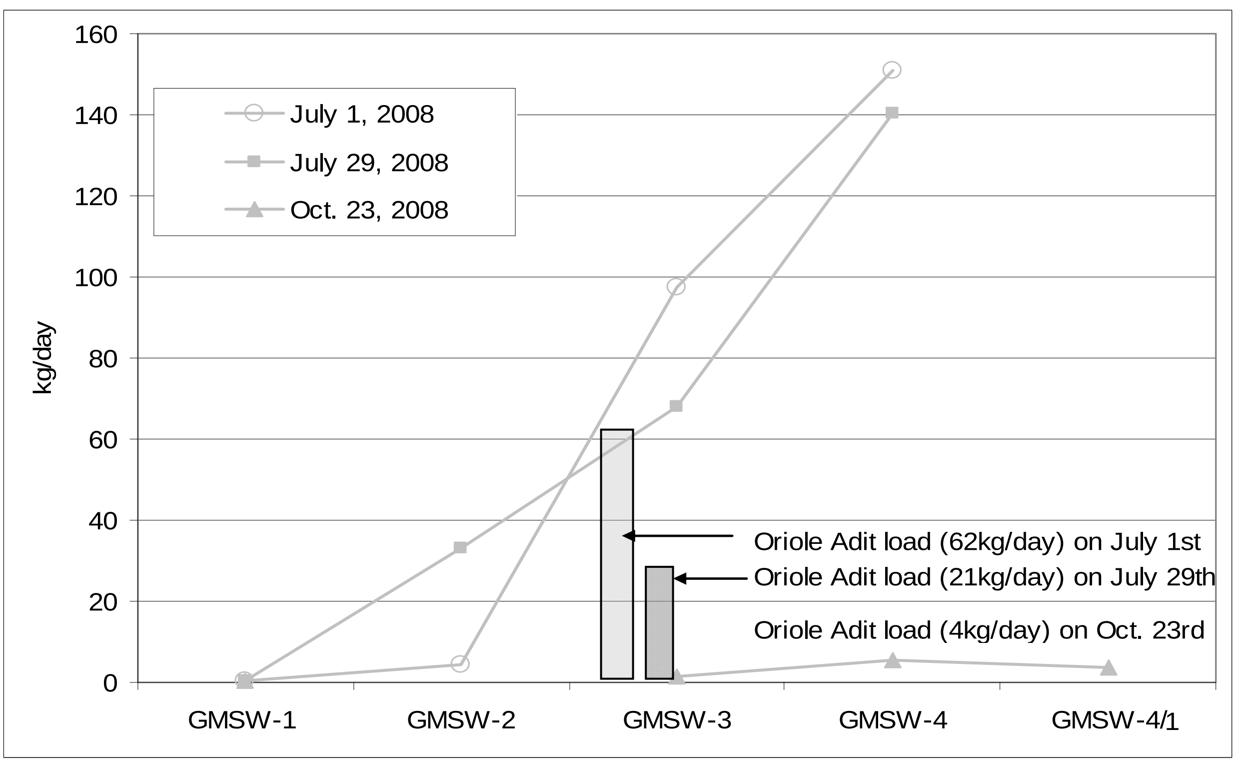

Figure 3-3. Copper loads in Cataract Creek and Garnet Mine surface water monitoring stations.

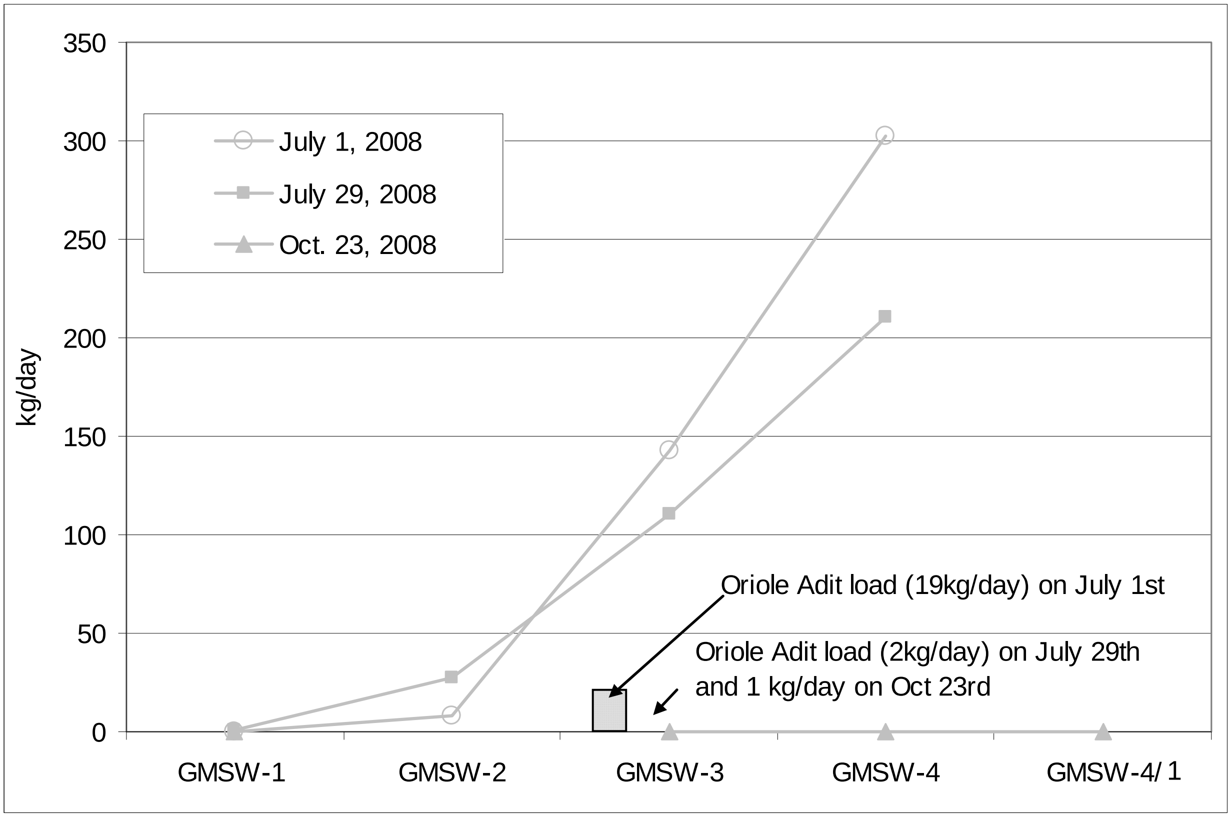

Figure 3-4. Lead loads in Cataract Creek and Garnet Mine surface water monitoring stations.

Figures 3-3 and **3-4** display copper and lead loads at each Cataract creek monitoring station and compare these loads to those in Oriole adit seepage. While these Figures depict adit discharge near Cataract creek station GMSW-2, it should be noted that the adit flow enters a wet marsh prior to contact with the creek. Therefore it is likely that adit flow does not enter the creek as a discreet point source, but rather as a diffuse source along the segment of creek between GMSW-2 and somewhere near GMSW-3 or -4. In any case, these data indicate that if copper and lead loads in adit seepage enter Cataract creek without attenuation (e.g. precipitation or sorption to immobile phases) along the flow-path, that only about 1/3 to 1/6 of the total copper load in Cataract Creek could be attributed to the adit seepage. Much less of the total lead load in Cataract Creek could be attributed to loading from the adit seepage.

3.5 GROUNDWATER

Data for the late August and October monitoring events are reported in **Table B-6** in **Appendix B**. Only monitoring well GMMW-3 was sampled in October as the two upgradient wells, GMMW-1 and GMMW-2, were dry at that time.

Groundwater from each of the three monitoring wells was of good quality with near neutral pH (5.68 to 6.74) and concentrations of most metals below their respective reporting limits. Cadmium was detected in monitoring well GMMW-2 and copper was detected in GMMW-2 and GMMW-3, all at concentrations near their reporting limit and well below DEQ-7 groundwater standards. Manganese was detected in all three wells and exceeded the secondary standard of

0.05 mg/L at GMMW-2 (0.68 mg/L) and GMMW-3 (1.240 mg/L). Manganese measured in the October sample from GMMW-3 was reduced compared to other samples and only marginally exceeded the standard with a concentration of 0.55 mg/L.

3.6 MINE ADIT AND TUNNELS

Two collapsed raises or open stopes (F-1 and F-2, **Site Map A-2**) were found at the site. F-1 is relatively shallow, approximately 10-ft deep with mild side slopes and accessible by foot. F-2 has vertical walls and is inaccessible. Two openings of a cross cut are visible in the bottom of the hole. F-2 measures 80-ft by 40-ft across the top with a depth ranging from 40ft to 60ft deep. An estimate volume to fill F-1 and F-2 is shown in **Table 3-5**. Waste rock from F-3, F3A, and F-5 is of sufficient volume to fill the collapsed raise/open stopes. An access road connects the waste rock piles with the collapsed raise/open stopes as shown on **Site Map A-2.**

TABLE 3-5
Collapsed Raise/Open Stope
Fill Volume Estimate
Garnet Mine Reclamation Area

Collapsed Raise/Open Stope	Fill Volume Estimate (CY)
F-1	2,000
F-2	4,000

The Oriole adit was driven late in the Garnet Mine's history along a heading trending N. 24^{o} W., and beneath structures previously mined from shallower underground workings located higher on the ridge (**Site Map A-2**). The intent of driving the adit seems to have been to intersect these previously mined structures at greater depth. As such the adit drives largely in barren quartz-monzonite to the northwest to intersect previously known and unknown northeast-trending mineralized structures. Mineralized shear zones intersected by the adit are shown on **Site Map A-5** as cross cutting drifts with stope raises, off of the main adit heading.

The portal consists of two timber sets with posts and caps and three-inch lagging on the back and two-inch lagging on the ribs. The portal has a wire mesh gate that is capable of being locked, but was unlocked at the time of mapping (**Photo 3-7**). Flow at the adit portal was measured on various dates and the flow rates are presented in **Table 3-6**. There is a 3 foot square sump of unknown depth, full of water on the sill in the east cross cut located at 125 feet, near its intersection of the main adit (**Site Map A-5**).

TABLE 3-6
2008 Flow rates from the Oriole Adit.
Garnet Mine Reclamation Area

Date	Flow (gpm)
July 12	2.7
July 29	8.5
October 23	3.6

The adit is nominally six (6) feet wide and seven (7) feet tall (**Photo 3-8**). The narrowest measured width of the mine was 5' 8" near the cave-in at 448 feet. The mine has been partially renovated as far as the cave-in at 448 feet. The sill has recently been mucked from the portal to 448 feet and there are utilities including a 4" Victaulic airline, a 1" poly water line, and an 18" vent bag (**Photo 3-9**) installed over this segment of the adit. Although all of these utilities are in disrepair, they appear to be useable.

The adit penetrates the Tobacco Root quartz monzonite for a total distance of 1,184 feet. The projection of the adit does in fact place it directly underneath shallower underground workings higher on the ridge (**Site Map A-2**). There are a number of short cross-cuts (drifts) developed in variously mineralized shear zones along the adit trend (**Photo 3-10**). The most productive of these developed shear zones have been stoped upward above the adit level in weak sulfide mineralization (**Photo 2-1**) to varying heights (20 to 30 feet visible) (**Photo 3-11**). Stopes developed out of the cross cuts were deemed too dangerous to enter and were not mapped. Mineralization is briefly described in Section 1.4 above.

Overall rock quality data (RQD) for the quartz monzonite host rock is good outside of the narrow mined shear zones (2-20 feet wide). Fracture density is quite variable in the quartz monzonite throughout the mine, with fracture densities as great as 4-5 or more per foot within the shear zones (**Photo 2-1)** to densities as low as one per 18-24 inches in barren portions of the quartz monzonite as shown left of the adit (**Photo 3-8**). The dominant fracture set is parallel to the mineralized shear zones and ranges from N. 47^{o} to 68^{o} E. dipping 52^{o} to 64^{o} to the south, other prominent sets occur at N. 40^{o} W. and N 20^{o} W. (parallel to the adit trend) (**Site Map A-5**).

Photo 3-8. Oriole Adit Portal.

Photo 3-9. Oriole Adit (1,070 feet).

Photo 3-10. Oriole Adit utilities.

Photo 3-11. Oriole Adit cross-cut drifts.

Significant fracture controlled water flows were observed at only three localities in the mine during the October mapping event, at 720 feet (<0.5 gpm), 890 feet (1.0 gpm), and from an exploration drill hole located at the northeast end of the cross cut at 1,095 feet (4.5 gpm) (**Site Map A-5**). All flow volumes were visually estimated, and the total estimated flow of 6.0 gpm exceeds actual flow measured (3.6 gpm) at the portal on the 23rd of October. The flow from the exploration drill hole was actively precipitating malachite ($CuCO_3 \bullet OH_2$) from the waters exiting the drill hole and there was evidence of ferricrete (ferrihydroxide minerals, $FeOH_3 \bullet H_2O$) being deposited on the sill at this location as well (**Photo 3-13**). Since the flow from the exploration drill hole was such a large portion of the total flow (75%) during the October mapping event, and because it is obviously contaminated with copper, it is recommended that as a minimum, a mechanical packer be set in this hole as soon as possible to stem this flow. A better long-term solution would be grouting of the nest of exploration drill holes (at least 5) at this location.

During the June 25th site visit, water was also observed flowing from the northeast cross cut at 125 feet at a rate of about 2 gpm. This flow is likely interconnected with the near-surface fracture system and located too close to the portal to effectively stem this flow from the mine.

Geologic mapping including observations of fracture density, rock competence, and points of water inflow suggest that the Oriole Tunnel would be a very likely candidate for mine closure using adit plugs to stem the flow of contaminated discharge from the portal. The plugging system is conceptually envisioned to consist of two water tight adit plugs one high strength water-tight plug set deeper in the mine (probably at either 600 or 800 feet from the portal) and a slightly lower strength water-tight plug set somewhere between 200 and 300 feet from the portal. In addition, a non-water tight portal closure plan should be constructed to block public access to the underground workings and as a substrate for surface reclamation.

Photo 3-12. Oriole Adit stope.

Photo 3-13. Oriole Adit exploration drill hole seep, malachite on rib, and ferricrete on sill.

3.7 POTENTIAL REPOSITORY /COVER AND SOIL BORROW SOURCES

During the field investigation for the tailings, potential borrow sources and siting areas for a repository were identified. The potential borrow and repository siting areas are identified on the **Site Map, A-6.** Following is a description of the three borrow areas and two repository sites identified during the site investigation.

Borrow Area 1

Borrow Area 1 is located at the old mill site (**F-9, -10, -11,** and **-12** on **Site Map A-2**). Samples of the borrow area were taken as bulk samples. The soil in the area was dry, very dark brown to black, fine to medium grained sand with gravel. Field XRF tests provided results that indicated the soil was non-impacted. Three bulk samples were taken and later tested for metals with the XRF. One of the samples provided impacted soil results while the other two provided non-impacted soil results. This area may have some pockets of impacted soil due to the proximity to the mining and milling operations. Material may be used from Borrow Area 1 if mixed or selectively excavated and monitored during construction.

Borrow Area 2

Borrow Area 2 is located along the haul road adjacent to the tailings deposit. The test pits conducted for the tailings indicated that the area adjacent to the road consists of non-impacted soil. The soil in the area generally consisted of moist, dark brown silt with clays and gravel or cobbles.

Borrow Area 3

Borrow Area 3 is located in a flat area at the base of a steep drainage on the north side of the valley just downstream of the breached dam. This area is located outside of the known areas where mining activity occurred and likely consists of non-impacted decomposed granite scree from the hillside above.

Repository Area 1

Repository Area 1 is located in a flat area adjacent to the Borrow Area 3 and may also contain similar suitable borrow material. This location is relatively flat, accessible and appears suitable for an approximate 50,000cy repository. Drainage to the area is generally contained to the hillside above the repository with minimal concentrated flows or drainages above the repository. An adjacent drainage could be confined and routed around the base of the repository to Cataract Creek.

Repository Area 2

Repository Area 2 is located at the top of the ridge south of the tailings deposit. The site is somewhat uneven with 5-10-ft of topographic relief across the pad area and is located about 50ft above the tailings deposit. However, the site does appear accessible by a small access road from the breached dam and has an area of sufficient size for an approximate 50,000cy repository.

3.8 CONCEPTUAL MODEL OF CONTAMINANT MIGRATION

Constituents of potential concern impacting Cataract creek are limited to copper and lead. These are also the two metals that were most often mobilized in elevated concentrations during metal mobility testing of tailings and waste rock samples. In addition to copper and lead, cadmium, iron, manganese, and zinc were measured in elevated concentrations in seepage from the Oriole adit.

Manganese concentrations exceeded the secondary groundwater standard in the two monitoring wells located down gradient of the Oriole adit. Metal mobility test results indicate that manganese is not released at elevated concentrations from tailings but that it can be released from waste rock.

The conceptual model of contaminant migration into Cataract creek includes tailings, Oriole adit waste rock, and Oriole adit seepage as potential sources of copper and lead loading. Waste rock located uphill of the Oriole adit portal are located a considerable distance from Cataract creek and are not thought to contribute to metal loads in the creek. As discussed in Section 3.3, at most 1/3 of the total copper load in Cataract creek could be attributed to adit seepage however this proportion could also be as low as 1/6 for copper and much less for lead. While unknown, it is possible that attenuation of metal concentrations in adit seepage occurs due to precipitation/adsorption reactions or dilution with non-impacted water along the approximately 450-foot flow path between the adit and the creek. For these reasons, and because copper and lead concentrations continue to increase below the breached tailings dam, the primary source of copper and lead loading to Cataract creek is most likely the tailings deposits located within the floodplain and lining the creek.

Acid-base account data are inconclusive with respect to the potential of tailings or waste rock to generate acid. However, consistently near neutral pH values measured in surface water (including adit seepage) and groundwater after 70+ years of atmospheric weathering of waste rock and tailings provide evidence that the likelihood of acid generation is minimal. If acidic leachate or runoff is being released from tailings or waste rock it is diluted to near neutral pH values by non-impacted upgradient water upon entering surface water and groundwater.

Manganese concentrations in groundwater increase with distance down the drainage and exceed the secondary standard at GMMW-2 located below the Oriole adit and also at GMMW-3 below the breached tailings dam. Elevated manganese concentrations in adit seepage, and in SPLP extracts from waste rock but not from tailings samples suggest that manganese is not contributed to groundwater by overlying tailings. Instead, it appears that manganese is released from mineralized rock within and nearby the mine workings. It is possible that this is a natural condition and the relatively low manganese concentration at GMMW-1 is due either to 1) a greater proportion of dilution from nearby Cataract Reservoir and/or 2) the possible location of GMMW-1 at the upper end of the hydrogeologic gradient from the mineralized fault zone. More detailed hydrogeologic study would be needed to support either of these hypotheses.

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4.0 SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 300.415(i) of the National Contingency Plan (NCP) and guidance issued by EPA require that removal actions attain Applicable or Relevant and Appropriate Requirements (ARARs) under federal or state environmental laws, to the extent practicable considering the urgency of the situation and scope of the removal (EPA, 1993). In addition to ARARs, DEQ may identify other federal or state advisories, criteria, or guidance to be considered for a particular release.

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental laws that specifically address a hazardous substance, pollutant, or contaminant found at a site. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental laws that are not applicable to a particular situation but apply to similar problems or situations, and therefore may be well suited requirements for a response action to address.

ARARs are divided into contaminant specific, location specific, and action specific requirements. Contaminant specific ARARs are listed according to specific media and govern the release to the environment of specific chemical compounds or materials possessing certain chemical or physical characteristics. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs generally relate to the geographic location or physical characteristics or setting of the site, rather than to the nature of the site contaminants.

Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Only the substantive portions of the requirements are ARARs. Administrative requirements are not ARARs and do not apply to actions conducted entirely on-site. Provisions of statutes or regulations that contain general goals expressing legislative intent, but are non-binding are not ARARs. In addition, in instances like the present case where the cleanup may proceed in stages, a particular phase of the remedy may not comply with all ARARs, so long as the overall remedy does meet ARARs.

Under Section 121 of CERCLA, 42 U.S.C. §9621, only those state standards that are more stringent than any federal standard are considered to be an ARAR provided that these standards are identified by the state in a timely manner. To be an ARAR, a state standard must be “promulgated,” which means the standards are of general applicability and are legally enforceable.

The State of Montana ARARs set forth in **Appendix C**, have been identified in cooperation with, and with assistance from, the State of Montana Department of Environmental Quality. Subsets of these ARARs have been screened in **Appendix C** as being either Applicable, or Relevant and Appropriate Requirements and identified for use within the Garnet Mine Reclamation Area.

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5.0 SUMMARY OF RISK ASSESSMENT

A streamlined risk evaluation process is used to assess threats to human health and the environment associated with exposure to mine wastes in the project area. Risks are evaluated using site-specific chemical concentration data, applicable exposure scenarios, and pertinent risk-based cleanup guidelines or ecological criteria. This streamlined risk evaluation examines risks under existing site conditions, assuming no cleanup activities are performed at the site.

5.1 BASELINE HUMAN HEALTH RISK ASSESSMENT

Risk-based guidelines were developed for abandoned mine sites under a recreational scenario (Tetra Tech, 1996). Although a risk evaluation method is not an EPA risk assessment process, it provides an additional level of detail to the process for sites characterized by mine waste and strictly as an evaluation for recreational use scenarios. This document and accompanying Excel worksheets (**Appendix D**) were used to complete the recreational human health risk evaluation for the proposed response activities presented herein.

The human health risk evaluation for the site involves four steps: (1) selection of contaminants of concern (COCs), (2) completion of an exposure assessment, (3) performance of a toxicity assessment, and (4) completion of risk characterization. These tasks are accomplished by evaluating available site data to select COCs, identifying applicable human populations and exposure routes, reviewing toxicity data, and characterizing overall risk by comparing COC concentrations in soil and surface water to previously derived, risk-based cleanup guidelines.

5.1.1 Contaminants of Concern

COCs are contaminants that pose significant potential risks to human health or the environment. Tetra Tech compared mine waste and surface water data with EPA industrial Regional Screening Levels and water quality standards, respectively, to evaluate which metals are contaminants of concern for the site. Based on the comparison with applicable screening levels and standards, lead and mercury are considered COCs for soils/mine wastes at the site; copper and lead are COCs for surface water in Cataract Creek; and copper, lead, iron, manganese, and zinc are COCs for the Oriole Adit discharge water. Mercury was detected in five of the 107 mine waste samples collected from the site. This is 0.47 percent which is much less than the 20 percent value used to select mercury as a COC, based on Tetra Tech (1996). However, because three of the five detected samples exceeded the EPA Regional Screening Level (RSL) of 28 mg/kg, mercury was retained as a COC for evaluation for site soil/mine waste under this risk assessment.

Some manganese results were also three times greater than background; however, there are no EPA RSLs for ingestion of manganese and the health data available for manganese are based on inhalation of manganese fumes. Inhalation of manganese fumes does not apply for this site as manganese is in surface water and soils. Therefore, manganese is not considered a human health COC for this site.

For surface water risk, COCs were identified if average site concentrations that exceeded the most restrictive water quality standard, the chronic aquatic standard for metallic contaminants. Average concentrations for copper and lead were the only concentrations that exceeded DEQ-7 standards. Therefore these two metals are the only human health COCs for surface water.

5.1.2 Exposure Assessment

An exposure assessment identifies potentially exposed human populations, exposure pathways, and typical exposure durations. Analytical results for soil and water samples are then used to estimate COC concentrations at exposure points and the potential intake of contaminants. Current human exposure to site-related contaminants in waste rock, tailings, and surface water is via seasonal recreational activities on and near the site. There is currently no residential use in the Garnet Mine project area.

The streamlined risk evaluation uses the exposure assessment developed for abandoned mine sites by the Montana's Mine Waste Clean-up Bureau (MWCB) that employs a recreational scenario (Tetra Tech, 1996). The scenario assumed four types of recreation populations: fishermen, hunters, gold panners/rockhounds, and ATV/motorcycle riders. Evaluated exposure pathways included soil and water ingestion, dermal contact, dust inhalation, and fish consumption. The assessment assumed a moderate to high level of recreational use. The types of activities, exposure pathways, and use levels considered in the recreational scenario are consistent with current recreational uses in the Garnet Mine area. Consequently, the recreational scenario exposure assessment is comparable and applicable to current exposure at the site.

5.1.3 Toxicity Assessment

A toxicity assessment provides information on the potential for COCs to cause carcinogenic and non-carcinogenic adverse health effects. Toxicity values for COCs are derived from dose-response evaluations performed by EPA. Sources of toxicity data include EPA's Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Health Effects Assessment Summary Tables (HEAST), and EPA criteria documents. Individual toxicity profiles for each COC are provided in the reference document (Tetra Tech, 1996). Lead and mercury are considered COCs for soils/mine waste and copper and lead are COCs for Cataract Creek surface water. These COCs are non-carcinogens. There are no known carcinogenic COCs for the site.

5.1.4 Risk Characterization

Findings of the recreational scenario exposure assessment were combined with toxicity data for the COCs to characterize health risks posed to each population through various exposure routes (Tetra Tech, 1996). The maximum calculated risks were for: (1) a rockhound/gold panner (soil contact and surface water ingestion); (2) a fisherman (soil contact, surface water ingestion, and fish consumption); and (3) an ATV/motorcycle rider (soil contact, dust inhalation).

To ensure the protection of the majority of recreational visitors, MWCB also developed a set of conservative, risk-based cleanup guidelines for abandoned mine sites based on the lowest cleanup concentration calculated for the various types of exposure and the possibility of multiple exposure routes. The guidelines thus account for visitors participating in several activities and metals exposure routes from both soil and surface water. The conservative, risk-based cleanup guidelines for soil and water are presented in **Tables 5-1** and **5-2**. The guidelines for each medium are based on a hazard quotient (HQ) of 1.0 for non-carcinogens, where a HQ is the ratio of a chemical exposure concentration to a reference dose that represents a threshold level for human health affects. An HQ greater than 1.0 may cause adverse health effects.

Tables 5-1 and **5-2** present a summary of the calculations made using the Recreational Risk Assessment Spreadsheet for Abandoned Mine Sites developed by Tetra Tech (1996). The calculations were made for the COCs of lead and mercury in mine waste and for copper and lead in Cataract Creek surface water. The data used included XRF results obtained by Pioneer (1994) and Tetra Tech during the remedial investigation.

Calculation of the HQs in **Table 5-1** for waste rock and tailings used the mean concentrations from the on-site feature presenting the highest overall concentrations. These two features include the Oriole adit waste pile and the dispersed tailings along Cataract Creek. For waste rock and tailings results that were not detected above the reporting limit (laboratory or XRF), one-half the reporting limit was used in the calculation for mean concentrations.

The calculations of the HQs in **Table 5-2** for surface water and fish ingestion used the highest concentrations measured in Cataract Creek surface water samples (see **Appendix B)**.

TABLE 5-1
Hazard Quotients for Recreational Visitors Exposed to Soil Ingestion and Dust Inhalation
Garnet Mine Reclamation Area

COC	Average Waste Rock Concentration (mg/kg) (1)	Average Tailings Concentration (mg/kg) (2)	Soil Ingestion/Dust Inhalation Guideline (mg/kg)(3)		Maximum Waste Rock/Tailings Hazard Quotient(4)
			RH/GP	ATV/MR	
Lead	367	1,047	2,200	3,920	0.2671
Mercury	58	5.9	440	738	0.1320
				Total Site HQ	**0.3991**

Notes: (1) Data from Tetra Tech (Appx B this report); mg/kg = milligrams/kilogram.
(2) Data from RTI (2004).
(3) Guidelines obtained from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 1.0 or an increased cancer risk of $5x10^{-5}$ and for 50 days of exposure for rock hound/gold panner scenario and 32 Days ATV/motorcycle rider scenario.
(4) Hazard quotient calculated for the greater of the waste rock or tailings concentration.

Appendix D provides a copy of the site recreational soil HQ calculation sheets. The total non-carcinogenic soil routes HQ for the site is 0.3991 for the RH/GP and ATV/MR exposure scenarios. Since the total non-carcinogenic risk is below an HQ of 1.0, mine wastes at the site do not pose an adverse health risk to recreationalists. The total non-carcinogenic HQ for waste rock was 0.2986 and the total non-carcinogenic HQ for tailings was 0.2751.The highest HQ for lead was 0.2671 for tailings, compared to an HQ of 0.1666 for waste rock. The HQ of 0.1320 for mercury in waste rock was higher than the HQ of 0.0080 for mercury in tailings. The HQs calculated for lead and mercury did not exceeded the human health HQ of 1.0 so these metals do not pose an adverse health risk to recreationalists.

TABLE 5-2
Hazard Quotients for Recreational Visitors Exposed to Surface Water and Fish Ingestion
Garnet Mine Reclamation Area

COC	Average Surface Water Concentration (µg/L) (1)	Surface Water Guideline (µg/L)(2)	RH/GP Water Ing. HQ	Fish Ingestion Guideline (µg/L)(2)	Fish Ingestion Hazard Quotient	Maximum Water Routes Hazard Quotient
Copper	7.0	18,900	0.0004	996	0.0070	0.0004
Lead	7.3	220	0.0332	165	0.0442	0.0332
		Total HQs	**0.0336**		**0.0515**	**0.0336**

Notes:
(1) Data from Tetra Tech (2009) - mean concentration at GMSW-4
(2) Guidelines obtained from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 1.0 or an increased cancer risk of $5x10^{-5}$ for 50 days exposure for rock hound/gold panner scenario and 42 days exposure for fisherman.

Appendix D provides a copy of the site recreational water and fish ingestion HQ calculation sheets. The total non-carcinogenic maximum water routes HQ is 0.0336. The total non-carcinogenic HQ for the RH/GP scenario for surface water is 0.0375 and the HQ for fish ingestion is 0.2213. Since the total and individual HQs are below an HQ of 1.0 surface water and fish ingestion at the site do pose an adverse health risk to recreationalists. Individually, copper and lead do not exceed 1.0 and; therefore, do not pose an adverse health risk to recreationalists at the site.

5.2 BASELINE ECOLOGICAL RISK ASSESSMENT

The ecological risk evaluation was completed to assess the potential risk that mine wastes at the site pose to plants and animals. The evaluation was performed by comparing concentrations of COCs in surface water, tailings, and soil at the site with ecological criteria and standards available in toxicity literature and risk-based EPA guidance. The key guidance documents used were EPA's *Ecological Risk Assessment Guidance for Superfund* (EPA, 1997), *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (EPA, 1989a), and *Ecological Assessment of Hazardous Waste Site* (EPA, 1989b). Because there are no site-specific ecological risk data available, this evaluation, although executed in a quantitative manner, is only intended to be qualitative.

Because this ecological risk evaluation focuses on COCs, no evaluation is done with respect to the physical habitat present at the site nor is it an assessment made toward how other factors may have affected aquatic or terrestrial populations. The presence or absence of appropriate habitat for animals, spawning redds for fish, or the health of wetlands and riparian areas, while it may affect the presence, diversity, or nature of aquatic and terrestrial populations, are not considered. A use attainability study is the mechanism that would assess the nature of the contamination in conjunction with other habitat factors.

The ecological risk evaluation, like the human health risk evaluation, estimates the effects of taking no action at the site and involves four steps: 1) identification of COCs; 2) exposure assessment; 3) ecological effects assessment; and 4) risk characterization. These steps are completed by evaluating currently available site data to select the COCs, identifying species and exposure routes of concern, assessing ecological toxicity of the COCs, and characterizing overall risk by integrating the results of the exposure and toxicity assessments.

5.2.1 Contaminants of Concern

Tetra Tech compared surface water results with Montana water quality standards (MDEQ, 2008) and EPA RSLs to evaluate what metals at the site are contaminants of concern. COCs identified in Cataract Creek surface water include copper and lead. COCs identified for Oriole Adit discharge water include cadmium, copper, iron, lead, manganese, and zinc. The COCs identified for mine wastes include lead and mercury.

5.2.2 Exposure Assessment

Three groups of ecological receptors have been identified as potentially being affected by site contamination. The first group includes aquatic life and wetlands in and near Cataract Creek located downgradient of the source areas. These receptors are of concern because the creek provides habitat for aquatic organisms, and wetlands typically support a diverse ecological community.

The second group of receptors is native terrestrial plants at the site whose ability to grow in mine waste appear to be limited by relatively high concentrations of certain metals in some areas of tailings deposition and waste rock piles.

The third group of receptors is terrestrial wildlife that may use this area as part of their summer range, including deer and moose. The possibility exists for use by wildlife which could pose a potential for contaminant accumulation and subsequent health effects in wildlife visiting the site. However, because the site is small relative to the range of much wildlife and all of the waste rock piles are unvegetated, it is unlikely that ungulates and other wildlife spend considerable time exposed to the potential hazards presented by the site.

Potentially adverse exposures of aquatic life and terrestrial plants can be quasi-quantitatively assessed by comparing site-specific surface water, sediment, and soil data to toxicity-based criteria and standards for the respective media. No standards are currently available to evaluate exposures in wetlands.

Exposure pathways for aquatic life include: 1) direct exposure of aquatic organisms to metals in surface water that exceed toxicity thresholds; 2) exposure of aquatic organisms (e.g. insect larvae, fish embryos) to sediment pore water that is toxic due to contaminants in the sediments; and 3) ingestion of aquatic species (e.g. insects) that have bio-accumulated contaminants to the extent that they are toxic to predators (e.g. fish). Native terrestrial plants could be exposed to phytotoxic effects related to elevated concentrations of metals in soil or mine wastes at the site.

5.2.3 Ecological Effects Assessment

The COCs are known to have toxic effects on plants and animals (Long and Morgan, 1991; Kabata-Pendias and Pendias, 1992). No ecological effects data have been collected from the site, and no site-specific toxicity tests have been performed. As a result, this risk evaluation assesses potential ecological effects using existing and proposed ecological criteria and guidelines. The criteria and guidelines used to evaluate ecological risks from surface water, sediment, and phytotoxic soil at the site are listed in **Table 5-3**.

TABLE 5-3
Ecological Assessment Guidelines
Garnet Mine Reclamation Area

Contaminant	Acute Aquatic Life Surface Water Standard (1) (µg/L)	Sediment Screening Levels(2) (mg/kg)	Phytotoxic Soil Screening Levels(3) (mg/kg)
Cadmium (4)	0.7	0.583 (5)	8
Copper(4)	6.0	390	60-125
Iron	---	35 (5)	--
Lead(4)	25.4	110	100-400
Mercury	1.7	0.174 (5)	0.3 (6)
Zinc(4)	59	270	70-400

Notes: (1) Acute aquatic life standards from DEQ-7, Montana Numeric Water Quality Standards (MDEQ, 2008).
(2) Effect Range - Median from Long and Morgan (1991).
(3) Concentration ranges from Kabata-Pendias and Pendias (1992).
(4) Calculated Acute Aquatic Life Standards based on site-specific hardness values: cadmium acute standard at total hardness of 32 mg/L; Copper acute standard at total hardness of 41 mg/L; lead acute standard at total hardness of 40 mg/L; zinc acute standard at total hardness of 43 mg/L
- - Criteria not currently available
(5) NOAA Screening Quick Reference Tables (SQuiRT), dated September 1999. 0.16 = most stringent of SQuiRT values.
(6) Oak Ridge National Laboratory (ORNL) plant soil screening benchmarks are from Efroymson et al. (1997).

The surface water criteria are the Acute Aquatic Life Standards promulgated by the State of Montana (MDEQ, 2008). Criteria for cadmium, copper, lead, and zinc are calculated as a function of water hardness while iron, lead, and mercury criteria are fixed numerical standards. The sediment guidelines consist of Effect Range - Median (ER-M) values generated from the pool of national fresh water and marine sediment toxicity information (Long and Morgan, 1991) and from NOAA Screening Quick Reference Tables (SquiRT, 1999). Guidelines for soil phytotoxicity are from Kabata-Pendias and Pendias (1992) and Oak Ridge National Laboratory (Efroymson, 1997). The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species.

5.2.4 Risk Characterization

This section integrates the ecological exposure and ecological effects assessments to provide a screening level estimate of potential adverse ecological impacts to aquatic life and native terrestrial plants. This was accomplished by calculating ecologic-impact quotients (EQs) which are analogous to the HQs calculated for human exposures to non-carcinogens. Site-specific surface water, mine waste, and soil data collected by Tetra Tech and used in this evaluation are provided in **Appendix B.** Data collected by Pioneer (1994) were also included in this analysis. The EQs were generated for each COC in surface water by dividing the maximum surface water concentrations in Cataract Creek (**Table B-5**) by the acute water quality criteria (**Appendix D** and **Table 5-3**). For mine wastes, EQs are generated by dividing the mean values from **Tables B-1, -2, -3,** and **-4**, as well as the Pioneer (1994) data, by the soil phytotoxicity values in **Table 5-3**. Adverse ecological impacts may occur if an EQ value is 1.0 or greater. Results of the EQ calculations are presented in **Table 5-4** and are discussed below.

TABLE 5-4
Ecological – Impact Quotients (EQ)
Garnet Mine Reclamation Area

Contaminant	Aquatic Life Surface Water	Aquatic Life Sediment	Plant Phytotoxic Mine Waste	Total EQ
Cadmium	0.1194	NC	NC	0.1194
Copper	1.1583	0.6128	2.7040	4.4751
Iron	NC	NC	NC	--
Lead	0.2871	8.3182	2.6175	11.2228
Mercury	0.029412	0.0	193.5	193.5
Zinc	0.1706	0.2941	0.8045	1.2692

Note: NC – Not calculated, toxicity data and/or concentration data unavailable

5.2.5 Surface Water - Aquatic Life

For this scenario, surface water quality data are compared to acute aquatic life criteria. This comparison is limited because water quality criteria are not species-specific but were developed to protect 95 percent of the species tested and may not protect the most sensitive species, which may or may not be present in Cataract Creek. In addition, toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The calculated EQ values indicate the potential for aquatic life impacts (EQs greater than 1.0) for copper in surface water (**Table 5-4**).

5.2.6 Sediment - Aquatic Life

Stream sediment concentration data are compared to sediment ER-M values determined by Long and Morgan (1991) and NOAA SQuiRT tables. This comparison is not definitive because sediment quality values are preliminary and are not species-specific. The guidelines represent sediment toxicity to the most sensitive species, which may or may not be present in Cataract Creek, and toxicity to the most sensitive species may not preclude a healthy aquatic community. EQ values in **Table 5-4** indicate potential for aquatic life impacts due to lead in stream sediment.

5.2.7 Mine Waste Phytotoxicity - Native Terrestrial Plants

Waste rock and tailings concentration data are compared to lower values in the range of phytotoxicity guidelines. This comparison is based on highest mean concentration measured in either waste rock or tailings for each individual COC. This comparison is limited because phytotoxicity ranges are not species-specific and thus represent toxicity to species that may or may not be present at the site. Additionally, other characteristics of waste materials, such as pH, texture, or nutrient deficiencies, may limit growth of terrestrial plants directly, or in combination with substrate toxicity. EQ values in **Table 5-4** indicate potential for impacts to terrestrial plant communities due to copper, lead, mercury, and zinc in soil at the site. Based on EQ values calculated, mine waste at the site appears to have the greatest potential to impact plants at the site.

6.0 RECLAMATION OBJECTIVES AND GOALS

The risk evaluation demonstrated that none of the constituents of concern in waste rock, tailings, or surface water present a concern for human health through ingestion or inhalation. Environmental risks associated with mine waste rock are limited to phytoxicity resulting in the non-vegetated status of the waste rock piles. Tailings also present a phytoxicity risk that appears to be ameliorated by wet conditions as evidenced by the presence of vegetation on much of the tailings surface except in areas where the tailings are mounded above the level of Cataract Creek. The risk evaluation determined that copper, lead, and mercury in mine wastes present a phytotoxicity hazard which may be compounded by other physico-chemical conditions such as salinity or soil texture that were not investigated.

Environmental risks associated with mine tailings also appear in surface water due to migration of contaminants into Cataract Creek. Copper and lead present risks to aquatic life in Cataract Creek due to concentrations of these metals that exceed DEQ-7 standards in surface water samples. Lead in creek sediment also presents an ecological risk to aquatic life.

Seepage from the Oriole adit is not considered to be a concern for human or ecological receptors because of limited contact, however this water does not comply with DEQ-7 standards for cadmium, copper, iron, lead, manganese, or zinc. This seepage likely contributes to overall metal loading to Cataract Creek albeit to a smaller degree relative to that from tailings deposits.

6.1 SCOPE OF THE RESPONSE ACTION

The scope of this removal action is directed at eliminating or reducing uncontrolled releases of metals from mining-related sources at the Garnet Mine site. By addressing risks from metals-enriched mine wastes, tailings, and impacted native soils in the Garnet Mine Reclamation Area, reduced contaminant concentrations are expected in surface water sources and in new stream sediment accumulations. This removal action will also address the discharge from the Oriole Adit from a source control approach.

The source control approach is considered to be a first step in attempting to reduce contaminant loading from point sources. Source control is preferred to water treatment as a first step toward mitigating impacts to water quality in Cataract Creek, as water treatment options typically involve construction and operation of passive and active treatment systems that are costly and difficult to operate in remote settings on a year around basis. Passive treatment systems are less expensive than active treatment systems, but increasing flow volumes and low water temperatures raise uncertainties relative to effectiveness and maintenance requirements. It is expected that the removal action alternative reviewed in this EEE/CA will be capable of reduction of contaminant loads and concentrations in surface water at the Garnet Mine Reclamation Area, thereby minimizing impacts to potential receptors such that active or passive water treatment will not be required.

6.2 REMOVAL ACTION OBJECTIVES (RAO)

The overall goals for the Garnet Mine Reclamation Area are to meet DEQ-7 standards and to mitigate environmental impacts that are a result of historic mining activity. Based on the risk evaluation, the primary goal of the Garnet Mine Reclamation Area response action is to protect the environment by reducing the migration of contaminants to the environment. The following RAOs were developed by Tetra Tech for the Garnet Mine site:

- Reduce or eliminate safety and health risks for humans, wildlife and livestock that might result in injury posed by accidental or intentional entry into hazardous mine openings (adits and collapsed stopes).

- Reduce or eliminate hazards to surface water presented by existing tailing sediment and other sources of metals contamination.

- Prevent the migration of soluble contaminants or contaminated solids from mine waste or tailings into surface waters.

- Reduce or eliminate concentrated run-off and discharges that generate sediment and/or otherwise transport metals contamination to adjacent surface water.

- Minimize or eliminate the outflow from the Oriole adit that currently transports soluble contaminants to the marsh area adjacent to or the surface waters of Cataract Creek.

- Prevent exposure to humans, wildlife and livestock from contact or ingestion and exposure to the food chain by metal contaminants from waste rock, tailings and the adit discharge.

- Prevent or limit future releases and mitigate the environmental effect of past releases of hazardous substances, pollutants or contaminants.

- Stabilize mine waste to prevent or reduce erosion and sedimentation.

- Minimize phytotoxicity resulting from high metal concentrations in waste rock and tailings.

- Achieve reclamation objectives for vegetation cover, production and diversity.

- Take into consideration the desirability of preserving the existing undeveloped character of the area when selecting response and restoration actions.

6.3 ARAR-BASED RESPONSE GOALS

Response action goals are primarily contaminate-based concentrations that are set by federal or state laws and regulations. For this project, the primary contaminant-specific ARARs apply to groundwater and surface water. There are no contaminant-specific ARARs for soil media. A preliminary list of ARARs is presented in **Appendix C.**

6.3.1 Surface Water

Aquatic life standards and human health standards are common ARARs for surface water. Generally, the more stringent of the two standards is identified as the ARAR-based reclamation goal. Because the aquatic life standards are more stringent than the human health standards for COCs and ecological risks predominate at the site, aquatic standards represent the surface water ARARs of this site. These goals are presented in **Table 6-1**. Those goals that are hardness dependant have been calculated based on a hardness of 40 mg/L. Hardness in Cataract Creek generally ranges from 25 to 43 mg/L. Enforcement of clean-up goals may be executed at specific water quality stations, in which case the clean-up standard for the hardness dependant contaminants should be calculated based on the hardness at those specific stations. COCs identified in Cataract Creek surface water include copper and lead. COCs identified for Oriole Adit discharge water include cadmium, copper, iron, lead, manganese, and zinc.

TABLE 6-1
ARAR-Based Reclamation Goals for Surface Water
Garnet Mine Reclamation Area

	Total Recoverable Metals (millograms/liter)[1]					
	Al	Cd	Cu	Fe	Pb	Zn
Goals	0.087	0.00014	0.0043	1.0	0.001	0.055

[1] Standards are in terms of total recoverable concentrations except for aluminum which is based on dissolved concentration for waters with pH between 6.5 and 9. Hardness based criteria are calculated for hardness = 40 milligrams/liter.

6.3.2 Groundwater

ARAR-based reclamation goals for groundwater are Montana Human Health Standards. Groundwater from each of the monitoring wells is of good quality with near neutral pH (5.68 to 6.74) and concentrations of most metals are below their respective reporting limits. Groundwater currently meets Montana standards except for manganese which exceeds the aesthetically based secondary standard in two of the three project monitoring wells.

6.4 SOIL CLEANUP GUIDELINES

There are no unacceptable human health risks associated with mine waste and tailings in the Garnet Mine Reclamation Area. Recreation cleanup goals for solid mine wastes have been adopted by MDEQ in the form of cleanup guidelines.

Ecological risks from waste rock dumps and tailings in the garnet Mine Reclamation Area are related to concentrations of copper, lead, and mercury that can result in phytotoxicity. Because high metal concentrations limit plant establishment on waste rock dumps and exposed tailings, other criteria could also apply to soil clean-up in the mine area (pH, texture, or nutrient deficiencies). In lieu of removing metals from the soil, amending the soil with nutrients and organic material or placement of imported growth media on the mine waste or tailings may be used to reduce phytotoxicity without reducing metals concentrations. Soil cleanup guidelines should be balanced with the goals for the project rather than used as absolute numerical criteria. Identified clean-up guidelines for COCs are listed in **Table 5-3**.

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7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES

The description of the source, nature, and extent of contamination (Section 3.0); release mechanisms, and exposure pathways (Section 3.8); and the RAOs developed for this phase of the project (Section 6.0) provide the basis for screening and development of response alternatives for waste rock dumps associated with the Garnet Mine, partially eroded tailings in Cataract Creek, and for the Oriole adit discharge. The process presented in this section follows EPA guidance for non-time-critical removal actions (EPA, 1993) by first identifying potential response technologies and process options, screening these options through consideration of practical applications of the technologies to the scope of the removal action, and then assembling the remaining technologies and options into response alternatives.

This section of the report presents the potential response technologies, screens the technologies, and then develops the remaining technologies into alternatives. The alternatives are then evaluated in detail against three primary criteria in Section 8.0.

7.1 RESPONSE TECHNOLOGY AND PROCESS OPTION SCREENING

The purpose of identifying and screening technology types and process options is to eliminate those technologies that are obviously unfeasible or ineffective, while retaining potentially effective options. General source control response actions and process options are specifically applied to the mitigation of contaminant release from the waste rock and tailings of the Garnet Mine area. In addition, response actions and process options for decreasing or stopping the flow of contaminated water from the Oriole Adit Tunnel No. 2 are also evaluated. A source control approach is considered a first step in attempting to reduce contaminant loading from point sources.

No evaluation was conducted for technologies that directly address contaminated groundwater or contaminated tailings sediments transported off-site below the breached tailings dam. Addressing environmental impacts associated with partially eroded on-site tailings, waste rock dumps, and the adit discharge presumes that some reduction in contaminant concentrations will occur in surface water, groundwater, and newly transported stream sediment as a result of removing or controlling these sources of contamination. Stemming the flow of metal-laden waters from the Oriole adit will also lead to a direct improvement in surface water quality in Cataract Creek. Improvements in surface water and groundwater quality are expected to result from implementation of the remedial actions; however, the absolute amount of improvement is difficult to quantify

General response actions potentially capable of achieving RAOs and goals at the selected waste rock dump and tailings areas are screened for applicability in **Table 7-1**. Response actions include no action, institutional controls, engineering controls, excavation and treatment, and in-situ treatment. The general response actions, technology types, and process options are discussed in text following the table. Screening comments are found in **Table 7-1**, and the logic and reasons for removing technologies or process options are discussed in the text. Technologies and options retained for alternative development are shaded in the **Table 7-1**.

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TABLE 7-1
Response Technology Screening Summary
Garnet Mine Reclamation Area Project

General Response Action	Response Technology	Process Option	Description	Screening Comment
NO ACTION	None	Not Applicable	No Action	Retained for comparison with other options.
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing and Gates	Install fences around contaminated areas to limit access. Gating of access roads or mine portals	Potentially effective in conjunction with other technologies; readily implementable; not considered as a stand-alone alternative.
		Land Use Controls	Legal restrictions to control current and future land use	Potentially effective in conjunction with other technologies; readily implementable; not considered as a stand-alone alternative
		Portal Closures	Close mine portals with backfill, plugging or installation of locking bared gates. Also necessary for public safety.	Potentially effective closure option, readily implementable; may be considered as a stand-alone alternative or used in conjunction with other technologies; readily implementable.
ENGINEERING CONTROLS	Underground Flow Control	Packer Installation to Stem Flow from Borehole	Placing hydraulic packer in borehole to prevent infiltration or seepage to workings.	Reduces seepage from boreholes discharging water into underground workings by use of a hydraulic packer (temporary-lasts for years); readily implementable; best when used in conjunction with backfill of workings for optimum structural support.
		Flowing Fracture/Borehole Grout Curtain	Drilling water-bearing fractured rock zones and filling fractures/flowing boreholes using high-pressure cement or bentonite grouting techniques. To stem or divert water flow and prevent infiltration or seepage to workings.	Effective in stopping or reducing flow through fractures and boreholes adjacent to workings. Diverts flow around workings. Implementable; best when used with backfill for optimum structural support.
		Close Adit with Hydraulic Plugs	Placing a high strength, concrete hydraulic plugs to block and seal workings to act as a water-tight seal or barrier to groundwater flow and discharge to surface waters	Effective as a barrier or seal to water flow along workings or isolating select areas of underground workings in order to prevent the discharge of groundwater; readily implementable, most effective when used with backfill (but not required).

Note: Shading indicates technology or process option retained for further consideration.

Table 7-1 (continued)
Response Technology Screening Summary
Garnet Mine Reclamation Area Project

General Response Action	Response Technology	Process Option	Description	Screening Comment
ENGINEERING CONTROLS (continued)	Containment	Soil Cover	Native or imported soil used to cover waste; soil vegetated; covers contaminant source to prevent direct contact and reduces infiltration.	Reduces surface infiltration by evapotranspiration; Not effective in early spring or late fall when plants are dormant, or under conditions of peak infiltration; Metal-bearing wastes may contaminate soil cover; readily implementable.
		Multi-layered Cap	Compacted clay-layer covered with growth media and vegetation in contaminated surface areas.	Effective in isolating wastes from infiltration; site characteristics key to success; readily implementable; not cost effective for small sites.
		Asphalt or Concrete Cover	Apply asphalt or concrete over areas of exposed ore/waste rock.	Limited feasibility due to cracking over the long term under thermal extremes; long-term maintenance required.
	Surface Controls	Consolidation	Consolidate mine waste into single area.	Consolidation of small outlying mine dumps into larger areas of disturbance or used as backfill for collapsed stopes; readily implementable.
		Grading and Compaction	Grading and compaction of waste dump surfaces to reduce slopes for managing runoff, erosion and surface infiltration.	Grading alone does not reduce contaminant mobility; potentially effective if combined with other process options; compaction helps to reduce infiltration to some degree: readily implementable.
		Revegetation	Seed mine waste with adaptive plants; controls or reduces water infiltration by evapotranspiration and controls erosion.	Effective in stabilizing wastes which do not contain phytotoxic contaminant concentrations; acid soils affect plant establishment; readily implementable.
		Erosion Protection Run-on / Run-off Control	Erosion resistant materials and/or commercial fabrics placed over mine wastes; storm-water diversion structures constructed to channel water away from mine wastes; lined and armored surface channels to maximize runoff from waste surfaces.	Potentially effective at reducing lateral contaminant migration; does not reduce contaminant mobility; potentially effective if combined with other process options; readily implementable.

Note: Shading indicates technology or process option retained for further consideration.

Table 7-1 (continued)
Response Technology Screening Summary
Garnet Mine Reclamation Area Project

General Response Action	Response Technology	Process Option	Description	Screening Comment
ENGINEERING CONTROLS (continued)	In Situ Capping	Soil Cover	Cover mine wastes with a soil cover.	Potentially effective. Increase water storage capacity and supports revegetation efforts. Readily implementable.
		Composite Cover	Cover mine waste with composite cover; compacted clay, growth media and revegetated surface cover system design.	Potentially effective. Increase water storage capacity, limits infiltration and supports revegetation efforts. Readily implementable.
	On-site Disposal	Waste Removal and Disposal in an On-Site Repository	Excavate mine waste and dispose of in an on-site repository with composite compacted clay/growth media cover.	Potentially effective. Increase water storage capacity, limits infiltration and supports revegetation efforts. Readily implementable.
	Off-site Disposal	RCRA Landfill	Excavate mine waste and dispose in RCRA-C permitted facility.	Potentially effective because contaminant sources would be removed; high costs associated with transportation, and disposal fees; implementable.
		Solid Waste Landfill	Excavate mine waste and dispose in non-hazardous solid waste facility.	Not feasible due to an administrative policy by the DEQ that does not allow disposal of mining wastes at a solid waste facility. Potentially effective for non-hazardous materials or residue from other treatment options; readily implementable; cost very high due to long haul distances and disposal fees.

Note: Shading indicates technology or process option retained for further consideration.

Table 7-1 (continued)
Response Technology Screening Summary
Garnet Mine Reclamation Area Project

General Response Action	Response Technology	Process Option	Description	Screening Comment
EXCAVATION & TREATMENT	Reprocessing	Milling and Smelting	Excavate and either treat on-site to ship a concentrate or haul mine waste to operating mill and/or smelter for extraction of precious and non-precious metals.	Potentially effective if economic concentrations of metals are present; probably not cost effective to ship all wastes but if a concentrate is produced and shipped, this would partially remove contaminants. Reduces toxicity of remaining wastes and improves quality and texture of waste rock remaining on-site for reclamation use. High capital costs.
	Fixation/ Stabilisation	Cement/ Pozzolan Additive	Solidify mine waste with non-leachable cement or pozzolan.	Extensive treatability testing and proper disposal of stabilized material would be required. Potentially implementable but cost prohibitive.
		Lime Fixation	Mine waste treated with lime amendments to reduce mobility of metals.	Lime treatment of mine waste is a demonstrated technology in Montana. Effectiveness limited by depth of mixing. Arsenic mobility may increase.
	Physical/ Chemical Treatment	Soil Washing	Separate hazardous constituents from solid media via dissolution & precipitation.	Not effective for waste rock; potential exists to increase mobility by providing partial dissolution of contaminants; implementable; high cost.
		Acid Extraction	Mobilize hazardous constituents via acid leaching & recover by precipitation.	Effectiveness is questionable. Sulfides would only be acid soluble under extreme temperature & pressure; high cost.
		Alkaline Leaching	Use alkaline solution to leach contaminants from solid media in heap, vat, or agitated vessel.	Effectiveness not well documented for arsenic; not readily implementable; high cost.
		Fluidized Bed Reactor/Rotary Kiln/Multi-Health Kiln	Concentrate hazardous constituents into small volume by volatilization of metals & formation of metallic oxide particulates.	Further treatment required to treat process by-product. Potentially implementable; cost prohibitive.
		Vitrification	Extremely high temperature used to melt and/or volatilize all components of the solid media. Molten material containing contaminants is rapidly cooled to form vitrified, non-leachable product.	Not readily implementable for solid wastes; extensive treatability testing required; emission controls necessary; cost prohibitive.

Note: Shading indicates technology or process option retained for further consideration.

Table 7-1 (continued)
Response Technology Screening Summary
Garnet Mine Reclamation Area Project

General Response Action	Response Technology	Process Option	Description	Screening Comment
IN-SITU TREATMENT	Physical/ Chemical Treatment	Lime Fixation	Mine waste treated in-situ with lime amendments to reduce mobility of metals.	Lime treatment of mine waste is a demonstrated technology in Montana. Effectiveness is limited by depth of mixing. Arsenic mobility may increase.
		Solidification	Solidifying agents used in conjunction with deep soil mixing techniques to promote a physical or chemical change in mobility of contaminants.	Extensive treatability testing required. Potentially implementable; cost prohibitive.
		Soil Flushing	Acid/base reagents or chelating agents injected into solid media to solubilize metals. Pregnant solution with contaminants is extracted using dewatering techniques.	Effectiveness unknown; innovative process currently in pilot stage. Likely cost prohibitive.
		Reactive Barrier Wall	Construction of a downgradient hollow core permeable wall, hollow portion of the wall is filled with reactive treatment agents (iron-fillings, organic material, etc) through which contaminated water flows	Migration treatment technique, effective at removing metals and raising pH depending on filler material used, requires on-going maintenance, potentially expensive but effective and implementable
	Thermal Treatment	Vitrification	Contaminated solid media subjected to extremely high temperature in-situ. Rapid cooling vitrifies material into non-leachable product.	Potentially implementable but would require extensive pilot testing; site layout not ideal at certain sites due to steep slopes and lack of adequate access; cost prohibitive.

Note: Shading indicates technology or process option retained for further consideration.

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7.1.1 No Action

No action involves no further response or monitoring. No action is generally used as a baseline against which other response options are compared so ***the no action alternative is retained*** for detailed analysis.

7.1.2 Institutional Controls

Institutional controls are used to restrict or control access to or use of a site. Land use and access restrictions are potentially applicable institutional controls. Land use restrictions would limit the possible future uses of the land at the site. Institutional controls involving access restrictions via mine portal closures, fencing and gates and/or land use controls do not achieve a clean-up goal. However, in addition to limiting access, these controls can provide for long-term public safety. ***Institutional controls are retained*** to complement clean up and safety actions and will be combined with other process options.

7.1.3 Engineering Controls

Engineering controls are used to reduce the mobility of contaminants by establishing barriers that limit contaminant exposure, reduce contaminant reactivity, and prevent or limit migration or flow of contaminated surface or groundwater. Engineering controls typically include containment, capping, run-on/run-off controls, revegetation and/or disposal. In underground applications, the engineering controls presented, are used to stem water flow or provide structural support or strength to materials or workings. These underground engineering controls may include grout curtains, cemented backfill, or cement plugs. Engineering controls generally do not reduce the volume or toxicity of hazardous materials. ***Engineering controls are retained.***

7.1.3.1 Underground Flow Control

Underground flow control technologies are used as contaminant source and migration control measures. They are used to eliminate, minimize, or divert contaminated water flows from either entering or leaving underground mine workings. By doing so, they minimize the impacts of discharging contaminated water to surface water flows. Often these flow controls reduce the toxicity or volume of the water because underground flows are usually diverted to other more restrictive pathways, typically the pathways used before the underground workings were excavated. Stemming adit discharge can place the mineralized rock in the mine workings beneath the water table producing more chemically reducing conditions that inhibit the formation of acid and the solubility of metals. Methods, such as grout curtains around flowing fracture systems or near-surface workings, or cemented backfills for structural support have reduced water flow along workings. Water flowing from bore holes can often be eliminated by placing a hydraulic packer in the hole (a multi-year solution) or by grouting the hole with cement (a permanent solution). Cement plugs that act as water-tight barriers or seals to groundwater flow are appropriate alternatives when underground flows need to be controlled, diverted or eliminated. Each of these alternatives uses common underground mining practices, with equipment that is readily available, and site- or application-specific designs. ***Underground flow techniques are retained*** as a possible response action.

7.1.3.2 Containment

Containment technologies are used as source control measures. These technologies are designed to eliminate direct contact and fugitive releases of contaminated materials. In addition, these controls are used to divert and minimize infiltration of surface water/precipitation that may contribute to erosion and/or leachate formation. The cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary from a simple soil cover to a multi-layered cap.

Capping is an appropriate alternative when contaminated materials are left on-site. A site-appropriate capping design is dependent on the relative toxicity and mobility of the contaminants and their demonstrated impacts to human health and/or environment. Capping also is an option when excavation and disposal or treatment actions are cost prohibitive. Capping of mine/mill wastes is a standard construction practice, uses standard equipment, and employs standard design methods. ***Containment process options are retained*** as a possible response action.

7.1.3.3 Surface Controls

Surface controls are used to minimize contaminant release and migration. Surface controls alone may not be appropriate in areas where direct human contact is a primary concern. In these instances, surface controls are commonly integrated with containment to provide further protection. Surface control process options are directed at controlling water and wind erosion, and transport of contaminated materials. These options include consolidation, grading, revegetation, and erosion controls.

Consolidation involves grouping wastes of similar type in a common area for more efficient management or treatment. Consolidation may be important in the Garnet Mine area where multiple smaller waste sources are present in the vicinity of a collapsed stope that requires backfilling.

Grading and compaction are used to reshape and compact waste areas in order to reduce slopes, manage the run-on/run-off and infiltration of surface water, and control erosion. Depending on site conditions, periodic maintenance may be necessary to control subsidence and erosion problems after closure. Grading of mine waste material in disturbed areas in the Garnet Mine area may be an important surface control in the Cataract Creek drainage.

Revegetation involves adding soil amendments to a limited depth in the waste in order to provide nutrients and organic materials to establish vegetation. Revegetation is essential to controlling water and wind erosion processes and minimizing infiltration of water through plant evapotranspiration processes. Revegetation generally involves the selection of appropriate plant species, preparation of the seeding area, seeding and/or planting, mulching and/or chemical stabilization, and fertilization. Depending on the success of revegetation, the site may require maintenance in order to establish a self-sustaining plant community.

In addition, neutralizing agents and/or additives to improve soil pH conditions and/or the water storage capacity of the waste may be appropriate. Neutralizing agents such as lime product, kiln dust, or limestone can be mixed to varying depths, or throughout the entire volume of waste materials.

Erosion protection includes using erosion resistant materials to control water and wind impact on the contaminated media surface. Processes include surface water diversions, application of mulch and natural or synthetic fabric mats, and rip rap. Erosion resistant materials are strategically placed based on knowledge of drainage area characteristics, slopes, vegetation types and densities, soil texture, and precipitation data.

Surface control process options are retained for inclusion into response alternatives. These process options would not be effective in controlling the release of hazardous substances alone. ***Addition of neutralizing agents is also retained***, as this process option is considered to be quite effective in controlling pH and the release of metals.

7.1.3.4 On-Site Disposal

On-site disposal can be used as a permanent source control measure. Contaminated media failing to meet toxicity characteristic leaching procedure (TCLP) criteria may require disposal in a RCRA hazardous waste-type repository and could be subject to RCRA landfill closure performance standards. Solid wastes from the beneficiation of ores and minerals, however, are not considered hazardous wastes under RCRA regulations (CFR 261.4 (b) (7). This reclamation technology involves placing the untreated or treated contaminated materials in an engineered repository located on-site. Design specifications could range from a simple, unlined, covered waste facility to a capped and lined facility with a leachate collection system. ***On-site disposal technologies are retained*** for further analysis.

7.1.3.5 Off-site Disposal

Off-site disposal involves excavating the contaminated materials and transporting them to an existing engineered repository permitted to accept such materials. Off-site disposal options include a centralized repository constructed for disposal of mine waste -- for example, a RCRA-permitted repository or a solid waste landfill. Materials classified as hazardous waste as defined in RCRA would require disposal in a RCRA-permitted facility. Less toxic materials could possibly be disposed of in a permitted solid waste or sanitary landfill. Off-site disposal from remote sites such as the Garnet Mine area are potentially effective and implementable, but are generally cost prohibitive due to very high transportation cost combined with high disposal costs. Also in this regard, there is a general reluctance of these facilities to accept mining wastes and there remains a liability to the state if such a facility were used. The ***off-site disposal alternative is not retained*** for further analysis.

7.1.4 Excavation and Treatment

Excavation and treatment processes involve the removal of the contaminated materials and subsequent treatment to reduce toxicity and/or volume. Treatment processes may involve a variety of techniques including chemical, physical or thermal methods. These methods are used to concentrate metal contaminants for additional treatment or recovery of economic constituents (reprocessing) or to reduce the toxicity of hazardous constituents.

7.1.4.1 Reprocessing

Reprocessing involves excavation and either on-site processing and shipping of a concentrate, or direct transportation of all contaminated materials to an existing mill or smelter for processing and recovery of valuable metals. Reprocessing of mine/mill wastes from outside sources is not commonly practiced due to the low concentrations of metals in source materials, operating permits limiting processing of off-site materials, and mixed waste issues. Applicability of this option is dependent on the concentration of economically viable elements and the ability and willingness of an off-site facility to process the material and dispose of waste. The mine wastes and tailing material at the Garnet Mine site do not contain economic concentrations of metals, and therefore, provide no economic incentive for reprocessing.

Reprocessing of the wastes greatly reduces contaminant content and acidity of the wastes and improves the texture and chemistry of remaining waste rock so that it might be used for reclamation purposes. The cost of transporting and reprocessing these materials is likely prohibitive. ***On-site reprocessing is not retained*** for further evaluation due to high transportation and processing costs, low metal values in the mine wastes, and liability issues associated with third-party off-site processing.

7.1.4.2 Fixation/Stabilization

Fixation/stabilization technologies employ treatment processes that chemically alter the contaminant to reduce its mobility or toxicity (fixation) or physically treat the contaminant by encapsulating it with an inert material (stabilization). The technology involves mixing materials with binding agents under specific conditions to form a stable matrix. For inorganic contaminants, fixation/stabilization employs a reagent or combination of reagents to promote a chemical and/or physical change in order to reduce the metal mobility. Fixation of acid-generating mine wastes with additives that raise the pH of the waste have been used widely in the last 25 years to reduce the mobility of metals. These additives include lime (calcium oxide), limestone (calcium carbonate), and calcium hydroxide. Other stabilization methods, such as phosphate addition (e.g., Envirobond) and the Dow manganese oxide passivation method have not been proven to be successful under field conditions and are not considered further. The in-situ process may use shallow surface, deep mixing, or complete incorporation techniques to achieve the best integration of the fixation agents with contaminated media. Fixation with a lime or other neutralizing amendment works because the contaminants of concern (acid rock drainage and some metals (Cu, Pb, Zn)) are mobilized in an oxidizing-acidic environment. The mobility of arsenic may be increased by neutralizing the wastes.

In sulfide bearing rocks, sulfide minerals are oxidized and release metals and sulfuric acid. The solubility and rate of release of these metals is greatly increased by the acidic conditions. The addition of lime as a neutralizing agent prevents the formation of acidic conditions and thereby restricts oxidation rate of the sulfide and the rate of metal release. Stabilization processes commonly use pozzolan/cement as additives. Obviously, the ability to ensure adequate mixing is a critical limitation for any amendment approach.

Fixation with lime is retained for further consideration. ***Stabilization using pozzolans is not retained*** due to higher costs associated with the process and volume of material requiring treatment.

7.1.4.3 Physical/Chemical Treatment

Physical treatment processes use physical characteristics to concentrate constituents into a smaller volume for disposal or further treatment. Chemical treatment processes treat contaminants by adding a chemical reagent that removes or fixates the contaminant. Chemical treatment processes reduce toxicity and/or mobility of contaminants in solid media. Chemical treatment processes generally work in conjunction with physical processes to flush the contaminated media with water, acids, bases, or surfactants. Potentially applicable physical/chemical treatment processes include flotation (an ore beneficiation process use to concentrate sulfides), soil washing, acid extraction, vitrification, alkaline leaching, and concentration by volitilization.

Soil washing is an innovative treatment process that consists of washing contaminated media with water in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires contaminants be readily soluble in water and sized sufficiently small so dissolution can be achieved in a practical retention time. Dissolved metal constituents contained in the wash solution are precipitated as insoluble compounds, and treated solids are dewatered before additional treatment or disposal. Precipitates form a sludge that requires additional treatment such as dewatering or stabilization prior to disposal. At the Garnet site, this process would remove sulfate salts, but would not remove relatively insoluble oxide and sulfide minerals.

Acid extraction applies an acidic solution to the contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of the metal constituents present in the contaminated media would be dissolved. A broader range of contaminants can be expected to be acid soluble at ambient conditions using acid extraction versus soil washing; however, sulfide compounds may only be acid soluble under extreme conditions of temperature and pressure. Dissolved contaminants are subsequently precipitated for additional treatment and/or disposal.

Alkaline leaching is similar to acid extraction in which a leaching solution, i.e., ammonia, lime, or caustic soda, is applied to contaminated media in a heap, vat, or agitated vessel. Alkaline leaching is potentially effective for leaching the majority of metals from contaminated media; however, removal of arsenic is not well documented. Alkaline addition to promote formation of oxide armor on sulfide minerals would be expected to reduce arsenic release from arsenic-bearing sulfide minerals. Arsenic-bearing salts, or sorbed arsenic species, would tend to leach under alkaline conditions and could therefore be removed. These process options are ***not retained*** for further consideration due to associated high costs and the relatively large volumes of material to be treated.

Thermal treatment technologies apply heat to contaminated media in order to volatilize and oxidize metals. This process renders the contaminated media amenable to additional processing or it produces an inert product via vitrification. Potentially applicable thermal processes, which volatilize metals and form metallic oxide particulates, include the fluidized bed reactor, rotary kiln, and multi-hearth kiln. High temperature vitrification is another thermal treatment technology that essentially melts or volatilizes the contaminated media. Volatile contaminants and gaseous oxides of sulfur are driven off as gases and the non-volatile component is vitrified when it cools. ***Thermal treatment is not retained*** for further consideration due to its high cost and the relatively large volume of material to be treated.

7.1.5 In-Situ Treatment

In-situ treatment involves treating contaminated materials in place with the objective of reducing mobility and toxicity of problem constituents. In-situ treatments provide less control than excavation and treatment options because it affords less efficient mixing of additives. In-situ treatment technologies include physical/chemical and thermal treatment processes. Physical/chemical treatment technologies include Lime Fixation, Solidification, Soil Flushing, and Reactive Barrier Wall, while thermal treatment technology relies on the process of vitrification.

7.1.5.1 Physical/Chemical Treatment

In-situ stabilization/solidification is similar to conventional stabilization in that a solidifying or chemical precipitating agent (or combination of agents) is used to create a chemical or physical change in the mobility and/or toxicity of the contaminants. Mine waste treatment with additives that raise the pH of the waste has been used widely and successfully in the last 25 years to reduce the mobility of metals. These additives include lime (calcium oxide), limestone (calcium carbonate), kiln dust, and calcium hydroxide. The in-situ process uses both surface and deep mixing techniques to achieve the best integration of the solidifying agents with the contaminated media. ***In-situ fixation with lime is retained*** for further consideration.

Soil flushing is an innovative process that injects an acidic or basic reagent or chelating agent into contaminated media to solubilize metals. Dissolved metals are extracted using established dewatering techniques, and the extracted solution is treated to recover metals or is disposed as aqueous waste. Low permeability materials may hinder proper circulation, solution reaction, and ultimate recovery. Currently, soil flushing has only been demonstrated at a pilot scale. ***Soil flushing is not retained*** for further consideration because of the difficulty in implementing this technology at dispersed sites that are situated in less than ideal environmental settings. The cost of this technology is expected to be high.

A ***Reactive Barrier Wall*** treatment technology is presented here as a migration and treatment control for infiltration or percolation waters that have been contaminated by passage through disturbed soils, mine waste, or tailings materials. Some surface and/or groundwater components would also be treated by this treatment technology, because it could not be separated from contaminated waters at the point of treatment. A permeable barrier wall is constructed down-gradient of the contamination source, to force surface and/or groundwater to flow through the wall. The wall is constructed as a thick and hollow wall that is filled with reactive material (iron filings, organic material, limestone or various other reactive agents) that reacts with contaminated water as it flows through the wall. The wall is isolated from atmospheric conditions and thermal stresses with a cover of low permeability material. Contaminants including sulfate, nitrate, and a variety of metals have been successfully removed in this way. Reactive barrier walls have been shown to be effective in the treatment of migrating contaminated groundwater on both pilot and full-scale field-testing projects, and a dozen or more are currently in use on various projects at the present time. There is established EPA guidance for their application. They are cost effective to construct and an excellent method to treat contaminated surface or groundwater along its migration pathway. Long-term maintenance is required as the agent filling the wall must be replaced periodically over time as it loses its reactive properties or becomes plugged with precipitated contaminants.

The University of Waterloo holds the patent for reactive barrier technology for treating acidic mine waters. Reactive barriers consists of four main components; an organic carbon source, a bacterial source, a neutralizing source, and a non-reactive porous medium. The organic source is usually made up of composted leaf mulch, composted municipal sewage waste, sawdust, composted manure and de-lignified cellulose, either placed alone or in some sort of a mixture. The bacterial source consists of sulfate reducing bacteria that are either cultured and grown in a laboratory or obtained from natural occurring sources. The neutralizing source is usually limestone and usually added at approximately 1-2% by volume or 2-7% by weight. Sand or gravel is mixed with the mixture to increase permeability of the mixture and is usually 5-10% by volume. The permeability of the mixture is an important parameter that must be considered while designing a reactive wall. The mixtures should be designed such that the permeability is the same as, or slightly greater than, that of the surrounding soil or aquifer material. The permeability usually ranges from 10^{-3} cm/sec to 10^{-4} cm/sec. Because of this low permeability, the systems are best designed for treating small volumes of surface or groundwater. Large volumes of contaminated surface water such as are seasonally present in the Garnet Mine tailings impoundment area, could not be handled by any reasonably sized barrier wall. In order for the sulfate reducing bacteria to be effective, a clay cap (typically 25 to 40 cm of clay) needs to be placed on the barrier to prevent diffusion of oxygen and allow reducing conditions to develop. Bacteria are tolerant to a temperature range of 23 to 150 °F. The optimum temperature range for sulfate reducing bacteria is 60 to 80 °F. Low temperatures, such as are present for rather long periods of time at the Garnet project site would reduce the efficiency and applicability of the bacteria media in the reactive barriers drastically.

A detailed pilot-scale study would be required in order to evaluate the effectiveness and applicability of this technology at the Garnet Site. A better understanding of the surface and groundwater flow and velocity through the marsh area within the Garnet tailings impoundment is also needed to accurately design this remedial system.

Reactive barrier walls are not retained as a migration pathway treatment process, as active source control options should be applied and monitored for success prior to implementing migration control treatment. Reactive barrier walls may best be considered as a second level treatment option if primary source controls do not provide the level of contaminant control desired.

7.1.5.2 Thermal Treatment

In-situ vitrification is an innovative process used to melt contaminated solid media in place to immobilize metals into a glass-like, inert, non-leachable solid matrix. Vitrification requires significant energy to generate sufficient current to force the solid media to act as a continuous electrical conductor. This technology is seriously inhibited by high-moisture content. Gases generated by the process must be collected and treated in an off-gas treatment system. In-situ vitrification has only been demonstrated at the pilot scale, and treatment costs are extremely high compared to other treatment technologies.

Thermal Treatment is not retained for further consideration because of the difficulty in implementing this technology at dispersed sites that are situated in less than ideal environmental settings. The cost of this technology is expected to be high.

7.2 RESPONSE ALTERNATIVE DEVELOPMENT

The most promising technologies and process options that were identified and retained through the screening process are summarized in **Table 7-2**. These options appear to be effective and readily implementable for a reasonable cost and will be used to develop response action alternatives for further consideration.

TABLE 7-2
Process Options Retained From Technology Screening
Garnet Mine Reclamation Area

General Response Action	Response Technology	Process Option
No Action	None	Not Applicable
Institutional Controls	Access Restrictions	Fencing/Signage
		Land Use Controls
		Portal Closures and/or Gates
Engineering Source Controls	Underground Flow Control	Install packer for Borehole Flow Control
		Flowing Fracture/Borehole Grout Curtain
		Water-Tight Cement Tunnel Plugs
	Surface Controls	Grading/Compaction
		Revegetation
		Erosion Protection, Run-on/Run-off Control
	In-Situ Capping and Containment	Soil Cover
		Cover mine waste with composite cover; compacted clay, growth media and revegetated surface cover system design.
	Waste Removal and Disposal in an On-Site Repository	Excavate mine waste and dispose of in an on-site repository with composite compacted clay/growth media cover.
Excavation and Treatment	Fixation/Stabilization	Lime Fixation - Mine waste treated with lime amendments to reduce mobility of metals.
In-Situ Treatment	Physical/Chemical Treatment	Lime Fixation - Mine waste treated in-situ with lime amendments to reduce mobility of metals.

EPA guidance for non-time-critical removal actions suggests that only the most qualified technologies that apply to the media or source of contamination be evaluated in detail in the EEE/CA. Using this guidance, remedial action alternatives for the Garnet Mine Reclamation area were developed by combining reclamation technologies and process options such that each alternative fulfilled in whole or part the RAOs and goals for the project. The No Action alternative is the one exception to this statement, but the No Action alternative is used in the detailed analysis as a baseline against which the other alternatives can be compared. Assembling the alternatives was accomplished by combining process options so that each alternative either offered a distinct benefit over another alternative, or provided a different approach to meeting the RAOs and goals. The alternatives also cover a reasonable range of costs, an important factor that will be considered in the detailed analysis.

There are three distinct types of problems being addressed in this particular remedial action, the first pertains to migration of contaminants from mining wastes and metal-rich soils, the second pertains to migration of contaminants from eroded in-valley mine tailings, and the third pertains to inflow into an underground mine that subsequently discharges into and contaminates surface water and groundwater via a discharge from the Oriole Adit. Two of the three (in-valley tailings and adit discharge) are important with respect to overall contaminant discharge to Cataract Creek based on the discussion presented in Section 3.4. That analysis indicates the tailings and, to a lesser extent, adit flows are the main sources of metals loading to Cataract Creek.

There is a considerable difference in the scale of the evaluated remedial actions between the volume of in-valley tailings and the relatively smaller volume of scatted mine waste rock piles associated with the Garnet Mine Reclamation area. The estimated volume of in-valley tailings consists of as much as 50,000 cubic yards of metal-rich mill-tailings. Whereas, waste rock dumps at various sites in the Garnet Mine area contain approximately 12,000 cubic yards of material at four (4) small, scattered sites. The repository is sized to hold the entire volume of water from both sources. Because of these two diverse settings and the difference in scale of areas to be reclaimed or materials to be moved, response alternatives discussed in this EEE/CA have been grouped for the following three types of source areas:

- Garnet Mine Features and Waste Source Areas -small outlying surface expressions of caved or collapsed underground mine workings and waste rock dumps in the Garnet Mine area,
- Garnet Mine Tailings Source Area -partially eroded in-valley tailing deposits associated with historic ore processing at the Garnet Mine, and
- Oriole Adit Discharge Source Area -inflow of contaminants in groundwater and outflow into surface water via adit discharge.

7.2.1 Garnet Mine Features and Waste Source Areas Response Alternative Development

Three (3) small, scattered, waste rock dumps (F-1, F-3A, and F-5) and four (4) collapsed adits/raises/stopes F-1, F-2, F-3 and F-5 (**Site Map A-2**) are associated with the Garnet Mine Reclamation Area. The Oriole adit (F-7A) and its waste rock dump (F-8) are treated as a separate source areas below in this section with somewhat different alternatives being analyzed.

Remedial action alternatives developed for the Garnet Mine and Waste Source Areas are presented in **Table 7-3** below. Not all the process options retained in **Table 7-2** apply to the Garnet Mine and Waste Source Area. The response technology using in-situ capping and containment was not carried forward in this analysis as the waste rock facilities in the Garnet Mine area are not proximal to surface water, and therefore, their impact to surface water is considered negligible. In addition, seasonal snowmelt infiltrates mine waste, but does not resurface as seeps or direct discharges to surface water. Lime fixation was also not carried forward as a process technology as the mine wastes at the Garnet site are only weekly acid generating and have not shown any evidence of or tendency toward acid generation in the 70 years they have been stored on the surface. The alternatives considered in the detailed analysis for the Garnet Mine and Waste Source Area are listed in **Table 7-3**.

TABLE 7-3
Remedial Action Alternatives for Waste Rock Piles F-1, F-3A and F-5
And Collapsed Adits/Raises/Stopes F-1, F-2, F-3 and F-5
Garnet Mine Reclamation Area Project

Alternative	Response Technology/Process Options
WR-1 No Action	Not Applicable
WR-2 Institutional Controls	Access Restrictions: Install fencing and signage around collapsed open stope (F-2)
WR-3 Surface Controls	Regrade waste rock in-situ, and revegetate waste rock dumps and collapsed adits sites at F-1, F-3, F-3A and F-5. Regrade for safe egress with possible blasting and fill as needed the collapsed open stope feature F-2. Install surface water diversions, run-on / run-off controls and revegetate all disturbances.
WR-4 Total Removal and Disposal in Collapsed Stope (F-2)	Remove waste rock stockpiles F-3A and F-5 and use as backfill for collapsed open stope F-2. Regrade raise/stope F-1 and collapsed adits F-3 and F-5. Install surface water diversion and revegetate all disturbances.

Remedial action alternatives for the Oriole Adit waste rock dump (F-8) are developed separately from the other waste rock dumps, because of its proximity to surface water from the adit discharge, the high flow from the areas bedrock seeps and springs during snowmelt, and the proximal location of the mine wastes to receiving waters in the wetlands/marsh along Cataract Creek. The Oriole adit discharge, in part, infiltrates through the mine waste in the Oriole Adit portal dump. The remedial action alternatives considered in the detailed analysis for the Garnet Mine and Waste Source Area are listed in **Table 7-4**. The variation in alternative presented relate principally to the final placement of some or all of the wastes either underground or in an on-site repository. The alternative of placing the Oriole adit portal waste rock dump into the collapsed stope (F-2) was eliminated because of the distance and steep topography between the two sites, and the fact that material in excess of that derived from waste rock dumps F-3A and F-5 are not needed to backfill the collapsed stope.

TABLE 7-4
Oriole Adit Waste Rock F-8 Source Area
Garnet Mine Reclamation Area Project

Alternative	Response Technology/Process Options
WR-F8-1 No Action	Not Applicable
WR-F8-2 Institutional Controls	Install signage around waste rock pile. Install up-gradient surface water drainage controls.
WR-F8-3 Partial Removal to Oriole Tunnel (F7) and Surface Controls	Partially backfill Oriole Adit Tunnel No 2 (F-7). Regrade remaining wastes to a stable slope. Install surface water diversion and revegetate all disturbances.
WR-F8-4 Total Removal and Disposal in Oriole Tunnel (F7)	Total removal of all waste rock and disposal in Oriole Adit Tunnel No 2 (F-7). Revegetate all disturbances.
WR-F8-5 Total Removal and Disposal in an On-Site Repository	Total removal of all wastes and disposal in an on-site repository. Revegetate all disturbances.

7.2.2 Garnet Mine Tailings Source Area Response Alternative Development

Table 7-5 lists response action alternatives that will be considered in the detailed analysis for the Garnet Mine Tailings Source Area. Also listed in **Table 7-5** are the process options and technologies that constitute each alternative. The in-valley tailing deposits along Cataract Creek below the Garnet Mine occur as: topographically elevated, long linear ridges of tailings adjacent to the active channel; as isolated mounds of tailings scattered throughout the tailing impoundment, but concentrated just above the breached tailing dam; and as relatively thin (1-2 foot thick) veneers of tailings dispersed across and near the surface of the wetland/marsh area. In addition, locally there has been leaching of metals from the tailings into the underlying native soil material. The alternatives evaluated look at institutional controls, stabilization in place, and partial removal or total removal of the tailing and contaminated soils to an on-site repository. Alternatives T-1 through T-3 are self explanatory (**Table 7-5**).

Alternative T-4 envisions regrading and in-place stabilization of the exposed tailings with six-inches of cover soil and re-vegetating. The Cataract Creek channel would be reclaimed and the banks and isolated mounds of tailings within the tailings basin would be armored to minimize lateral migration of the channel and erosion of the mounds of tailing materials. All disturbances would be covered with six-inches of soil/growth media and revegetated. Soil will be obtained from one of the borrow or repository sources identified on **Site Map A-6**.

Alternative T-5 includes partial removal of the tailings and disposal in an on-site repository. Select portions of the tailings including those located along banks of Cataract Creek and in the larger mounded deposits within the tailings basin will be removed to an on-site repository. A six-inch thick cover soil/growth media cover will be placed over the disturbed areas in the tailing basin and the disturbed areas will be revegetated. Cover soil would be obtained from one of the borrow or repository sources identified on **Site Map A-6**. The Cataract Creek channel will be reclaimed, armored and stabilized to minimize the risk of lateral migration of the creek and erosion of the remaining tailing materials within the basin. The removed tailings wastes would be placed in an on-site repository the location of which is shown on **Site Map A-6**. All disturbances would be covered with six-inches of soil/growth media and revegetated. Soil will be obtained from one of the borrow or repository sources identified on **Site Map A-6**.

Alternative T-6 calls for total removal of all in-situ tailings in the tailings basin in Cataract Creek including mounded tailings, those adjacent to the creek channel, tailings in wetland/marsh area and the underlying impacted natural soils and their disposal in an on-site repository. Eroded tailings transported downstream of the breached tailing dam will not be removed. All disturbances would be covered with six-inches of soil/growth media and revegetated. Soil will be obtained from one of the borrow or repository sources identified on **Site Map A-6**.

TABLE 7-5
Cataract Creek Tailings Deposit Source Area
Garnet Mine Reclamation Area Project

Alternative	Response Technology/Process Options
T-1 No Action	Not Applicable
T-2 Institutional Controls	Install fencing and signage around tailings deposits.
T-3 Institutional Controls with Land Use Controls	Install fencing and signage around tailings deposits, combined with land use restrictions.
T-4 In-place Stabilization / Surface Controls	Regrade exposed tailings and cover with six-inches of growth media/ soil. Armor existing creek banks and tailings piles adjacent to creek. Revegetate all disturbed areas.
T-5 Partial Removal and Disposal in an On-Site Repository	Remove select tailings generally located along banks of Cataract Creek and in larger mounded deposits within the tailings basin. Place removed tailings wastes in on-site repository. Reclaim Cataract Creek. Revegetate all disturbances.
T-6 Total Removal and Disposal in an On-Site Repository	Remove all tailings wastes which will include mounded tailings, those adjacent to the creek channel, tailings in wetland/marsh area and impacted natural soils. Place removed tailings wastes in an on-site repository. Revegetate all disturbances.

7.2.3 Oriole Adit Discharge Response Alternative Development

Table 7-6 lists response action alternatives that will be considered for groundwater inflow into the Oriole Adit and the resulting contaminated outflow of the Oriole Adit with discharge to the marshlands in the vicinity of the tailing impoundment area of Cataract Creek. Also listed in the table are the relevant process options and technologies that constitute each alternative.

Institutional controls in the form of a portal closure or gate for restricted access and public safety purposes are assumed to be an essential part of all of the alternatives developed below. The response action alternatives, with the exception of the no action alternative, and access restrictions are all engineering controls designed to control contaminated underground water flows into and out of the Oriole Adit.

TABLE 7-6
Response Action Alternatives for the Oriole Adit Source Area
Garnet Mine Reclamation Area Project

Alternative	Response Technology/Process Options
OA-1 No action	Not Applicable
OA-2 Install locking gate at the portal	Access Restriction: Install heavy-duty, locking, barred gate at the portal.
OA-3 Constructed portal closure	Access Restriction and Portal Closure: Construct backfilled portal closure with coarse rock plug and under-drain. Construct gravel filled infiltration basin at portal into which under-drain discharges. Backfill and regrade portal area with growth media and revegetate.
OA- 4 Packer installation to stem flow from borehole	Underground flow control: Placing hydraulic packer in borehole to prevent infiltration or seepage to workings.
OA-5 Grout borehole and adjacent seeping fractures with a grout curtain	Underground flow control: Drilling and pressure grouting of the rock surrounding the flowing borehole and adjacent seeping fractures to produce a grout curtain that eliminates or minimizes water flow into the underground workings.
OA-6 Plug the Oriole Adit at two critical locations	Underground flow control and Adit Closure: Construct two water-tight concrete hydraulic plugs within the Oriole Adit drift. Probable locations centered at approximately 550 feet and 200 feet in from the portal.

8.0 DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives presented in this section have been organized into alternatives for each of the four different source areas, mine features F-1 through F-5 uphill from the Oriole Adit, the Oriole Adit Waste Pile F-8, the Oriole Adit Portal, and Cataract Creek tailings deposits. For each of the source areas, a complete discussion of the applicable alternatives identified for each area and carried forward from Section 7.0 is presented. These alternatives are evaluated as stand-alone alternatives; that is, a detailed analysis of a combination of alternatives from the four site areas is not done.

8.1 EVALUATION CRITERIA

The following three criteria will be used to evaluate response action alternatives:

1. Effectiveness
2. Implementability
3. Cost

According to EPA guidance for non-time-critical removal actions (EPA, 1993), the effectiveness of an alternative should be evaluated by the following criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and, short-term effectiveness. The ability of each alternative to meet RAOs is considered when evaluating these criteria.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required to accomplish its implementation. Technical feasibility considerations include the applicability of the alternative to the waste source, availability of the required equipment and expertise to implement the alternative, and overall reliability of the alternative. Administrative feasibility evaluates logistical and scheduling constraints.

Evaluating the cost of alternatives involves developing conservative cost estimates based on the materials needed and the construction elements associated with implementing the alternative. These costs do not necessarily represent the cost that may actually be incurred during construction of the alternative because many design details are preliminary at this stage. However, a similar set of assumptions is used for all the alternatives so that the relative differences in cost between alternatives are fairly represented. Unit costs were developed by analyzing data available from nationally published cost estimating guides and engineering experience and to the largest extent cost data incorporate actual operating costs and unit costs that have been realized during similar reclamation projects. Unit costs for construction, often referred to as hard costs, are based on assessments of construction techniques, equipment, site accessibility, material handling distances and methods as well as site conditions. A construction contingency is added to the subtotal of all the construction costs. Soft costs which include construction administration, surveying and engineering costs are valued at a percentage of the total construction costs estimate.

In line with EPA guidance, the total estimated cost is expected to be within plus 50% and minus 30% of actual costs. Total costs for each alternative are presented in the cost discussion for each alternative with the supporting unit cost spreadsheets presented in **Appendix E**. Costs reported for individual alternatives do not include costs that are common to all alternatives. Specifically, the common cost to upgrade the access road leading to the site for safe access by construction vehicles is estimate separately. The cost breakdown for this presented in **Appendix E** and added to the total cost of the preferred alternative.

8.1.1 Source Areas Uphill of Oriole Adit

This section presents the detailed analysis of alternatives for the mine features located uphill from the Oriole Adit. These features consist of collapsed adits or raises (F-1 and F-5), a large collapsed open stope (F-2), and four relatively small waste rock dumps (F-1, F-3, F-3A, and F-5). As discussed in Section 3.2 and 7.2.1, these waste rock piles do not impact surface water resources and are not a source of acid generation. The human health and ecological risk assessment presented in Section 5 determined that these wastes do not pose a hazard to human health but do impact vegetation.

No Action - Alternative WR-1

The No Action Alternative involves leaving the mine sites F-1, F-2, F-3, F-3A, and F-5 in the existing condition of unvegetated mine dumps and an open, steep-walled, collapsed stope. No reclamation would be accomplished at these sites to control contaminant migration or reduce toxicity or volume. No provisions would be implemented to mitigate the physical hazard presented by the open stope.

Effectiveness

The No Action Alternative does not provide any controls on contaminant migration via direct contact or particulate emissions. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative. However, these sources are far removed from and do not impact surface water resources.

Only one of the RAOs would be met for the site -- preserving the existing undeveloped character of the District and surrounding area.

Federal or state contaminant-specific ARARs would either not be met or are not applicable to the No Action Alternative because wastes would not be moved or treated in any way. Any action specific ARARs that are applicable to the waste piles and the No Action Alternative also would not be met. Applicable location-specific ARARs, particularly those associated with cultural and historic resources, would be met. ARARs associated with surface water quality would not be met as these wastes do not impact surface water quality. Removal or reclamation of the wastes would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions.

Implementability

This alternative is both technically and administratively feasible. It is not a reliable means of controlling wastes that impact environmental or human receptors.

Cost

No capital costs would be incurred under this alternative. However, long term costs associated with no action are unknown since there is an on-going physical risk associated with the open stope that could result in damage to other resources and may require future action.

Institutional Controls - Alternative WR-2

Alternative WR-2 involves construction of a fence and signage around the collapsed open stope (F-2) and installation of drainage controls (ditches) uphill of all waste rock piles.

Effectiveness

Alternative WR-2 would be effective in preventing injury to humans and wildlife that could otherwise result from accidentally entry into the collapsed open stope (F-2). There is a chance of the fence and signage resulting in an attractive nuisance whereby some people may feel compelled to breach the fence in order to gain a closer view of the stope.

Institutional controls provide minor improvements to conditions at the site related to the waste rock piles. Toxicity, mobility, and volume of contaminants migrating from the waste rock piles would not be reduced. However, these sources are far removed from and do not impact surface water resources and do not pose a risk to human health. They would continue to present a phytotoxicity hazard. Construction of drainage controls uphill of waste piles would decrease the potential for erosion of the piles during spring snowmelt.

Removal Action Objectives

Only one of the RAOs would be met for the site -- Reduce or eliminate safety and health risks for humans, wildlife, and livestock that might result in injury posed by accidental or intentional entry into hazardous mine openings (adits and collapsed stopes). Exposure of the food chain to metal contaminants would continue to occur for those animals that graze on vegetation growing in treated areas and burrowing animals that penetrate cover soil to come into contact with the underlying waste.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. Constructing drainage controls above the waste dumps would reduce the potential for further erosion and migration of phytotoxic contaminants from source areas. Fencing the collapsed stope at F-2 would prevent injury to humans and animals resulting from accidental falls into the stope.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-2. Federal or state contaminant-specific ARARs would either not be met or are not applicable because wastes would not be moved or treated in any way. ARARs associated with surface water quality would not be met as these wastes do not impact surface water quality. Removal or reclamation of the wastes would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions. Contaminant-specific ARARs for ambient air are not expected to be met under this alternative because the wastes will not be revegetated.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash. Historic structures and debris located adjacent to the dumps will be protected during drainage control construction work.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Periodic monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term. Specifically, damage to the fence surrounding the collapsed open stope could render it ineffective for preventing entry by humans and wildlife. Drainage control ditches are likely to fill with sediment over time which would allow erosion of waste piles to resume in response to snowmelt and high precipitation events.

Reduction of Toxicity, Mobility, or Volume through Treatment

There will be some reduction in mobility but no reduction of toxicity or volume under this alternative. Reduction in the mobility of contaminants will be achieved through erosion prevention provided by drainage controls.

Short-term Effectiveness

This alternative should immediately prevent injury associated with the physical hazards presented by the collapsed open stope.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

Short-term air quality impacts to the immediate environment may occur during excavation of drainage control ditches. These impacts are expected to be minor but may require the use of BMPs to limit fugitive dust.

Implementability

Institutional controls are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-2 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$47,070**. About 39% of that cost is associated with upgrading the road between the Oriole adit and F-2 to make it passable for hauling materials to the open stope. About one third of the remaining cost is associated with fencing materials.

Surface Controls – Alternative WR-3

Alternative WR-3 involves regrading waste rock piles and collapsed adits at F-1, F-3, F-3A, and F-5. The collapsed stope at F-2 would be regraded for safe egress by blasting the vertical walls and backfilling as necessary. All disturbances would be revegetated after application of cover soil and drainage controls would be installed to redirect run-on to avoid contact with these areas. Best management practices include constructing diversion ditches along the waste rock dump margins, constructing sediment basins down slope of waste dumps, and regrading waste rock to provide positive drainage would be implemented.

Effectiveness

Surface controls provide considerable improvements over existing conditions at the site. While wastes would remain at their current locations, regrading, application of cover soil and establishment of vegetation on these wastes would reduce the potential for ingested/inhalation by recreationists using the area and would greatly limit the potential for erosion of the wastes by run-on. Surface controls would eliminate the potential for injury to humans and wildlife resulting from accidental falls into the collapsed open stope.

Removal Action Objectives

Surface controls would meet all of the RAOs that are applicable to mine features located uphill of the Oriole adit. Regrading the collapsed stope would eliminate the potential for injury to humans, livestock, and wildlife due to entry into the mine opening. Revegetating the waste dumps would greatly reduce the amount of water infiltration that dissolves metals and then migrates from the dumps. Soluble metals would not be eliminated because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation. Potential exposure of the food chain to metal contaminants would be reduced to a large extent in the treated waste dumps, except possibly for those animals that graze on vegetation growing in treated areas and burrowing animals that penetrate cover soil to come into contact with the underlying waste.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. Constructing drainage controls and revegetating the waste dumps would reduce the potential for further erosion and migration of phytotoxic contaminants from source areas. Reducing the angle of the collapsed stope walls at F-2 would prevent injury to humans and animals resulting from accidental falls into the stope.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-3. ARARs associated with surface water quality would not be met as these wastes do not impact surface water quality. Removal or reclamation of the wastes would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash. Historic structures and debris located adjacent to the dumps will be protected during waste pile recontouring and drainage control work.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 <u>et seq</u>).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as the wastes will be revegetated.

Revegetation requirements contained in the Surface Mining Control and Reclamation Act, Montana Strip and Underground Mine Reclamation Act and Metal Mining Act would be substantively met by grading, backfilling, and topsoiling removal areas, and using primarily native species and matching species to surrounding habitat types. BMPs for seeding, planting, mulching, soil amendments, control of noxious weeds, and erosion control will also be followed under this alternative.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Periodic monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term. Specifically, damage to the fence surrounding the collapsed open stope could render it ineffective for preventing entry by humans and wildlife. Drainage control ditches are likely to fill with sediment over time which would allow erosion of waste piles to resume in response to snowmelt and high precipitation events.

Surface controls are considered to be a permanent solution if vegetation is successfully established on regraded wastes. Some amount of monitoring and maintenance may be necessary to ensure successful revegetation.

The potential exists for upward migration of phytotoxic contaminants into overlying cover soil. If this occurs to an extent that results in plant mortality, erosion of the cover soil would eventually re-expose the wastes.

Reduction of Toxicity, Mobility, or Volume through Treatment

There will be no reduction in the toxicity or volume of mine wastes under this alternative. However, establishment of vegetation and drainage controls would greatly reduce the potential for accidental ingestion or inhalation of the mine wastes. It is unclear whether metals in the waste would be accumulated by vegetation or if such an occurrence would pose a risk to wildlife.

Short-term Effectiveness

This alternative would eliminate physical hazards presented by the collapsed open stope immediately upon completion of construction activities. Hazards associated with waste rock piles would not be reduced until vegetation is successfully established, which could take one or more growing seasons.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Surface controls are technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-3 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$101,273**. About 18% of that cost is associated with upgrading the road between the Oriole adit and F-1 to make it passable for hauling materials to the open stope and waste rock piles. About 28% is associated with blasting and regrading the open stope.

Total Removal and Disposal in Collapsed Stope - Alternative WR-4

Alternative WR-4 involves complete removal of waste rock from the dumps located at F-1, F-3, F-3A, and F-5 for use as backfill for the collapsed open stope (F-2). The collapsed raise/stope or adits located at F-1, F-2, F-3, and F-5 would be regraded and all disturbances would be revegetated after application of cover soil. Drainage diversions would be installed around all disturbances as well.

Effectiveness

Under this alternative, mine wastes would be removed and disposed of in the collapsed open stope. Because wastes would be consolidated to one location, this alternative is more effective in preventing ingestion or inhalation of mine wastes compared to other alternatives described above. The potential for erosion of mine waste is also greatly reduced. Because the volume of wastes to be removed is roughly equal to the volume of the collapsed open stope, physical hazards associated with the stope would be completely eliminated.

Removal Action Objectives

Total removal and disposal in collapsed stope F-2 (**Site Map A-2)** would meet all of the RAOs that are applicable to mine features. Backfilling the collapsed stope would eliminate the potential for injury to humans, livestock, and wildlife due to entry into the mine opening. Revegetating the waste dumps would greatly reduce the amount of water infiltration that dissolves metals and then migrates from the dumps. Soluble metals would not be eliminated because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation. Potential exposure of the food chain to metal contaminants would be reduced to a large extent in the treated waste dumps, except possibly for those animals that graze on vegetation growing in treated areas and burrowing animals that penetrate coversoil to come into contact with the underlying waste.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. Backfilling waste rock into and regrading the collapsed stope at F-2 would prevent injury to humans and animals resulting from accidental falls into the stope. This alternative would also minimize the potential for further erosion and migration of phytotoxic contaminants from source areas.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-4. ARARs associated with surface water quality would not be met as these wastes do not impact surface water quality. Removal or reclamation of the wastes would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash. Historic structures and debris located adjacent to the dumps will be protected during waste pile removal work.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as the wastes will be revegetated.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Removing the wastes from current locations should be a permanent solution requiring little maintenance and providing long-term effectiveness at the waste sites. Monitoring and maintenance of reclamation and revegetation will improve the chances for achieving long-term effectiveness.

The potential exists for upward migration of phytotoxic contaminants into overlying cover soil. If this occurs to an extent that results in plant mortality, erosion of the cover soil would eventually re-expose the wastes.

Reduction of Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity or volume would result from this alternative. However, consolidating wastes into one location within the open stope would result in a reduction of the aerial extent of the waste. This, along with successful revegetation of the relocated waste, would result in a considerable decrease in the potential for erosion, ingestion, or inhalation of the wastes. It is unclear whether metals in the waste would be accumulated by vegetation or if such an occurrence would pose a risk to wildlife.

Short-term Effectiveness

This alternative would eliminate physical hazards presented by the collapsed open stope immediately upon completion of construction activities. Hazards associated with waste rock piles would be reduced in the short-term as a result of reducing the acreage of wastes once the wastes are consolidated into the stope. The hazards of waste erosion, ingestion, and inhalation would persist to some degree until vegetation is successfully established, which could take one or more growing seasons.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Removal of wastes to the collapsed open stope is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-4 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$86,616**. About 21% of that cost is associated with upgrading the road between the Oriole adit and F-1 to make it passable for hauling materials to the open stope and accessing the waste rock piles. An additional 19% is hauling waste rock from its present locations to backfill the open stope.

8.1.2 Oriole Adit Waste Rock

This section presents the detailed analysis of alternatives for the approximately 8,000 cubic yards of waste rock located below the Oriole Adit (F-8). This material is generally of the same geochemical character compared to other waste rock at the Garnet site but is thought to contribute to surface water quality degradation due to its close proximity to Cataract Creek. Its location adjacent to the Cataract Reservoir access road also increases the potential for human contact with the waste material.

No Action - Alternative WR-F8-1

The No Action Alternative involves leaving the waste rock in the existing condition of an unvegetated steeply sloping waste pile adjacent to the Cataract Reservoir access road. No reclamation would be accomplished at this site to control contaminant migration or reduce toxicity or volume.

Effectiveness

The No Action Alternative does not provide any controls on contaminant migration via direct contact or particulate emissions. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative. The waste pile would continue to contribute some amount of metals loading to Cataract Creek, particularly during times when surface run-off from the pile occurs in large volumes. Only one of the RAOs would be met for the site -- preserving the existing undeveloped character of the District and surrounding area.

Federal or state contaminant-specific ARARs would either not be met or are not applicable to the No Action Alternative because wastes would not be moved or treated in any way. Any action specific ARARs that are applicable to the waste piles and the No Action Alternative also would not be met. Applicable location-specific ARARs, particularly those associated with cultural and historic resources would be met. ARARs associated with surface water quality would not be met because as water quality in Cataract Creek does not meet DEQ-7 standards. The Oriole adit waste rock pile likely contributes to some amount of metals loading to Cataract Creek but the proportion of this load is believed to be small relative to other sources in the area (i.e, tailings in the floodplain).

Implementability

This alternative is both technically and administratively feasible. It is not a reliable means of controlling wastes that impact environmental or human receptors.

Cost

No capital costs would be incurred under this alternative. However, long term costs associated with no action are unknown since there is an on-going physical risk of the waste material eroding onto the adjacent access road that may require future action.

Institutional Controls - Alternative WR-F8-2

Alternative WR-F8-2 involves installing signage around the waste pile and installation of drainage controls uphill of the pile.

Effectiveness

Alternative WR-F8-2 would not be effective in preventing physical injury to humans and wildlife that could result from falling down the steep slope of the waste pile to the road below. This alternative would not also reduce the risk of contaminants entering the food chain.

Institutional controls provide minor improvements to conditions at the site. Toxicity, mobility, and volume of contaminants migrating from the waste rock piles would not be reduced. Construction of drainage controls uphill of the waste pile would decrease the potential for erosion of the pile, particularly during spring snowmelt.

Removal Action Objectives

This alternative would reduce the migration of contaminants in the Oriole adit waste by controlling run-off from the pile. No other RAOs would be achieved.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. This alternative would reduce but not eliminate migration of contaminants from the waste rock pile to Cataract Creek. It also would not treat the phytotoxic nature of the waste.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-F8-2. Federal or state contaminant-specific ARARs would either not be met or are not applicable because wastes would not be moved or treated in any way. ARARs associated with surface water quality would not be met because the majority of metals loading to Cataract Creek is from other sources that would not be addressed under this alternative without other clean up actions. Contaminant-specific ARARs for ambient air are not expected to be met under this alternative because the wastes will not be revegetated.

Location-specific ARARs, particularly those associated with cultural and historic resources, are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 <u>et seq</u>).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Periodic monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term. Specifically, damage to the fence surrounding the waste pile could render it ineffective for preventing entry by humans and wildlife. Drainage control ditches are likely to fill with sediment over time which would allow erosion of waste to resume in response to snowmelt and high precipitation events.

Reduction of Toxicity, Mobility, or Volume through Treatment

There will be some reduction in mobility but no reduction of toxicity or volume under this alternative. Reduction in the mobility of contaminants will be achieved through erosion prevention provided by drainage controls.

Short-term Effectiveness

This alternative should immediately prevent injury associated with the physical hazards presented by waste pile.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

Short-term air quality impacts to the immediate environment may occur during excavation of drainage control ditches. These impacts are expected to be minor but may require the use of BMPs to limit fugitive dust.

Implementability

Institutional controls are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-F8-2 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$741**, most of which would be for excavating drainage controls above the waste rock pile.

Partial Removal to Oriole Tunnel and Surface Controls – Alternative WR-F8-3

Alternative WR-F8-3 involves backfilling a portion of the waste into the Oriole adit tunnel (F-7) and regrading the remaining waste into a stable slope that would be revegetated after application of cover soil. Drainage diversions would be constructed along the perimeter of the reclaimed area.

Effectiveness

Surface controls provide considerable improvements over existing conditions at the site. While a portion of the waste would remain at the current location, regrading and establishment of vegetation on the waste would reduce the potential for ingested/inhalation by recreationists using the area and would greatly limit the potential for erosion of the wastes by run-on. Regrading the pile to eliminate the existing steep slope would eliminate the potential for physical injury to humans and wildlife resulting from accidental falls. Diversion of upgradient water would reduce metals loading to Cataract Creek.

Removal Action Objectives

This alternative would reduce the migration of contaminants in the Oriole adit waste by controlling run-off from the pile and reducing the volume of precipitation infiltrating the waste. Backfilling a portion of the waste into the adit would eliminate the potential for accidental injury due to access to the adit. No other RAOs would be achieved. Potential exposure of the food chain to metal contaminants would be reduced to a large extent in the treated waste dumps, except possibly for those animals that graze on vegetation growing in treated areas and burrowing animals that penetrate cover soil to come into contact with the underlying waste.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. Backfilling some of the waste rock into the adit, construction of drainage controls and establishment of vegetation would limit exposure to precipitation and overland flow thus reducing metal loading to Cataract Creek. This alternative would also minimize the potential for further erosion and migration of phytotoxic contaminants from the waste pile. Regrading wastes remaining on the surface would reduce the potential for injury due to accidental falls down the current steep face of the waste pile.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-F8-3. ARARs associated with surface water quality would not be met as removal or reclamation of the waste would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 <u>et seq</u>).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as a portion of the waste will be backfilled into the mine tunnel while wastes remaining on the surface will be revegetated.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Surface controls are considered to be a permanent solution once vegetation is successfully established on regraded waste. Some amount of monitoring and maintenance may be necessary to ensure successful revegetation.

The potential exists for upward migration of phytotoxic contaminants into overlying cover soil. If this occurs to an extent that results in plant mortality, erosion of the cover soil would eventually re-expose wastes remaining on the surface outside of the Oriole adit.

Reduction of Toxicity, Mobility, or Volume through Treatment

There will be no reduction in the toxicity or volume of mine wastes under this alternative. However, establishment of vegetation and drainage controls would greatly reduce the potential for accidental ingestion or inhalation of the mine wastes and would reduce metal loading to Cataract Creek. It is unclear whether metals in the waste would be accumulated by vegetation or if such an occurrence would pose a risk to wildlife.

Short-term Effectiveness

This alternative would eliminate physical hazards presented by the steeply sloping waste immediately upon completion of construction activities. Other hazards associated with the waste rock pile would not be fully realized until vegetation is successfully established, which could take one or more growing seasons.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Surface controls are technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-F8-3 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$68,580**. About 48% of that cost is associated with excavating the waste rock pile and backfilling into the mine tunnel.

Total Removal and Disposal in Oriole Tunnel - Alternative WR-F8-4

Alternative WR-F8-4 involves complete removal of waste rock from the dump located at F-8 for use as backfill for the Oriole adit tunnel (F-7). The disturbance remaining after removal of the waste pile would be revegetated.

Effectiveness

This alternative would eliminate the potential for human or wildlife contact with the waste rock. The potential for ingestion or inhalation would be eliminated as would the physical and erosive hazards associated with the existing steep waste slope.

Removal Action Objectives

Removal of the Oriole waste rock pile to the Oriole adit tunnel would meet RAOs that are applicable to this source area. Backfilling the tunnel would eliminate the potential for injury to humans, livestock, and wildlife due to entry into the mine opening. Underground placement of the waste rock would greatly reduce the amount of water infiltration that dissolves metals and then migrates from the dump. Potential exposure of the food chain to metal contaminants would be eliminated except possibly for small animals that borrow into the backfilled tunnel.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. Backfilling the waste rock into the adit would eliminate exposure to precipitation and overland flow thus reducing metal loading to Cataract Creek. This alternative would also minimize the potential for further erosion and migration of phytotoxic contaminants from the waste pile and would eliminate the potential for injury due to accidental falls down the current steep face of the waste pile.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-F8-4. ARARs associated with surface water quality would not be met as removal or reclamation of the waste would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions.

Location-specific ARARs, particularly those associated with cultural and historic resources, are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as all of the waste would be backfilled into the mine tunnel.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Removing the waste from the current location should be a permanent solution requiring little maintenance and providing long-term effectiveness at the site. Monitoring and maintenance of reclamation and revegetation will improve the chances for achieving long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity or volume would result from this alternative. However, placement in an underground location would eliminate the potential for erosion, ingestion, or inhalation of the waste. While the ability of soluble metals to be released from the waste would not be reduced, a considerable decrease in the volume of meteoric water contacting the waste would result in reduced metal loading to Cataract Creek.

Short-term Effectiveness

This alternative would eliminate physical hazards presented by the waste pile immediately upon completion of construction activities. Hazards related to erosion, ingestion, and inhalation would also be eliminated.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Placement of waste into the Oriole adit tunnel is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-F8-4 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$115,682**. About 57% of that cost is associated with excavating the waste rock pile and backfilling into the mine tunnel.

Total Removal and Disposal in an On-Site Repository - Alternative WR-F8-5

Alternative WR-F8-5 involves complete removal of waste rock from the dump located at F-8 and placement in an on-site repository. The disturbance remaining after removal of the waste pile would be revegetated.

Effectiveness

This alternative would eliminate the potential for human or wildlife contact with the waste rock. The potential for ingestion or inhalation would be eliminated as would the physical and erosive hazards associated with the existing steep waste slope.

Removal Action Objectives

Removal of mine waste to an on-site repository would meet RAOs to the maximum extent if associated actions to block access to the tunnel are also conducted. Such actions would include using a portion of the waste to fill the adit portal or installing a gate or other engineering control at the portal.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in waste rock at the Garnet Mine site. Placing the waste rock into an engineered repository would eliminate exposure to precipitation, overland flow, and groundwater thus reducing metal loading to Cataract Creek. This alternative would also eliminate the potential for further erosion and migration of phytotoxic contaminants from the waste pile and would eliminate the potential for injury due to accidental falls down the current steep face of the waste pile.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative WR-F8-5. ARARs associated with surface water quality would not be met as removal or reclamation of the waste would not improve water quality in Cataract Creek to meet DEQ-7 standards without other clean up actions.

Location-specific ARARs, particularly those associated with cultural and historic resources, are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as all of the waste would be placed into a repository.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Removing the waste from the current location should be a permanent solution requiring little maintenance and providing long-term effectiveness at the site. Monitoring and maintenance of reclamation and revegetation will improve the chances for achieving long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity or volume would result from this alternative. However, placement in an on-site repository would eliminate the potential for erosion, ingestion, or inhalation of the waste. While the ability of soluble metals to be released from the waste would not be reduced, a considerable decrease in the volume of meteoric water contacting the waste would result in reduced metal loading to Cataract Creek.

Short-term Effectiveness

This alternative would eliminate physical hazards presented by the waste pile immediately upon completion of construction activities. Hazards related to erosion, ingestion, and inhalation would also be eliminated.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Placement of waste into an on-site repository is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative WR-F8-5 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$82,881**. About 40% of that cost is associated with excavating the waste rock pile and hauling to the repository. Remaining costs include upgrades to the access/haul road and subsequent reclamation/revegetation work.

8.1.3 Cataract Creek Tailings Deposits

This section presents the detailed analysis of alternatives for the approximately 30,000 to 50,000 cubic yards of mine tailings located along Cataract Creek and in the adjacent marsh. Leaching of metals (particularly copper and lead) from this material is responsible for the majority of water quality degradation in Cataract Creek.

No Action - Alternative T-1

The No Action Alternative involves leaving the tailings in the current location along Cataract Creek and the adjacent marsh. Vegetation is currently established over much of the tailings deposits however isolated mounds of nonvegetated tailings exist at and near the breached tailings dam. No reclamation would be accomplished at this site to control contaminant migration or reduce toxicity or volume.

Effectiveness

The No Action Alternative does not provide any controls on contaminant migration via direct contact or particulate emissions. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative. The tailings would continue to contribute to metals loading to Cataract Creek. Only one of the RAOs would be met for the site -- preserving the existing undeveloped character of the District and surrounding area.

Federal or state contaminant-specific ARARs would not be met by No Action Alternative because wastes would not be moved or treated in any way. Water quality in Cataract Creek would continue to exceed DEQ-7 standards.

Implementability

This alternative is both technically and administratively feasible. It is not a reliable means of controlling wastes that impact environmental or human receptors.

Cost

No capital costs would be incurred under this alternative. However, long term costs associated with no action are unknown since there are on-going human and ecological risks due to the presence of the tailings that may require future action.

Institutional Controls - Alternative T-2

Alternative T-2 involves construction of a fence and signage around the tailings.

Effectiveness

Alternative T-2 would reduce the risk of accidental ingestion of the tailings material. There is a chance of the fence and signage resulting in an attractive nuisance whereby some people may feel compelled to breach the fence in order to gain access to the tailings or Cataract Creek.

Institutional controls provide minor improvements to conditions at the site. Toxicity, mobility, and volume of contaminants migrating from the tailings would not be reduced and water quality in Cataract Creek would not be improved.

Removal Action Objectives

Institutional Controls would limit exposure to the food chain of metal contaminants from tailings except for animals that are able to pass through, under, or over the fence. No other RAOs would be met.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in tailings at the Garnet Mine site. This alternative would not result in attainment of water quality standards that are protective of aquatic life in Cataract Creek.

Compliance with ARARs

Federal or state contaminant-specific ARARs would not be met by Alternative T-2 because wastes would not be moved or treated in any way. Water quality in Cataract Creek would continue to exceed DEQ-7 standards.

Long-term Effectiveness and Permanence

Periodic monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term. Specifically, damage to the fence surrounding the tailings could render it ineffective for preventing entry by humans, wildlife, or livestock.

Reduction of Toxicity, Mobility, or Volume through Treatment

There would be no reduction of toxicity, mobility, or volume of the tailings under this alternative.

Short-term Effectiveness

This alternative should immediately prevent ingestion or inhalation of the tailings.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

Implementability

Institutional controls are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative T-2 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$12,640** for construction of a 3-wire fence and signage.

Institutional Controls with Land Use Controls – Alternative T-3

Alternative T-3 involves construction of a fence and signage around the tailings as well as implementing land-use restrictions for the area where tailings are located.

Effectiveness

Alternative T-3 would reduce the risk of accidental ingestion of the tailings material. There is a chance of the fence and signage resulting in an attractive nuisance whereby some people may feel compelled to breach the fence in order to gain access to the tailings or Cataract Creek.

Institutional and land-use controls provide minor improvements to conditions at the site. Toxicity, mobility, and volume of contaminants migrating from the tailings would not be reduced and water quality in Cataract Creek would not be improved.

Removal Action Objectives

Institutional Controls with Land Use Controls would limit exposure to the food chain of metal contaminants from tailings except for animals that are able to pass through, under, or over the fence. No other RAOs would be met.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in tailings at the Garnet Mine site. This alternative would not result in attainment of water quality standards that are protective of aquatic life in Cataract Creek.

Compliance with ARARs

Federal or state contaminant-specific ARARs would not be met by Alternative F-2 because wastes would not be moved or treated in any way. Water quality in Cataract Creek would continue to exceed DEQ-7 standards.

Long-term Effectiveness and Permanence

Periodic monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term. Specifically, damage to the fence surrounding the tailings could render it ineffective for preventing entry by humans, wildlife, or livestock.

Reduction of Toxicity, Mobility, or Volume through Treatment

There would be no reduction of toxicity, mobility, or volume of the tailings under this alternative.

Short-term Effectiveness

This alternative should immediately prevent ingestion or inhalation of the tailings.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

Implementability

Institutional controls are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative T-3 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$27,688**. About 37% of that cost is for legal fees associated with the implementation of land use restrictions. Remaining costs are for installation of fencing and signage.

In-Place Stabilization / Surface Controls - Alternative T-4

Alternative T-4 involves covering exposed tailings with cover soil and revegetating. Cataract Creek would be modified to include step pools and the banks armored with rip-rap. All disturbances resulting from this work would also be revegetated.

Effectiveness

This alternative would reduce the potential for human or wildlife contact with the tailings. However, frequent visitation of the tailings area by cattle and wildlife would continue to result in some amount of exposure as vegetated tailings are uncovered, particularly in moist areas where hooves easily penetrate through the vegetated surface. Leaching of soluble metals from the tailings and into the creek would not be reduced however transport of tailings as suspended sediment would decrease as a result of stream bank armoring.

Removal Action Objectives

This alternative would meet the RAO of stabilizing mine waste to prevent erosion and sedimentation. Reclamation cover objectives would also be met. Soluble metals would not be eliminated because some tailings in the floodplain would remain untreated and in contact with infiltrating precipitation and subsurface water flow.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in tailings at the Garnet Mine site. This alternative would not result in attainment of water quality standards that are protective of aquatic life in Cataract Creek.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative T-4. ARARs associated with surface water quality would not be met as metals mobilized from tailings would continue to degrade water quality in Cataract Creek.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading existing roads, no permanent facilities will be constructed, and construction and maintenance work will occur over a short period of time, likely during a single construction season.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff and sediment controls will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 <u>et seq</u>).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as all areas of barren tailings would be revegetated.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

In-place stabilization and surface controls are considered to be a medium- to long-term solution once vegetation is successfully established on the tailings. However, the potential would exist for flooding to occur and this flooding could be expected to erode and expose tailings underlying revegetated areas. The stream may also relocate itself to areas outside the armored banks.

Some amount of monitoring and maintenance may be necessary to ensure successful revegetation. The potential exists for upward migration of phytotoxic contaminants into overlying coversoil. If this occurs to an extent that results in plant mortality, erosion of the coversoil could eventually re-expose the tailings that are currently unvegetated.

Reduction of Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity or volume would result from this alternative. Placement of cover soil and subsequent revegetation would decrease, but not eliminate, the potential for erosion, ingestion, or inhalation of the tailings. While the ability of soluble metals to be released from the waste would not be reduced, the potential for tailings to enter the creek as suspended sediment would decrease.

Short-term Effectiveness

Hazards associated with tailings that are currently non-vegetated would not be reduced until vegetation is successfully established, which could take one or more growing seasons. Reduced sediment/tailings loading to the creek would occur after rip-rap is in place. Increased metals loading to Cataract Creek would occur due to disturbance during construction activities but this impact is expected to by short-lived. Using heavy equipment to access the area(s) for rip-rap and cover soil placement will have temporary negative impacts on vegetation currently established in the area.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

In-place stabilization and surface controls are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative T-4 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$354,230**. Nearly 47% of that cost is for construction of step pools and installation of rip-rap during stream reconstruction. About 14% of the cost would be spent to control the flow of creek water during reclamation activities.

Partial Removal and Disposal in an On-Site Repository - Alternative T-5

Alternative T-5 involves removing tailings from the banks immediately adjacent to Cataract Creek along with the larger unvegetated mounds of tailings located at and nearby the breached tailings dam. The removed tailings would be placed into an engineered repository located above the water table outside of the Cataract Creek floodplain. A compacted soil cover would be constructed above the repository and revegetated. The creek would be reclaimed and all disturbances would be revegetated.

Effectiveness

This alternative would eliminate the potential for human or wildlife contact with tailings except in areas of the marsh where tailings would remain beneath a matt of vegetation. The potential for ingestion or inhalation would be greatly reduced as would metal loading to the creek.

Removal Action Objectives

Partial removal of mine wastes to an on-site repository largely would meet RAOs however tailings remaining in the marsh would remain a source of contaminants to be released to surface water or the food chain.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in tailings at the Garnet Mine site. This alternative would greatly reduce metal loading to Cataract Creek and may result in water quality that meets DEQ-7 standards for aquatic life.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative T-5. It is possible that ARARs associated with surface water quality would be met as the majority of tailings that contribute to degradation of surface water quality in Cataract Creek would be removed. However, to allow tailings to remain in the marshy area of the floodplain would violate state location-specific ARARs for floodplain management.

Location-specific ARARs associated with cultural and historic resources are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances would be limited to upgrading existing roads and relatively limited areas (i.e. upper reach of Cataract Creek and the repository location) within the overall project area. Construction and maintenance work will occur over a short period of time, likely during a single construction season. The only permanent facility would be the repository which would be revegetated.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff and sediment controls will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as all areas of barren tailings would be placed into the repository and revegetated.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Removing tailings from the current location and placing them in a repository would be a permanent solution requiring little maintenance and providing long-term effectiveness at the site. Monitoring and maintenance of reclamation and revegetation would improve the chances for achieving long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity or volume of the tailings would result from this alternative. However, placement in an on-site repository would eliminate the potential for erosion, ingestion, or inhalation of the waste. While the ability of soluble metals to be released from the tailings would not be reduced, the tailings would be isolated such that metal loading to Cataract Creek would only occur from the relatively small volume of tailings that would remain in the marsh. Because water quality standards in Cataract Creek are currently only marginally exceeded, this alternative may result in full compliance with DEQ-7 standards despite the presence of some tailings and impacted soil remaining in the marsh adjacent to the creek.

Short-term Effectiveness

This alternative would minimize hazards related to erosion, ingestion, and inhalation of the tailings and would also improve water quality in Cataract Creek upon completion of construction activities. Using heavy equipment to access the area(s) for tailings removal will have temporary negative impacts on vegetation currently established in the area.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Placement of tailings into an on-site repository is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative T-5 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$857,751**. About 19% of that cost is for construction of step pools and installation of rip-rap during stream reconstruction. About 14% would be spent to excavate and haul tailings to the repository.

Total Removal and Disposal in an On-Site Repository - Alternative T-6

Alternative T-6 involves removing all tailings from the Cataract Creek floodplain including banks immediately adjacent to Cataract Creek, unvegetated mounds of tailings located at and nearby the breached tailings dam, and tailings and impacted soil dispersed throughout the adjacent marsh. The removed tailings would be placed into an engineered repository located above the water table outside of the Cataract Creek floodplain. A compacted soil cover would be constructed above the repository and revegetated. The creek would be reclaimed and all disturbances would be revegetated.

Effectiveness

This alternative would eliminate all potential for human or wildlife contact with tailings and would eliminate metal loading to the creek contributed by the tailings.

Removal Action Objectives

Removal of tailings to an on-site repository would meet RAOs to the maximum extent.

Overall Protection of Human Health and the Environment

No identified unacceptable human health risks are associated with the average concentration of metals present in tailings at the Garnet Mine site. It is believed that this alternative would greatly reduce metal loading to Cataract Creek, resulting in water quality that meets DEQ-7 standards for aquatic life.

Compliance with ARARs

Compliance with ARARs would be fully achieved under Alternative T-6. It is expected that ARARs associated with surface water quality would be met as all tailings that contribute to degradation of surface water quality in Cataract Creek would be removed. ARARs related to protection of wetlands would be temporarily violated during tailings removal operations but subsequent revegetation and stream channel reconstruction would comply with these ARARs upon completion of construction activities.

Location-specific ARARs associated with cultural and historic resources are expected to be met.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances would be limited to upgrading existing roads and relatively limited areas (i.e. upper reach of Cataract Creek and the repository location) within the overall project area. Construction and maintenance work will occur over a short period of time, likely during a single construction season. The only permanent facility would be the repository which would be revegetated.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff and sediment controls will be complied with using BMPs during construction. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment.

Because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 et seq).

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs. Contaminant-specific ARARs for ambient air are expected to be met under this alternative as all tailings would be placed into the repository and revegetated.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Removing tailings from the current location and placing them in a repository would be a permanent solution requiring little maintenance and providing long-term effectiveness at the site. Monitoring and maintenance of reclamation and revegetation would improve the chances for achieving long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity or volume would result from this alternative. However, placement in an on-site repository would eliminate the potential for erosion, ingestion, or inhalation of the waste. While the ability of soluble metals to be released from the tailings would not be reduced, the tailings would be isolated such that metal loading to the creek would cease. This alternative is expected to result in full compliance with DEQ-7 standards.

Short-term Effectiveness

This alternative would eliminate hazards related to erosion, ingestion, and inhalation of the tailings and would also improve water quality in Cataract Creek upon completion of construction activities. Using heavy equipment to access the area(s) for tailings removal will have temporary negative impacts on vegetation currently established in the area.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

Implementability

Placement of tailings into an on-site repository is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available. Availability of these items will allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative T-6 are shown in the detailed cost analysis found in **Appendix E**. Total cost for this alternative is about **$1,022,395**. About 16% of that cost is for construction of step pools and installation of rip-rap during stream reconstruction. About 20% would be spent to excavate and haul tailings to the repository.

8.1.4 Oriole Adit Tunnel

This section presents the detailed analysis of alternatives for the Oriole Adit as listed in **Table 7-6**. The adit poses a potential physical hazard to humans, livestock, and wildlife that may intentionally or accidentally enter the adit portal and sustain injuries. Seepage from the adit does not comply with DEQ-7 standards as discussed in Section 3.0.

No Action - Alternative OA-1

The no action alternative involves leaving the Oriole Adit in its existing condition. No further closure actions or flow control measures would be attempted at the site to control contaminant migration from the mine to Cataract Creek or to reduce its toxicity or volume. The waste rock dump at the mine portal would remain in place and waters would continue to infiltrate into the mine wastes from the adit discharge. Contaminated water would continue to flow from the portal and discharge contaminated water into the marshland adjacent to Cataract Creek. No further investigations would be conducted and monitoring mine outflow would be discontinued. It is likely that a more permanent institutional or physical closure would be designed for the portal area, both to prevent public access and to provide for public safety.

Effectiveness

Overall effectiveness of the no action alternative is poor. Under existing conditions, mine water containing dissolved metals would continue to flow from the mine portal and into surface water of the marsh adjacent to Cataract Creek. The No Action Alternative does not address surface water impacts, nor does it provide any controls on contaminant migration via direct contact or ingestion. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative, although contaminant sources would likely diminish over time as oxidation of sulfides depletes the source. The No Action is not expected to move water quality toward compliance with B-1 standards for the receiving waters of Cataract Creek. Protection of the environment would not be achieved under this alternative.

Implementability

This alternative is both technically and administratively feasible. However, it is not a viable means of controlling the migration of contaminants that flow from the mine in waters that impact environmental receptors.

Cost

No capital costs would be incurred under this alternative and no additional costs for routine surface or groundwater monitoring are anticipated. Long-term costs associated with No Action are unknown since there is an on-going risk that mine wastes at the portal may erode, and adit discharges will continue resulting in further damage to other downstream resources that may require additional action. There are also external costs associated with no action, including the potential loss of certain ecological functions.

Install Locking Gate at the Portal- Alternative OA-2

Alternative OA-2 uses an access control involving the installation of a heavy-duty, locking, barred gate and the placing of a sign restricting access at the portal of the Oriole Adit to prevent entry by humans or wildlife that might result in injury. Contaminated water would continue to flow from the portal and discharge contaminated water into the marshland adjacent to Cataract Creek. No further closure actions or flow control measures would be attempted at the site to control contaminant migration from the mine portal to Cataract Creek or to reduce its toxicity or volume. No further investigations would be conducted and monitoring mine outflow would be discontinued.

Effectiveness

Alternative OA-2 would be effective in preventing the risk of injury to humans and wildlife that could otherwise result from accidental or intentional entry into the Oriole Adit (F-7A). There is a chance of the locking barred gate fence and signage resulting in an attractive nuisance whereby some people may feel compelled to damage or destroy the gate in order to gain access to the mine workings. With the installation of a locking barred gate at the portal of the Oriole adit, mine water containing dissolved metals would continue to flow from the mine portal and into surface water of the marsh adjacent to Cataract Creek. The locked gate/sign alternative does not address surface water impacts, nor does it provide any controls on contaminant migration via direct contact or ingestion. Toxicity, mobility, and volume of contaminants would not be reduced under this alternative, although contaminant sources would likely diminish over time as oxidation of sulfides depletes the source. The locked gate/sign alternative is not expected to move water quality toward compliance with B-1 standards for the receiving waters of Cataract Creek. Protection of the environment would not be achieved under this alternative.

Removal Action Objectives

Access control that uses a locking gate and signage meets *the ROA for* reducing or eliminating safety and health risks for humans, wildlife and livestock that might result in injury posed by accidental or intentional entry into Oriole Adit hazardous mine openings.

Overall Protection of Human Health and the Environment

Institutional controls limiting access to underground workings will provide improvements to human and wildlife safety conditions at the site. Toxicity, mobility, and volume of contaminants migrating from the adit would not be reduced and water quality in Cataract Creek would not be improved by implementation of this alternative.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative OA-2. Federal or state contaminant-specific ARARs would either not be met or are not applicable because mine wastes at the Oriole Adit portal would not be moved or treated in any way. ARARs associated with surface water quality would not be met as the flow of contaminated water from the Oriole adit would not be reduced or treated. Water quality in Cataract Creek would not meet DEQ-7 standards without treatment or reduction of the flow of this effluent in combination with other clean up actions that treat tailings in the Garnet tailing basin. Contaminant-specific ARARs for ambient air are not expected to be met under this alternative because the mine wastes at the portal would not be revegetated.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash in the vicinity of the mine portal. Historic structures and debris located adjacent to the portal will be protected during construction of the locking gate at the Oriole adit portal site.

Threatened and endangered species are present in or near the project area. Bald eagles have been observed during site visits. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading an existing road to access the portal, no permanent facilities will be constructed, and construction and maintenance work at the portal will occur over a short period of time, likely during a week or two during a single construction season.

Some action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction of the portal gate. Substantive MPDES permit regulations will not be met, as the Oriole adit will continue to discharge contaminated water without a permit.

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

Periodic monitoring and maintenance will be essential to maintaining the long-term effectiveness of this alternative. Specifically, damage to the gate barring access to the Oriole Adit could render it ineffective for preventing entry by humans, wildlife or livestock.

Reduction of Toxicity, Mobility, or Volume through Treatment

There will be no reduction in mobility, toxicity or volume of wastes associated with adit discharge or treatment or removal of mine wastes at the portal site under this alternative.

Short-term Effectiveness

This alternative should eliminate the risk of injury associated with physical and safety hazards posed by the open Oriole adit, by denying access to the underground mine workings immediately upon completion of the construction of the locking portal gate.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

Implementability

Access controls such as a locked gate and signs are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available from the area near the site and would allow the timely implementation and successful execution of the alternative. However, it is not a viable means of controlling the migration of contaminants that flow from the mine in waters that impact environmental receptors.

Cost

Estimated costs for Alternative OA-2 are **$6,118**. The detailed cost analysis can be found in **Appendix E**. Long-term costs associated with limiting access by institutional controls are unknown since there is an on-going risk that mine wastes at the portal may erode, and adit discharges will continue resulting in further damage to other downstream resources that may require additional action.

Constructed Portal Closure – Alternative OA-3

Alternative OA-3 uses access controls involving the construction of portal plug to restrict access to the Oriole Adit, thereby preventing entry by humans or wildlife to underground workings that might result in injury. The constructed portal backfill would consist of a wedge-shaped, coarse rock plug with a constructed under-drain for adit discharge. The under-drain would be constructed by burying a pipe in a gravel lined trench that would transport water from the adit into a gravel filled, and fabric covered infiltration/dispersion basin constructed near the portal. The entire portal area would be regraded, covered with growth media and revegetated. No further mine closure, mine waste removal actions or flow control measures are necessarily anticipated by this alternative to control contaminant migration from the mine portal to Cataract Creek or to reduce its toxicity or volume. Contaminated water would continue to flow from the mine and be dispersed into shallow colluvial materials via the buried infiltration/dispersion basin and ultimately into the marshland adjacent to Cataract Creek. No further investigations would be conducted and monitoring mine outflow would be discontinued.

Effectiveness

Alternative OA-3 would be effective in preventing injury to humans and wildlife that could otherwise result from accidental entry into the Oriole Adit (F-7A). With the construction of an adit under-drain system that reports to a gravel-filled infiltration/dispersion basin, contaminated water would continue to flow from the mine workings in shallow colluvial materials and ultimately into the marsh adjacent to Cataract Creek. However, because the remaining mine discharge takes place within shallow subsurface colluvial materials, controls are provided by this alternative that eliminate the risk of impacts to human, wildlife or livestock receptors via direct contact or ingestion. Toxicity, mobility, and volume of contaminants would not be reduced under this alternative, although contaminant sources would likely diminish over time as oxidation of sulfides depletes the source of metal contaminants within the mine. Mine discharge waters would also likely continue to see some reduction of metals concentration and loading as contaminated waters flow through the wetlands which act as natural treatment systems chemically reducing and fixing metals. The constructed portal closure alternative by itself is not expected to move water quality toward compliance with B-1 standards for the receiving waters of Cataract Creek. Protection of the surface water environment would only be partially achieved under this alternative. The effectiveness of this alternative could be greatly enhanced by the selection and implementation of other alternatives such as borehole plugging or the placement of adit plugs within the Oriole adit that minimize or eliminate flow from the adit.

Removal Action Objectives

Access control that uses the construction of portal plug to restrict access to the Oriole Adit meets *the ROA for* reducing or eliminating safety and health risks for humans, wildlife and livestock that might result in injury posed by accidental or intentional entry into Oriole Adit hazardous mine openings. The use of an under drain for adit discharge and a constructed infiltration/dispersion basin will also meet the ROA for preventing exposure of humans, wildlife and livestock from contact or ingestion and exposure to the food chain by metal contaminants from the adit discharge.

Overall Protection of Human Health and the Environment

Institutional controls limiting access to underground workings will provide improvements to human, wildlife and livestock safety conditions at the site. Restricting the mine discharge to flows within shallow colluvial material, into and out of the infiltration/dispersion basin, also eliminates the risks resulting to humans and animals from direct contact or ingestion of contaminated mine water. Toxicity, mobility, and volume of contaminants migrating from the mine workings would not be reduced and water quality in Cataract Creek would not be expected to improve as a direct result of implementation of this alternative.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative OA-3. Federal or state contaminant-specific ARARs would either not be met or are not applicable because mine wastes at the Oriole Adit portal would not be moved or treated in any way. ARARs associated with surface water quality would not be met as the flow of contaminated water from the Oriole mine workings would not be reduced or treated. Water quality in Cataract Creek would not meet DEQ-7 standards without treatment or reduction of the flow of this effluent from the mine workings in combination with other clean up actions that treat tailings in the Garnet tailing basin. Contaminant-specific ARARs for ambient air are not expected to be met under this alternative because the mine wastes at the portal would not be revegetated.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash in the vicinity of the mine portal and the constructed infiltration basin.

Threatened and endangered species are present in or near the project area. There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading an existing road to access the portal, no permanent surface facilities will be constructed, and construction and maintenance work at the portal will occur over a short period of time, likely during a week or two during a single construction season.

Some action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using BMPs during construction of the portal plug and infiltration basin. Substantive MPDES permit regulations will not be met, as the Oriole adit will continue to discharge contaminated water without a permit.

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using\BMPs.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-term Effectiveness and Permanence

This alternative should eliminate the risk of injury associated with physical and safety hazards posed by the open Oriole adit, by denying access to the underground mine workings. In addition, this alternative should eliminate the risk to human and animals from direct contact with or ingestion of mine effluent by forcing the mine discharge into an infiltration/dispersion basin in the shallow subsurface near the portal. Periodic monitoring and maintenance of erosional disturbances may be needed until vegetation is reestablished on the site.

Reduction of Toxicity, Mobility, or Volume through Treatment

There will be no reduction in mobility, toxicity or volume of wastes associated with adit discharge or treatment or removal of mine wastes at the portal site under this alternative.

Short-term Effectiveness

This alternative should eliminate the risk of injury associated with physical and safety hazards posed by the open Oriole adit, by denying access to the underground mine workings immediately upon completion of the construction of portal plug. In addition, this alternative should eliminate the risk to human and animals from direct contact with or ingestion of mine effluent immediately upon completion of the construction of the infiltration/dispersion basin in the shallow subsurface near the portal.

Impacts associated with construction activities are considered short-term and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures.

Implementability

This alternative is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available from the area near the site and would allow the timely implementation and successful execution of the alternative. It is also a viable means of controlling the migration of contaminants that flow from the mine in waters that impact environmental receptors with respect to contact and ingestions risks. However, there will be no reduction in mobility, toxicity or volume of wastes associated with mine discharge or treatment or removal of mine wastes at the portal site under this alternative.

Cost

Estimated costs for Alternative OA-3 are **$30,581**. The detailed cost analysis can be found in **Appendix E**. Long-term costs associated with limiting access by institutional controls are unknown since there is an on-going risk that mine wastes at the portal may erode, and mine discharges will continue, albeit in the shallow subsurface but may still result in further down-gradient impacts to surface water to other downstream resources that may require additional action.

Packer Installation to Stem Flow from Borehole – Alternative OA-4

Alternative OA-4 proposes to use a mechanical packer to stem the flow of contaminated water into the underground workings from a leaking drill hole at the northeast end of a cross-cut located about 1,095 feet from the portal of the Oriole adit (**Site Map A-5**). The borehole is a jackleg drill hole with a diameter between 1.25 and 1.5 inches, and the flow from the drill hole at the time of mapping was estimated at about 4.5 gallons per minute or about 73% of the total estimated inflow into the mine on October 23 (low flow). Water quality of the inflow was not measured during the mine mapping; however, the water from the hole was actively precipitating malachite (?) (a hydrated copper carbonate mineral) and a seep nearby on the sill was actively precipitating a ferri-hydroxide complex (**Site Map A-5**). There are four other jackleg drill holes in the vicinity of the leaking hole and more than one hole may ultimately need to be plugged. No other mine closure, mine waste removal actions or flow control measures are necessarily anticipated by this alternative to control contaminant migration from the mine portal to Cataract Creek or to further reduce its toxicity or volume. If the alternative of using a mechanical packer(s) to stem the flow from this (or other drill holes) is implemented, a much reduced flow of contaminated water (about 27% of the total flow) might remain as a discharge from the mine portal and ultimately flow into the marshland adjacent to Cataract Creek. No further investigations would be conducted and monitoring mine outflow would be discontinued.

Effectiveness

Alternative OA-4, plugging a leaking borehole in the in the Oriole adit with a mechanical packer, would be effective in reducing the toxicity, mobility, and perhaps as much as 73% of the volume of contaminants currently discharging from the portal of the adit. The protection of the surface water quality environment would only be partially achieved under this alternative. In addition, to potentially removing this component of flow from the discharge, contaminant sources would likely diminish over time as oxidation of sulfides depletes the source of metal contaminants within the mine. Mine discharge waters would also likely continue to see some reduction of metals concentration and loading as contaminated waters flow through the wetlands adjacent to the Cataract Creek channel, which act as natural treatment systems chemically reducing and fixing metals.

Removal Action Objectives

Implementation of Alternative OA-4, stemming the flow from a leaking underground borehole in the Oriole Adit meets the RAO that calls for minimizing or eliminating the outflow from the Oriole adit that currently transports soluble contaminants to the marsh area adjacent to or the surface waters of Cataract Creek. Elimination of this component of flow could reduce inflow into the mine (and subsequent discharge from the mine portal) by as much as 73% (4.5 gpm) based on low flow values estimated in October of 2008.

Overall Protection of Human Health and the Environment

The borehole plugging would be expected to improve water quality in Cataract Creek by reducing toxicity and mobility, including metal concentrations and loading, by reducing the flow by perhaps as much as 73% from discharge the from at the Oriole adit portal. However, this alterative by itself is not expected to provide water quality compliance with B-1 standards for Cataract Creek. Therefore, the protection of the surface water environment would only be partially achieved under this alternative. The effectiveness of the protection of human health and the environment from this alternative could be greatly enhanced by the selection and implementation of other alternatives such as placement of adit plugs within the Oriole adit that minimize or eliminate flow from the adit. This is particularly true because blocking flow from the drill holes often just diverts the flow into other structures, albeit structures that are often not as highly mineralized, and therefore result in lower loads and metal concentrations reporting to the portal discharge. Stemming the flow from the borehole would also facilitate the placement of adit plugs.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative OA-4. Federal or state contaminant-specific ARARs would either not be met or are not applicable, because mine wastes at the Oriole Adit portal would not be moved or treated in any way. ARARs associated with surface water quality would be partially met as the flow of contaminated water from the Oriole mine workings would be reduced but not otherwise treated. Substantive MPDES permit regulations will not be met, as the Oriole adit will continue to discharge contaminated water without a permit. Water quality in Cataract Creek would not meet DEQ-7 standards without additional treatment or further reduction of the flow of this effluent from the mine workings in combination with other clean up actions that treat tailings in the Garnet tailing basin.

Contaminant-specific ARARs for ambient air are not expected to be met under this alternative because the mine wastes at the portal would not be revegetated.

Location-specific ARARs, particularly those associated with cultural and historic resources are expected to be met as no cultural resources are expected to be affected by the implementation of this alternative.

There is not expected to be any impact to threatened and endangered species because new disturbances will be limited to upgrading an existing road to access the portal. In addition, construction and maintenance work associated with this alternative will all occur underground and over a short period of time (days), during a single construction season.

Occupational Safety and Health Administration requirements would be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120. Underground workers will be MSHA Certified and operate under the site specific Health and Safety Plan for underground operations.

Long-term Effectiveness and Permanence

Mechanical packers under wet, oxidizing underground mine conditions would have a life expectancy from as little as ten to as much as thirty years before requiring replacement. Mechanical packers would not, therefore, represent a permanent solution to controlling the discharge from the borehole, unless it was to be combined with other alternatives.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative OA-4, plugging a leaking borehole in the in the Oriole adit with a mechanical packer, would be effective in reducing the toxicity, mobility, and perhaps as much as 73% of the volume of contaminants currently discharging from the portal of the adit.

Short-term Effectiveness

Once the packer is installed, this alternative should be effectively immediately in reducing toxicity and mobility of contaminants by reduction in the volume of flow discharging from the borehole, and therefore, the adit portal. The packers should be effective in stemming the flow from the borehole over a period of ten to thirty years, before requiring replacement.

Impacts associated with construction activities are considered short-term and except for access related issues, take place underground and should not therefore significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures. Underground workers will be MSHA Certified and operate under the site specific Health and Safety Plan for underground operations.

Implementability

This alternative is both technically and administratively feasible. Key project components such as equipment and MSHA certified construction expertise are available from the area near the site and would allow the timely implementation and successful execution of the alternative. Mechanical packers, although not available locally, are readily available from a number of suppliers, and can be delivered to the site easily with very little notice.

Cost

Estimated costs for Alternative OA-4 are **$11,047**. The detailed cost analysis can be found in **Appendix E**. Long-term costs associated with implementation of this alternative are unknown since there is an on-going risk that mine wastes at the portal may erode, and mine discharges will continue, but may still result in further down-gradient impacts to surface water to other downstream resources that may require additional action.

Grout Borehole and Adjacent Fractures with Grout Curtain - Alternative OA-5

The purpose of Alternative OA-5 is to construct a grout curtain to stem the flow of contaminated water into the underground workings from a leaking drill hole at the northeast end of a cross-cut located about 1,095 feet from the portal of the Oriole adit (**Site Map A-5**). The borehole is a jackleg drill hole with a diameter between 1.25 and 1.5 inches, and the flow from the drill hole at the time of mapping was estimated at about 4.5 gallons per minute or about 73% of the total estimated inflow into the mine on October 23 (low flow). Water quality of the inflow was not measured during the mine mapping; however, the water from the hole was actively precipitating malachite (?) (a hydrated copper carbonate mineral) and a seep nearby on the sill was actively precipitating a ferri-hydroxide complex (**Site Map A-5**). There are four other jackleg drill holes in the vicinity of the leaking hole and stemming the flow from this leaking drill hole may divert the flow into one or more of the other holes or into nearby fractures at the margins of the drift.

Alternative Task OA-5 Description

The following work is included in the implementation of Alternative OA-5:

- *Install utilities:* Prior to beginning grouting operations 1,150 feet of 2 - 4 inch compressed air pipe and 1,150 meters of 1.5 inch water line will be installed from the portal to the leaking borehole site. Ventilation duct will likely need to be installed to provide fresh air to the work area. The area in the vicinity of the borehole will be barred down and the back (roof) will be supported with five-foot friction bolts, plates, and chain-link fencing for safety purposes as necessary.

- *Initial Grouting:* Pump-through mechanical packers with shut-off valves will be placed in each of the five existing 1.25 to 1.5 inch diameter jackleg drill holes. The appropriate type of grout will be determined after the assessment holes are analyzed. It is expected that Portland cement, micro-fine cement, a bentonite-based grout, or bentonite grout followed by a cement-based grout will be used. The highest elevation, non-flowing holes will be grouted first. Each of the holes will be pressure grouted to between 100 and 200 psi. Flowing holes will be grouted last. All valves will be left open to evaluate the effectiveness of grouting. If grout communication develops between holes, secondary holes will be shut in with primary grouting holes upon completion of the grouting.

Completion of the grouting will be determined by no "grout take" for 20 minutes at the final confining pressure. The amount of grout required is highly variable and extremely difficult to predict prior to initiation of the drilling and grouting. The overall objective in grouting is to produce a grout curtain that prevents flow of groundwater into the workings.

- *Drilling and Secondary Grouting*: If the flow from the boreholes is diverted to fractures within the drift that are not sealed by the initial borehole grouting, secondary holes may need to be drilled and the fracture systems grouted in a second round of grout curtain development. All secondary grouting holes in Alternative OA-4 will be approximately 1.5 inch (BX) diameter diamond drill holes. Data from the initial diamond drill holes will be used to characterize the nature and orientation of the water bearing structure and the country rock around it. This could require from two to ten, 20 to 40-foot long holes for a total of approximately 400 feet of drilling. Hole grouting under this scenario would be completed as described above.

Effectiveness

The grouting project, if completely successful, will eliminate water inflow into the workings from boreholes and nearby fractures. Even if the grouting project is only partially successful, water flow into the Oriole Adit through the boreholes and adjacent fractures should be substantially reduced. Either case will be a significant improvement over the existing condition.

The grout curtain can be viewed as an impermeable donut-shaped ring around a fracture controlled permeable plane that transmits groundwater. The Oriole adit would be represented by the hole in the donut. Water flowing in the plane of the permeable structure will flow around the grouted donut ring and continue traveling down the hydrologic gradient (probably in the direction of and in a volume of flow similar to that developed under pre-mining conditions). Thus, the grout curtain will not stop the flow of water along the permeable structure or cause an increase in hydrostatic pressure around the drift; it will just keep the water from entering the drift and exiting via the portal.

Removal Action Objectives

Implementation of Alternative OA-4 meets two of the RAOs for the project by preventing soluble contaminants from migrating into Cataract Creek, and preventing future releases of contaminants into the drift from the area in the vicinity of the boreholes.

Overall Protection of Human Health and the Environment

This alternative, attempts to stem the flow from the borehole and adjacent nearby fractures from entering the adit, and provides a reasonable measure for controlling exposure to contaminated water and reduces risk to the environment. It reduces the volume of metals-bearing water flowing directly into the underground workings and its subsequent discharge into Cataract Creek by constructing a permanent physical barrier to water movement. The removal of the 4.5 gallon per minute inflow into the mine (73% of the total estimated mine inflow) would significantly reduce the amount of contaminated water exiting the Oriole Adit and will lessen exposure of the environment to this contaminated water source.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative OA-4. Water quality standards are currently not being met in Cataract Creek under existing conditions. These standards will not be achieved without other additional cleanup actions as discussed for tailings treatment above (Alternatives T-1 through T-5) and perhaps by implementation of Alternative OA-6 that involves setting hydraulic plugs in the Oriole Adit proper (below).

Surface water quality at Station GMSW-2 through 4 will improve as a direct result of grouting the leaking boreholes in the Oriole Mine. While improvements in water quality are limited by other controls of water chemistry at SW-2 and 3 (in-valley mine tailings) a considerable reduction in metals loading would be realized with this alternative.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no significant cultural or historic features will be impacted if this alternative is implemented. Threatened and endangered species are present in or near the Garnet Mine Area Reclamation Project will not be affected by this alternative as there will be no new disturbances, no permanent facilities, and implementation of the alternative will be completed in one season. No other location-specific ARARs apply.

Action-specific ARARs are expected to be met by this alternative. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment. The Montana Water Quality Act will not be fully complied with under this alternative as the Oriole Adit will continue to discharge metals from other sources within the mine that exceed standards. Other requirements for treating surface drainage, sediment control, construction and maintenance of sedimentation ponds to control underground sediment sources during construction, and discharges from sedimentation ponds, will be met during underground construction by using BATs.

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using BMPs.

OSHA requirements will be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120. Underground workers will be MSHA Certified and operate under the site specific Health and Safety Plan for underground operations.

Long-Term Effectiveness and Permanence

Grouting is a proven long-term method of constructing a nearly impermeable barrier in fractured rock. Upon completion of grouting, the water inflow in the vicinity of the leaking borehole will be reduced or nearly eliminated. Thus the long-term effect will be a smaller load of metals reporting to Cataract Creek via the Oriole Adit discharge.

The long-term effectiveness of rock fracture grouting to prevent water flow can be lost due to ground movement and re-opening of fractures. The back (roof) of the drift in the vicinity of the bore holes is composed of many rock blocks keyed together and held in place by friction only. Inter-block movement over time is very likely to occur. The long-term effectiveness of Alternative OA-5 can best be guaranteed by tightly backfilling the Oriole Adit drift in the vicinity of the grout curtain to hold the roof blocks in place. Backfill material is available in nearby cross cuts and in the vicinity of the drift containing the boreholes.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative OA-5 will significantly reduce the mobility of metals. The Oriole Adit will no longer receive 4.5 gallons per minute of metal-bearing water through the borehole or nearby fractures. While there will be no reduction in toxicity or volume, the Oriole adit will be eliminated as a point-source discharge for the borehole water that represents 73% of the current inflow into the mine (as measured on October 23, 2008).

Short-term Effectiveness

The effectiveness of the grouting program will be immediate. Upon completion of grouting, the water inflow from the borehole leak will be reduced or eliminated. No impacts to the community or the environment are expected with the implementation of this borehole grouting alternative. Only a limited amount of equipment and supplies will be required, all of which will travel on existing roads. Protection to workers will be afforded through standard work practices. Exposure to hazardous substances will be minimal, although direct contact with the water draining the mine will not be eliminated. All underground work will be conducted using standard work practices and protective devices.

Implementability

Grouting of borehole and nearby fractured bedrock to reduce permeability has been commonly used to stop groundwater in-flow in tunneling, dams, and construction sites for over a century (Houlsby, 1990). The proposed application in Alternative OA-5 is not significantly different. Key project components such as equipment and MSHA certified construction expertise are available from within the state of Montana and would allow the timely implementation and successful execution of the alternative. The success of the grouting program can be monitored as the grout is pumped. The success of the grouting can be further determined by measuring water flows along the sill of the drift upstream and downstream of the borehole area and calculating the difference in flow. Decisions concerning the need for additional (secondary) holes to enlarge the grout curtain can be made immediately.

Cost

Estimated costs for Alternative OA-5 are **$403,480**. The detailed cost analysis can be found in **Appendix E**. Long-term costs associated with implementation of this alternative are unknown since there is an on-going risk that mine wastes at the portal may erode, and mine discharges will continue, but may still result in further down-gradient impacts to surface water to other downstream resources that may require additional action.

Plug Oriole Adit Drift at Two Critical Locations - Alternative OA-6

The Oriole adit is driven along a heading of N. 24° W. for a distance of 1,184 feet in coarse-grained quartz monzonite of the Tobacco Root batholith. Sulfide mineralization is associated with narrow (2 - 20 foot wide) northeast trending shear, fracture and fault structures that have been stoped upwards for at least 20- 30 feet (all that is visible, but likely higher in many areas). The workings are nominally six feet wide by seven feet tall. The mine has been mucked from the portal to a small cave-in that dams water about 448 feet from the portal. Utilities including a 4-inch Victaulic airline, a 1-inch poly water line, and an 18-inch vent bag have been installed over this initial 448 foot of the adit. The utilities are in disrepair, but appear to be usable. Overall rock quality data (RQD) for the quartz monzonite is good outside of the mineralized shear zones.

Alternative OA-6 calls for setting two water tight hydraulic cement/grout plugs in the adit, to stem the flow of contaminated water from the portal of the Oriole mine to the marshes along Cataract Creek (**Site Map A-2**). Both plugs would be constructed in the coarse-grained quartz monzonite porphyry of the Cretaceous Tobacco Root batholith. Approximate locations for each of the two plugs would be at distances of 550 and 200 feet in from the portal. This alternative would likely be used in conjunction with either alternative OA-2 or OA-3 to close the portal opening, and with alternative OA-4 to install a packer in the leaking borehole at 1059 feet in the workings to stem the flow from the borehole. Implementation of Alternative OA-5, construction of an underground grout curtain, would be precluded by the implementation of this alternative as the grout curtain would be unnecessary because all underground working would be flooded and a regional groundwater table reestablished.

Alternative Task Description

The following work is required for the implementation of Alternative OA-6:

- *Engineering:* Adit plugs will be designed assuming that the entire Oriole Adit could fill with water and the fractures above the workings could fill with water to as much as 500 feet in elevation above the adit level, exerting approximately 1.2 mega pascals (Mpa) pressure against each plug.

- *Excavation and plug-site preparation*: The sill of the mine will be mucked of loose debris and rock fall, and damaged timber will be removed from the portal to the most distant plug site (550 to 600 feet). Debris will be hauled to the portal or placed behind the innermost plug station with a one cubic yard load-haul-dump. Timber will be set aside in underground cross cuts. Plugs will be constructed beginning with the innermost plug and working toward the portal. The same procedure will be followed for each plug. Prior to construction, 550 feet of 2 - 4 inch compressed air pipe and 550 meters of 1.5 inch water line will be installed from the portal to the plug site. Ventilation duct will have to be installed to provide fresh air to the work area. The sill, back, and ribs at the plug location will be notched at both ends of the plug location, scaled, and cleaned to allow a water-tight bond between the concrete and rock. A dam upstream of the plug location (further into the mine) will be constructed to prevent water from entering the plug excavation during placement of the cement. A bypass pipe will be installed in the dam to pass water through the plug site and discharge the water downstream of the plug site. Plug locations will be nominally 20-feet long along the axis of the adit and arch will be cut in the back at the center of the plug to an elevation of 12-16 feet above the sill. The arch will be screened and rock bolted as necessary to support the arch.

- *Plug construction:* Bulkheads will be constructed 16 to 20-feet apart at the front and back of the each plug station. Steel I-beams (6-inch flange) will be used to support bulkheads constructed of 3-inch thick wooden lagging wrapped in burlap at each ends of the plug site. To facilitate concrete pumping, a 4-inch diameter steel pipe (possibly the Victaulic airline) will be installed from the portal to the plug sites. The space between the back form and the front form will be pumped full of concrete grout. Air will discharge through two or three breather pipes installed at the highest point of the arch in the plug station. Once the bulk of the plug is poured, the arch will be filled by pumping grout into one of the breather pipes in the arch. The forms will be abandoned in place. If necessary, during construction and curing time, water in the mine will pass through the bypass pipe.

- *Grouting:* Upon completion of the plug, fractured bedrock immediately surrounding the plug will be drilled and pressure grouted with Portland cement grout. When grouting is complete, the bypass pipe will be grouted shut.

Effectiveness

Concrete plugs combined with pressure grouting to stop water flow are commonly used in dams and similar water retaining structures as well as in underground mines. In some mine reclamation applications, plugs have been inadequate, because they have been installed too near the portal. Over time, hydrostatic head behind the plug has risen to a level sufficient to force water through fractures, by-passing the plug, and allowing the water to exit through other fractures in the vicinity of the mine opening.

Alternative OA-6 addresses the problem of high head behind the plugs by installing two plugs beginning 550 feet back in the drift where the surrounding rock is tight and the hydrostatic head will not be large enough to force water to the surface through fractures.

Removal Action Objectives

Implementation of Alternative OA-6 meets two of the RAOs for the project by preventing soluble contaminants from migrating into Cataract Creek, and preventing future releases of contaminants into the Oriole adit from the leaking boreholes.

Overall Protection of Human Health and the Environment

Alternative OA-6 provides a reasonable measure of control to contaminated water flow and reduces risk to the environment. It reduces the flow of metal-laden water directly into Cataract Creek by constructing two barriers to water movement through the Oriole adit.
The removal of as much as 6.0 gallons per minute of metal-bearing water exiting the Oriole Adit will lessen exposure of the environment to contaminated water. While this alternative alone has the potential to significantly diminish or eliminate the flow of water from the Oriole Adit, there is no redundancy in-place in the event of failure of the system in the future. The greatest degree of protection to the environment will be achieved by combining this alternative with other alternatives such as eliminating the flow of water into the adit from the borehole at 1049 feet from the portal and the construction of a portal plug with an infiltration basin to ensure an effective, permanent reduction in exposure to contaminants.

Compliance with ARARs

Compliance with ARARs will not be fully achieved under Alternative OA-6. Surface water quality at Stations GMSW-2, 3 and 4 are expected to improve as a direct result of setting plugs in the Oriole Adit. However, contaminant-specific standards associated with the Montana Water Quality Act will not be achieved in surface water of Cataract Creek without other alternatives being combined with Alternative OA-6 that specifically minimize or eliminate contaminant migration from tailings source materials.

Contaminant specific ARARs for groundwater are currently being met at the Garnet Mine site and groundwater in the Cataract Creek drainage area is of good quality with near neutral pHs and metal concentrations generally below their reporting limits. Contaminant-specific ARARs for ambient air will be met under this alternative, as air quality will not be impacted by construction operations.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no significant cultural or historic features will be impacted if this alternative is implemented. Threatened and endangered species are present in or near the District will not be affected by this alternative as there will be no new disturbances, no permanent facilities, and implementation of the alternative will be completed in one season. No other location-specific ARARs apply.

Action-specific ARARs are expected to be met by this alternative. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment. The Montana Water Quality Act will be complied with under this alternative if the flow from the Oriole Adit can be effectively stemmed. Other requirements for treating surface drainage, sediment control, construction and maintenance of sedimentation ponds, discharges from sedimentation ponds and provisions for protecting groundwater will be met by using best BATs.

Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met using BMPs.

OSHA requirements will be met by requiring appropriate safety training for all on-site workers during construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site per OSHA 29 CFR 1910.120. Site personnel will have completed 40-hour hazardous waste operations and emergency response training and would be current with the 8-hour annual refresher training as required by OSHA 29 CFR 1910.120.

Long-Term Effectiveness and Permanence

Alternative OA-6 should permanently eliminate the Oriole Adit as a major conduit for transporting metal-laden groundwater discharges from the mine.

Reduction of Toxicity, Mobility or Volume through Treatment

The mobility of metals will be substantially reduced or eliminated by Alternative OA-6. The Oriole Adit will no longer be a conduit for transporting metals-laden water to Cataract Creek.

Mobility will exist within each isolated segment of the mine, but the plugs will preclude mobility of contaminants between segments of the Oriole adit. There will be no reduction in toxicity or volume.

Short-term Effectiveness

The effect of constructing the adit plugs will be immediate. Upon completion of the first plug and the surrounding grout curtain, the by-pass pipe will be grouted shut and water flow from the groundwater sources within the Oriole mine raises to the portal will be substantially reduced or eliminated.

No impacts to the community or the environment are expected with the implementation of this alternative. Only a limited amount of equipment and supplies will be required, all of which will travel on existing roads. Protection to workers will be afforded through standard work practices. Exposure to hazardous substances will be minimal, although direct contact with the water draining the mine will not be eliminated. All underground work will be conducted using standard work practices and protective devices.

Implementability

Numerous portal and drift plugs have been previously installed in abandoned, underground mines. The greatest technical difficulty with Alternative OA-6 is pumping concrete to the plug sites. This will be accomplished by pumping concrete from the portal site through a pipeline into the Oriole drift. Key project components such as equipment and MSHA certified construction expertise are available from within the state of Montana or outside contract mining companies and would allow the timely implementation and successful execution of the alternative.

Cost

Estimated costs for Alternative OA-6 are **$794,931**. The detailed cost analysis can be found in **Appendix E**. Long-term costs associated with implementation of this alternative are unknown since there is an on-going risk that mine wastes at the portal may erode. However, adit discharge should be greatly reduced or eliminated and any remaining flow should not result in further down-gradient impacts to surface water to other downstream resources that may require additional action within the adit.

8.1.5 Actions Common to All Alternatives

Except for the no action alternative, ancillary construction activities will be done in addition to the primary removal action components associated with each alternative. These activities consist of work needed to improve the Cataract Creek access road to a suitable condition for transport of equipment and supplies to the project area. All but the no action alternative for source areas uphill from the Oriole Adit would additionally require improvements to the road leading north (uphill) from the Cataract Reservoir dam.

Where required, existing roads would be widened to accept large equipment (e.g. haul trucks, and track-hoes). This will necessitate blasting a rock outcrop currently located on the main access road downstream of the project area. Switchbacks may need to be added to the road above Cataract Reservoir dam in order to reduce the grade on steep sections of this road. Trees may need to be removed from some locations to allow the road(s) to be widened.

Road improvements needed to implement the alternatives may have some short-term impacts on the watershed. Increased sedimentation may result from road improvements due to an increased sediment load from exposed and widened roads and deeper and wider borrow ditches. These impacts will be mitigated by implementing BMPs for storm water runoff.

The major short-term impact to the surrounding community, residents, and wildlife involves increased vehicle traffic and temporary closures of some forest roads. An increase in traffic would occur during mobilization and demobilization of construction equipment.

Dust control on designated truck routes is an expected requirement.

A separate fixed cost for these ancillary activities is **$56,000**. This does not include $8,000 for the upper access road that if required would be a contingency action.

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9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

9.1 SOURCE AREAS UPHILL OF ORIOLE ADIT

Because waste rock piles uphill of the Oriole adit do not impact water in Cataract Creek, none of the alternatives evaluated would improve surface water quality. All but the No Action alternative would provide for protection of human health by preventing access to F-2, the collapsed open stope, either through installation of fencing (Alternative WR-2, Institutional Controls), regrading (Alternative WR-3, Surface Controls), or backfilling (Alternative WR-4, Total Removal and Disposal in Collapsed Stope). Alternatives WR-3 and WR-4 would be most effective at reducing mine related impacts as they both include provisions to revegetate the waste rock piles and/or the footprint of the piles after removal. Alternatives WR-3 and WR-4 would both require obtaining a local source of borrow soil for use as a revegetation medium, which involves disturbance and reclamation of a borrow site.

All of the alternatives analyzed are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available from the area near the site. These conditions should allow for the timely implementation and successful execution of each of the alternatives.

9.2 ORIOLE ADIT WASTE ROCK

Due its proximity to Cataract Creek, the Oriole adit waste rock pile, F-8, likely contributes some degree of metals loading to the creek. This mine feature does not present a risk to human health through its environmental geochemical nature but it could present a physical hazard if one was to fall down its steep face.

All but the No Action alternative would provide for protection of human health by preventing access to the crest of the waste dump, either through installation of fencing (Alternative WR-F8-2, Institutional Controls), regrading (Alternative WR-F8-3, Partial Removal and Surface Controls), or complete removal (Alternative WR-F8-4, Total Removal and Disposal in Oriole Adit or Alternative WR-F8-5, Total Removal and Disposal in On-Site Repository). Alternatives WR-F8-2 and WR-F8-3 would provide some measure of environmental protection through construction of drainage controls with or without additional revegetation work. Because some volume of waste rock would remain on the surface, albeit revegetated under WR-F8-3, metal loading to Cataract Creek would still occur when direct precipitation infiltrating the waste migrates to the creek. Complete removal of the waste pile to a sub-surface location either in the Oriole adit (Alternative WR-F8-4) or to an engineered repository (WR-F8-5) would greatly reduce or eliminate the potential for metals loading to Cataract Creek from this waste. As it is anticipated that an on-site repository will be constructed to accept tailings removed from the Cataract Creek floodplain, Alternative WR-F8-5 would be more implementable from a cost efficiency and worker safety standpoint compared to WR-F8-4.

All of the alternatives analyzed are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available from the area near the site. These conditions should allow for the timely implementation and successful execution of each of the alternatives.

9.3 CATARACT CREEK TAILINGS DEPOSIT

Tailings located within the Cataract Creek floodplain do not pose a concern for human or ecological health due to direct ingestion or inhalation of the tailings. However the tailings do present an environmental concern by acting as the primary contributor of metals loading that degrades water quality in Cataract Creek.

Because tailings present an environmental risk due to their location in direct contact with waters of Cataract Creek and the adjacent marsh, the no action alternative and Alternatives T-2 (Institutional Controls), T-3 (Institutional Controls with Land Use Controls), and T-4 (In-Place Stabilization / Surface Controls) that would not prevent contact between the tailings and surface water would not improve water quality in Cataract Creek. Implementation of Alternatives T-5 (Partial Removal and Disposal in an On-Site Repository) or T-6 (Complete Removal and Disposal in an On-Site Repository) would likely improve water quality in Cataract Creek to meet DEQ-7 standards.

Under Alternative T-5, tailings located in the marsh would remain in place while the majority of the tailings, which are located along the banks of the creek and at the breached tailings dam, would be removed. This alternative would reduce the amount of disturbance to vegetation in the marsh compared to Alternative T-6. However, some amount of marsh disturbance would be unavoidable during any activities conducted within the floodplain and such disturbance would require subsequent reclamation.

All of the alternatives analyzed are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available from the area near the site. These conditions should allow for the timely implementation and successful execution of each of the alternatives.

9.4 ORIOLE ADIT PORTAL

Issues concerning the Oriole Adit Source Area involve risks to public safety related to access to mine openings, and contaminated inflow into the underground workings. The principal impacts are contaminated outflow from the mine portal to both marshes adjacent to and surface water within Cataract Creek. Therefore, all of the proposed engineering controls and alternatives for the Oriole Adit involve access control or underground engineering flow control of water into and out of the mine.

The No Action Alternative (OA-1) involves leaving the Oriole Adit in its existing condition. Overall effectiveness of no action is poor. Under existing conditions dissolved metal contaminants will continue to flow from the portal and contaminate marshes and surface water in Cataract Creek.

Alternatives OA-2 (gating the portal) and OA-3 (constructing a portal closure) each involve access control. Both Alternative OA-2 and OA-3 would be effective in preventing the risk of injury to humans and wildlife that could otherwise result from accidental or intentional entry into the Oriole Adit (F-7A). With the construction of an adit under-drain system that reports to a gravel-filled infiltration/dispersion basin (OA-3), contaminated water would continue to flow from the mine workings in shallow colluvial materials and ultimately into the marsh adjacent to Cataract Creek. However, because the remaining mine discharge takes place within shallow subsurface colluvial materials, controls are provided by this alternative that eliminate the risk of impacts to human, wildlife or livestock receptors via direct contact or ingestion. Toxicity, mobility, and volume of contaminants would not be reduced under either alternative. Access control that uses either a locking gate or a portal plug to restrict access to the Oriole Adit meets the ROA for reducing or eliminating safety and health risks for humans, wildlife and livestock that might result in injury posed by accidental or intentional entry into Oriole Adit hazardous mine opening. The use of an under drain for adit discharge and a constructed infiltration/dispersion basin (OA-3) will also meet the ROA for preventing exposure of humans, wildlife and livestock from contact or ingestion and exposure to the food chain by metal contaminants from the adit discharge.

Alternatives OA-4 (packer installation in borehole) and OA-5 (grout curtain around borehole) are both designed to stem the flow from a borehole located approximately 1,049 feet from the portal of the Oriole Adit. Alternative OA-4, plugging a leaking borehole in the in the Oriole adit with a mechanical packer, would be effective in reducing the toxicity, mobility, and perhaps as much as 73% of the volume of contaminants currently discharging from the portal of the adit. The protection of the surface water quality environment would only be partially achieved under this alternative. Mechanical packers under wet, oxidizing underground mine conditions would have life expectancy from as little as ten to as much as thirty years before requiring replacement. Mechanical packers would not, therefore, represent a permanent solution to controlling the discharge from the borehole, unless it was to be combined with other alternatives.

Alternative OA-5 involves pressure grouting of the rock surrounding the leaking borehole and adjacent fractures within the drift. Grouting is a proven long-term method of constructing a permanent, nearly impermeable barrier in fractured rock. Upon completion of grouting, the water inflow in the vicinity of the leaking borehole will be reduced or nearly eliminated. Even if the grouting project is only partially successful, water flow into the Oriole Adit through the boreholes and adjacent fractures should be substantially reduced. As much as 73% of the volume of contaminants currently discharging from the portal of the adit may be eliminated by Alternative OA-5. Thus the long-term effect will be a smaller load of metals reporting to Cataract Creek via the Oriole Adit discharge. The short term affect of both the use of packers and the creation of a grout curtain to stem the flow from the borehole should be both immediate and highly effective. Implementation of either Alternative OA-4 or OA-5 meets two of the RAOs for the project by preventing soluble contaminants from migrating into Cataract Creek, and preventing future releases of contaminants into the drift from the area in the vicinity of the boreholes.

Alternative OA-6 proposes to use underground engineering flow controls involving the construction of two water tight, hydraulic plugs to stem the flow from the Oriole Adit. Concrete plugs combined with pressure grouting to stop water flow are commonly used as permanent solutions to water discharge from underground workings and have found to be highly effective long-term solutions to the problem. Short-term effectiveness is immediate once the plugs are placed. Alternative OA-6 provides a reasonable measure of control to contaminated water flow and reduces risk to the environment. It reduces the flow of metal-laden water directly into Cataract Creek by constructing two barriers to water movement through the Oriole adit. Implementation of Alternative OA-6 meets two of the RAOs for the project by preventing soluble contaminants from migrating into Cataract Creek, and preventing future releases of contaminants into the Oriole adit from the leaking boreholes.

All of the alternatives analyzed are both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, are available from the area near the site for Alternatives OA-2, OA-3 and OA-4, and materials, equipment and MSHA certified construction expertise are available from within the state of Montana or from outside contract mining companies for alternatives OA-5 and OA-6. These conditions should allow for the timely implementation and successful execution of each of the alternatives.

The costs to implement each alternative vary widely and are presented in the appropriate sections of Chapter 8 and in the detailed cost analysis tables (**Appendix E**).

10.0 PREFERRED ALTERNATIVE

The preferred alternative for the Garnet Mine reclamation project is a combination of the alternatives discussed for each of the separate source areas. The preferred alternative for each of the four sources areas is discussed below.

10.1 SOURCE AREAS UPHILL OF ORIOLE ADIT

The preferred alternative for source areas located uphill of the Oriole adit is a combination of alternatives WR-3 and WR-4. Specifically, Alternative WR-4 would be applied to waste rock piles F-3, F-3A, and F-5, the entire volumes of which would be used to completely backfill the collapsed stope at F-2. Alternative WR-3 would be applied at F-1 where the relatively small waste rock pile would be regraded and revegetated at its current location. This combination of alternatives would provide the maximum possible protection of human health and the environment for these source areas at a cost of $57,560.

10.2 ORIOLE ADIT WASTE ROCK

WR-F8-5 is the preferred alternative for reclamation of the Oriole adit waste rock pile because subsurface placement of the waste rock would be most effective at eliminating metals loading from this source to Cataract Creek. While Alternative WR-F8-4 would result in a similar level of environmental protection, WR-F8-5 would be more implementable. The estimated cost for this Alternative is $55,925.

10.3 CATARACT CREEK TAILINGS DEPOSIT

Only by removing tailings from the floodplain will metals loading to Cataract Creek be reduced to an extent that would allow water quality to meet DEQ-7 standards. Because disturbance and reclamation of the marsh would occur under either Alternative T-5 or T-6, it would be advantageous to remove the tailings that underlie the marsh vegetation, in addition to deposits along the creek banks, prior to reclamation in the marsh. For this reason, the preferred alternative for reclamation of the Cataract Creek tailings deposit is Alternative T-6 at a cost of **$679,423**.

10.4 ORIOLE ADIT PORTAL

The most effective means of closure for the Oriole Adit involves a combination of alternatives that attempt to minimize mobility of contaminants as inflow and outflow from the mine. These alternatives are also selected for their implementability that also combines alternatives that offer the most in terms of long term effectiveness and permanency, and provide for the maxim protection of the environment. Although there is some need for "back-up" systems, for example backfilling of intervals in the workings surrounding grouted areas or adit plugs, the choice of alternatives has been selected to minimize redundancy. For these reasons the following alternatives have been selected for stemming the flow from and closing the Oriole Adit:

- OA-3, a constructed portal closure that consists of a coarse rock plug with an adit under-drain (buried pipe in a gravel trench) that delivers remaining adit flow to a gravel-filled, fabric-covered, infiltration/dispersion basin. The entire disturbed area of the portal and infiltration basin would be reclaimed with a revegetated growth media cover.

- OA-4, underground flow control using a hydraulic Packer(s) installed to stem or minimize the flow from a borehole(s) located approximately 1,049 feet into the adit.
- OA-6, underground flow controls using two water-tight, concrete, hydraulic plugs within the Oriole adit. Probable locations for the two plugs are centered approximately 550 and 200 feet in from the portal.

Total cost for this combination of alternatives is $873,239.

10.5 Combined Cost for the Preferred Alternative

Table 10.1 presents the combined cost for the various components of the preferred alternative.

TABLE 10-1
Preferred Alternative Estimated Cost
Garnet Mine Reclamation Area Project

Item	Estimated Cost
Source Areas Uphill of Oriole Adit	
WR-3 (Surface Controls for F-1 waste rock pile and adit)	Included in WR-4 cost
WR-4 (Total Removal and Disposal in Stope [F-2] for remaining wastes)	$86,616
Oriole Adit Waste Rock Pile	
WR-F8-5 (Total Removal and Disposal in On-Site Repository)	$82,881
Cataract Creek Tailings Deposit	
T-6 (Complete Removal and Disposal in an On-Site Repository)	$1,022,395
Oriole Adit Portal	
OA-3 (Coarse Rock Plug Portal Closure)	$30,581
OA-4 (Packer Installation in Leaking Bore Hole)	$11,047
OA-6 (Concrete Hydraulic Plugs)	$831,611
Activities Common to All Alternatives	
Upgrading Access Roads	$84,269
Total Estimated Cost	**$2,149,400**

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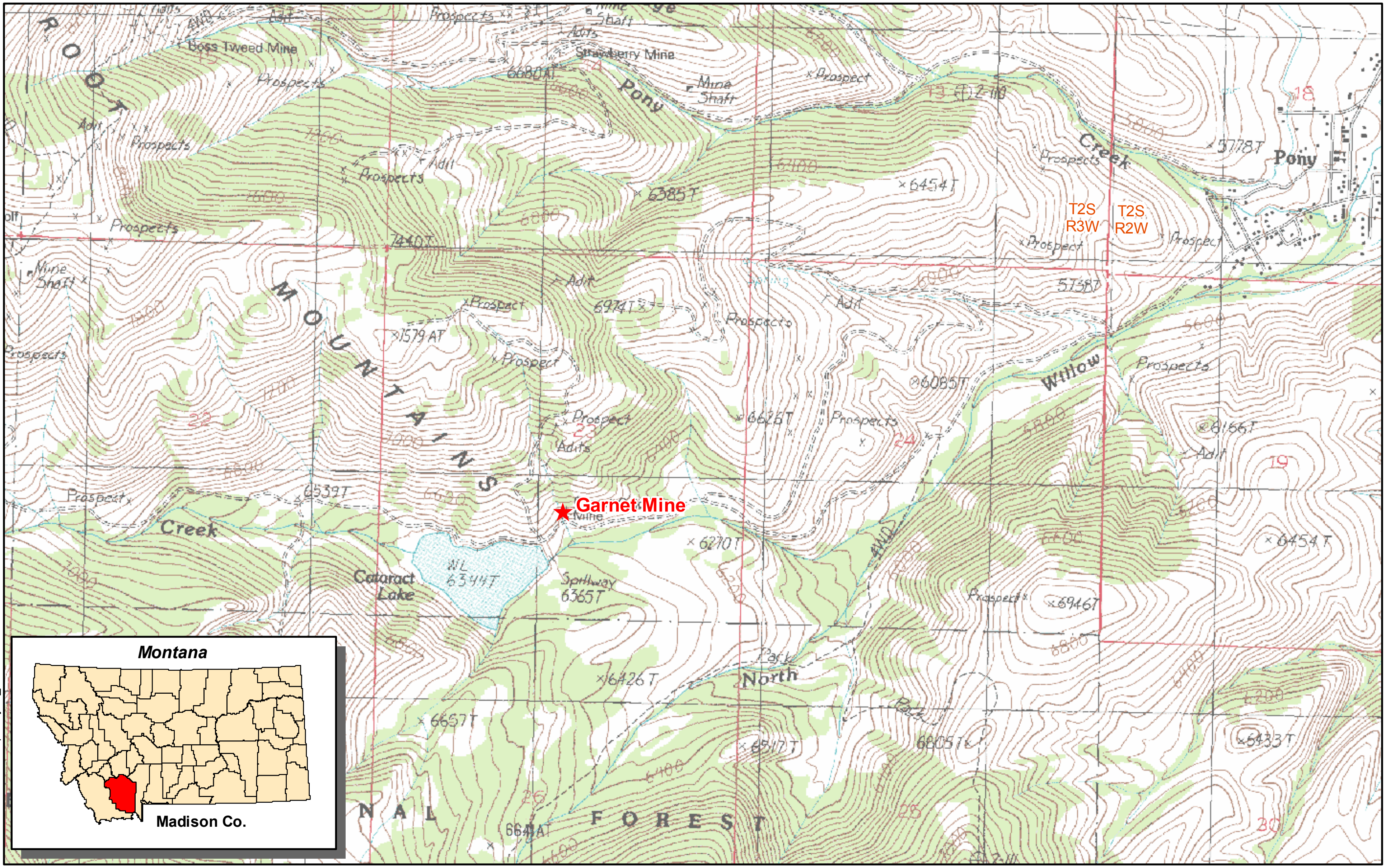
APPENDIX A

SITE MAPS



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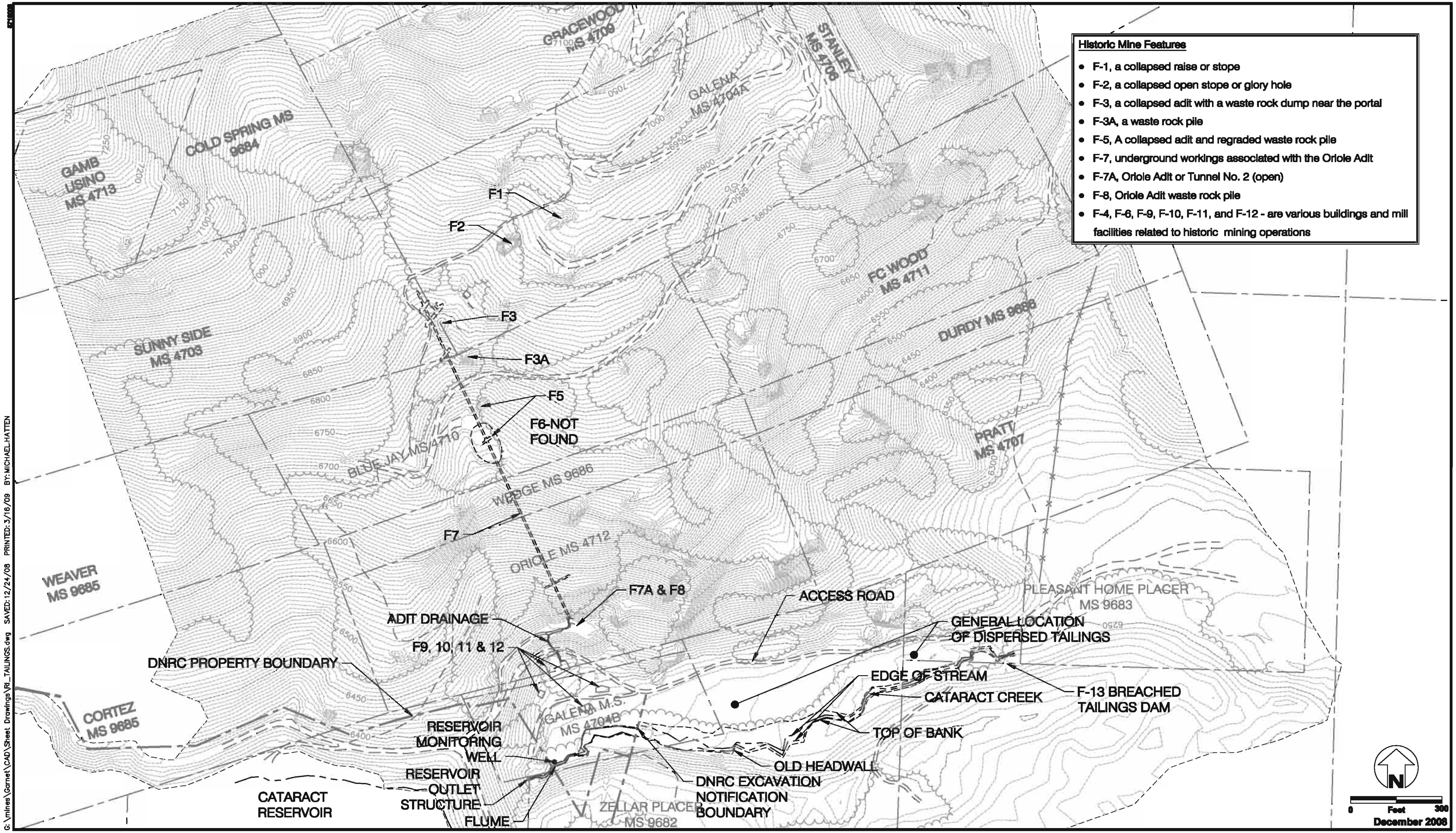
December 2008

General Location Map
Garnet Mine Reclamation Project
Madison County, Montana
SITE MAP A-1



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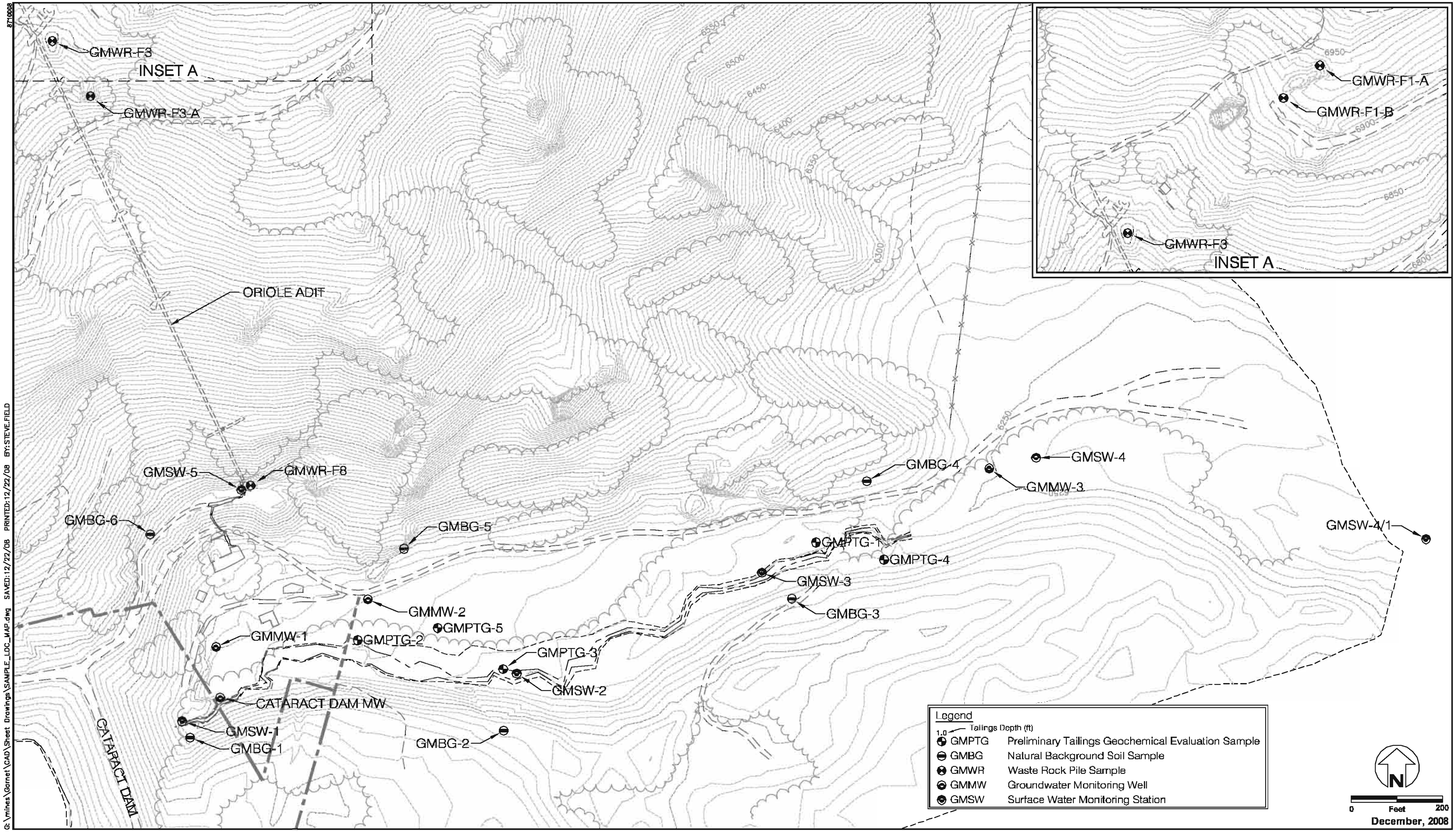
Historic Mine Features and Mine Waste
Garnet Mine Reclamation Project
Madison County, Montana
SITE MAP A-2



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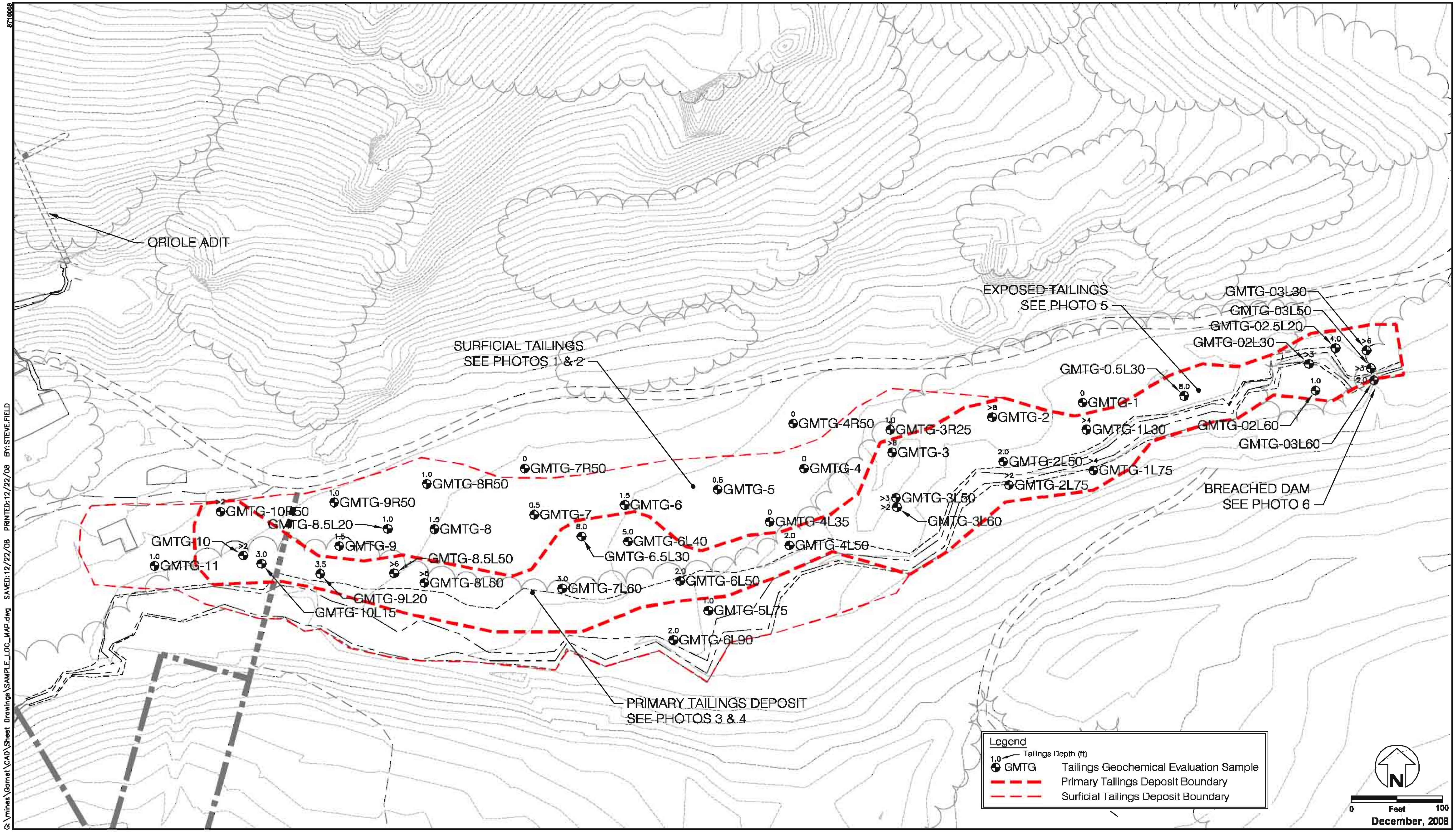
Ground Water, Surface Water, Waste Rock, Background Soil, and Preliminary Tailings Geochemical Sample Locations Map
Garnet Mine Reclamation Project
Madison County, Montana
SITE MAP A-3



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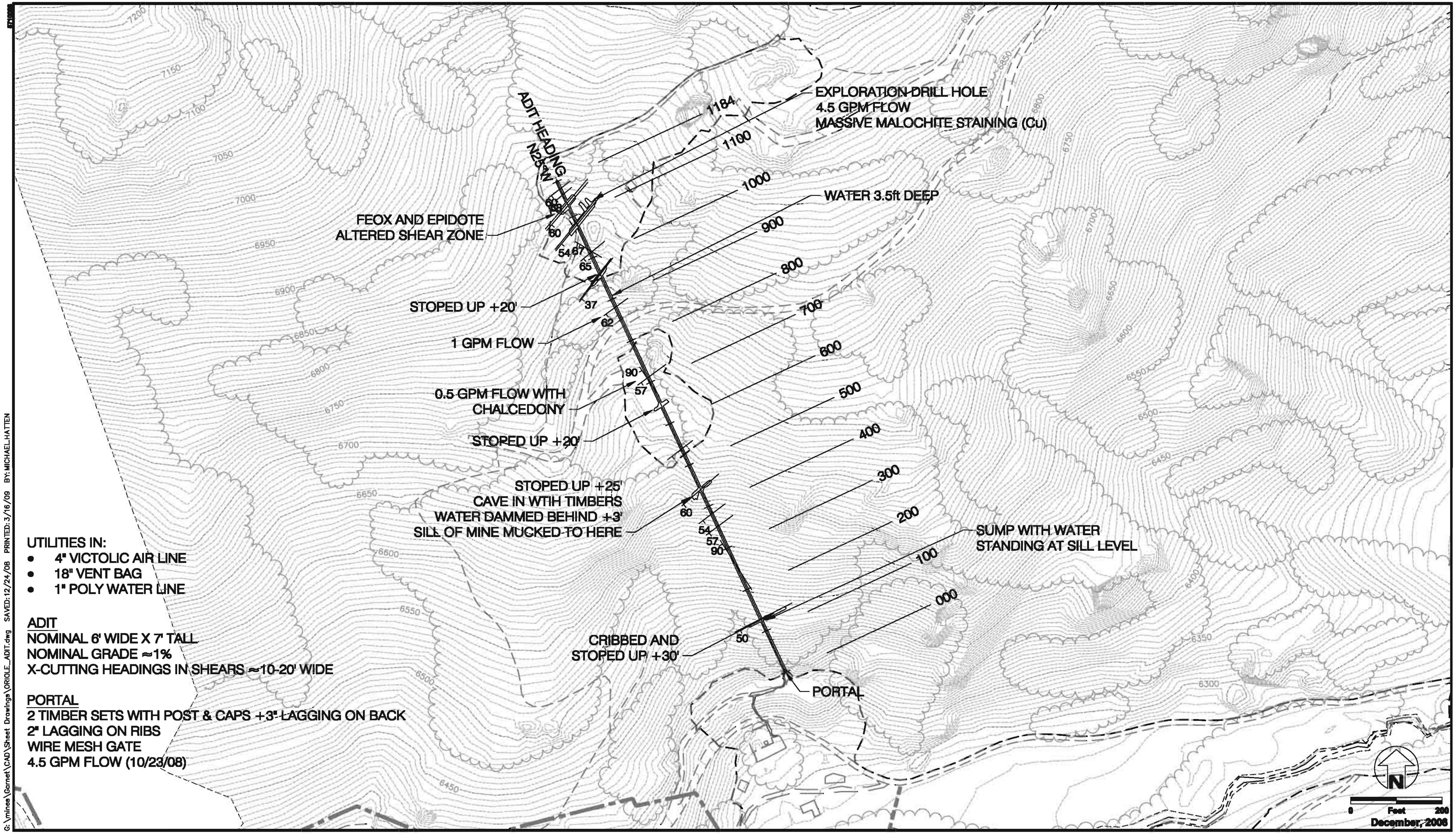
Tailings Sample Locations Map
Garnet Mine Reclamation Project
Madison County, Montana
SITE MAP A-4



G:\mines\Garnet\CAD\Sheet Drawings\ORIOLE_ADIT.dwg SAVED:12/24/08 PRINTED: 3/16/09 BY: MICHAEL HATTEN

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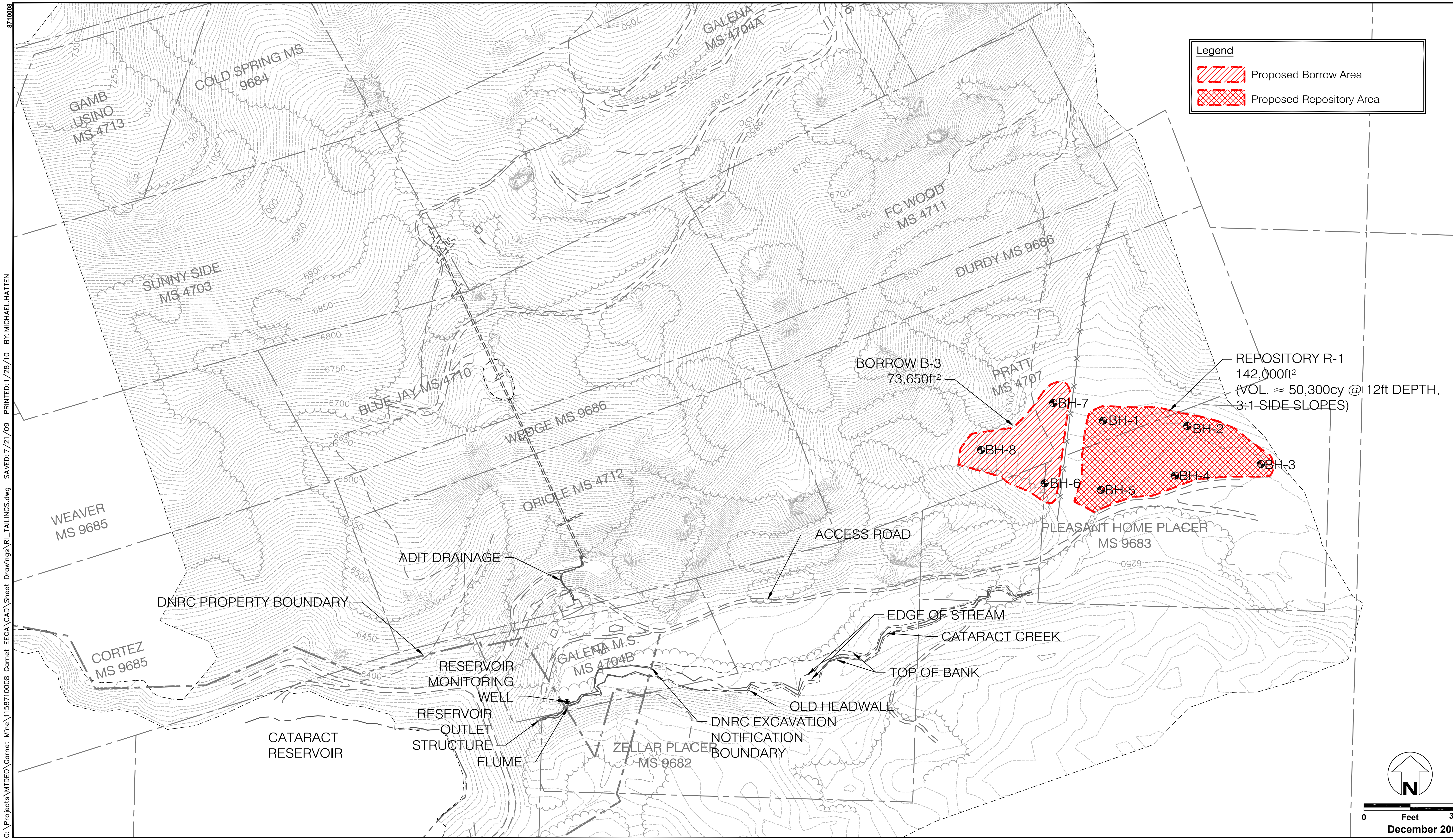
Oriole Adit Survey Map
Garnet Mine Reclamation Project
Madison County, Montana
SITE MAP A-5



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Borrow and Repository Areas
Garnet Mine Reclamation Project
Madison County, Montana
SITE MAP A-6

APPENDIX B

MONITORING DATA TABLES

Table B-1. Waste rock and tailings analytical data.

NOTES:
Red indicates ABA data suggesting the sample is potentially acid generating or metal concentration that exceeds Human Health SW standards
Orange indicates ABA data for sample is inconclusive or metal concentration that exceed acute SW standards
Yellow indicates sample exceeds SMCL or chronic SW standards
Hardness dependent standards calculated for 40 mg/L hardness (avg hardness of Cataract Ck for July 1st 2008 monitoring event).
a=acute, c=chronic, h=human health, 2=secondary SMCL

				Tailing Samples					**Waste Rock Samples**					
Parameter	Unit	RL	Standard or Guideline	GMTG-1	GMTG-2	GMTG-3	GMTG-4	GMTG-5	GMWR-F1-A	GMWR-F1-B	GMWR-F3	GMWR-F3-A	GMWR-F5	GMWR-F8
Acid Base Accounting														
Acid/Base Potential	t/kt	-5000	<-20, >+20	-5	3	0	-2	0	6	-6	-2	3	4	-1
NP/AP		NA	<1, >3	0.0	3.8	1.6	0.0	1.2	6.0	0.3	0.6	2.2	2.6	0.7
Acid Potential	t/kt	1		4.9	0	0	2.2	2.2	0	8.4	5.5	2.7	2.5	4.7
Neutralization Potential	t/kt	1		0	3.8	1.6	0	2.7	6	2.7	3.3	6	6.6	3.3
Sulfur, HCl Extractable	%	0.01		0.05	ND	0.01	0.03	0.02	ND	0.2	0.06	0.01	0.02	0.02
Sulfur, HNO3 Extractable	%	0.01		0.1	0.02	0.02	0.04	0.05	ND	0.07	0.11	0.07	0.06	0.12
Sulfur, Hot Water Extractable	%	0.01		0.07	0.03	0.04	0.08	0.05	ND	0.14	0.09	0.03	ND	ND
Sulfur, Residual	%	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfur, Total	%	0.01		0.22	0.05	0.07	0.14	0.12	ND	0.41	0.26	0.11	0.07	0.16
Metal Mobility (SPLP)														
Aluminum*	mg/L	0.3	0.750(a), 0.087(c)	ND	11.3	0.6	ND	3	8.5	ND	0.4	1.2	10.6	0.4
Arsenic	mg/L	0.003	0.34(a), 0.15(c), 0.010(h)	ND	0.008	0.006	ND	0.004	0.015	ND	ND	ND	ND	ND
Cadmium	mg/L	0.00008	0.00084(a), 0.00014(c), 0.005(h)	0.011	0.0004	0.001	0.0021	0.0004	0.00068	ND	0.00033	0.0002	ND	ND
Copper	mg/L	0.001	0.0059(a), 0.0043(c), 1.3(h)	1.14	0.154	0.117	0.02	0.19	0.041	0.021	0.004	0.084	0.054	0.008
Iron	mg/L	0.05	1.0(c), 0.3(2)	ND	5.97	5.14	0.05	3.95	5.48	0.08	ND	2.4	4.06	0.43
Lead	mg/L	0.0005	0.025(a), 0.001(c), 0.015(h)	7.23	1.16	0.759	2.05	0.994	0.384	0.337	0.541	0.495	0.202	0.0378
Manganese	mg/L	0.005	0.05(2)	0.034	0.036	0.011	0.023	0.165	0.63	0.058	0.849	0.076	0.356	0.01
Mercury	mg/L	0.00001	0.0017(a), 0.00091(c), 0.00005(h)	ND	0.00148	0.00083	ND	0.00071	0.00002	ND	ND	0.00016	0.0001	ND
Zinc	mg/L	0.01	0.055 (a and c), 2.0 (h)	1	0.08	0.08	0.2	0.07	0.12	0.03	0.04	0.04	0.05	ND

* Surface water standards for aluminum are based on dissolved concentrations and apply only to water with pH values between 6.5 and 9. SPLP extracts are analyzed for total concentrations.

Table B-2. Comparison of background soil and initial tailings XRF data.

Tailings Samples	Cr	Cu	Hg	Pb
	ppm			
GMTG-1	< 147.2	258.7 +/- 44.1	< 8.2	1916 +/- 74
GMTG-1 reshoot		279	< 9.1	
GMTG-1 avg		268.85	< 8.65	
GMTG-2	< 119.9	83.9 +/- 28.2	< 6.9	877 +/- 47.2
GMTG-3	< 127.6	91.4 +/- 28.2	< 7.3	792.4 +/- 43.8
GMTG-4	< 144.8	160.5 +/- 36.4	< 7.8	1,573 +/- 66
GMTG-5	< 137.8	626.7 +/- 59.8	13.6 +/- 7.2	3,870 +/- 98
Tailings Average	**< 135.5**	**246.27**	**< 8.85**	**1,806**
Standard Deviation	**< 11.56**	**225.25**	**< 2.73**	**1247**
Avg + 1 Std Dev	**< 147**	**471.52**	**< 11.6**	**3052**

Background Soil Samples	Cr	Cu	Hg	Pb
	ppm			
GMBG-1	< 187.2	< 36.8	< 6.1	36.4 +/- 13.3
GMBG-2	< 139.9	< 32.1	< 7.1	27.0 +/- 11.6
GMBG-3	< 162.4	327.6 +/- 48.8	< 7.8	894.2 +/- 51.2
GMBG-3 reshoot 1	< 151.2	190.9	< 7.8	447.7
GMBG-3 reshoot 2	< 173.3	210.2	< 8.6	639.5
GMBG-3 avg	< 162.3	242.9	< 8.07	660.5
GMBG-4	< 169.4	< 36.2	< 7.4	28.2 +/- 12.9
GMBG-5	< 135.9	< 40.1	< 7.8	219 +/- 26.3
GMBG-5 reshoot	< 147.1	60.1 +/- 29	< 6.5	226.5 +/- 26.7
GMBG-5 avg	< 141.5	50.1	< 7.15	222.8
GMBG-6	< 201	< 40.6	< 7.4	29.0 +/- 13.8
Bkgnd Average	**< 166.9**	**73.117**	**< 7.2**	**167.3**
Standard Deviation	**< 24.4**	**83.4**	**< 0.64**	**253.6**
Avg + 1 Std Dev	**< 191.3**	**156.52**	**< 7.84**	**420.9**

Screening Values
For Tailings Delineation

Cr, not applicable
<70 ppm Cu = Not Impacted
Hg, not applicable
<400 ppm Pb = Not Impacted

Table B-3. Comparison of tailings delineation survey data to screening values.

SAMPLE	Arsenic (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)	Cu Screen	Pb Screen	Screen Total	Pass/Fail	Depth of Tailings (ft)	Comments
Tailings/Background Screening Level	**None**	**70**	**None**	**400**	**None**	**None**	**None**						
GMTG-03L30-00-01	<	88	7006	485	<	<	100	1	1	2	FAIL		
GMTG-03L30-01-02	<	344	16238	128	1840	<	89	1	0	1	FAIL		
GMTG-03L30-02-03	<	55	5519	668	544	<	39	0	1	1	FAIL		
GMTG-03L30-03-04	<	189	9193	2053	252	<	62	1	1	2	FAIL		
GMTG-03L30-04-05	<	152	11448	655	1073	<	62	1	1	2	FAIL		
GMTG-03L30-04-05R	<	270	16021	1317	652	<	279	1	1	2	FAIL		
GMTG-03L30-05-06	<	139	11098	1186	860	<	44	1	1	2	FAIL		Refusal Boulders
GMTG-03L50-00-01	<	196	7400	1921	<	<	48	1	1	2	FAIL		
GMTG-03L50-01-02	<	374	14978	20	505	<	71	1	0	1	FAIL		
GMTG-03L50-02-03	<	1094	15594	175	1205	<	142	1	0	1	FAIL		Refusal Boulders
GMTG-03L60-00-01	<	122	6418	1357	<	<	36	1	1	2	FAIL		
GMTG-03L60-00-01R	<	115	5006	1143	<	<	<	1	1	2	FAIL		
GMTG-03L60-01-02	<	1024	14874	34	323	<	43	1	0	1	FAIL		
GMTG-03L60 01-02R	<	<	17827	65	481	<	199	0	0	0	PASS	2.0	
GMTG-02L30-00-01	<	249	8687	699	149	<	<	1	1	2	FAIL		
GMTG-02L30-01-02	<	145	2783	381	<	<	<	1	0	1	FAIL		
GMTG-02L30-02-03	<	216	12809	62	215	<	418	1	0	1	FAIL		Water - adjacent to creek
GMTG-02L60-00-01	<	478	11952	2939	<	<	225	1	1	2	FAIL		
GMTG-02L60-01-02	<	<	17299	19	598	<	188	0	0	0	PASS	1.0	1.0
GMTG-02.5L20-00-01	<	144	11277	732	296	<	55	1	1	2	FAIL		
GMTG-02.5L20-01-02	<	483	9224	5671	206	<	43	1	1	2	FAIL		
GMTG-02.5L20-02-03	<	56	4893	655	<	<	<	0	1	1	FAIL		
GMTG-02.5L20-03-04	<	197	3972	657	<	<	<	1	1	2	FAIL		
GMTG-02.5L20-04-05	<	<	14828	25	310	<	28	0	0	0	PASS	4.0	4.0
GMTG-02.5L20-05-06	<	<	15854	34	274	<	40	0	0	0	PASS		
GMTG-0.5L30-00-03	<	165	7321	1264	<	<	122	1	1	2	FAIL		
GMTG-0.5L30-03-06	<	282	8509	2196	<	<	71	1	1	2	FAIL		
GMTG-0.5L30-06-09	<	42	25299	36	358	<	44	0	0	0	PASS		8.0
GMTG-1-00-01	<	<	8235	36	251	<	<	0	0	0	PASS	0.0	
GMTG-1-01-02	<	<	11630	24	586	<	<	0	0	0	PASS		Water at 2ft
GMTG-1-02-03	<	<	7456	19	573	<	27	0	0	0	PASS		
GMTG-1L30-00-01	<	122	7749	1173	<	<	83	1	1	2	FAIL		
GMTG-1L30-01-02	<	<	1995	403	<	<	<	0	1	1	FAIL		
GMTG-1L30-02-03	<	84	11256	1273	<	<	106	1	1	2	FAIL		Water at 3 ft
GMTG-1L30-03-04	<	320	8150	2581	<	<	31	1	1	2	FAIL		

< indicates that paramter was not detected with XRF unit.
For "Copper Screen" and "Lead Screen", a value of 1 indicates that sample exceeded screening level for that respective metal while a 0 indicates that sample did not exceed screening level.

Tailings/Background Screening Level	None	70	None	400	None	None	None						
SAMPLE	**Arsenic (mg/kg)**	**Copper (mg/kg)**	**Iron (mg/kg)**	**Lead (mg/kg)**	**Manganese (mg/kg)**	**Mercury (mg/kg)**	**Zinc (mg/kg)**	Cu Screen	Pb Screen	Screen Total	**Pass/Fail**	**Depth of Tailings (ft)**	**Comments**
GMTG-1L75-00-01	<	210	13044	639	<	<	103	1	1	2	FAIL		
GMTG-1L75-01-02	<	162	7910	1117	<	<	190	1	1	2	FAIL		
GMTG-1L75-02-03	<	123	8029	436	<	<	38	1	1	2	FAIL		Water at 3ft
GMTG-1L75-03-04	<	<	20017	2547	373	<	61	0	1	1	FAIL		
GMTG-2-00-03	<	83	5792	749			24	1	1	2	FAIL		
GMTG-2-03-06	<	97	5333	977	<	<	43	1	1	2	FAIL		
GMTG-2-07-08	<	125	3586	2176	<	<	411	1	1	2	FAIL		Unsafe
GMTG-2L50-00-01	<	177	6596	511	<	<	96	1	1	2	FAIL		
GMTG-2L50-01-02				1592			32	0	1	1	FAIL		
GMTG-2L50-02-03	<	48	17438	54	197	<	50	0	0	0	PASS	2.0	
GMTG-2L75-00-01	<	1006	6780	3178	<	<	131	1	1	2	FAIL		
GMTG-2L75-00-02	<	213	4794	236	319	<	29	1	0	1	FAIL		Reach across creek
GMTG-3-00-03	<	134	7091	736	<	<	49	1	1	2	FAIL		
GMTG-3-03-06	<	93	5293	596	<	<	29	1	1	2	FAIL		
GMTG-3-07-08	<	94	10088	533	217	<	42	1	1	2	FAIL		Unsafe
GMTG-3L50-00-01	<	156	6508	1367	<	<	33	1	1	2	FAIL		
GMTG-3L50-01-02	<	383	13626	26	448	<	44	1	0	1	FAIL		
GMTG-3L50-02-03	<	571	16190	275	561	<	92	1	0	1	FAIL	??	
GMTG-3L60-00-01	<	715	16568	4810	<	<	177	1	1	2	FAIL		
GMTG-3L60-01-02	<	1150	15484	57	160	<	39	1	0	1	FAIL	??	
GMTG-3R25-00-01	<	84	8401	382	139.58	<	<	1	0	1	FAIL		
GMTG-3R25-01-02	<	<	10620	27	376	<	<	0	0	0	PASS	1.0	
GMTG-4-00-0.5	<	47	12572	111	160	<	<	0	0	0	PASS	0.0	
GMTG-4-0.5-1.0	<	<	13966	108	368	<	<	0	0	0	PASS		
GMTG-4-1.0-1.5	<	<	23319	31	352	<	<	0	0	0	PASS		
GMTG-4-1.5-2.0	<	<	9368	<	402	<	<	0	0	0	PASS		
GMTG-4L35-00-01	<	<	16924	82	352	<	65	0	0	0	PASS	0.0	
GMTG-4L35-01-02	<	<	23121	22	224	<	<	0	0	0	PASS		
GMTG-4L5O-00-01	<	103	5534	964	<	<	<	1	1	2	FAIL		
GMTG-4L50-01-02	<	114	7255	684	172	<	27	1	1	2	FAIL		
GMTG-4L50-02-03	<	<	24371	21	394	<	36	0	0	0	PASS	2.0	

< indicates that paramter was not detected with XRF unit.
For "Copper Screen" and "Lead Screen", a value of 1 indicates that sample exceeded screening level for that respective metal while a 0 indicates that sample did not exceed screening level.

Table B-3. Results of Tailings Delineation Survey.

Tailings/Background Screening Level	None	70	None	400	None	None	None						
SAMPLE	**Arsenic (mg/kg)**	**Copper (mg/kg)**	**Iron (mg/kg)**	**Lead (mg/kg)**	**Manganese (mg/kg)**	**Mercury (mg/kg)**	**Zinc (mg/kg)**	Cu Screen	Pb Screen	Screen Total	**Pass/Fail**	**Depth of Tailings (ft)**	**Comments**
GMTG-4R50-00-0.5	<	65	24332	394	<	<	<	0	0	0	PASS	0.0	
GMTG-4R50-0.5-1.0	<	39	9061	148	<	<	25	0	0	0	PASS		
GMTG-4R50-1.0-1.5	<	<	17351	37	<	<	<	0	0	0	PASS		
GMTG-4R50-1.5-2.0	<	<	21763	27	234	<	<	0	0	0	PASS		
GMTG-5-00-0.5	<	85	13123	285	344	<	33	1	0	1	FAIL		
GMTG-5-0.5-1.0	<	<	17137	109	253	<	53	0	0	0	PASS	0.5	
GMTG-5-1.0-1.5	<	<	27233	37	302	<	<	0	0	0	PASS		
GMTG-5-1.5-2.0	<	<	28378	<	393	<	<	0	0	0	PASS		
GMTG-5L75-00-01	<	54	4221	742	<	<	<	0	1	1	FAIL		
GMTG-5L75-01-02	<	<	26228	32	342	<	30	0	0	0	PASS	1.0	
GMTG-5L75-02-03	<	<	10412	24	237	<	<	0	0	0	PASS		
GMTG-5L75-02-03R	<	<	31026	278	532	<	<	0	0	0	PASS		
GMTG-6-00-0.5	<	139	14508	217	336	<	40	1	0	1	FAIL		
GMTG-6-0.5-1.0	<	144	15590	184	853	<	42	1	0	1	FAIL		
GMTG-6-1.0-1.5	<	81	27870	69	1358	<	52	1	0	1	FAIL		
GMTG-6-1.5-2.0	<	<	25141	<	524	<	<	0	0	0	PASS	1.5	
GMTG-6L50-00-01	<	60.3	4947	454	<	<	<	0	1	1	FAIL		
GMTG-6L50 01-02	<	626	22567	93	454	<	30	1	0	1	FAIL		
GMTG-6L50 02-03	<	<	21649	22	356	<	<	0	0	0	PASS	2.0	
GMTG-6L90-00-01	<	149	14728	510	777	<	156	1	1	2	FAIL		
GMTG-6L90-01-02	<	<	27887	51	622	<	35	0	0	0	PASS	2.0	
GMTG-6.5L30-00-03	<	126	6233	802	<	<	70	1	1	2	FAIL		
GMTG6.5L30 3-6	<	197	8124	1730	164	<	59	1	1	2	FAIL		
GMTG6.5L30 6-9	<	42	25299	36	358	<	44	0	0	0	PASS	8.0	
GMTG-7-00-0.5	<	241	13784	254	342	<	70	1	0	1	FAIL		
GMTG-7-0.5-1.0	<	<	30783	20	529	<	37	0	0	0	PASS	0.5	
GMTG-7-1.0-1.5	<	<	27913	19	559	<	36	0	0	0	PASS		
GMTG6L40 00-01LBANK	<	153	17906	600	560	<	116	1	1	2	FAIL		
GMTG6L40 00-01RBANK	<	611	18406	3781	<	<	102	1	1	2	FAIL		
GMTG-6L40-01-02	<	215	19938	99	811	10	80	1	0	1	FAIL		
GMTG-6L40-02-03	<	247	21572	99	818	<	83	1	0	1	FAIL		
GMTG-6L40-03-04	<	176	21938	80	818	<	67	1	0	1	FAIL		
GMTG-6L40-04-05	<	259	21391	74	609	<	60	1	0	1	FAIL		
GMTG-6L40-05-06	<	63	20296	27	745	<	33	0	0	0	PASS	5.0	

< indicates that paramter was not detected with XRF unit.
For "Copper Screen" and "Lead Screen", a value of 1 indicates that sample exceeded screening level for that respective metal while a 0 indicates that sample did not exceed screening level.

SAMPLE	Arsenic (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)	Cu Screen	Pb Screen	Screen Total	Pass/Fail	Depth of Tailings (ft)	Comments
Tailings/Background Screening Level	None	70	None	400	None	None	None						
GMTG-7L60-00-01	<	83	5647	808	140	<	36	1	1	2	FAIL		
GMTG-7L60-01-02	<	413	35603	<	834	<	52	1	0	1	FAIL		
GMTG-7L60-02-03	<	159	28513	24	536	<	47	1	0	1	FAIL		
GMTG-7L60-03-04	<	<	23320	37	357	<	<	0	0	0	PASS	3.0	
GMTG-7R50-00-0.5	<	42	7074	329	<	<	38	0	0	0	PASS	0.0	0.0
GMTG-7R50-0.5-1.0	<	44	18166	32	586	<	119	0	0	0	PASS		
GMTG-7R50-1.0-1.5	<	<	20415	24	345	<	37	0	0	0	PASS		
GMTG-7R50-1.5-2.0	<	<	27211	17	417	<	<	0	0	0	PASS		
GMTG-8 00-0.5	<	259	18306	82	318	<	67	1	0	1	FAIL		
GMTG-8-0.5-1.0	<	261	21398	124	256	<	48	1	0	1	FAIL		
GMTG-8-1.0-1.5	<	149	37336	18	658	<	44	1	0	1	FAIL		
GMTG-8-1.5-2.0	<	<	33778	21	1103	<	47	0	0	0	PASS	1.5	1.5
GMTG-8L50-03-04	<	299	28906	258	957	<	81	1	0	1	FAIL		
GMTG-8L50-04-05	<	96	26023	108	861	<	95	1	0	1	FAIL	??	Missing 0-1,1-2,2-3 and 5-6
GMTG-8R50-00-0.5	<	241	8736	525	395	<	133	1	1	2	FAIL		
GMTG-8R50-0.5-1.0	<	118	13819	51	882	<	214	1	0	1	FAIL		
GMTG-8R50-1.0-1.5	<	<	18806	24	404	<	49	0	0	0	PASS	1.0	1.0
GMTG-8R50-1.5-2.0	<	<	21991	26	338	<	83	0	0	0	PASS		
GMTG-8.5L20-00-01	<	661	20994	44	1087	<	77	1	0	1	FAIL		
GMTG-8.5L20-01-02	<	<	20045	62	773	<	54	0	0	0	PASS	1.0	1.0
GMTG-8.5L5O-00-01	<	1960	24156	12813	<	<	141	1	1	2	FAIL		
GMTG-8.5L5O-01-02	<	714	23428	938	596	<	56	1	1	2	FAIL		
GMTG-8.5L50 03-04	<	405	26952	26.5	1021	<	61	1	0	1	FAIL		
GMTG-8.5L50 04-05	<	298	29231	26	1070	<	64	1	0	1	FAIL		
GMTG-8.5L50 05-06	<	684	21515	46	691	<	<	1	0	1	FAIL	??	Visible depth of Tailings 18"
GMTG-9-00-0.5	<	737	22529	468	3822	<	244	1	1	2	FAIL		
GMTG-9-0.5-1.0	<	127	23496	40	1946	<		1	0	1	FAIL		
GMTG-9-1.0-1.5	<	167	34410	<	1143	<	54	1	0	1	FAIL		
GMTG-9-1.5-2.0	<	<	269.05	<	<	<	<	0	0	0	PASS	1.5	1.5
GMTG-9L20-00-0.5	<	92	6598	957	<	<	50	1	1	2	FAIL		
GMTG-9L20-0.5-1.0	<	56	6632	610	<	<	49	0	1	1	FAIL		
GMTG-9L20-1.0-1.5	<	49	6208	442	<	<	42	0	1	1	FAIL		
GMTG-9L20-1.5-2.0	<	135	7182	1116	<	<	78	1	1	2	FAIL		
GMTG-9L20-2.0-2.5	<	733	20367	1305	491	<	55	1	1	2	FAIL		
GMTG-9L20-2.5-3.0	<	122	24553	24	683	<	59	1	0	1	FAIL		
GMTG-9L20-3.0-3.5	<	72	25886	42	1339	<	64	1	0	1	FAIL	3.5	Cu just over cutoff

< indicates that paramter was not detected with XRF unit.
For "Copper Screen" and "Lead Screen", a value of 1 indicates that sample exceeded screening level for that respective metal while a 0 indicates that sample did not exceed screening level.

Tailings/Background Screening Level	None	70	None	400	None	None	None						
SAMPLE	**Arsenic (mg/kg)**	**Copper (mg/kg)**	**Iron (mg/kg)**	**Lead (mg/kg)**	**Manganese (mg/kg)**	**Mercury (mg/kg)**	**Zinc (mg/kg)**	Cu Screen	Pb Screen	Screen Total	**Pass/Fail**	**Depth of Tailings (ft)**	**Comments**
GMTG-9R50-00-0.5	<	233	8665	713	<	<	46	1	1	2	FAIL		
GMTG-9R50-0.5-1.0	<	672	19718	32	1227	<	73	1	0	1	FAIL		
GMTG-9R50-1.0-1.5	<	<	28154	59	1816	<	93	0	0	0	PASS	1.0	1.0
GMTG-9R50-1.5-2.0	<	<	41172	65	1774	<	63	0	0	0	PASS		
GMTG-10-00-0.5	<	209	10623	792	166	<	75	1	1	2	FAIL		
GMTG-10-0.5-1.0	<	190	13977	286	341	<	75	1	0	1	FAIL		
GMTG-10-1.0-1.5	<	251	20534	38	724	<	81	1	0	1	FAIL		
GMTG-10-1.5-2.0	<	224	21344	51	744	<	38	1	0	1	FAIL	??	Visible tailings 06"-12"
GMTG-10L15-00-0.5	<	157	9371	2124	<	<	122	1	1	2	FAIL		
GMTG-10L15-0.5-1.0	<	394	10955	558	232	<	66	1	1	2	FAIL		
GMTG-10L15-0.5-1.0R	<	381	10823	524	245	<	46	1	1	2	FAIL		
GMTG-10L15-1.0-1.5	<	534	17969	27	892	<	83	1	0	1	FAIL		
GMTG-10L15-1.5-2.0	<	431	19350	36	785	<	45	1	0	1	FAIL		
GMTG-10L15-2.0-2.5	<	215	22705	<	832	<	37	1	0	1	FAIL		
GMTG-10L15-2.5-3.0	<	188	28258	21	1066	<	74	1	0	1	FAIL		
GMTG-10L15-03-04	<	<	27949	73	<	<	<	0	0	0	PASS	3.0	3.0
GMTG-10R50-00-06	<	534	15138	105.9	604	<	63	1	0	1	FAIL		
GMTG-10R50-06-12	<	790	15766	73	1033	<	68	1	0	1	FAIL		
GMTG-10R50-12-18	<	917	15535	35	1133	<	93	1	0	1	FAIL		
GMTG-10R50-18-24	<	974	15102	40	1042	<	59	1	0	1	FAIL	??	No Visible Tailing
GMTG-11-00-0.5	<	580	13781	737	7391	<	511	1	1	2	FAIL		
GMTG-11-0.5-1.0	<	219	17835	314	4280	<	334	1	0	1	FAIL		
GMTG-11-01-1.5	<	<	12699	66	1113	<	92	0	0	0	PASS	1.0	1.0
GMTG-11-1.5-2.0	<	<	15810	41	832	<	64	0	0	0	PASS		
GMTG-11-2.0-2.5	<	<	14029	46	809	<	82	0	0	0	PASS		
GMTG-11-R50	<	171	17948	627	1083	<	114	1	1	2	FAIL	Bulk	Passed in Field Test
GMTG-11R100	<	<	16111	84	1079	<	162	0	0	0	PASS	Bulk	
GMTG-11.5R50	<	<	21247	59	1229	<	100	0	0	0	PASS	Bulk	

< indicates that paramter was not detected with XRF unit.
For "Copper Screen" and "Lead Screen", a value of 1 indicates that sample exceeded screening level for that respective metal while a 0 indicates that sample did not exceed screening level.

Table B-4. XRF database (used for risk analysis).

SAMPLE	As	As Error	Co	Co Error	Cr	Cr Error	Cu	Cu Error	Fe	Fe Error	Hg	Hg Error	Mn	Mn Error	Mo	Mo Error
Background Soil Samples																
GMBG-1	< LOD	16.23	< LOD	231.01	< LOD	187.24	< LOD	36.8	18243.13	526.26	< LOD	6.11	1239.64	194.86	< LOD	5.8
GMBG-2	< LOD	12.98	< LOD	202.05	< LOD	139.88	< LOD	32.12	14842.52	457.23	< LOD	7.11	837.48	157.67	< LOD	5.58
GMBG-3	< LOD	58.94	< LOD	217.81	< LOD	162.44	327.58	48.82	16375.53	496.75	< LOD	7.82	950.14	174.34	6.69	4.08
GMBG-4	< LOD	14.79	< LOD	252.8	< LOD	169.37	< LOD	36.16	19817.85	562.73	< LOD	7.37	1462.58	213.68	< LOD	6.04
GMBG-5	< LOD	30.55	< LOD	219.71	< LOD	135.89	< LOD	40.09	16654.54	500	< LOD	7.76	1160.79	185.97	< LOD	5.72
GMBG-6	< LOD	16.29	< LOD	267.54	< LOD	201.03	< LOD	40.59	20194.57	606.59	< LOD	7.44	1209.32	212.52	< LOD	6.61
Tailings Samples																
GMTG-1	< LOD	82.45	< LOD	199.22	< LOD	147.19	258.67	44.09	13564.15	446.84	< LOD	8.17	< LOD	131.94	13.56	4.11
GMTG-2	< LOD	51.8	< LOD	129.26	< LOD	119.87	83.93	28.22	6398.86	291.86	< LOD	6.89	< LOD	118.8	8.98	3.7
GMTG-3	< LOD	49.8	< LOD	133.66	< LOD	127.6	91.37	28.16	7172.43	300.26	< LOD	7.31	< LOD	106.84	10.89	3.66
GMTG-4	< LOD	72.13	< LOD	159.5	< LOD	144.81	160.48	36.38	9398.36	366.49	< LOD	7.77	< LOD	132.26	11.15	3.95
GMTG-5	< LOD	110.91	< LOD	189.41	< LOD	137.82	626.72	59.79	13160.45	415.85	13.61	7.2	243.61	110.76	7.08	3.69
GMTG-0.5L30-00-03	< LOD	68.15	< LOD	156.44	< LOD	143.53	165.88	37.85	7321.83	331.74	< LOD	7.43	< LOD	118.51	12.98	4.11
GMTG-0.5L30-03-06	< LOD	84.09	< LOD	158.96	< LOD	128.35	282.54	43.51	8509.82	341	< LOD	8.53	< LOD	107.03	8.21	3.74
GMTG-0.5L30-07-08	< LOD	11.98	< LOD	255.33	< LOD	167.44	44.97	25.05	24928.84	571.44	< LOD	6	320.92	121.51	7.67	3.9
GMTG-01-01-02	< LOD	13.78	< LOD	181.57	< LOD	136.1	< LOD	31.86	11630.19	423.15	< LOD	7.2	586.64	142.2	< LOD	5.71
GMTG-01L30-00-01	< LOD	61.25	< LOD	142.51	< LOD	125.73	122.69	31.48	7749.29	318.28	< LOD	6.34	< LOD	109.74	7.28	3.64
GMTG-01L30-01-02	< LOD	32.16	< LOD	73.57	< LOD	93.08	< LOD	25.62	1995.29	153.9	< LOD	5.54	< LOD	95.34	< LOD	4.84
GMTG-01L30-02-03	< LOD	63.66	< LOD	176.27	< LOD	125.22	84.76	28.65	11256.78	384.71	< LOD	6.94	< LOD	121.97	10.89	3.81
GMTG-01L30-03-04	< LOD	87.67	< LOD	152.41	< LOD	148.34	320.68	44.95	8150.35	328.75	< LOD	8.8	< LOD	123.72	9.13	3.71
GMTG-01L75-00-01	< LOD	45.54	< LOD	184.5	< LOD	139.11	210.7	37.92	13044.99	411.88	< LOD	6.44	< LOD	130.47	< LOD	5.32
GMTG-01L75-01-02	< LOD	57.19	< LOD	139.14	< LOD	117.27	162.35	33.34	7910.56	312.12	< LOD	7.25	< LOD	113.69	< LOD	5.27
GMTG-01L75-02-03	< LOD	35.62	< LOD	135.98	< LOD	117.93	123.67	29.71	8029.02	309.98	< LOD	5.47	< LOD	107.1	5.29	3.41
GMTG-01L75-03-04	< LOD	13.42	< LOD	240.01	< LOD	172.71	< LOD	33.86	20017.64	522.65	< LOD	6.14	373.9	125.24	< LOD	5.73
GMTG02.5 0-1	< LOD	53.06	< LOD	187.06	< LOD	153.95	144.39	36.16	11277.94	410.48	< LOD	8.32	296.05	115.64	< LOD	5.74
GMTG02.5 1-2	< LOD	141.77	< LOD	181.96	< LOD	146.17	483.47	60.24	9224.21	389.07	< LOD	10.51	206.91	118.11	14.46	4.37
GMTG02.5 4-5	< LOD	12.46	< LOD	208.57	< LOD	149.59	< LOD	35.11	14828.92	458.04	< LOD	6.55	310.42	115.63	< LOD	5.6
GMTG-02.5L20-02-0	< LOD	42.24	< LOD	109.58	< LOD	100.74	56.61	23.55	4893.01	240.77	< LOD	6.25	< LOD	94.51	6.13	3.38
GMTG-02.5L20-03-0	< LOD	42.36	< LOD	100.21	< LOD	110.16	197.61	34.89	3972.2	220.34	< LOD	6.35	< LOD	94.93	6.26	3.42
GMTG-02.5L20-04-0	< LOD	14.38	< LOD	218.58	< LOD	148.21	< LOD	34.31	15854.9	480.92	< LOD	7.41	274.5	114.7	< LOD	5.47
GMTG02L30 0-1	< LOD	55.05	< LOD	198.43	< LOD	145.14	390.65	50.77	13886	444.36	< LOD	6.86	< LOD	142.93	< LOD	5.61
GMTG02L30 1-2	< LOD	36.53	< LOD	84.02	< LOD	91.19	179.01	33.26	2757.51	184.5	< LOD	5.72	126.17	72.23	5.78	3.38
GMTG02L30 2-3	< LOD	48.43	< LOD	132.06	< LOD	102.88	2042.32	85.7	8384.81	277.48	< LOD	5.44	< LOD	94.3	22.79	3.42
GMTG-02L30-00-01	< LOD	46.87	< LOD	153.77	< LOD	137.51	249.87	40.42	8687.38	337.83	< LOD	6.98	149.99	89.62	7.06	3.65
GMTG-02L30-01-02	< LOD	33.2	< LOD	83.85	< LOD	96.8	145.43	30.17	2783.71	180.79	< LOD	5.78	< LOD	91.17	< LOD	4.83
GMTG-02L30-02-03	< LOD	15.7	< LOD	176.35	< LOD	142.49	216.73	35.01	12809.78	377.89	< LOD	5.65	215.55	93	7.05	3.45
GMTG-02L60-00-01	< LOD	97.28	< LOD	187.21	< LOD	150.96	478.92	54.11	11952.62	403.15	< LOD	9.67	< LOD	125.94	6.56	3.73

GMTG-02L60-01-03	< LOD	11.46	< LOD	208.06	< LOD	143.81	< LOD	30.82	17299.78	469.33	< LOD	6.88	598.38	135.16	< LOD	5.42
GMTG-02L75-00-01	< LOD	88.31	< LOD	120.01	< LOD	105.46	1006.82	65.93	6780.09	269.16	< LOD	7.55	< LOD	102.84	8.45	3.31
GMTG-02L75-00-02	< LOD	26.99	< LOD	114.48	< LOD	112.85	213.76	36.34	4794.32	244.95	< LOD	6.3	319.66	98.14	< LOD	5.07
GMTG-03L30 03-04	< LOD	79.74	< LOD	162.52	< LOD	126.97	189.65	38.08	9193.13	359.72	< LOD	7.87	252.22	106.19	9.98	3.89
GMTG-03L30 04-05	< LOD	50.48	< LOD	182.42	< LOD	167.82	152.54	36.69	11448.41	414.93	< LOD	7.67	1073.31	178.69	< LOD	5.81
GMTG-03L30 04-05	< LOD	68.72	< LOD	223.77	< LOD	163.57	270.38	45.25	16021.94	488.34	< LOD	8.43	652.37	152.51	< LOD	5.72

Table B-4. XRF database (used for risk analysis).

SAMPLE	As	As Error	Co	Co Error	Cr	Cr Error	Cu	Cu Error	Fe	Fe Error	Hg	Hg Error	Mn	Mn Error	Mo	Mo Error
Tailings Samples																
GMTG-03L30 05-06	< LOD	61.42	< LOD	183.12	< LOD	128.3	139.93	34.85	11098.65	399.66	< LOD	7.77	860.83	159.05	< LOD	5.6
GMTG-03L50-00-01	< LOD	77.79	< LOD	146.54	< LOD	112.6	196.08	37.87	7400.17	319.28	< LOD	8.19	< LOD	113.82	6.09	3.68
GMTG-03L50-01-02	< LOD	11.75	< LOD	209.88	< LOD	170.92	374.79	50.69	14978.29	467.52	< LOD	8.06	505.01	136.94	< LOD	5.67
GMTG-03L50-02-03	< LOD	25.01	< LOD	210.51	< LOD	134.79	1094.04	77.97	15594.54	460.54	< LOD	7.93	1205.68	179.22	< LOD	5.74
GMTG03L60 0-1	< LOD	62.42	< LOD	128.22	< LOD	116.25	115.55	32.23	5006.46	267.21	< LOD	8.22	< LOD	108.93	12.01	3.94
GMTG03L60 1-2	< LOD	17.2	< LOD	217.73	< LOD	141.91	< LOD	35.1	17827.14	481.19	< LOD	7.11	481.64	127.8	< LOD	5.57
GMTG-03L60-00-01	< LOD	67.96	< LOD	137.18	< LOD	124.16	122.52	33.47	6418.12	304.48	< LOD	7.26	< LOD	106.31	7.4	3.81
GMTG-03L60-01-02	< LOD	13.33	< LOD	193.55	< LOD	143.44	1024.2	71.63	14874.35	425.8	< LOD	5.62	323.7	109.01	< LOD	5.19
GMTG1 0-1	< LOD	13.09	< LOD	143.98	< LOD	119.71	< LOD	31.03	8235.33	326.43	< LOD	6.92	251.31	96.99	< LOD	5.26
GMTG1 1-2	< LOD	11.68	< LOD	178.93	< LOD	131.6	< LOD	29.48	11480.71	408.87	< LOD	6.52	573.11	136.94	< LOD	5.45
GMTG-10-00-06	< LOD	58.4	< LOD	187.6	< LOD	162.18	209.39	43.9	10623.24	422.76	< LOD	8.77	166.32	107.4	< LOD	6.32
GMTG-10-06-12	< LOD	35.41	< LOD	213.96	< LOD	168.62	190.93	41.88	13977.04	477.02	< LOD	7.99	341.02	127.82	< LOD	6.23
GMTG-10-12-18	< LOD	15.47	< LOD	253.72	< LOD	187.38	251.49	45.74	20534.22	572.1	< LOD	7.44	724.53	165.58	< LOD	6.17
GMTG-10-18-24	< LOD	17.8	< LOD	264.43	< LOD	200.82	224.78	45.06	21344.27	597.11	< LOD	7.46	744.6	172.13	< LOD	6.13
GMTG10L15 03-04	< LOD	42.88	< LOD	637.58	< LOD	490.34	< LOD	86.24	27949.4	1465.36	< LOD	16.3	< LOD	494.41	< LOD	13.27
GMTG10L15 03-04	< LOD	17.56	< LOD	301.75	< LOD	206.77	43.87	28.32	28154.64	661.3	8.86	5.88	637.05	163.27	< LOD	5.94
GMTG10L15 03-04	< LOD	18.96	< LOD	210.14	< LOD	136.32	< LOD	35.63	14440.96	469.33	< LOD	6.71	694.2	152.8	< LOD	5.93
GMTG10L15 03-04	< LOD	18.41	< LOD	185.71	< LOD	180.03	< LOD	32.67	13403.65	445.95	< LOD	6.86	645.94	148.58	< LOD	5.88
GMTG10L15 03-04	< LOD	24.9	< LOD	219.54	< LOD	148.49	72.36	32.36	14020.11	496.85	< LOD	8.66	1700.13	233.33	< LOD	6.36
GMTG10L15 03-04	< LOD	42.83	< LOD	435.15	< LOD	123.36	< LOD	98.13	12046.28	970.57	< LOD	13.88	848.86	362.96	< LOD	13.77
GMTG10L15 03-04	< LOD	41.61	< LOD	234.66	< LOD	143.08	125.59	37.69	16851.54	537.57	< LOD	7.55	1935.22	245.49	10.91	4.45
GMTG10L15 03-04	< LOD	25.09	< LOD	363	< LOD	249.58	< LOD	53.18	19883.31	833.22	< LOD	12.08	856.76	257.55	< LOD	8.36
GMTG-10L15-00-06	< LOD	91.1	< LOD	174.78	< LOD	163.98	157.89	39.51	9371.29	392.98	< LOD	8.81	< LOD	141.77	15.29	4.41
GMTG-10L15-06-12	< LOD	46.41	< LOD	181.06	< LOD	133.18	394.61	51.86	10955.5	402.26	< LOD	7.67	232.14	106.18	6.87	3.97
GMTG-10L15-06-12R	< LOD	31.65	< LOD	129.71	< LOD	90.89	381.42	36.63	10823.88	286.71	< LOD	5.1	245.96	76.71	7.77	2.87
GMTG-10L15-12-18	< LOD	15.26	< LOD	241.19	< LOD	144.27	534.1	63.74	17969.66	551.03	< LOD	8.14	892.35	179.02	< LOD	6.28
GMTG-10L15-18-24	< LOD	15.88	< LOD	233.26	< LOD	176.1	431.35	56.23	19350.29	553.01	< LOD	6.24	785.33	167.9	< LOD	6.02
GMTG-10L15-24-30	< LOD	11.48	< LOD	272.78	< LOD	194.96	215.79	45.06	22705.18	621.75	< LOD	5.51	832.39	180.79	< LOD	6.35
GMTG-10L15-30-36	< LOD	15.11	< LOD	321.71	< LOD	209.27	188.24	46.64	28258.29	737.96	< LOD	7.72	1066.9	214.1	< LOD	6.83
GMTG10R50 00-06	< LOD	22.36	< LOD	201.26	< LOD	141.8	534.94	58.08	15138.51	464.72	< LOD	6.68	604.32	141.9	< LOD	5.6
GMTG10R50 06-12	< LOD	18.2	< LOD	204.59	< LOD	153.95	790.94	69.46	15766.83	477.37	< LOD	7.78	1033.1	174.51	< LOD	5.71
GMTG10R50 12-18	< LOD	14.14	< LOD	209.29	< LOD	154.99	917.27	74.19	15535.89	473.29	< LOD	6.42	1133.17	180.58	< LOD	5.62

GMTG10R50 18-24	< LOD	15.19	< LOD	202.67	< LOD	152.03	974.72	76.31	15102.05	467.15	< LOD	7.62	1042.52	174.63	< LOD	5.87
GMTG11.5R50	< LOD	16.88	< LOD	253.33	< LOD	169.29	< LOD	36.03	21247.54	566.36	< LOD	7.43	1229.27	194.72	< LOD	5.67
GMTG11.5R50	< LOD	42.52	< LOD	216.24	< LOD	155.34	113.97	33.99	15529.44	482.72	< LOD	7.28	1016.65	177.05	< LOD	6
GMTG11.5R50	< LOD	24.99	< LOD	198.86	< LOD	141.76	< LOD	38.17	14477.58	458.14	< LOD	7.23	854.08	161.17	< LOD	5.54
GMTG-11-00-06	< LOD	51.86	< LOD	199.93	< LOD	165.97	580.36	61.18	13781.25	462.56	< LOD	7.7	7391.42	423.3	15.64	4.23
GMTG-11-06-12	< LOD	36.51	< LOD	235.11	< LOD	140.57	219.38	43.42	17835.19	538.07	< LOD	8	4280.24	340.13	8.95	4.22
GMTG-11-12-18	< LOD	19.08	< LOD	196.91	< LOD	148.03	< LOD	36.75	12699.18	453	< LOD	7.46	1113.33	186.95	< LOD	6.15
GMTG-11-18-24	< LOD	16.68	< LOD	220.28	< LOD	169.86	< LOD	39.41	15810.74	502.11	< LOD	7.25	832.91	169.35	< LOD	6.17
GMTG-11-24-30	< LOD	17.1	< LOD	222.99	< LOD	171.83	< LOD	34.84	14029.87	488.84	< LOD	7.9	809.03	171.86	< LOD	6.28
GMTG11R100	< LOD	19.81	< LOD	215.96	< LOD	161	< LOD	38.11	16111.81	489.58	< LOD	7.03	1079.15	180.46	< LOD	5.8
GMTG2 0-3	< LOD	47.7	< LOD	122.36	< LOD	97.96	83	27.37	5792.39	270.75	< LOD	6.74	< LOD	106.85	6.37	3.52
GMTG-2-03-06	< LOD	53.25	< LOD	126.21	< LOD	118.88	97.16	28.93	5333.63	263.29	< LOD	6.34	< LOD	107.61	8.1	3.61

Table B-4. XRF database (used for risk analysis).

SAMPLE	As	As Error	Co	Co Error	Cr	Cr Error	Cu	Cu Error	Fe	Fe Error	Hg	Hg Error	Mn	Mn Error	Mo	Mo Error
							Tailings Samples									
GMTG-2-07-08	< LOD	77.03	< LOD	97.88	< LOD	101.51	125.84	30.02	3586.71	209.59	< LOD	7.84	< LOD	104.22	7.02	3.42
GMTG2L50 1-2	< LOD	70.04	< LOD	189.07	< LOD	148.72	127.88	31.69	13067.28	409.74	< LOD	7.53	< LOD	132.68	10.94	3.83
GMTG-2L50-00-01	< LOD	40.12	< LOD	124.78	< LOD	114.56	177.15	34.53	6596.32	288.23	< LOD	7.25	< LOD	109.79	5.84	3.49
GMTG-2L50-02-03	< LOD	14.52	< LOD	209.12	< LOD	154.68	48.51	24.17	17438.36	461.45	< LOD	6.64	197.08	99.86	< LOD	5.35
GMTG3 0-3	< LOD	48.96	< LOD	136.53	< LOD	128.76	134.37	32.73	7091.83	306.82	< LOD	7.3	< LOD	112.2	9.19	3.72
GMTG-3-00-03	< LOD	36.11	< LOD	106.85	< LOD	117.82	65.34	25.8	4481.26	241.04	< LOD	7.15	< LOD	100.53	8.22	3.6
GMTG-3-03-06	< LOD	43.52	< LOD	118	< LOD	116.84	93.16	28.74	5293.68	263.57	< LOD	6.78	< LOD	111.68	8.66	3.65
GMTG-3-07-08	< LOD	39.95	< LOD	160.05	< LOD	107.74	94.67	28.27	10088.73	354.42	< LOD	6.78	217.37	93.47	< LOD	5.19
GMTG3L30 0-1	< LOD	41.32	< LOD	146.81	< LOD	119.51	88.75	30.92	7006.91	322.85	< LOD	6.33	< LOD	112.36	13.26	4.08
GMTG3L30 1-2	< LOD	24.01	< LOD	225.21	< LOD	145.66	344.6	51.64	16238.88	510.39	< LOD	6.9	1840.23	232.18	< LOD	5.94
GMTG3L30 2-3	< LOD	47.12	< LOD	125.18	< LOD	132.04	55.88	27.09	5519.95	282.58	< LOD	7.18	544.05	129.05	7.19	3.82
GMTG3L50 0-1	< LOD	64.59	< LOD	142.85	< LOD	120.4	156.86	35.11	6508.56	300.16	< LOD	7.4	< LOD	97.2	10.03	3.83
GMTG3L50 1-2	< LOD	12.55	< LOD	192.84	< LOD	163.26	383.15	51.71	13626.67	450.51	< LOD	6.82	448.29	131.61	< LOD	5.71
GMTG3L50 2-3	< LOD	32.8	< LOD	212.04	< LOD	155.22	571.38	59.48	16190.77	478.18	< LOD	7.3	561.08	139.63	< LOD	5.76
GMTG3L60 0-1	< LOD	129.19	< LOD	223	< LOD	155.73	715.7	67.25	16568.12	491.73	< LOD	11.44	< LOD	151.4	6.79	3.89
GMTG3L60 1-2	< LOD	17.92	< LOD	205.19	< LOD	170.4	1150.28	80.97	15484.46	463.48	< LOD	6.03	160.03	101.96	< LOD	5.73
GMTG3R25 0-1	< LOD	32.44	< LOD	155.47	< LOD	118.89	84.96	26.37	10525.27	349.57	< LOD	6.42	139.58	83.11	< LOD	4.96
GMTG-3-R25 01-02	< LOD	12.63	< LOD	176.44	< LOD	128.75	< LOD	32.48	10620.67	393.23	< LOD	5.66	376.4	118.24	< LOD	5.6
GMTG4 R50	< LOD	50.34	< LOD	233.45	< LOD	159.63	171	38.61	17948.19	520.5	< LOD	8.02	1083.27	183.93	< LOD	5.96
GMTG-4-00-06	< LOD	23.15	< LOD	197.2	< LOD	165.5	47.19	28.97	12572.53	449.86	< LOD	7.27	160.72	105.36	< LOD	6.36
GMTG-4-06-12	< LOD	25.57	< LOD	219.75	< LOD	162.75	< LOD	45.05	13966.46	504.06	< LOD	7.37	368.02	136.53	< LOD	6.74
GMTG-4-12-18	< LOD	14.84	< LOD	268.58	< LOD	186.11	< LOD	36	23319.07	610.79	< LOD	7.81	352.57	136.45	< LOD	6.21
GMTG-4-18-24	< LOD	10.2	< LOD	164.82	< LOD	133.22	< LOD	26.33	9368.77	350.86	< LOD	6.28	402.65	114.16	6.72	3.72
GMTG4L35-00-01	< LOD	19.88	< LOD	217.22	< LOD	133.75	< LOD	36.9	16924.2	489.47	< LOD	6.47	352.28	120.4	< LOD	5.8
GMTG4L35-01-02	< LOD	11.8	< LOD	261.22	< LOD	177.96	< LOD	33.94	23121.53	576.31	< LOD	6.12	224.8	117.16	< LOD	5.7
GMTG4L50 1-2	< LOD	43.98	< LOD	134.44	< LOD	116.82	114.47	29.19	7255	296.59	< LOD	7.34	172.57	85.45	8.95	3.53

Table B-4. XRF database (used for risk analysis).

SAMPLE	As	As Error	Co	Co Error	Cr	Cr Error	Cu	Cu Error	Fe	Fe Error	Hg	Hg Error	Mn	Mn Error	Mo	Mo Error
GMTG4L50 2-3	< LOD	11.26	< LOD	248.05	< LOD	181.12	< LOD	34.34	24371.63	561.46	< LOD	6.5	394.94	127.43	< LOD	5.47
GMTG4L5O-00-12	< LOD	51.36	< LOD	120.93	< LOD	115.88	103.46	28.42	5534.16	260.02	< LOD	6.96	< LOD	101.17	< LOD	5.03
GMTG-4R50-00-06	< LOD	38.24	< LOD	128.35	< LOD	137.21	65.76	29.77	4727.09	273.89	< LOD	7.37	< LOD	123.35	< LOD	5.83
GMTG-4R50-06-12	< LOD	22.94	< LOD	154.13	< LOD	129.68	39.16	25.15	9061.03	355.83	< LOD	5.09	< LOD	132.03	< LOD	5.58
GMTG-4R50-12-18	< LOD	13.99	< LOD	230.95	< LOD	173.44	< LOD	34.37	17351.3	507.43	< LOD	6.69	< LOD	155.83	< LOD	5.77
GMTG-4R50-18-24	< LOD	14.04	< LOD	262.88	< LOD	166.21	< LOD	41.17	21763.25	593.35	< LOD	8.15	234.3	122.7	< LOD	6.16
GMTG-5-00-06	< LOD	35.13	< LOD	212.97	< LOD	150.44	85.33	33.37	13123.59	468.01	< LOD	5.9	344.56	127.29	< LOD	6.27
GMTG-5-06-12	< LOD	22.49	< LOD	228.09	< LOD	168.34	< LOD	36.1	17137.62	510.56	< LOD	7.11	253.5	117.32	< LOD	6.15
GMTG-5-12-18	< LOD	15.28	< LOD	332.61	< LOD	232.74	< LOD	43.49	27233.65	734.12	< LOD	7.47	302.4	152.33	< LOD	7.26
GMTG-5-18-24	< LOD	11.87	< LOD	301.61	< LOD	220.38	< LOD	40.23	28378.76	699.67	< LOD	7.68	393.61	151.43	< LOD	6.34
GMTG5L75 1-2	< LOD	13.49	< LOD	270.22	< LOD	174.52	< LOD	37.3	26228.55	607	< LOD	8.19	342.27	129	< LOD	6.03
GMTG5L75 2-3	< LOD	13.19	< LOD	294.94	< LOD	200.12	< LOD	32.93	31026.67	664.59	< LOD	7.88	532.79	150.28	< LOD	5.73
GMTG5L75-01-02	< LOD	47.86	< LOD	110.62	< LOD	127.43	54.3	25.19	4221.63	236.91	< LOD	6.1	< LOD	105.09	9.62	3.7
GMTG5L75-02-03	< LOD	13.4	< LOD	183.69	< LOD	139.13	< LOD	36.23	10412.49	415.28	< LOD	7.4	237.84	110.86	< LOD	5.51
GMTG6 00-06	< LOD	29.3	< LOD	202.78	< LOD	156.77	139.88	35.93	14508.32	466.89	< LOD	6.59	336.35	121.9	< LOD	5.92
GMTG6 06-12	< LOD	27.64	< LOD	207.5	< LOD	164.81	144.93	35.97	15590.48	478.49	< LOD	6.64	853.21	164.05	< LOD	5.67
GMTG6 12-18	< LOD	19.06	< LOD	290.57	< LOD	199.16	81.59	33.38	27870.71	678.09	< LOD	6.85	1358.48	216.5	< LOD	6.03
GMTG6 18-24	< LOD	12.01	< LOD	272.13	< LOD	169.71	< LOD	38.31	25141.88	612.58	< LOD	8.16	524.66	147.02	< LOD	5.86
Tailings Samples																
GMTG6L50 0-1	< LOD	37.42	< LOD	111.94	< LOD	112.92	60.3	25.18	4947.73	249.7	< LOD	6.35	< LOD	88.65	8.82	3.57
GMTG6L50 01-02	< LOD	19.4	< LOD	255.38	< LOD	174.86	626.97	62.61	22567.43	568.56	< LOD	6.4	454.95	137.31	< LOD	5.95
GMTG6L50 02-03	< LOD	12.46	< LOD	243.02	< LOD	150.6	< LOD	34.96	21649.86	538.34	< LOD	6.84	356.6	122.06	< LOD	5.58
GMTG6L50 02-03	< LOD	100.75	< LOD	249.78	< LOD	181.39	463.42	60.03	18933.41	563.03	< LOD	9.29	262.43	131.25	20.57	4.66
GMTG6L50 02-03	< LOD	73.74	< LOD	182.59	< LOD	134.88	242.59	41.46	11820.44	404.82	< LOD	7.9	< LOD	134.89	9.03	3.85
GMTG6L90 00-01	< LOD	39.48	< LOD	190.68	< LOD	138.35	149.61	32.41	14728.22	424.7	< LOD	6.8	777.62	143.76	9.59	3.65
GMTG6L90 01-02	< LOD	16.45	< LOD	292.94	< LOD	194.92	< LOD	41.14	27887.16	663.75	< LOD	7.94	622.13	162.35	< LOD	6.29
GMTG6O.5L30 0-3	< LOD	52.45	< LOD	137.93	< LOD	134.66	126.82	33.82	6233.62	302.59	< LOD	8.17	< LOD	116.41	16.43	4.15
GMTG7 00-06	< LOD	26.42	< LOD	172.91	< LOD	128.76	241.58	36.32	13784.83	390.16	< LOD	5.08	202.06	91.14	< LOD	4.93
GMTG7 06-12	< LOD	13.54	< LOD	338.29	< LOD	207.58	< LOD	40.52	30783.07	746.54	< LOD	8.45	529.73	168.38	< LOD	6.62
GMTG7 12-18	< LOD	13.99	< LOD	302.12	272.36	158.46	< LOD	44.98	27913.99	690.02	< LOD	8.5	559.25	166.14	< LOD	6.27
GMTG7L50 03 04	< LOD	18.72	< LOD	252.86	< LOD	166.1	176.23	37.39	21938.59	555.83	< LOD	6.78	818.36	162.42	< LOD	5.71
GMTG7L50 04-05	< LOD	18.89	< LOD	244.86	< LOD	159.22	259.42	43.24	21391.09	551.35	< LOD	6.5	609.07	147.2	< LOD	5.73
GMTG7L50 05-06	< LOD	13.25	< LOD	257.35	< LOD	168.94	63.08	31.04	20296.22	575.78	< LOD	7.1	745.39	167.6	< LOD	5.92
GMTG7L50 1-2	< LOD	22.4	< LOD	247.63	< LOD	158.76	215.42	43.82	19938.92	569.45	10.37	6.26	811.58	171.91	< LOD	6.18
GMTG7L50 2-3	< LOD	21.91	< LOD	247.6	< LOD	179.44	247.91	43.54	21572.04	565.94	< LOD	7.37	818.13	167.06	< LOD	5.82
GMTG7L50 LBANK	< LOD	50.46	< LOD	241.96	< LOD	150.72	153.56	39.48	17906.76	542.11	< LOD	7.24	560.99	151.58	< LOD	6.36
GMTG7L50 RBANK	< LOD	115.65	< LOD	236.37	< LOD	153.08	611.83	64.26	18406.47	529.42	< LOD	10.37	< LOD	158.77	19.87	4.39
GMTG7L60 0-1	< LOD	50.88	< LOD	123.2	< LOD	119.95	83.11	28.3	5647.81	275.88	< LOD	7.12	140.85	84.64	7.44	3.66
GMTG7L60 1-2	< LOD	13.49	< LOD	343.67	270.76	163.81	413.66	57.04	35603.08	768.6	< LOD	7.59	834.88	190.33	< LOD	6.13

GMTG7L60-02-03	< LOD	13.93	< LOD	295.91	< LOD	200.95	159.83	40.47	28513.78	689.11	< LOD	7.62	536.74	160.32	< LOD	6.07
GMTG7L60-03-04	< LOD	14.67	< LOD	267.2	< LOD	211.78	< LOD	41.89	23320.48	620.23	< LOD	7.94	357.76	140.79	< LOD	6.16
GMTG7L60-03-04	< LOD	139.38	< LOD	208.39	< LOD	181.86	860.59	73.23	14678.98	464.89	< LOD	11.09	406.28	138.77	8.11	3.95
GMTG7L60-03-04	< LOD	57.12	< LOD	138.73	< LOD	118.5	101.74	30.57	6608.17	301.2	9.74	5.86	142.18	87.48	7.81	3.76
GMTG7L60-03-04	< LOD	64.98	< LOD	150.04	< LOD	126.28	231.93	40.15	8633.49	342.15	< LOD	8.29	< LOD	130.53	9.06	3.77
GMTG-7R50-00-06	< LOD	26.4	< LOD	108.99	< LOD	99.26	42.68	20.4	7074.92	242.67	< LOD	5	< LOD	95.13	< LOD	4.3
GMTG-7R50-06-12	< LOD	8.5	< LOD	137.29	< LOD	89.53	44.27	16.56	18166.87	312.2	< LOD	3.45	586.44	87.48	< LOD	3.56
GMTG-7R50-12-18	< LOD	13.23	< LOD	252.88	< LOD	147.42	< LOD	34.76	20415.2	564.81	< LOD	7.86	345.82	129.49	< LOD	6.28
GMTG-7R50-18-24	< LOD	13.26	< LOD	292.31	< LOD	179.15	< LOD	36.88	27211.29	679.22	< LOD	6.94	417.56	148.66	< LOD	6.24
GMTG8 00-06	< LOD	19.18	< LOD	225.48	< LOD	161.27	259.52	43.01	18306.12	508.21	< LOD	6.48	318.11	120.06	< LOD	5.85
GMTG8 02-18	< LOD	13.67	< LOD	349.3	< LOD	241.31	149.21	39.62	37336.37	783.9	< LOD	7.89	658.86	177.93	< LOD	6.64
GMTG8 06-12	< LOD	23.74	< LOD	254.73	< LOD	180.37	261.65	44.05	21398.31	557.71	< LOD	7.21	256.21	120.07	< LOD	5.77
GMTG8 18-24	< LOD	13.03	< LOD	328.37	< LOD	223.76	< LOD	40.23	33778.62	738.06	< LOD	6.71	1103.19	202.89	< LOD	6.09
GMTG8.5L20-00-01	< LOD	16.89	< LOD	257.05	< LOD	184.04	661.95	66.17	20994.12	566.03	< LOD	5.97	1087.39	187.66	< LOD	6.07
GMTG8.5L20-01-02	< LOD	18.6	< LOD	245.48	< LOD	174.28	< LOD	38.43	20045.62	549.84	< LOD	6.97	773.75	163.89	< LOD	5.87
GMTG8.5L50 03-04	< LOD	13.32	< LOD	296.91	< LOD	176.1	405.3	55.01	26952.24	654.16	< LOD	8.41	1021.58	189.87	< LOD	6.1
GMTG8.5L50 03-04	< LOD	13.69	< LOD	303.49	< LOD	214.72	298.73	50.09	29231.96	695.39	< LOD	7.55	1070.77	200.24	< LOD	6.42
GMTG8.5L50 03-04	< LOD	28.5	< LOD	429.21	< LOD	263.42	684.49	108.93	21515.64	928.77	< LOD	14.51	691.85	258.2	< LOD	10.1
GMTG8.5L5O-00-01	< LOD	238.18	< LOD	296.18	< LOD	195.99	1960.1	122.23	24156.13	671.04	< LOD	16.77	< LOD	222.05	19.13	4.91
GMTG8.5L5O-01-02	< LOD	232.33	< LOD	314.68	< LOD	214.47	1928.52	123.09	25297.99	696.32	< LOD	15.23	< LOD	219.02	19.58	5
GMTG8.5L5O-01-02	< LOD	61.23	< LOD	269.5	< LOD	158.98	714.4	70.75	23428.96	614.42	< LOD	8.4	596.31	158.38	< LOD	5.99
GMTG8L50 03-04	< LOD	35.02	< LOD	321.29	< LOD	205.86	299.57	52.36	28906.6	719.24	< LOD	9.09	957.71	199.64	< LOD	6.74
GMTG8L50 04-05	< LOD	23.24	< LOD	283.88	< LOD	188.12	96.08	33.22	26023.04	633.28	< LOD	6.79	861.43	176.41	< LOD	5.94
GMTG-8R50-00-06	< LOD	43.86	< LOD	159.91	< LOD	126.48	241.35	43.51	8736.65	365.87	< LOD	7.48	395.3	122.18	< LOD	5.93

Table B-4. XRF database (used for risk analysis).

SAMPLE	As	As Error	Co	Co Error	Cr	Cr Error	Cu	Cu Error	Fe	Fe Error	Hg	Hg Error	Mn	Mn Error	Mo	Mo Error
Tailings Samples																
GMTG-8R50-06-12	< LOD	16.61	< LOD	199	< LOD	151.58	118.08	34.29	13819.17	457.51	< LOD	7.16	882.3	166.45	< LOD	5.79
GMTG-8R50-12-18	< LOD	14.84	< LOD	249.25	< LOD	146.27	< LOD	34.73	18806.99	562.86	< LOD	7.3	404.75	138.51	< LOD	6.29
GMTG-8R50-18-24	< LOD	14.33	< LOD	262.19	< LOD	181.2	< LOD	37.32	21991.34	598.9	< LOD	8	338.19	134.91	< LOD	6.34
GMTG9 00-06	< LOD	43.66	< LOD	264.23	< LOD	170.88	737.22	69.75	22529.98	591.38	< LOD	7.84	3822.75	319.75	< LOD	6.01
GMTG9 06-12	< LOD	15.24	< LOD	255.95	< LOD	197.86	127.61	35.24	23496.92	595.99	< LOD	7.47	1946.06	236.72	< LOD	5.92
GMTG9 12-18	< LOD	13.44	< LOD	331.48	< LOD	206.86	167.49	40.99	34410.75	756.11	< LOD	7.66	1143.91	207.94	< LOD	6.46
GMTG9 12-18	< LOD	7.1	< LOD	39.85	< LOD	99.34	< LOD	25.33	269.05	83.24	< LOD	5.88	< LOD	93.74	12.99	4.12
GMTG-9L20-00-06	< LOD	58.25	< LOD	143.41	< LOD	127.32	92.93	31.6	6598.59	314.99	< LOD	7.84	< LOD	121.68	10.64	4.02
GMTG-9L20-06-12	< LOD	48.09	< LOD	138.53	< LOD	118.12	56.9	28.37	6632.75	317.58	< LOD	7.07	< LOD	117.59	11.48	4.07
GMTG-9L20-12-18	< LOD	39.12	< LOD	135.2	< LOD	111.85	49.37	25.92	6208.32	296.43	< LOD	7.54	< LOD	101.17	6.74	3.76
GMTG-9L20-18-24	< LOD	61.63	< LOD	143.66	< LOD	118.03	135.12	34.12	7182.98	319.83	< LOD	6.86	< LOD	120.87	12.37	3.95
GMTG-9L20-24-30	< LOD	66.71	< LOD	238.9	< LOD	163.57	733.7	65.99	20367.6	531.07	< LOD	8.02	491.25	137.95	8.72	4
GMTG-9L20-30-36	< LOD	14.43	< LOD	294.92	< LOD	197.42	122.63	38.21	24553.43	653.27	< LOD	5.95	683.36	172.56	< LOD	6.39
GMTG-9L20-36-42	< LOD	16.54	< LOD	289.15	< LOD	206.63	72.03	31.98	25886.41	649.11	< LOD	6.82	1339.3	213.12	< LOD	6.46

GMTG-9R50-00-06	< LOD	52.6	< LOD	158.1	< LOD	148.62	233.75	44.78	8665.98	375.95	< LOD	7.52	< LOD	141.72	9.92	4.21
GMTG-9R50-06-12	< LOD	15.79	< LOD	260.84	< LOD	174.18	672.11	69.56	19718.28	571.54	< LOD	6.53	1227.98	202.96	< LOD	6.23
GMTG-9R50-12-18	< LOD	17.87	< LOD	308.71	< LOD	173.37	< LOD	36.61	28154.71	688.76	< LOD	6.98	1816.98	244.14	< LOD	6.53
GMTG-9R50-18-24	< LOD	20.59	< LOD	398.95	< LOD	216.69	< LOD	38.68	41172.18	888.66	< LOD	8.34	1774.61	266.43	< LOD	7.23
GMTGO.5L30 3-6	< LOD	74.74	< LOD	151.98	< LOD	136.08	197.05	38.36	8124.99	336.51	< LOD	8.17	164.48	95.29	9.04	3.82
GMTGO.5L30 6-9	< LOD	13.43	< LOD	260.73	199.1	130.12	42.7	25.58	25299.02	586.93	< LOD	6.18	358.65	129.32	6.07	3.92
TP1A*							380.83		16768							
TP1B*							183.03		7311.67		52.1					
TP1C1*							175.948		10724.5							
TP1C2*							2922.1		15940.2		192.433					
TP1D1*							287.8		11486.9							
TP1D2*							239.79		7972.2							

Waste Rock Samples

WR1A*							382.04		25161.6				3646.88			
WR1B*							508.05		33301.7				645.115		10.7	
WR1C*							104.69		30656.1		58.067				10.51	
WR1D*							87.25		26672.1				1249.83			
WR3A*							78.4		26101.9				1841.31			
WR3B*									17588.5				1275.72			
WR4*							363.55		21636.7				1980.48		8.4	

* Asterisk indicates samples and data collected by Pioneer (1994). All other data collected by Tetra Tech (2009).

Table B-4. XRF database (used for risk analysis).

SAMPLE	Ni	Ni Error	Pb	Pb Error	Rb	Rb Error	Se	Se Error	Sr	Sr Error	Zn	Zn Error	Zr	Zr Error
Background Soil Samples														
GMBG-1	< LOD	59.53	36.41	13.35	107.59	9.12	< LOD	6.25	405.42	18.1	50.69	20.26	132.98	17.63
GMBG-2	< LOD	56.75	26.99	11.63	91.74	8.15	< LOD	5.24	339.24	16	43.75	18.47	113.37	16.08
GMBG-3	< LOD	52.95	894.22	51.18	113.04	9.34	< LOD	7.63	267.67	14.85	192.76	32.29	123.73	16.55
GMBG-4	< LOD	59.25	28.25	12.85	87.65	8.62	< LOD	5.82	756.31	25.11	67.45	22.69	107.82	19.49
GMBG-5	< LOD	56.33	218.99	26.31	105.43	9.02	< LOD	5.78	529.64	20.46	92.08	24.06	74.65	16.75
GMBG-6	< LOD	61.02	29.01	13.75	101.14	9.72	< LOD	7.04	392.79	19.55	88.52	26.26	147.8	19.67
Tailings Samples														
GMTG-1	< LOD	54.43	1916.13	73.65	108.88	9.15	< LOD	9.64	92.94	9.26	76.3	23.3	< LOD	16.51
GMTG-2	< LOD	41.94	876.96	47.23	84.55	7.6	< LOD	6.39	88.65	8.47	50.11	18.24	< LOD	14.49
GMTG-3	< LOD	50.49	792.37	43.84	94.04	7.75	< LOD	7.04	72.25	7.6	132.83	24.5	< LOD	14.24
GMTG-4	< LOD	52.04	1572.68	65.53	95	8.42	< LOD	7.98	105.86	9.57	37.9	18.55	< LOD	16.2
GMTG-5	< LOD	57.26	3869.56	98.37	124.03	9.31	< LOD	10.49	85.88	8.63	89.71	24.46	18.85	11.38
GMTG-0.5L30-00-03	< LOD	57.61	1264.31	60.22	138.33	10.17	< LOD	8.6	117.5	10.2	122.39	26.42	< LOD	16.74
GMTG-0.5L30-03-06	< LOD	53.9	2196.62	75.56	116.59	9.07	< LOD	9.65	95.42	9	71.47	21.75	< LOD	14.8
GMTG-0.5L30-07-08	< LOD	59.19	18.31	10.16	75.98	7.22	< LOD	5.52	189.5	11.81	30.98	17.25	177.66	16.32
GMTG-01-01-02	< LOD	52.64	24.1	11.89	94.73	8.65	< LOD	5.59	423.15	18.56	< LOD	21.24	80.72	16.43
GMTG-01L30-00-01	< LOD	50	1173.06	54.23	91.88	7.87	< LOD	8.57	71.6	7.75	83	21.37	< LOD	15.16
GMTG-01L30-01-02	< LOD	40.28	403.06	29.65	67.09	6.21	< LOD	5.26	70.55	7.01	< LOD	17.31	< LOD	13.49
GMTG-01L30-02-03	< LOD	50.73	1273.32	56.83	112.03	8.69	< LOD	7.95	116.35	9.55	106.06	23.5	18	11.37
GMTG-01L30-03-04	< LOD	53.62	2581.63	80.52	76.53	7.46	< LOD	9.62	83.52	8.42	31.82	17.93	< LOD	14.79
GMTG-01L75-00-01	< LOD	53	639.14	40.42	85.7	7.61	< LOD	6.48	133.81	10.06	103.04	23.44	82.6	13.42
GMTG-01L75-01-02	< LOD	50.16	1117.57	51.34	87.04	7.46	< LOD	6.73	109.68	8.96	190.48	28.19	39.58	11.58
GMTG-01L75-02-03	< LOD	44.08	436.09	32.13	76.74	6.89	< LOD	6.09	98.75	8.4	38.71	16.26	< LOD	14.62
GMTG-01L75-03-04	< LOD	60.98	23.3	10.9	56.06	6.45	< LOD	5.3	219.29	12.88	61.9	20.3	171.14	16.65
GMTG02.5 0-1	< LOD	55.25	732.4	46.24	106.18	9	< LOD	8.06	213.74	13.3	55.65	20.76	29.02	13.25
GMTG02.5 1-2	< LOD	67.76	5671.35	132.32	108.33	9.94	< LOD	15.15	112.77	10.81	43.63	22.93	< LOD	18.17
GMTG02.5 4-5	< LOD	53.14	25.58	11.41	76.38	7.55	< LOD	4.77	398.43	17.34	28.37	16.87	71.97	15.4
GMTG-02.5L20-02-0	< LOD	39.77	655.7	38.56	76.42	6.8	< LOD	6.16	85.55	7.82	< LOD	19.4	< LOD	13.79
GMTG-02.5L20-03-0	< LOD	45.93	657.4	38.98	64.64	6.4	< LOD	5.69	146.97	9.98	< LOD	20.26	< LOD	14.73
GMTG-02.5L20-04-0	< LOD	61.3	34.12	12.73	76.04	7.66	< LOD	5.75	400.48	17.67	40.7	18.67	122.18	17.01
GMTG02L30 0-1	< LOD	52.54	819.61	47.73	68.81	7.27	< LOD	7.86	226.79	13.36	< LOD	26.18	20.34	12.77
GMTG02L30 1-2	< LOD	43.09	454.19	32.33	74.77	6.74	< LOD	4.5	85.59	7.83	< LOD	18.49	< LOD	13.71
GMTG02L30 2-3	< LOD	42.99	1031.89	42.63	31.84	4.23	< LOD	6.17	70.49	6.42	936.16	51.06	< LOD	12.62
GMTG-02L30-00-01	< LOD	52.91	699.42	42.28	84.26	7.57	< LOD	7.24	159.57	10.88	< LOD	23.32	< LOD	16.36
GMTG-02L30-01-02	< LOD	46.12	381.98	29.14	71.03	6.43	< LOD	5.11	86.59	7.68	< LOD	19.06	< LOD	13.52
GMTG-02L30-02-03	< LOD	47.64	62.74	13.34	45.64	5.3	< LOD	4.99	167.85	10.26	418.98	37.78	85.54	12.64
GMTG-02L60-00-01	< LOD	54.14	2939.5	87.34	140.7	9.94	< LOD	9.82	77.34	8.36	225.98	33.06	< LOD	16.73

GMTG-02L60-01-03	< LOD	55.19	19.85	10.21	77.93	7.19	< LOD	5.41	229.9	12.7	188.72	28.63	168.47	16.04
GMTG-02L75-00-01	< LOD	47.23	3178.78	79.91	59.09	6.06	< LOD	9.02	79.83	7.42	131.5	24.66	< LOD	14.49
GMTG-02L75-00-02	< LOD	44.18	236.19	24.41	98.22	7.77	< LOD	5.71	99.54	8.51	29.26	15.54	< LOD	13.82
GMTG-03L30 03-04	< LOD	48.8	2053.33	74.14	99.2	8.55	< LOD	9.87	111.05	9.7	62.37	20.92	< LOD	16.77
GMTG-03L30 04-05	< LOD	47.3	655.48	43.75	98.19	8.7	< LOD	6.59	327.87	16.22	62.85	21.45	41.83	14.48
GMTG-03L30 04-05	< LOD	55.5	1317.65	61.63	97.97	8.8	< LOD	9.9	481.01	19.51	279.05	37.16	63.06	16.15

Table B-4. XRF database (used for risk analysis).

SAMPLE	Ni	Ni Error	Pb	Pb Error	Rb	Rb Error	Se	Se Error	Sr	Sr Error	Zn	Zn Error	Zr	Zr Error
Tailings Samples														
GMTG-03L30 05-06	< LOD	52.01	1186.95	57.17	83.55	7.95	< LOD	7.59	221.51	13.24	44.43	19.18	49.6	13.7
GMTG-03L50-00-01	< LOD	43.97	1921.98	70.86	115.42	9.02	< LOD	9.12	96.85	9.05	48.3	19.24	< LOD	14.89
GMTG-03L50-01-02	< LOD	54.7	20.69	11.28	88.31	8.21	< LOD	5.54	555.56	20.67	71.04	22.77	122.77	17.88
GMTG-03L50-02-03	< LOD	53.72	175.45	22.65	76.73	7.37	< LOD	6.44	240.39	13.37	142.24	28.86	135.95	15.79
GMTG03L60 0-1	< LOD	47.87	1143.9	55.46	84.02	7.84	< LOD	8.05	95.21	9.03	< LOD	24.36	< LOD	16.24
GMTG03L60 1-2	< LOD	54.91	65.17	14.77	77.51	7.25	< LOD	5.45	218.42	12.54	199.95	29.71	198.85	16.87
GMTG-03L60-00-01	< LOD	55.01	1357.62	61.02	90.27	8.21	< LOD	8.6	103.74	9.47	36.11	17.95	< LOD	15.56
GMTG-03L60-01-02	< LOD	52.62	34.26	11.62	67.87	6.6	< LOD	6	199.61	11.62	43.56	20.09	156.94	15.25
GMTG1 0-1	< LOD	48.13	36.45	12.03	65.05	6.69	< LOD	4.95	401.29	16.54	< LOD	20.26	28.61	13.47
GMTG1 1-2	< LOD	54.04	19.04	10.97	88.26	8.14	< LOD	5.78	433.44	18.25	27.56	16.62	64.77	15.59
GMTG-10-00-06	< LOD	54.6	792.71	50.92	91.84	8.95	< LOD	8.01	220.39	14.31	75.12	24.28	82.03	15.91
GMTG-10-06-12	< LOD	59.4	286.11	30.92	85.22	8.49	< LOD	6.29	269.92	15.48	75.94	23.99	125.95	17.27
GMTG-10-12-18	< LOD	62.51	38.17	13.53	87.87	8.52	< LOD	4.25	300.12	16.12	81.94	24.8	175.33	18.6
GMTG-10-18-24	< LOD	58.74	51.81	15.41	52.84	7	< LOD	5.48	358.84	17.95	38.51	21.06	92.19	17.12
GMTG10L15 03-04	< LOD	139.88	73.32	38.05	62.47	16.15	< LOD	14.7	309.84	36.02	< LOD	63.85	115.86	37.65
GMTG10L15 03-04	< LOD	67.21	61.61	16.01	63.05	7.28	< LOD	6.64	310.08	16.2	30.15	19.25	119.58	16.98
GMTG10L15 03-04	< LOD	56.65	70.64	16.58	98.68	8.79	< LOD	5.77	419.92	18.44	124.06	26.61	100.13	16.9
GMTG10L15 03-04	< LOD	57.64	69.42	16.38	92.47	8.43	< LOD	6.53	477.33	19.33	55.41	20.14	88.34	16.69
GMTG10L15 03-04	< LOD	57.6	117.55	21.78	104.79	9.66	< LOD	7.39	368.19	18.54	119.92	28.3	110.84	18.04
GMTG10L15 03-04	< LOD	140.62	57.67	34.37	74.07	17.37	< LOD	9.59	289	34.84	< LOD	67.7	< LOD	49.15
GMTG10L15 03-04	< LOD	57.22	364.02	35.47	139.05	10.87	< LOD	7.53	247.46	15.2	81.39	25.05	78.15	16.08
GMTG10L15 03-04	< LOD	100.95	51.52	22.7	89.46	12.79	< LOD	9.72	510.86	30.74	96.22	37.52	113.86	27
GMTG-10L15-00-06	< LOD	52.65	2124.29	81.59	110.04	9.7	< LOD	9.5	86.44	9.5	122.69	28.14	< LOD	17.76
GMTG-10L15-06-12	< LOD	53.71	558.35	40.28	84.75	8.05	< LOD	7.01	159.53	11.56	66.51	22.32	69.41	14.06
GMTG-10L15-06-12R	< LOD	34.88	524.32	28	84.82	5.77	< LOD	4.65	153.62	8.15	46.81	14.61	67.03	10
GMTG-10L15-12-18	< LOD	67.48	27.33	12.67	75.35	8.16	< LOD	5.26	262.86	15.56	83.14	26.35	107.97	17.01
GMTG-10L15-18-24	< LOD	63.46	36.34	13.57	84.03	8.31	< LOD	6.66	316.16	16.43	45.63	21.71	129.61	17.4
GMTG-10L15-24-30	< LOD	67.1	< LOD	16.32	62.27	7.55	< LOD	5.56	271.05	15.87	37.17	21.13	114.84	17.37
GMTG-10L15-30-36	< LOD	76.79	21.94	12.9	58.85	7.85	< LOD	6.01	269.49	16.87	74.23	27.03	140.53	19.3
GMTG10R50 00-06	< LOD	54.79	105.9	18.77	95.8	8.39	< LOD	5.78	405.46	17.55	63.98	22.29	94.73	16.11
GMTG10R50 06-12	< LOD	55.33	73.69	16.45	88.59	8.15	< LOD	6.28	415.33	17.85	68.63	23.63	134.51	17.28
GMTG10R50 12-18	< LOD	59.36	35.92	13.12	98.66	8.52	< LOD	7.34	364.41	16.73	93.25	25.82	123.32	16.67

GMTG10R50 18-24	< LOD	52.49	40.97	13.37	89.58	8.17	< LOD	5.55	398.57	17.49	59.53	23.32	134.61	17.17
GMTG11.5R50	< LOD	55.73	59.21	15.63	115.72	9.43	< LOD	6.32	481.24	19.63	100.26	24.98	133.7	18.06
GMTG11.5R50	< LOD	57.78	450.31	36.67	87.74	8.31	< LOD	6.07	463.63	19.19	97.64	24.71	126.71	17.72
GMTG11.5R50	< LOD	56.29	143.67	21.47	95.58	8.46	< LOD	5.77	471.73	19.01	84.94	22.81	96.86	16.68
GMTG-11-00-06	< LOD	53.72	737.07	46	87.04	8.17	< LOD	6.81	172.37	11.98	511.93	48.25	43.83	13.34
GMTG-11-06-12	< LOD	58.16	314.07	31.93	104.64	9.23	< LOD	6.35	301.85	16.13	334.05	41.27	71.53	15.7
GMTG-11-12-18	< LOD	57.28	66.92	16.67	103.31	9.2	< LOD	5.82	408.49	18.67	92.82	24.61	80.24	16.71
GMTG-11-18-24	< LOD	55.08	41.69	14.27	100.83	9.08	< LOD	6.55	428.29	19.04	64.17	22.07	85.05	16.92
GMTG-11-24-30	< LOD	62.59	46.79	15.25	93.38	9.06	< LOD	6.37	480.69	20.78	82.7	24.49	106.89	18.43
GMTG11R100	< LOD	56.76	84.11	17.58	93.32	8.48	< LOD	6.38	489.64	19.6	162.82	29.24	98.92	17.06
GMTG2 0-3	< LOD	49.89	749.91	42.7	85.9	7.44	< LOD	7.4	79.62	7.89	24.17	14.97	< LOD	14.36
GMTG-2-03-06	< LOD	46.94	977.11	49.05	92.21	7.79	< LOD	6.27	85.34	8.22	43.57	17.28	< LOD	14.23

Table B-4. XRF database (used for risk analysis).

SAMPLE	Ni	Ni Error	Pb	Pb Error	Rb	Rb Error	Se	Se Error	Sr	Sr Error	Zn	Zn Error	Zr	Zr Error
Tailings Samples														
GMTG-2-07-08	< LOD	43.76	2176.81	69.96	83.41	7.27	< LOD	9.08	62.92	7.1	411.96	38.37	< LOD	13.01
GMTG2L50 1-2	< LOD	46.37	1592.96	62.75	54.44	6.3	< LOD	7.79	61.47	7.32	32.56	17.13	71.59	12.6
GMTG-2L50-00-01	< LOD	47.6	511.93	35.45	95.52	7.78	< LOD	5.71	81.7	7.96	96.56	21.94	< LOD	13.51
GMTG-2L50-02-03	< LOD	57.75	54.36	13.38	69.36	6.68	< LOD	5.28	161.47	10.59	50.95	18.08	137.97	14.62
GMTG3 0-3	< LOD	56.8	736.85	43.45	92.66	7.91	< LOD	6.59	72.92	7.83	49.53	18.44	< LOD	14.96
GMTG-3-00-03	< LOD	42.4	410.32	32.2	94.73	7.8	< LOD	6.46	89.06	8.3	67.92	19.26	< LOD	14.29
GMTG-3-03-06	< LOD	48.73	596.96	38.85	84.13	7.47	< LOD	6.95	68.95	7.56	29.63	15.8	< LOD	14.09
GMTG-3-07-08	< LOD	48.87	533.19	36.12	61.42	6.39	< LOD	6.16	103.1	8.75	42.33	17.12	< LOD	15.28
GMTG3L30 0-1	< LOD	48.61	485.09	37.61	112.11	9.11	< LOD	6.5	89.19	8.97	100	24	< LOD	15.74
GMTG3L30 1-2	< LOD	65.97	128.71	21.61	90.46	8.68	< LOD	6.65	543.9	21.36	89.32	25.45	70.64	17.25
GMTG3L30 2-3	< LOD	51.63	668.37	42.84	92.22	8.17	< LOD	6.05	146.17	10.86	39.21	17.64	< LOD	17.82
GMTG3L50 0-1	< LOD	48.72	1367.14	59.97	96.21	8.27	< LOD	8.19	99.39	9.11	33.72	17.38	< LOD	15.61
GMTG3L50 1-2	< LOD	55.52	26.74	12.05	94.34	8.54	< LOD	5.22	568.78	21.1	44.12	20.37	93.42	17.4
GMTG3L50 2-3	< LOD	54.34	275.12	28.29	79.88	7.71	< LOD	5.82	364.12	16.61	92.17	24.73	112.84	16.28
GMTG3L60 0-1	< LOD	55.43	4810.51	115.82	154.41	10.91	< LOD	12.51	75.53	8.77	177.94	32.5	< LOD	17.18
GMTG3L60 1-2	< LOD	58.47	57.18	14.55	83.67	7.74	< LOD	5.64	207.29	12.63	39.37	21.61	152.32	16.23
GMTG3R25 0-1	< LOD	50.51	382.4	29.84	66.4	6.39	< LOD	6.17	158.65	10.21	< LOD	21.11	48.9	11.83
GMTG-3-R25 01-02	< LOD	53.65	27.95	11.74	51.44	6.39	< LOD	5.19	272.82	14.64	< LOD	23.25	31.03	13.51
GMTG4 R50	< LOD	53.95	627.41	43.22	102.99	8.98	< LOD	7.5	435.17	18.7	114.87	26.54	92.07	16.73
GMTG-4-00-06	< LOD	56.12	111.04	20.27	69.7	7.72	< LOD	5.73	326.99	16.83	< LOD	25.64	181.95	18.99
GMTG-4-06-12	< LOD	59.55	108.55	21.26	63.2	7.85	< LOD	5.49	268.63	16.31	< LOD	26.67	175.83	19.68
GMTG-4-12-18	91.87	47.7	31.23	12.85	52.56	6.81	< LOD	5.54	246.9	14.76	< LOD	27.49	211.7	19.28
GMTG-4-18-24	< LOD	54.33	< LOD	13.48	39.46	5.41	< LOD	4.64	235.12	12.95	< LOD	20.49	74.81	13.82
GMTG4L35-00-01	< LOD	50.56	82.97	16.97	59.52	6.75	< LOD	6.2	275.88	14.59	65.62	20.91	128.89	16.2
GMTG4L35-01-02	< LOD	58.41	22.26	11.16	56.9	6.69	< LOD	5.68	306.27	15.47	< LOD	25.06	145.72	16.97
GMTG4L50 1-2	< LOD	45.82	684.51	40.05	66.73	6.52	< LOD	6.32	63.38	7.07	27.31	15.2	< LOD	13.53

GMTG4L50 2-3	< LOD	59.54	21.04	10.27	63.58	6.63	< LOD	4.86	199.28	12.01	36.93	17.63	136.06	15.24
GMTG4L5O-00-12	< LOD	48.42	964.92	47.36	73.41	6.83	< LOD	7.15	66.44	7.22	< LOD	21.68	< LOD	13.24
GMTG-4R50-00-06	< LOD	52.25	394.52	34.92	74.87	7.77	< LOD	6.73	131.53	10.85	< LOD	23.96	27.35	12.75
GMTG-4R50-06-12	< LOD	49.73	148.45	21.21	63.66	6.88	< LOD	5.37	306.93	15.15	25.7	15.97	68.23	14.57
GMTG-4R50-12-18	< LOD	60.89	37.36	13.11	64.61	7.17	< LOD	5.72	302.69	15.61	< LOD	25.32	171.27	17.86
GMTG-4R50-18-24	< LOD	68.32	27.34	12.56	62.14	7.36	< LOD	6.01	261.36	15.24	< LOD	26.05	181.38	18.7
GMTG-5-00-06	< LOD	53.87	285.01	31.19	66.64	7.68	< LOD	6.51	187.65	13.22	33.99	19.33	94.93	16
GMTG-5-06-12	< LOD	50.35	109.1	19.59	66.49	7.35	< LOD	5.99	265.88	14.87	53.04	20.5	174.67	17.96
GMTG-5-12-18	< LOD	67.96	37.42	15.3	61.37	8.11	< LOD	7.11	248.68	16.49	< LOD	30.25	175.25	20.48
GMTG-5-18-24	< LOD	64.11	< LOD	15.98	47.28	6.76	< LOD	5.75	233.29	14.94	< LOD	29.77	125.12	17.58
GMTG5L75 1-2	66.05	43.25	32.28	12.2	79.4	7.65	< LOD	5.37	237.52	13.6	30.36	18.03	207.19	17.9
GMTG5L75 2-3	< LOD	65.8	27.28	11.89	60.05	6.82	< LOD	6.51	297.27	15.2	< LOD	26.16	93.53	15.46
GMTG5L75-01-02	< LOD	45.39	742.3	43.18	67.22	6.79	< LOD	6.6	71.31	7.67	< LOD	20.05	< LOD	15.03
GMTG5L75-02-03	< LOD	53.35	24.65	12.24	79.98	8.25	< LOD	5.79	191.2	13.25	< LOD	21.5	< LOD	18.95
GMTG6 00-06	< LOD	53.88	217.3	26.2	74.19	7.66	< LOD	6.19	237.9	14.01	40.2	19.26	122.14	16.27
GMTG6 06-12	< LOD	58.42	184.69	24.06	70.45	7.42	< LOD	5.76	347.8	16.54	42.34	19.35	121.7	16.72
GMTG6 12-18	< LOD	63.34	69.22	17.27	92.51	8.94	< LOD	6.4	515.8	21.25	52.16	22.34	106.66	18.42
GMTG6 18-24	82.82	45.88	< LOD	15.04	55.3	6.73	< LOD	5.49	278.27	15.08	< LOD	27.07	165.6	17.64

Table B-4. XRF database (used for risk analysis).

SAMPLE	Ni	Ni Error	Pb	Pb Error	Rb	Rb Error	Se	Se Error	Sr	Sr Error	Zn	Zn Error	Zr	Zr Error
Tailings Samples														
GMTG6L50 0-1	< LOD	52.43	454.71	33.39	70.47	6.74	< LOD	6.37	53.79	6.71	< LOD	20.99	< LOD	13.53
GMTG6L50 01-02	< LOD	61.26	93.93	17.93	71.74	7.37	< LOD	6.29	207.3	12.87	30.69	19.99	164.34	16.84
GMTG6L50 02-03	< LOD	53.42	22.67	10.82	49.45	6.05	< LOD	6.03	224.07	12.89	< LOD	22.58	77.97	14.07
GMTG6L50 02-03	< LOD	64.64	2587.51	91.23	134.06	10.8	< LOD	10.54	96.65	10.12	99.81	28.14	< LOD	18.41
GMTG6L50 02-03	< LOD	52.27	1669.5	66.68	107.7	8.8	< LOD	8.84	102.38	9.32	54.95	20.41	< LOD	16.77
GMTG6L90 00-01	< LOD	52.39	510.76	35.17	83.35	7.27	< LOD	6.21	122.33	9.37	156.16	26.22	38.68	11.61
GMTG6L90 01-02	69.14	46.07	51.11	14.95	71.76	7.76	< LOD	5.47	255.98	14.93	35.28	19.91	171.07	18.18
GMTG6O.5L30 0-3	< LOD	44.82	802.56	47.56	129.51	9.69	< LOD	7.4	97.18	9.26	70.56	21.42	< LOD	15.72
GMTG7 00-06	< LOD	50.15	254.69	24.04	50.97	5.55	< LOD	4.83	142.85	9.51	70.9	19.09	118.06	13.29
GMTG7 06-12	< LOD	77.21	20.37	12.46	59.75	7.67	< LOD	6.67	260.06	16.11	37.42	21.89	230.83	21.13
GMTG7 12-18	< LOD	68	19.92	11.81	84.48	8.7	< LOD	4.77	353.22	18.05	36.62	20.99	125.36	18.26
GMTG7L50 03 04	< LOD	57.68	80.23	16.75	74.25	7.42	< LOD	6.33	255.99	14.06	67.9	21.82	174.12	17.19
GMTG7L50 04-05	< LOD	56.19	74.98	16.43	73.75	7.44	< LOD	6.48	291.8	15.02	60.81	21.52	192.35	17.92
GMTG7L50 05-06	< LOD	61.77	27.76	12.5	78.35	8.18	< LOD	5.12	273.99	15.62	33.38	19.48	< LOD	20.44
GMTG7L50 1-2	< LOD	63.19	99.79	19.64	77.77	8.17	< LOD	6.4	364.85	17.86	80.46	24.88	130.12	17.98
GMTG7L50 2-3	< LOD	55.94	99.67	18.62	104.76	8.89	< LOD	5.13	189.34	12.57	83.44	24.05	196.17	17.84
GMTG7L50 LBANK	< LOD	66.5	600.97	44.21	83.03	8.47	< LOD	8.26	255.55	15.18	116.63	27.84	166.85	18.41
GMTG7L50 RBANK	< LOD	61.7	3781.65	105.07	167.63	11.49	< LOD	11.85	89.27	9.46	102.83	27.66	< LOD	16.33
GMTG7L60 0-1	< LOD	44.32	808.89	45.59	84.56	7.61	< LOD	6.83	63.81	7.45	36.88	16.9	< LOD	14.28
GMTG7L60 1-2	< LOD	70.51	< LOD	17.01	62.52	7.49	< LOD	6.68	269.35	15.67	52.91	24.09	180.18	18.97

GMTG7L60-02-03	69.81	46.01	24.76	12.55	63.95	7.6	< LOD	6.48	348.11	17.71	47.97	22.37	134.28	18.25
GMTG7L60-03-04	88.27	47.25	37.67	13.8	68.25	7.75	< LOD	5.05	262.76	15.43	< LOD	27.83	188.3	19.08
GMTG7L60-03-04	< LOD	57.45	5562.7	124.77	149.07	10.83	< LOD	14.37	86.3	9.28	93.1	27.23	< LOD	17.82
GMTG7L60-03-04	< LOD	50	1011.13	51.5	90.44	7.98	< LOD	8.22	113.52	9.58	80.33	21.56	< LOD	16.88
GMTG7L60-03-04	< LOD	55.4	1343.9	59.09	106.89	8.61	< LOD	8.8	107.59	9.36	126.06	25.6	< LOD	15.92
GMTG-7R50-00-06	< LOD	40.21	329.78	23.46	90.84	6.21	< LOD	4.65	307.7	11.68	38.52	13.55	46.69	10.76
GMTG-7R50-06-12	< LOD	32.74	32.47	7.55	87.18	4.92	< LOD	3.17	326.37	9.72	119.87	15.78	122.36	10.06
GMTG-7R50-12-18	< LOD	61.45	24.03	11.86	74.99	7.87	< LOD	5.16	314.97	16.34	37.15	19.34	196.98	19.06
GMTG-7R50-18-24	81.18	47.38	17.73	11.33	67.16	7.8	< LOD	4.74	255.89	15.45	< LOD	29.27	94.3	16.65
GMTG8 00-06	< LOD	54.92	82.46	16.95	68.29	7.15	< LOD	6.51	225.6	13.27	67.02	21.81	189.49	17.42
GMTG8 02-18	107.65	52.95	18.46	11.39	54.26	7.04	< LOD	5.19	304.4	16.55	44.11	22.46	334.22	22.77
GMTG8 06-12	< LOD	60.45	124.91	20.2	79.31	7.78	< LOD	4.81	273.24	14.75	48.77	20.71	151.45	17.02
GMTG8 18-24	81.26	49.13	21.43	11.74	61.36	7.31	< LOD	5.94	248.96	14.88	47.74	21.76	157.19	17.96
GMTG8.5L20-00-01	< LOD	56.97	44.92	14.2	90.75	8.46	< LOD	5.89	334.56	16.58	77.42	25	213.46	19.31
GMTG8.5L20-01-02	< LOD	60.25	62.88	15.76	72.93	7.62	< LOD	5.73	279.09	15.15	54.4	20.78	205.02	18.71
GMTG8.5L50 03-04	< LOD	63.99	26.5	12.26	54.34	6.89	< LOD	5.61	291.09	15.87	61.59	23.78	185.63	18.79
GMTG8.5L50 03-04	76.39	47.67	26.51	12.62	62.21	7.46	< LOD	6.08	293.58	16.27	64.51	24.4	172.66	18.87
GMTG8.5L50 03-04	< LOD	96.7	46.18	23.13	85.85	13.37	< LOD	9.13	264.7	24.12	< LOD	52.52	252.76	32.2
GMTG8.5L5O-00-01	< LOD	73.6	12813.71	213.42	191.84	14.25	< LOD	21.27	81.67	10.93	141.87	39.44	< LOD	20.43
GMTG8.5L5O-01-02	< LOD	79.17	11776.02	207.62	196.99	14.53	< LOD	21.96	87.84	11.26	123.26	38.5	< LOD	20.62
GMTG8.5L5O-01-02	< LOD	66.01	938.39	54.38	76.83	8.17	< LOD	8.06	243.13	14.75	56.86	24.53	185.6	18.72
GMTG8L50 03-04	< LOD	68.23	258.99	31.05	72.51	8.32	< LOD	6.32	245.56	15.59	81.28	27.1	129.91	18.14
GMTG8L50 04-05	< LOD	67.63	108.35	19.74	64.06	7.28	< LOD	6.58	248.33	14.51	95.19	25.34	89.83	15.66
GMTG-8R50-00-06	< LOD	52.37	525.48	39.69	80.52	8	< LOD	6.72	246.51	14.31	133	27.61	60.87	14.62

Table B-4. XRF database (used for risk analysis).

SAMPLE	Ni	Ni Error	Pb	Pb Error	Rb	Rb Error	Se	Se Error	Sr	Sr Error	Zn	Zn Error	Zr	Zr Error
Tailings Samples														
GMTG-8R50-06-12	< LOD	53.07	51.33	14.65	78.63	7.88	< LOD	5.63	351.77	16.86	214.64	32.99	91.34	16.15
GMTG-8R50-12-18	< LOD	61.04	24.26	12.48	74.64	8.16	< LOD	6.06	367.42	18.24	49.25	21.32	154.31	18.98
GMTG-8R50-18-24	< LOD	68.12	26.84	12.61	89.53	8.71	< LOD	5.93	307.08	16.51	83.95	24.68	170.17	18.75
GMTG9 00-06	< LOD	66.63	468.86	37.91	91.06	8.52	< LOD	7.23	239.7	14.24	244.69	36.81	169.26	17.74
GMTG9 06-12	< LOD	58.92	40.79	13.69	97.33	8.68	< LOD	5.93	327.36	16.32	149.51	29.15	170.31	18.1
GMTG9 12-18	< LOD	69.94	< LOD	17.2	82.56	8.49	< LOD	6.57	318.23	16.96	54.91	23.46	276.02	21.61
GMTG9 12-18	< LOD	41.97	< LOD	9.74	< LOD	3.3	< LOD	4.71	12.71	4.78	< LOD	15.07	< LOD	12.72
GMTG-9L20-00-06	< LOD	51.35	957.72	52.44	91.43	8.38	< LOD	7.34	90.15	9.09	50.19	19.66	< LOD	16.59
GMTG-9L20-06-12	< LOD	52.2	610	42.35	97.41	8.63	< LOD	6.13	82.09	8.77	49.48	19.46	< LOD	16.35
GMTG-9L20-12-18	< LOD	42.06	442.3	35.06	101.46	8.46	< LOD	6.59	71.22	7.98	42.05	17.78	< LOD	15.46
GMTG-9L20-18-24	< LOD	51.35	1116.05	55.09	113.56	9.02	< LOD	7.56	68.85	7.96	78.93	21.98	< LOD	14.75
GMTG-9L20-24-30	< LOD	59.1	1305.61	59.16	83.79	7.89	< LOD	6.83	232.48	13.39	55.07	22.41	141.84	16.19
GMTG-9L20-30-36	< LOD	67.03	24.16	12.48	67.47	7.91	< LOD	5.61	278.36	16.25	59.87	23.62	130.29	18.07
GMTG-9L20-36-42	< LOD	64.56	42	14.29	64.94	7.53	< LOD	6.35	287.56	15.96	64.88	23.21	200.43	19.37

GMTG-9R50-00-06	< LOD	59.41	713.33	47.51	103.04	9.24	< LOD	7.13	187.36	13.04	46	20.79	< LOD	19.4
GMTG-9R50-06-12	< LOD	59.82	32.02	13.25	87.38	8.66	< LOD	5.74	357.6	17.81	73.46	25.68	130.33	18.08
GMTG-9R50-12-18	< LOD	63.11	59.31	16.35	89.19	8.84	< LOD	5.86	360.76	18.08	93.17	26.21	209.39	20.35
GMTG-9R50-18-24	< LOD	70.39	65.68	18.18	82.89	9.18	< LOD	6.24	421.27	20.83	63.54	26.12	277.65	23.86
GMTGO.5L30 3-6	< LOD	53.26	1730.12	67.65	90.43	8.12	< LOD	7.93	83.68	8.57	59.91	20.49	< LOD	15.62
GMTGO.5L30 6-9	< LOD	61.72	36.09	12.39	80.58	7.56	< LOD	5.48	195.18	12.21	44.6	19.06	174.26	16.6
TP1A*			4438.28		176.69				112.454		133.051			
TP1B*			934.426		133.54				88.99					
TP1C1*			2121.94		244.37				114.73		380.59			
TP1C2*			125599		199.171				117.316		126.275			
TP1D1*			2337.08		143.14				100.159					
TP1D2*			1733.97		124.106				95.45		72.7585			

Waste Rock Samples

WR1A*			199.58		162.76				230.44		96.126			
WR1B*			1090.5		201.09				162.42		123.473			
WR1C*			67.77		251.986				90.87		92.71			
WR1D*			108.59		144.75				368.95		95.578			
WR3A*					160.86				360.678		183.259			
WR3B*			52.3		119.365				663.11		70.48			
WR4*			802.43		135.908				219.257		99.637			

* Asterisk indicates samples and data collected by Pioneer (1994). All other data collected by Tetra Tech (2009).

Table B-5. Surface Water Data

NOTES:
Red indicates sample exceeds Human Health SW standards
Orange indicates sample exceeds acute SW standards
Yellow indicates sample exceeds SMCL or chronic SW standards
Hardness dependent standards calculated for 40 mg/L hardness (avg hardness of Cataract Ck for July 1st 2008 monitoring event).
a=acute, c=chronic, h=human health, 2=secondary MCL

Parameter	Unit	RL	Standard	GMSW-1 (Cataract Dam Outfall)			GMSW-2			GMSW-3		
				7/1/2008	7/29/2008	10/23/2008	7/1/2008	7/29/2008	10/23/2008	7/1/2008	7/29/2008	10/23/2008
Discharge	cfs			0.213	0.215	0.185	1.796	2.262	No Flow	7.978	6.964	0.268
Acidity, Total as CaCO3	mg/L	1		6	6	2	7	4	No Flow	6	4	4
Bicarbonate as HCO3	mg/L	1		36	35	39	43	38	No Flow	42	38	45
Carbonate as CO3	mg/L	1		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Calcium	mg/L	1		7	8	8	13	10	No Flow	12	9	9
Chloride	mg/L	1		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Conductivity (LAB)	umhos/cm	1		69	65	72	92	73	No Flow	87	72	80
Conductivity (Field)	umhos/cm			71.4	68.3	77.8	92.7	74.7	No Flow	86.7	73.7	82.4
Hardness as CaCO3	mg/L	1		25	29	28	43	33	No Flow	40	32	31
Magnesium	mg/L	1		2	2	2	3	2	No Flow	3	2	2
pH (LAB)	s.u.	0.1		7.1	6.7	8.0	6.7	6.6	No Flow	6.6	6.6	7.2
pH (Field)	s.u.			6.51	6.10	6.11	7.02	6.10	No Flow	7.25	6.28	5.85
Potassium	mg/L	1		ND	ND	ND	ND	ND	No Flow	1	ND	ND
Sodium	mg/L	1		2	2	3	2	2	No Flow	2	2	3
Solids, Total Dissolved TDS @ 180 C	mg/L	10		28	47	61	40	46	No Flow	32	45	53
Solids, Total Suspended TSS @ 105 C	mg/L	10		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Sulfate	mg/L	1		3	3	3	7	4	No Flow	6	4	3
Total Recoverable Metals												
* Aluminum	mg/L	0.03		0.04	ND	ND	0.03	0.12	No Flow	0.07	0.06	ND
Arsenic	mg/L	0.003	0.34(a), 0.15(c), 0.010(h)	ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Cadmium	mg/L	0.00008	0.00084(a), 0.00014(c), 0.005(h)	ND	ND	ND	ND	ND	No Flow	ND	0.00008	ND
Copper	mg/L	0.001	0.0059(a), 0.0043(c), 1.3(h)	ND	ND	ND	0.001	0.006	No Flow	0.005	0.004	0.002
Iron	mg/L	0.05	1.0(c), 0.3(2)	0.12	0.09	ND	0.05	0.14	No Flow	0.11	0.1	ND
Lead	mg/L	0.0005	0.025(a), 0.001(c), 0.015(h)	ND	0.0009	ND	0.0019	0.005	No Flow	0.0073	0.0065	0.0034
Manganese	mg/L	0.005	0.05(2)	0.04	0.022	ND	0.01	0.02	No Flow	0.008	0.011	0.017
Mercury	mg/L	0.0001	0.0017(a), 0.00091(c), 0.00005(h)	ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Zinc	mg/L	0.01	0.055 (a and c), 2.0 (h)	ND	ND	ND	0.01	ND	No Flow	ND	ND	ND
Dissolved Metals												
* Aluminum	mg/L	0.03	0.750(a), 0.087(c)	ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Arsenic	mg/L	0.003		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Cadmium	mg/L	0.00008		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Copper	mg/L	0.001		ND	ND	ND	0.001	ND	No Flow	0.002	0.002	ND
Iron	mg/L	0.05		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
Lead	mg/L	0.0005		ND	ND	ND	0.0005	0.0006	No Flow	0.0009	0.0007	0.0010
Manganese	mg/L	0.005		0.037	0.007	ND	0.008	0.016	No Flow	0.005	0.007	0.017
Zinc	mg/L	0.01		ND	ND	ND	ND	ND	No Flow	ND	ND	ND
LOADS												
Copper	kg/day			0.521	0.526	0.453	4.394	33.205	No Flow	97.594	68.152	1.311
Lead	kg/day			0.000	0.473	0.226	8.349	27.671	No Flow	142.488	110.747	2.229

* Surface water standards for aluminum are based on dissolved concentrations and apply only to water with pH values between 6.5 and 9.

Table B-5. Surface Water Data

NOTES:
Red indicates sample exceeds Human Health SW standards
Orange indicates sample exceeds acute SW standards
Yellow indicates sample exceeds SMCL or chronic SW standards
Hardness dependent standards calculated for 40 mg/L hardness (avg hardness of Cataract Ck for July 1st 2008 monitoring event).
a=acute, c=chronic, h=human health, 2=secondary MCL

Parameter	Unit	RL	Standard	GMSW-4 (500 ft below breached tailings dam)			GMSW-4/1 (Downstream end of meadow)	GMSW-5 (Oriole Adit)		
				7/1/2008	7/29/2008	10/23/2008	10/23/2008	7/1/2008	7/29/2008	10/23/2008
Discharge	cfs			8.822	9.550	0.719	0.478	0.006	0.019	0.008
Acidity, Total as CaCO3	mg/L	1		6	5	4	3	9	4	4
Bicarbonate as HCO3	mg/L	1		43	39	42	43	71	87	100
Carbonate as CO3	mg/L	1		ND	ND	ND	ND	ND	ND	ND
Calcium	mg/L	1		12	10	9	9	78	71	60
Chloride	mg/L	1		ND	ND	ND	ND	1	1	1
Conductivity (LAB)	umhos/cm	1		88	73	83	82	506	469	438
Conductivity (Field)	umhos/cm			86.9	75.9	84.9	86.2	490	484	429
Hardness as CaCO3	mg/L	1		41	34	31	31	253	236	194
Magnesium	mg/L	1		3	2	2	2	14	14	11
pH (LAB)	s.u.	0.1		6.7	6.8	7.4	7.8	7.3	7.6	8.0
pH (Field)	s.u.			6.96	6.35	6.20	6.46	7.06	6.88	6.09
Potassium	mg/L	1		1	ND	1	1	2	2	2
Sodium	mg/L	1		3	2	3	3	6	6	7
Solids, Total Dissolved TDS @ 180 C	mg/L	10		36	45	50	54	336	309	291
Solids, Total Suspended TSS @ 105 C	mg/L	10		31	ND	ND	ND	95	ND	ND
Sulfate	mg/L	1		6	4	5	5	183	158	134
Total Recoverable Metals										
* Aluminum	mg/L	0.03		0.08	0.06	ND	ND	2.96	0.11	0.11
Arsenic	mg/L	0.003	0.34(a), 0.15(c), 0.010(h)	ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	0.00008	0.00084(a), 0.00014(c), 0.005(h)	ND	ND	ND	ND	0.0443	0.00899	0.00447
Copper	mg/L	0.001	0.0059(a), 0.0043(c), 1.3(h)	0.007	0.006	0.003	0.003	4.19	0.443	0.204
Iron	mg/L	0.05	1.0(c), 0.3(2)	0.13	0.1	0.05	ND	7.75	0.19	0.32
Lead	mg/L	0.0005	0.025(a), 0.001(c), 0.015(h)	0.014	0.009	0.0049	0.0037	1.3	0.051	0.0536
Manganese	mg/L	0.005	0.05(2)	0.008	0.01	0.012	0.005	22.4	5.1	2.80
Mercury	mg/L	0.0001	0.0017(a), 0.00091(c), 0.00005(h)	ND	ND	ND	Not Analyzed	ND	ND	ND
Zinc	mg/L	0.01	0.055 (a and c), 2.0 (h)	ND	ND	ND	ND	2.9	0.68	0.37
Dissolved Metals										
* Aluminum	mg/L	0.03	0.750(a), 0.087(c)	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/L	0.003		ND	ND	ND	ND	ND	ND	ND
Cadmium	mg/L	0.00008		ND	ND	ND	ND	0.0137	0.00879	0.00400
Copper	mg/L	0.001		0.003	0.002	ND	ND	0.259	0.284	0.067
Iron	mg/L	0.05		ND	ND	ND	ND	ND	ND	ND
Lead	mg/L	0.0005		0.0014	0.0013	0.0012	0.0009	0.0074	0.0067	0.0028
Manganese	mg/L	0.005		0.005	0.008	0.010	ND	7.21	5.16	2.55
Zinc	mg/L	0.01		ND	ND	ND	ND	0.86	0.67	0.30
LOADS										
Copper	kg/day			151.087	140.190	5.277	3.508	61.507	20.593	3.993
Lead	kg/day			302.173	210.284	8.620	4.327	19.083	2.371	1.049

* Surface water standards for aluminum are based on dissolved concentrations and apply only to water with pH values between 6.5 and 9.

Table B-6. Ground Water Data

NOTES:

Red indicates sample exceeds Human Health SW standards
Yellow indicates sample exceeds SMCL or chronic SW standards

h=human health, 2=secondary MCL

Parameter	Unit	RL	Standard	GMMW-1		GMMW-2		GMMW-3	
				8/22/2008	10/23/2008	8/22/2008	10/23/2008	8/22/2008	10/23/2008
Water Level	Depth to water (ft)			9.79	DRY	9.21	DRY	13.34	14.6
Acidity, Total as CaCO3	mg/L	4		ND	DRY	ND	DRY	ND	11
Bicarbonate as HCO3	mg/L	4		51	DRY	45	DRY	46	41
Carbonate as CO3	mg/L	4		ND	DRY	ND	DRY	ND	ND
Calcium	mg/L	1		12	DRY	11	DRY	13	10
Chloride	mg/L	1		ND	DRY	ND	DRY	ND	ND
Conductivity (LAB)	umhos/cm	1		89	DRY	77	DRY	105	88
Conductivity (Field)	umhos/cm			99	DRY	80	DRY	121	92.7
Hardness as CaCO3	mg/L	1		40	DRY	34	DRY	44	33
Magnesium	mg/L	1		2	DRY	2	DRY	3	2
pH (LAB)	s.u.	0.1		6.9	DRY	6.9	DRY	6.7	6.8
pH (Field)	s.u.			6.67	DRY	6.74	DRY	6.52	5.68
Potassium	mg/L	1		1	DRY	2	DRY	1	1
Sodium	mg/L	1		3	DRY	2	DRY	3	3
Solids, Total Dissolved TDS @ 180 C	mg/L	10		92	DRY	54	DRY	68	67
Solids, Total Suspended TSS @ 105 C	mg/L	10		498	DRY	1500	DRY	368	1010
Sulfate	mg/L	1							
Dissolved Metals									
Aluminum	mg/L	0.03	None	ND	DRY	ND	DRY	ND	ND
Arsenic	mg/L	0.003	0.010 (h)	ND	DRY	ND	DRY	ND	ND
Cadmium	mg/L	0.00008	0.005 (h)	ND	DRY	0.00010	DRY	ND	ND
Copper	mg/L	0.001	1.3 (h)	ND	DRY	0.003	DRY	0.001	ND
Iron	mg/L	0.05	0.30 (2)	ND	DRY	ND	DRY	ND	0.14
Lead	mg/L	0.0005	0.015 (h)	ND	DRY	ND	DRY	ND	ND
Manganese	mg/L	0.005	0.05 (2)	0.009	DRY	0.068	DRY	1.240	0.055
Mercury	mg/L	0.00001	0.002 (h)	ND	DRY	ND	DRY	ND	ND
Zinc	mg/L	0.01	2.0 (h)	ND	DRY	ND	DRY	ND	ND

APPENDIX C

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR RECLAMATION PROJECTS (ARARS)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

(ARARS)

FOR

RECLAMATION PROJECTS

NOVEMBER, 2008

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ARARS FOR RECLAMATION PROJECTS

1.0 INTRODUCTON - HISTORY OF ARARS AT ABANDONED MINED LAND RECLAMATION SITES

After the enactment of the Federal Surface Mining Control and Reclamation Act in 1977 (“SMCRA”, 30 USC §§ 1201-1238), the State of Montana could be delegated the authority to implement the Abandoned Mined Lands Reclamation (“AMLR”) program authorized by that Act, as well as funding for implementation of that program, by the Federal Office of Surface Mining, Reclamation, and Enforcement (“OSM”). The State enacted necessary legislation to implement the AMLR program according to State law and had a plan (“Reclamation Plan”) to do so, which was approved by OSM. Delegation of exclusive authority for the program would follow. Montana passed necessary legislation for reclamation of coal mines (Title 82, Chapter 4, Part 2, MCA), as well as legislation for reclamation of other types of mines (Title 82, Chapter 4, Part 3, MCA – Metal Mine Reclamation, and Title 82, Chapter 4, Part 4, Part 4, MCA – Open Cut Mining Reclamation).

Satisfaction of the requirements of SMCRA by the State of Montana resulted in the delegation by OSM to the State of Montana of the exclusive authority to implement the Reclamation Plan in the State of Montana on November 24, 1980. While the delegation of the program in 1980 was limited to abandoned coal mine reclamation, it was expanded by Montana’s showing it had reclaimed all eligible abandoned coal mines, whereupon OSM approved the 1995 amendments to the State’s Reclamation Plan to include non-coal abandoned mines. This approval resulted in additional delegation of authority to the State of Montana to implement reclamation of abandoned hardrock mines as well as quarries.

In the 1995 Amendments to its Reclamation Plan, the State of Montana stated that the AMLR program would comply with the National Contingency Plan (“NCP”). Among other things, the NCP provides a procedure for evaluating alternative cleanup methods for hazardous wastes. The NCP also establishes cleanup standards for hazardous wastes, which standards are referred to in the NCP as “ARARs.” By requiring compliance with the NCP, the State adopted the NCP procedures for evaluation of alternatives in addressing AMLR Reclamation Projects, as well as ARARS. At the same time, utilization of the evaluation of alternatives procedures found in the NCP satisfied the evaluation of alternatives required for major Federal actions undertaken by the Federal government which could have a significant effect on the environment as required by the Federal National Environmental Policy Act (“NEPA”, 42 USC 4321 – 4370).

AMLR, which is based upon SMCRA, is one of several legal authorities available in the State of Montana for cleanup of mine wastes, the others being the Federal Comprehensive Environmental Response, Compensation, and Liability Act (“CERCLA” or “Superfund”, 42 USC 9601 – 9675) and the State’s counterpart to the Federal

Superfund law, the Comprehensive Environmental Cleanup and Responsibility Act ("CECRA," §§ 75-10-701 - 752 MCA).

To paraphrase the Federal Superfund statute, at 42 USC 121(d)(E)(4), in remedy selection for cleanup of an hazardous waste site, if a State ARAR is not consistently applied, a remedy may be selected by the Federal government which does attain that ARAR. Such a decision could result in State standards not being applied to Federal mine waste cleanups in the State of Montana. Consequently, to avoid the risk that State standards would not be applied within the State of Montana, ARARs should be consistently applied in the State's three mine waste cleanup programs (Superfund, CECRA, and AMLR).

The interaction of SMCRA and CERCLA requirements, particularly the interaction of the consistency requirement of CERCLA and the adoption of the NCP in Montana's 1995 Reclamation Plan, resulted in procedures and standards for the Montana AMLR program which address NEPA alternatives analysis and incorporate CERCLA standards (i.e., ARARs).

The ARARs described below are, by necessity, generic because they are to be used as part of the evaluation process developed by the AMLR program for analysis of alternatives for AMLR Projects. This evaluation results in the Expanded Engineering Evaluation/Cost Analysis ("EEE/CA") which precedes selection of a Reclamation alternative.

The ARARs listed below are based upon those identified for the Neihart Operable Unit 1, Carpenter-Snow Creek Mining District NPL Site (June, 2007). The wastes include both mining and milling wastes, which exist at a typical AMLR site. The text of the ARARs analysis used has been updated and adapted to allow its application to AMLR sites in general.

2.0 TYPES OF ARARS

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location or other circumstances found at a CERCLA site. 40 CFR Section 300.5 Relevant and appropriate requirements are those "Standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site." Id. Factors which may be considered in making this determination are presented in 40 CFR 300.400 (g)(2).

Each ARAR or group of related ARARs indentified herein is followed by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate, and a description which summarizes the requirements.

ARARs are divided into contaminant specific, location specific, or action specific requirements, as described in the NCP and EPA Guidance.

Contaminant specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographic or physical position of the site, rather than to the nature of the contaminants. Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Many requirements listed here are promulgated as identical or nearly identical requirements in both federal and state law, usually pursuant to delegated environmental programs administered by both EPA and the states, such as many of the requirements of the federal Clean Water Act and the Montana Water Quality Act. The Preamble to the final NCP states that such a situation results in citation to the state provision as the appropriate standard, but treatment of the provisions is a federal requirement. ARARs and other laws which are unique to state law are identified as state ARARs.

As noted previously, the 1995 Reclamation Plan provides that the NCP was adopted for Reclamation activities. Those activities are directly analogous to “removal actions” under CERCLA. As stated in the NCP at 55 FR 8695 (March 8, 1990):

> The purpose of removal actions generally is to respond to a release…so as to prevent, minimize, or mitigate harm to human health and the environment. Although all removals must be protective…removals are distinct from remedial actions in that they may mitigate or stabilize the threat rather than comprehensively address all the threats at a site. Consequently, <u>removal actions cannot be expected to attain all ARARs.</u> Remedial actions, in contrast, must comply with all ARARs or obtain a waiver. (emphasis supplied).

Consequently, the NCP, at 40 CFR 300.410 provides that ARARS at removal actions:

> …shall, to the extent practicable, considering the exigencies of the situation, attain…[ARARs]. In determining whether compliance with ARARs is

> practicable, the lead agency may consider appropriate factors, including:
> a) the urgency of the situation; and
> b) the scope of the removal action to be conducted.

Therefore, based upon the NCP, after an ARAR has been identified for a Reclamation project, the EEE/CA should evaluate how the alternatives will attain ARARs and select an alternative that complies with ARARs to the extent practicable. If an ARAR cannot be complied with, the EEE/CA should indicate why, utilizing the two part test set out above, attainment is not practicable.

3.0 CONTAMINANT-SPECIFIC ARARs

3.1 Federal

3.1.1 Safe Drinking Water Act

Safe Drinking Water Act, 42 U.S.C. ' 300f, et seq., National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141 and 142 (relevant and appropriate). The National Primary and Secondary Drinking Water Regulations (40 CFR Parts 141 and 143) establish maximum contaminant levels (MCL) for chemicals in drinking water distributed in public water systems. These are enforceable in Montana under the Public Water Supplies, Distribution, and Treatment Act and corresponding regulations, MCA ' 75-6-101, et seq., and ARM ' 17.38.203. Safe Drinking Water Act MCLs are relevant and appropriate to for reclamation projects because the groundwater in a reclamation project area is a potential source of drinking water.

The determination that the drinking water standards are relevant and appropriate for reclamation projects is supported by the regulations and guidance. The Preamble to the NCP clearly states that the MCLs are relevant and appropriate for ground or surface water that is a current or potential source of drinking water. See 55 Fed. Reg. 8750, March 8, 1990, and 40 CFR ' 300.430(e)(2)(I)(B). MCLs developed under the Safe Drinking Water Act generally are ARARs for current or potential drinking water sources. See, EPA Guidance On Remedial Action For Contaminated Groundwater at Superfund Sites, OSWER Dir. #9283.1-2, December 1988.

In addition, maximum contaminant level goals (MCLG) may also be relevant and appropriate . See 55 Fed. Reg. 8750-8752. MCLGs are health-based goals which are established at levels at which no known or anticipated adverse effects on the health of persons occur and which allow an adequate margin of safety. According to the NCP, MCLGs that are set at levels above zero must be attained for ground or surface waters that are current or potential sources of drinking water. Where the MCLG for a contaminant has been set at a level of zero, the MCL promulgated for that contaminant must be attained.

The MCLs and MCLGs for contaminants of concern are:

Contaminant	MCL (mg/L)	MCLG[a] (mg/L)
Antimony	0.006	0.006
Arsenic	0.01	NE
Cadmium	0.005[b]	0.005[b]
Copper	1.3[c]	1.3[c]

Iron	0.3[d]	NE
Lead	0.015[c]	0
Manganese	0.05[d]	NE
Mercury	0.002[b]	0.002[b]
Silver	NE	NE
Thallium	0.002[b]	0.0005
Zinc	5.0[d]	NE

NE - Not Established

[a] 40 CFR ' 141.51(b)
[b] 40 CFR ' 141.62(c)
[c] 40 CFR ' 141.80(c) B No MCL, but specifies BAT to be applied.
[d] 40 CFR ' 143.3 B Secondary MCL

ARM 17.38.203 incorporates by reference into State law the MCLs for inorganic substances set forth in 40 CFR Part 141 (Primary Drinking Water Standards).

3.1.2 Clean Water Act

<u>Federal Surface Water Quality Requirements, Clean Water Act, 33 USC ' 1251, et seq. (applicable)</u>. As provided under Section 303 of the Clean Water Act, 33 U.S.C. ' 1313, the State of Montana has promulgated water quality standards. See the discussion concerning State surface water quality requirements.

3.1.3 National Ambient Air Quality Standards

<u>National Ambient Air Quality Standards, 40 CFR ' 50.6 (PM-10); 40 CFR ' 50.12 (lead) (applicable)</u>. These provisions establish standards for PM-10 and lead emissions to air. (Corresponding state standards are found at ARM ' 17.8.222 [lead] and ARM ' 17.8.223 [PM-10].) The PM-10 standard is 150 micrograms per cubic meter (μg/m^{3}), 24-hour average concentration, and the lead standard is 1.5 μg/m^{3}, maximum arithmetic mean averaged over a calendar quarter.

3.2 State

3.2.1 Groundwater Protection

<u>ARM 17.30.1005 (applicable)</u> explains the applicability and basis for the groundwater standards in ARM ' 17.30.1006, which establish the maximum allowable changes in groundwater quality and may limit discharges to groundwater.

<u>ARM 17.30.1006 (applicable)</u> provides that groundwater is classified into Classes I through IV based on its specific conductance and establishes the applicable ground water quality standards with respect to each groundwater classification.

Concentrations of dissolved substances in Class I or II groundwater may not exceed the human health standards listed in department Circular DEQ-7.[1] These levels are listed below for the primary contaminants of concern.

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[1] Montana Department of Environmental Quality, Water Quality Division, <u>Circular DEQ-7, Montana Numeric Water Quality Standards</u> (February 2008).

Contaminant	DEQ-7 Standard (mg/L)[a]
Antimony	0.006
Arsenic	0.01
Cadmium	0.005
Copper	1.3
Iron	NE[b]
Lead	0.015
Manganese	NE[b]
Mercury	0.002
Silver	0.1
Thallium	0.002
Zinc	2.0

NE- Not Established

[a] DEQ-7 standards for metals and arsenic in ground water are based on the dissolved portion of the sample (after filtration through a 0.45 Φm membrane filter).

[b] Concentrations of iron and manganese must not reach values that interfere with the uses specified in the surface and groundwater standards (ARM 17.30.601 et seq. and ARM 17.30.1001 et seq.). The secondary maximum contaminant levels of 300 Φg/L and 50 Φg/L, respectively, may be considered guidance to determine levels that will interfere with the specified uses.

Reclamation projects must meet the DEQ-7 standards for all contaminants at a Reclamation site. In addition, for Class I and Class II ground water, no increase of a parameter may cause a violation of Section 75-5-303, MCA (nondegradation).

ARM 17.30.1006 requires that concentrations of other dissolved or suspended substances must not exceed levels that render the waters harmful, detrimental or injurious to public health. Maximum allowable concentrations of these substances also must not exceed acute or chronic problem levels that would adversely affect existing or designated beneficial uses of groundwater of that classification.

ARM 17.30.1011 (applicable)

This section provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with Section 75-5-303, MCA, and ARM Title 17, Chapter 30, Subchapter 7.

An additional concern with respect to ARARs for groundwater is the impact of groundwater upon surface water. If significant loadings of contaminants from groundwater sources to any surface water within a Reclamation Project contribute to the inability of the stream to meet classification standards, then alternatives to alleviate such groundwater loading must be evaluated and, if appropriate, implemented. Groundwater in certain areas may have to be remediated to levels more stringent than the groundwater classification standards in order to achieve the standards for affected surface water. See Compliance with Federal Water Quality Criteria, OSWER Publication 9234.2-09/FS (June 1990) (AWhere the ground water flows naturally into the surface water, the ground-water remediation should be designed so that the receiving surface-water body will be able to meet any ambient water-quality standards [such as State WQSs or FWQC] that may be ARARs for the surface water.@)

3.2.2 Montana Water Quality Act

State of Montana Surface Water Quality Requirements, Montana Water Quality Act, Section 75-5-101, et seq., MCA, and implementing regulations (applicable). General. The Clean Water Act, 33 U.S.C. ' 1251, et seq., provides the authority for each state to adopt water quality standards (40 CFR Part 131) designed to protect beneficial uses of each water body and requires each state to designate uses for each water body. The Montana Water Quality Act, Section 75-5-101, et seq., MCA, establishes requirements to protect, maintain and improve the quality of surface and groundwater. Montana's regulations classify State waters according to quality, place restrictions on the discharge of pollutants to State waters, and prohibit degradation of State waters. Pursuant to this authority and the criteria established by Montana surface water quality regulations, ARM ' 17.30.601, et seq., Montana has established the Water-Use Classification system. The classification for specific surface water bodies within the State are set for in ARM 17.30.607 et. seq. The applicable standards for each classification are set forth in ARM 17.30.621 through ARM 17.30.629, inclusive.

ARM 17.30.637 (applicable). Provides that surface waters must be free of substances attributable to industrial practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.

ARM 17.30.637 also states that no waste may be discharged and no activities conducted which, either alone or in combination with other waste activities, will cause violation of surface water quality standards.

In addition, ARM 17.30.637 provides that leaching pads, tailings ponds, or water or waste or product holding facilities must be located, constructed, operated and maintained in such a manner and of such materials to prevent any discharge, seepage, drainage, infiltration, or flow which may result in pollution of state waters, and a monitoring system may be required to ensure such compliance.

Section 75-5-605, MCA (applicable) provides that it is unlawful to cause pollution of any state waters or to place or cause to be placed, any wastes where they will cause pollution of aany state waters.

Section 75-5-303, MCA (applicable) states that existing uses of state waters and the level of quality of state waters necessary to protect those uses must be maintained and protected.

ARM 17.30.705 (applicable). For all state waters, existing and anticipated uses and water quality necessary to support those uses must be maintained and protected.

3.2.3 Montana Ambient Air Quality Regulations

Montana Ambient Air Quality Regulations, ARM 17.8.206, -.222, -.220, and -.223 (applicable). The following provisions establish air quality standards.

ARM 17.8.206. This provision establishes sampling, data collection, and analytical requirements to ensure compliance with ambient air quality standards.

ARM 17.8.222. Lead emissions to ambient air shall not exceed a ninety (90) day average of 1.5 micrograms per cubic liter of air.

ARM 17.8.220. Settled particulate matter shall not exceed a thirty (30) day average of 10 grams per square meter.

ARM 17.8.223. PM-10 concentrations in ambient air shall not exceed a 24 hour average of 150 micrograms per cubic meter of air and an annual average of 50 micrograms per cubic meter of air.

4.0 LOCATION-SPECIFIC ARARS

The statutes and regulations set forth below relate to solid waste, floodplains, floodways, streambeds, and the preservation of certain cultural, historic, natural or other national resources located in certain areas that may be adversely affected by Reclamation.

4.1 Federal

4.1.1 National Historic Preservation Act

National Historic Preservation Act, 16 USC ' 470, 40 CFR ' 6.301(b), 36 CFR Part 63, Part 65, and Part 800 (NHPA) (applicable). This statute and implementing regulations require Federal agencies to take into account the effect of Reclamation upon any district, site, building, structure, or object that is included in or eligible for the Register of Historic Places. If the effect of Reclamation cannot be reasonably avoided, Measures will be implemented to minimize or mitigate the potential effects of the activity. In addition, Indian cultural and historical resources must be evaluated and effects avoided, minimized or mitigated.

4.1.2 Archaeological and Historic Preservation Act

Archaeological and Historic Preservation Act, 16 USC ' 469, 40 CFR 6.301(c) (applicable). This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data, including Indian cultural and historic data, which may be destroyed through alteration of terrain as a result of a Federal program (such as AMLR). This requires the AMLR Program to survey the site for covered scientific, prehistorical or archaeological artifacts. If eligible scientific, prehistoric, or archeological data are developed during reclamation, they shall be preserved in accordance with these requirements.

4.1.3 Historic Sites Act of 1935

Historic Sites Act of 1935, 16 USC ' 461, et seq., 40 CFR 6.310(a) (applicable). This statute and implementing regulations require federal agencies to consider the existence and location of land marks on the National Registry of National Landmarks and to avoid undesirable impacts on such landmarks.

4.1.4 Protection and Enhancement of the Cultural Environment

Executive Order 11593 Protection and Enhancement of the Cultural Environment, 16 USC ' 470 (applicable). Directs federal agencies to institute procedures to ensure programs contribute to the preservation and enhancement of non-federally owned historic resources. Consultation with the Advisory Council on Historic Preservation is required if Reclamation activities should threaten cultural resources.

4.1.5 The Archaeological Resources Protection Act of 1979

<u>The Archaeological Resources Protection Act of 1979, 16 USC ' ' 470aa-47011 (relevant and appropriate)</u>. Requires a permit for any excavation or removal of archeological resources from public lands or Indian lands. Substantive portions of this act may be relevant and appropriate if archeological resources are encountered during Reclamation activities.

4.1.6 American Indian Religious Freedom Act

<u>American Indian Religious Freedom Act, 42 U.S.C. ' 1996. (applicable).</u> This Act establishes a federal responsibility to protect and preserve the inherent right of American Indians to believe, express and exercise the traditional religions of American Indians. This right includes, but is not limited to, access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. The Act requires Federal agencies to protect Indian religious freedom by refraining from interfering with access, possession and use of religious objects, and by consulting with Indian organizations regarding proposed actions affecting their religious freedom.

4.1.7 Native American Graves Protection and Repatriation Act

<u>Native American Graves Protection and Repatriation Act, 25 U.S.C. ' 3001, et seq. (applicable).</u> The Act prioritizes ownership or control over Native American cultural items, including human remains, funerary objects and sacred objects, excavated or discovered on Federal or tribal lands. Federal agencies and museums that have possession or control over Native American human remains and associated funerary objects are required under the Act to compile an inventory of such items and, to the extent possible, identify their geographical and cultural affiliation. Once the cultural affiliation of such objects is established, the Federal agency or museum must expeditiously return such items, upon request by a lineal descendent of the individual Native American or tribe identified**.**

4.1.8 Fish and Wildlife Coordination Act

<u>Fish and Wildlife Coordination Act, 16 USC ' 661, 40 CFR 6.302 (applicable)</u>. This statute and implementing regulations require that Federal agencies or federally funded projects ensure that any modification of any stream or other water body affected by any action authorized or funded by the Federal agency provide for adequate protection of fish and wildlife resources. This ARAR requires consultation with the U.S. Fish and Wildlife Service and the Montana Department of Fish, Wildlife, and Parks. Further consultation will occur during Reclamation design and construction.

4.1.9 Endangered Species Act

<u>Endangered Species Act, 16 USC ' 1531, 50 CFR Parts 17 and 402 (applicable)</u>. This statute and implementing regulations provide that federal activities not jeopardize the continued existence of any threatened or endangered species. This ARAR will be achieved through consultation with the U.S. Fish and Wildlife Service and the Montana Department of Fish, Wildlife and Parks during Reclamation design and construction action. Specific avoidance or other mitigation measures identified shall be incorporated into the Reclamation design and implemented as part of construction.

4.1.10 Floodplain Management Regulations

Floodplain Management Regulations, Executive Order No. 11988 and 40 CFR ' 6.302(b) (applicable). These require that actions be taken to avoid, to the extent possible, adverse effects associated with direct or indirect development of a floodplain, or to minimize adverse impacts if no practicable alternative exists.

4.1.11 Protection of Wetlands Regulations

Protection of Wetlands Regulations, 40 CFR Part 6, Appendix A, and Executive Order No. 11990 (applicable). Steps will be taken to avoid or mitigate the adverse impacts associated with the destruction or loss of wetlands to the extent possible and avoidance of new construction in wetlands if a practicable alternative exists. Wetlands are defined as those areas that are inundated or saturated by groundwater or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Compliance with this ARAR will be achieved through consultation with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers, to determine the existence and category of wetlands present at the site, and any avoidance or mitigation and replacement which may be necessary.

4.1.12 Clean Water Act

Section 404, Clean Water Act, 33 USC '' 1251 et seq., 33 CFR Part 330 (applicable). Regulates discharge of dredged or fill materials into waters of the United States. Substantive requirements of portions of Nationwide Permit No. 38 (General and Specific Conditions) are applicable to Reclamation activities conducted within waters of the United States within the Reclamation Project area.

4.1.13 Migratory Bird Treaty Act

Migratory Bird Treaty Act, 16 USC ' 703, et seq. (applicable). This requirement establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during Reclamation design and construction to ensure that Reclamation of the site does not unnecessarily impact migratory birds.

4.1.14 Bald Eagle Protection Act

Bald Eagle Protection Act, 16 USC ' 668, et seq. (applicable). This requirement establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation with the U.S. Fish and Wildlife Service during Reclamation design and construction to ensure that Reclamation of the site does not unnecessarily adversely affect bald and golden eagles.

4.1.15 Resource Conservation and Recovery Act

Resource Conservation and Recovery Act and regulations, 40 CFR ' 264.18 (a) and (b) (relevant and appropriate). These regulations provide seismic and floodplain restrictions on the location of a waste management unit.

4.2 State

4.2.1 Montana Antiquities Act

Montana Antiquities Act, Section 22-3-421, et seq., MCA (relevant and appropriate). The Montana Antiquities Act addresses the responsibilities of State agencies regarding historic and prehistoric sites including buildings, structures, paleontological sites, archaeological sites on state owned lands. Each State agency is responsible for establishing rules regarding historic resources under their jurisdiction which address National Register eligibility, appropriate permitting procedures and other historic preservation goals. The State Historic Preservation Office maintains information related to the responsibilities of State Agencies under the Antiquities Act.

4.2.2 Montana Human Skeletal Remains and Burial Site Protection Act

Montana Human Skeletal Remains and Burial Site Protection Act (1991), Section 22-3-801, MCA (applicable). The Human Skeletal Remains and Burial Site Protection Act is the result of years of work by Montana Tribes, State agencies and organizations interested in ensuring that all graves within the State of Montana are adequately protected. If human skeletal remains or burial sites are encountered during Reclamation, then requirements will be applicable.

4.2.3 Montana Floodplain and Floodway Management Act

Montana Floodplain and Floodway Management Act and Regulations, Section 76-5-401, et seq.,MCA, ARM 36.15.601, et seq. (applicable). The Floodplain and Floodway Management Act and regulations specify types of uses and structures that are allowed or prohibited in the designated 100-year floodway[2] and floodplain.[3] If a Reclamation Project contains streams or creeks that run through areas that can flood, these standards are applicable to Reclamation Projects within these floodplain areas.

A. Prohibited uses. Uses prohibited anywhere in either the floodway or the floodplain are:

- solid and hazardous waste disposal; and
- storage of toxic, flammable, hazardous, or explosive materials.

ARM 36.15.605(2) and 36.15.703 (Applicable); see also ARM 36.15.602(5)(b) (Applicable). These provisions effectively prohibit the placement of mine waste repositories within the 100-year floodplain and require mine wastes addressed by Reclamation to be removed from the floodplain.

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[2] The "floodway" is the channel of a watercourse or drainway and those portions of the floodplain adjoining the channel that are reasonably required to carry and discharge the floodwater of the watercourse or drainway. ARM 36.15.101(13).

[3] The "floodplain" is the area adjoining the watercourse or drainway which would be covered by the floodwater of a base (100-year) flood except for sheetflood areas that receive less than one foot of water per occurrence. The floodplain consists of the floodway and flood fringe. ARM 36.15.101(11).

In the floodway, additional prohibitions apply, including prohibition of:

P a building for living purposes or place of assembly or permanent use by human beings;

P any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; and

P the construction or permanent storage of an object subject to flotation or movement during flood level periods.

Section 76-5-403, MCA (Applicable).

B. <u>Applicable considerations in use of floodplain or floodway.</u> Applicable regulations also specify factors that must be considered in allowing diversions of the stream, changes in place of diversion of the stream, flood control works, new construction or alteration of artificial obstructions, or any other nonconforming use within the floodplain or floodway. Many of these requirements are set forth as factors that must be considered in determining whether a permit can be issued for certain obstructions or uses. While permit requirements are not directly applicable to Reclamation construction conducted entirely on site, the substantive criteria used to determine whether a proposed obstruction or use is permissible within the floodway or floodplain are applicable standards. Factors which must be considered in addressing any obstruction or use within the floodway or floodplain include:

P the danger to life and property from backwater or diverted flow caused by the obstruction or use;

P the danger that the obstruction or use will be swept downstream to the injury of others;

P the availability of alternate locations;

P the construction or alteration of the obstruction or use in such a manner as to lessen the danger;

P the permanence of the obstruction or use; and

P the anticipated development in the foreseeable future of the area which may be affected by the obstruction or use.

<u>See</u> Section 76-5-406, MCA; ARM 36.15.216 (Applicable, substantive provisions only). Conditions or restrictions that generally apply to specific activities within the floodway or floodplain are:

P the proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount (2 foot or as otherwise determined by the permit issuing authority) or significantly increase flood velocities, ARM 36.15.604 (Applicable, substantive provisions only); and

P the proposed activity, construction, or use must be designed and constructed to minimize potential erosion. See ARM 36.15.605.

For the substantive conditions and restrictions applicable to specific obstructions or uses, see the following applicable regulations:

Excavation of material from pits or pools - ARM 36.15.602(1).

Water diversions or changes in place of diversion - ARM 36.15.603.

Flood control works (levees, floodwalls, and riprap must comply with specified safety standards) - ARM 36.15.606.

Roads, streets, highways and rail lines (must be designed to minimize increases in flood heights) - ARM 36.15.701(3)(c).

Structures and facilities for liquid or solid waste treatment and disposal (must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with Montana Department of Environmental Quality (DEQ) regulations, which include certain additional prohibitions on such disposal) - ARM 36.15.701(3)(d).

Residential structures - ARM 36.15.702(1).

Commercial or industrial structures - ARM 36.15.702(2).

4.2.4 Montana Stream Protection Requirements

Montana Natural Streambed and Land Preservation Act and Regulations, Section 75-7-101, et.seq., MCA, and ARM 36.2.401, et.seq., (applicable). Applicable if Reclamation alters or affects a streambed or its banks. The adverse effects of any such action must be minimized.

ARM 36.2.410 (applicable) establishes minimum standards which would be applicable if Reclamation alters or affects a streambed, including any channel change, new diversion, riprap or other streambank protection project, jetty, new dam or reservoir or other commercial, industrial or residential development. Reclamation Projects must be designed and constructed using methods that minimize adverse impacts to the stream (both upstream and downstream) and future disturbances to the stream. All disturbed areas must be managed during construction and reclaimed after construction to minimize erosion. Temporary structures used during construction must be designed to handle high flows reasonably anticipated during the construction period. Temporary structures must be completely removed from the stream channel at the conclusion of construction, and the area must be restored to a natural or stable condition. Channel alterations must be designed to retain original stream length or otherwise provide hydrologic stability. Streambank vegetation must be protected except where removal of such vegetation is necessary for the completion of the Reclamation project. When removal of vegetation is necessary, it must be kept to a minimum. Riprap, rock, and other material used in a project must be of adequate size, shape, and density and must be properly placed to protect the streambank from erosion. The placement of road fill material in a stream, the placement of debris or other materials in a stream where it can erode or float into the stream, Reclamation projects that permanently prevent fish migration, operation of construction equipment in a stream, and excavation of streambed gravels are prohibited unless specifically authorized by the district. Such projects must also protect the use of water for any useful or beneficial purpose. See Section 75-7-102, MCA.

Sections 87-5-502 and 504, MCA (applicable -- substantive provisions only). provide that a state agency or subdivision shall not construct, modify, operate, maintain or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, modify, or vary the natural existing shape and form of any stream or its banks or tributaries in a manner that will adversely affect any fish or game habitat.

While the administrative / procedural requirements, including the consent and approval requirements set forth in these statutes and regulations are not ARARs, consultation with the Montana Department of Fish, Wildlife and Parks, and any conservation district or board of county commissioners (or consolidated city/county government) is encouraged during the design and implementation of Reclamation to assist in the evaluation of the factors discussed above.

4.2.5 Montana Solid Waste Management Act

Montana Solid Waste Management Act and regulations, Section 75-10-201, et seq., MCA, ARM 17.50.505 (applicable) . Sets forth requirements applying to the location of any solid waste management facility. Among other things, the location must have sufficient acreage, must not be within a 100-year floodplain, must be located so as to prevent pollution of ground, surface, and private and public water supply systems, and must allow for reclamation of the land.

Under ARM 17.50.505, a facility for the treatment, storage or disposal of solid wastes:

1. must be located where a sufficient acreage of suitable land is available for solid waste management;

2. may not be located in a 100-year floodplain;

3. may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems;

4. must be located to allow for reclamation and reuse of the land;

5. drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and

6. where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved[4].

Even Class III landfills may not be located on the banks of or in a live or intermittent stream or water saturated areas, such as marshes or deep gravel pits which contain exposed ground water. ARM 17.54.505(2)(j).

[4] Group III consist of primarily inert wastes, including industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents. ARM 17.50.503(1)(b).

These standards apply to any facility for the treatment, storage, or disposal of mine wastes, including, for example, any mine waste repository, tailings deposit, or waste rock pile that is actively managed as part of a Reclamation Project.

Section 75-10-212, MCA. For solid wastes, Section 75-10-212, MCA, prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted.

4.2.6 Endangered Species and Wildlife

Sections 87-5-106, 107 and 111, MCA (applicable). Endangered species should also be protected in order to maintain and to the extent possible, enhance their numbers. These Sections list endangered species, prohibited acts, and penalties. Section 87-5-201, MCA (applicable) concerns protection of wild birds, nests and eggs and under ARM 12.5.201 certain activities are prohibited with respect to specified endangered species.

5.0 ACTION-SPECIFIC ARARS

5.1 Federal and State Water Protection Requirements

5.1.1 Clean Water Act

Clean Water Act, Point Source Discharges requirements, 33 USC ' 1342 (applicable, substantive provisions only). Section 402 of the Clean Water Act, 33 USC ' 1342, et seq., authorizes the issuance of permits for the Adischarge@ of any Apollutant.@ This includes storm water discharges associated with Aindustrial activity.@ See, 40 CFR ' 122.1(b)(2)(iv). AIndustrial activity includes inactive mining operations that discharge storm water contaminated by contact with or that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations, see, 40 CFR ' 122.26(b)(14)(iii); landfills, land application sites, and open dumps that receive or have received any industrial wastes including those subject to regulation under RCRA subtitle D, see, 40 CFR ' 122.26(b)(14)(v); and construction activity including clearing, grading, and excavation activities, see, 40 CFR ' 122.26(b)(14)(x). Because the State of Montana has been delegated the authority to implement the Clean Water Act, these requirements are enforced in Montana through the Montana Pollutant Discharge Elimination System (MPDES). The MPDES requirements are set forth below.

5.1.2 Montana Pollutant Discharge Elimination System Requirements

Substantive MPDES Permit Requirements, ARM 17.30.1342-1344 (applicable). These set forth the substantive requirements applicable to all MPDES and National Pollutant Discharge Elimination System (NPDES) permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements for a repository containing mine waste.

Technology-Based Treatment, ARM 17.30.1203 and 1344 (applicable). Provisions of 40 CFR Part 125 for criteria and standards for the imposition of technology-based treatment requirements are adopted and incorporated in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125 are applicable, i.e., for toxic and nonconventional pollutants treatment must apply the best available technology economically achievable (BAT); for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BCT/BAT technology-based treatment requirements are determined on a case by case basis using best professional judgment (BPJ). See CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p. 3-4 and 3-7.

5.1.3 Water Quality Statutes and Regulations

Causing of Pollution, Section 75-5-605, MCA (applicable). This section of the Montana Water Quality Act prohibits the causing of pollution of any state waters. Pollution is defined as contamination or other alteration of physical, chemical, or biological properties of state waters which exceeds that permitted by the water quality standards. Also, it is unlawful to place or caused to be placed any wastes where they will cause pollution of any state waters.

Nondegradation, Section 75-5-303, MCA (applicable). This provision states that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected. Section 75-5-317, MCA, provides an exemption from nondegradation requirements which allows changes of existing water quality resulting from an emergency or Reclamation that is designed to protect the public health or the environment and that is approved, authorized, or required by the department. Degradation meeting these requirements may be considered nonsignificant.

Surface Water, ARM 17.30.637 (applicable). Prohibits discharges containing substances that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; or (e) create conditions which produce undesirable aquatic life.

ARM 17.30.705 (applicable). This provides that forall state waters, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.708.

5.1.4 Stormwater Runoff Control Requirements

ARM 17.24.633 (applicable). All surface drainage from a disturbed area must be treated by the best technology currently available.

General Permits (applicable). Pursuant to ARM 17.30.1341, DEQ has issued general storm water permits for certain activities. The substantive requirements of the following permits are applicable for the following activities: for construction activities B General Permit for Storm Water Discharge Associated with Construction Activity, Permit No. MTR100000 (April 16, 2007); for mining activities B General Discharge Permit for Storm Water Associated with Mining and with Oil and Gas Activities, Permit No. MTR300000 (November 17, 2002);[5] and for industrial activities B General Permit for Storm Water Discharge Associated with Industrial Activity, Permit No. MTR000000 (October 1, 2006).[6]

[5] This permit covers point source discharges of storm water from mining and milling activities (including active, inactive, and abandoned mine and mill sites) including activities with Standard Industrial Code 14 (metal mining).

[6] Industrial activities are defined as all industries defined in 40 CFR '' 122, 123, and 124, excluding construction, mining, oil & gas extraction activities and storm water discharges subject to effluent limitations guidelines. This includes wood treatment operations, as well as the production of slag.

Generally, the permits require the permittee to implement best management practice (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment. However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, an individual MPDES permit or alternative general permit may be required.

A related mine reclamation requirement is set out in ARM 17.24.633 (relevant and appropriate), which requires that all surface drainage from disturbed areas that have been graded, seeded or planted must be treated by the best technology currently available (BTCA) before discharge. Sediment control through BTCA practices must be maintained until the disturbed area has been reclaimed, the revegetation requirements have been met, and the area meets state and federal requirements for the receiving stream.

5.2 Federal and State RCRA Subtitle C Requirements

Federal and State RCRA Subtitle C Requirements, 42 U.S.C. Section 6921, et seq. (relevant and appropriate for solid wastes, applicable for hazardous wastes). The presentation of RCRA Subtitle C requirements in this section assumes that there will be solid wastes left in place in Awaste management areas@ (i.e., a repository) as a result of Reclamation. Because of the similarity of this waste management area to the RCRA Awaste management unit,@ certain discrete portions of the RCRA Subtitle C implementing regulations will be relevant and appropriate for Reclamation. RCRA Subtitle C and implementing regulations are designated as applicable for any hazardous wastes that are actively Agenerated@ as part of this remedial action or that were Aplaced@ or Adisposed@ after 1980. Also, should hazardous wastes be discovered as part of any Reclamation , EPA reserves the right to identify RCRA Subtitle C requirements in more detail at a later date. All federal RCRA Subtitle C requirements set forth below are incorporated by reference as State of Montana requirements as provided for under ARM 17.53.105(2) unless mentioned otherwise below.

40 CFR Part 264 Subpart F.

General Facility Standards. These are potentially relevant and appropriate for solid wastes at Reclamation sites. Any waste management unit or similar area would be required to comply with the following requirements.

> **40 CFR ' 264.92, .93. and .94.** Prescribes groundwater protection standards.
>
> **40 CFR ' 264.97.** Prescribes general groundwater monitoring requirements.
>
> **40 CFR ' 264.98.** Prescribes requirements for monitoring and detecting indicator parameters.

Closure requirements.

> **40 CFR ' 264.111.** Provides that the owner or operator of a hazardous waste management facility must close the facility in a way that minimizes the need for further maintenance, and controls or eliminates the leaching or escape of hazardous waste or its constituents, leachate, or runoff to the extent necessary to protect human health and the environment.

40 CFR ' 264.117. Incorporates monitoring requirements in Part 264, including those mentioned at Part 264.97 and Part 264.303. It governs the length of the post-closure care period, permits a lengthened security period, and prohibits any use of the property which would disturb the integrity of the management facility.

40 CFR ' 264.310. Specifies requirements for caps, maintenance, and monitoring after closure.

40 CFR ' 264.301. Prescribes design and operating requirements for landfills.

40 CFR ' 264.301(a). Provides for a single liner and leachate collection and removal system.

40 CFR ' 264.301(f). Requires a run-on control system.

40 CFR ' 264.301(g). Requires a run-off management system.

40 CFR ' 264.301(h). Requires prudent management of facilities for collection and holding of run-on and run-off.

40 CFR ' 264.301(i). Requires that wind dispersal of particulate matter be controlled.

5.3 Federal and State RCRA Subtitle D and Solid Waste Management Requirements

40 CFR Part 257 establishes criteria under Subtitle D of the Resource Conservation and Recovery Act for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment. See 40 CFR ' 257.1(a). This part comes into play whenever there is a Adisposal@ of any solid or hazardous waste from a Afacility.@ ADisposal@ is defined as Athe discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.@ See 40 CFR ' 257.2. AFacility@ means Aany land and appurtenances thereto used for the disposal of solid wastes.@ Solid waste requirements are either applicable to mine wastes as solid waste or are relevant and appropriate for the management, handling, storage, monitoring and disposal of the mine wastes to be addressed in a Reclamation Project.

5.3.1. Federal Requirements

40 CFR ' 257 (applicable). ExtablishesCriteria for Classification of Solid Waste Disposal Facilities and Practices. Reclamation will comply with the following requirements.

40 CFR ' 257.3-1. Washout of solid waste in facilities in a floodplain posing a hazard to human life, wildlife, or land or water resources shall not occur.

40 CFR ' 257.3-2. Facilities shall not contribute to the taking of endangered species or the endangering of critical habitat of endangered species.

40 CFR ' 257.3-3. A facility shall not cause a discharge of pollutants, dredged or fill material, into waters of the United States in violation of Sections 402 and 404 of the Clean Water Act, as amended, and shall not cause non-point source pollution, in violation of applicable legal requirements implementing an area wide or statewide water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

<u>40 CFR ' 257.3-4</u>. A facility shall not contaminate an underground source of drinking water beyond the solid waste boundary or beyond an alternative boundary specified in accordance with this section.

<u>40 CFR ' 257.3-8(d)</u>. Access to a facility shall be controlled so as to prevent exposure of the public to potential health and safety hazards at the site.

5.3.2. State of Montana Solid Waste Requirements.

The Montana Solid Waste Management Act, Section 75-10-201 et seq., MCA, and regulations are applicable to the management and disposal of all solid wastes, including mine wastes at sites that are not currently subject to operating permit requirements.

<u>ARM ' 17.50.505(1) and (2) (applicable)</u>. Sets forth standards that all solid waste disposal sites must meet, including the requirements that (1) Class II landfills must confine solid waste and leachate to the disposal facility. If there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters; (2) adequate separation of group II wastes from underlying or adjacent water must be provided[7]; and (3) no new disposal units or lateral expansions may be located in wetlands. ARM 17.50.505 also specifies general soil and hydrogeological requirements pertaining to the location of any solid waste management facility.

<u>ARM 17.50.506 (applicable)</u>. Specifies design requirements for landfills. Landfills must either be designed to ensure that MCLs are not exceeded or the landfill must contain a composite liner and leachate collection system which comply with specified criteria.

<u>ARM 17.50.511 (applicable)</u>. Sets forth operational and maintenance and design requirements for solid waste management facilities using land filling methods. Specific requirements specified in ARM 17.50.511 that are applicable are run-on and run-off control systems requirements, requirements that sites be fenced to prevent unauthorized access, and prohibitions of point source and nonpoint source discharges which would violate Clean Water Act requirements.

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[7] The extent of separation shall be established on a case-by-case basis, considering terrain and the type of underlying soil formations, and facility design.

<u>ARM 17.50.523 (applicable)</u>. Specifies that solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.

<u>ARM 17.50.530 (applicable)</u>. Sets forth the closure requirements for landfills. Class II landfills must meet the following criteria: (1) install a final cover that is designed to minimize infiltration and erosion; (2) design and construct the final cover system to minimize infiltration through the closed unit by the use of an infiltration layer that contains a minimum 18 inches of earthen material and has a permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoils or a permeability no greater than 1 X 10-5 cm/sec, whichever is less; (3) minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth and protecting the infiltration layer from frost effects and rooting damage; (4) revegetate the final cover with native plant growth within one year of placement of the final cover.

<u>ARM17.50.531 (applicable)</u>. Sets forth post closure care requirements for Class II landfills. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post closure care requires maintenance of the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cover and comply with the groundwater monitoring requirements found at ARM Title 17, chapter 50, subchapter 7.

Section 75-10-206, MCA, allows variances to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship.

5.4 Federal and State Mine Reclamation Requirements

5.4.1 Surface Mining Control and Reclamation Act

<u>Surface Mining Control and Reclamation Act, 30 USC ' ' 1201-1326 (relevant and appropriate)</u>. This Act and implementing regulations found at 30 CFR Parts 784 and 816 establish provisions designed to protect the environment from the effects of surface coal mining operations, and to a lesser extent non-coal mining. These requirements are relevant and appropriate to the covering of discrete areas of contamination. The regulations require that revegetation be used to stabilize soil covers over reclaimed areas. They also require that revegetation be done according to a plan which specifies schedules, species which are diverse and effective, planting methods, mulching techniques, irrigation if appropriate, and appropriate soil testing. Reclamation performance standards are currently relevant and appropriate to mining waste sites.

5.4.2 Montana Statutory and Regulatory Requirements

<u>Montana Strip and Underground Mine Reclamation Act, Section 82-4-201, et seq., MCA (relevant and appropriate) and Montana Metal Mining Act, Section 82-4-301, et seq., MCA (relevant and appropriate)</u>. The specified portions of the following statutory or regulatory provisions, as identified below, are relevant and appropriate requirements.

<u>Section 82-4-231, MCA</u>. Requires operators to reclaim and revegetate affected lands using most modern technology available. Operators must grade, backfill, topsoil, reduce high walls, stabilize subsidence, control water, minimize erosion, subsidence, land slides, and water pollution.

Section 82-4-233, MCA. Operators must plant vegetation that will yield a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of self-regeneration.

Section 82-4-336, MCA. Disturbed areas must be reclaimed to utility and stability comparable to adjacent areas.

ARM 17.24.501. Provides general backfilling and grading requirements. Backfill must be placed so as to minimize sedimentation, erosion, and leaching of acid or toxic materials into waters, unless otherwise approved. Final grading must be to the approximate original contour of the land and final slopes must be graded to prevent slope failure, may not exceed the angle of repose, and must achieve a minimum long term static safety factor of 1:3. The disturbed area must be blended with surrounding and undisturbed ground to provide a smooth transition in topography.

ARM 17.24.519. Requires monitoring of settling of regraded areas.

ARM 17.24.631(1), (2), (3)(a) and (b). Requires minimization of disturbances to the prevailing hydrologic balance. Changes in water quality and quantity, in the depth to groundwater and in the location of surface water drainage channels will be minimized. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 17.24.633. Surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 17.24.634. Requires disturbed drainages be restored to the approximate pre-disturbance configuration. Drainage design must emphasize channel and floodplain dimensions that approximate the pre-mining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to: (1) approximate an appropriate geomorphic habit or characteristic pattern; (2) remain in dynamic equilibrium with the system without the use of artificial structural controls; (3) improve unstable premining conditions; (4) provide for floods and for the long-term stability of the landscape; and (5) establish a premining diversity of aquatic habitats and riparian vegetation.

ARM 17.24.635 through 17.24.637 set forth requirements for temporary and permanent diversions.

ARM 17.24.638. Sediment control measures must be implemented during operations.

ARM 17.24.639. Sets forth requirements for construction and maintenance of sedimentation ponds.

ARM 17.24.640. Discharges from sedimentation ponds, permanent and temporary impoundments, must be controlled to reduce erosion and enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

ARM 17.24.641. Establishes practices to avoid drainage from acid or toxic forming spoil material into ground and surface water.

ARM 17.24.643 through 17.24.646. Provisions for groundwater protection, groundwater recharge protection, and groundwater and surface water monitoring.

ARM 17.24.701 and 702. Requirements for redistributing and stockpiling of soil for reclamation. Also, outlines practices to prevent compaction, slippage, erosion, and deterioration of biological properties of soil.

ARM 17.24.703. When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 17.24.701 and 702.

ARM 17.24.711. Requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. See also Section 82-4-233, MCA (Relevant and Appropriate). Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural vegetation during each season of the year. This requirement may not be appropriate where other cover is more suitable for the particular land use or another cover is requested by the landowner.

ARM 17.24.713. Seeding and planting of disturbed areas must be conducted during the first appropriate period favorable for planting after final seedbed preparation.

ARM 17.24.714. Mulch or cover crop or both must be used until adequate permanent cover can be established.

ARM 17.24.716. Establishes method of revegetation.

ARM 17.24.717. Relates to the planting of trees and other woody species if necessary, as provided in Section 82-4-233, MCA, to establish a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the affected area and capable of self-regeneration and plant succession at least equal to the natural vegetation of the area, except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved land use plan.

ARM 17.24.718. Requires soil amendments, irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 17.24.721. Specifies that rills or gullies in reclaimed areas must be filled, graded or otherwise stabilized and the area reseeded or replanted if the rills and gullies are disrupting the reestablishment of the vegetative cover or causing or contributing to a violation of water quality standards for a receiving stream.

ARM 17.24.723. States that operators shall conduct approved periodic measurements of vegetation, soils, water, and wildlife, and if data indicate that corrective measures are necessary, shall propose such measures.

ARM 17.24.724. Specifies that revegetation success must be measured against approved technical standards or unmined reference areas. Reference areas and standards must be representative of vegetation and related site characteristics occurring on lands exhibiting good ecological integrity. Required management for these reference areas is set forth.

ARM 17.24.726. Requires standard and consistent field and laboratory methods to obtain and evaluate revegetated area data with reference area data and/or technical standards, and sets out the required methods for measuring productivity.

ARM 17.24.731. If toxicity to plants or animals on the revegetated area or the reference area is suspected due to the effects of the disturbance, comparative chemical analyses may be required.

ARM 17.24.751. Sets forth requirements to protect and enhance fish and wildlife habitat.

ARM 17.24.824. If land use is to be other than grazing land or fish and wildlife habitat, areas of land affected by mining must be restored in a timely manner to higher or better uses achievable under criteria and procedures set forth.

5.5 Air Requirements

Remedial activities will comply with the Montana Ambient Air Quality Regulations (above) and with the following requirements to ensure that existing air quality will not be adversely affected by Reclamation.

ARM 17.8.308(1), (2) and (3) (applicable). Airborne particulate matter. There shall be no production, handling, transportation, or storage of any material, use of any street, road, or parking lot, or operation of a construction site or demolition project unless reasonable precautions are taken to control emissions of airborne particles. Emissions shall not exhibit an opacity exceeding 20% or greater averaged over 6 consecutive minutes.

ARM 17.8.304(2) (applicable). Visible Air Contaminants. Emissions into the outdoor atmosphere shall not exhibit an opacity of 20% or greater averaged over 6 consecutive minutes.

ARM 17.8.604 (applicable). Lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste which is moved from the site where it was generated and any trade waste (material resulting from construction or operation of any business, trade, industry, or demolition project) may be open burned only in accordance with the substantive requirements of ARM 17.8.611 or 612.

ARM 17.24.761 (relevant and appropriate). Specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant and appropriate to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of Reclamation at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

5.6 Noxious Weeds

Noxious Weeds, Section 7-22-2101(8)(a), MCA. Defines "noxious weeds" as any exotic plant species established or that may be introduced in the state which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities and that is designated: (I) as a statewide noxious weed by rule of the department; or (ii) as a district noxious weed by a board, following public notice of intent and a public hearing. Designated noxious weeds are listed in ARM 4.5.201 through 4.5.204 and must be managed consistent with weed management criteria developed under Section 7-22-2109(2)(b), MCA.

6.0 TO BE CONSIDERED (TBC) DOCUMENTS

A list of TBC documents is included in the Preamble to the NCP, 55 Fed. Reg. 8765 (March 8, 1990). Those documents, plus any additional similar or related documents issued since that time, should be considered during the conduct of the Reclamation design and construction.

7.0 OTHER LAWS (NON-EXCLUSIVE LIST)

CERCLA defines as ARARs only federal environmental and state environmental and siting laws. Reclamation design, implementation, and operation and maintenance must comply with other applicable laws, except as may be provided in SMCRA.

The following Aother laws@ are included here to provide a reminder of other legal requirements Reclamation activity. They are not an exhaustive list of such requirements, but are included because they set out matters that must be addressed and, in some cases, may require advance planning. They are not included as ARARs because they are not Aenvironmental or facility siting laws.@ Because they are not ARARs, they are not subject to ARAR waiver provisions.

7.1 Other Federal Laws

Occupational Safety and Health Regulations. The federal Occupational Safety and Health Act regulations found at 29 CFR Part 1910 and Part 1926 are applicable to worker protection during the conduct of Reclamation .

7.2 Other State Laws

A. Groundwater Act

The Groundwater Act, ' 85-2-501, et seq., MCA, and implementing regulations, ARM 17.30.601, et seq. govern uses of groundwater and provide measures to protect groundwater from depletion or contamination. The regulations also set requirements for water wells.

Section 85-2-505, MCA, precludes the wasting of groundwater. Any well producing waters that contaminate other waters must be plugged or capped, and wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater.

Section 85-2-516, MCA, states that within 60 days after any well is completed a well log report must be filed by the driller with the DNRC and the appropriate county clerk and recorder.

B. Public Water Supply Regulations

If remedial action at the site requires any reconstruction or modification of any public water supply line or sewer line, the construction standards specified in ARM 17.38.101(4) (Applicable) must be observed.

C. Water Rights

Section 85-2-101, MCA, declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.

Parts 3 and 4 of Title 85, Chapter 2, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

Section 85-2-301, MCA, of Montana law provides that a person may only appropriate water for a beneficial use.

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefor except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation. While the permit itself may not be required under federal law, appropriate notification and submission of an application should be performed and a permit should be applied for in order to establish a priority date in the prior appropriation system.

Section 85-2-306, MCA, specifies the conditions on which groundwater may be appropriated, and, at a minimum, requires notice of completion and appropriation within 60 days of well completion.

Section 85-2-311, MCA, specifies the criteria which must be met in order to appropriate water and includes requirements that:

1. there are unappropriated waters in the source of supply;
2 the proposed use of water is a beneficial use; and
3. the proposed use will not interfere unreasonably with other planned uses or developments.

Section 85-2-402, MCA, specifies that an appropriator may not change an appropriated right except as provided in this section with the approval of the DNRC.

Section 85-2-412, MCA, provides that, where a person has diverted all of the water of a stream by virtue of prior appropriation and there is a surplus of water over and above what is actually and necessarily used, such surplus must be returned to the stream.

D. Controlled Ground Water Areas

Pursuant to Section 85-2-507, MCA, the Montana Department of Natural Resources and Conservation may grant either a permanent or a temporary controlled ground water area. The maximum allowable time for a temporary area is two years, with a possible two-year extension.

Pursuant to Section 85-2-506, MCA, designation of a controlled ground water area may be proposed if: (i) excessive ground water withdrawals would cause contaminant migration; (ii) ground water withdrawals adversely affecting ground water quality within the ground water area are occurring or are likely to occur; or (iii) ground water quality within the ground water area is not suited for a specific beneficial use.

E. Occupational Health Act, Section 50-70-101, et seq., MCA.

ARM 17.74.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This rule is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.95 applies.

ARM 17.74.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the rule. This rule is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

F. Montana Safety Act

Sections 50-71-201, 202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.

G. Employee and Community Hazardous Chemical Information

Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.

APPENDIX D

RISK ANALYSIS TABLES

GARNET MINE RECLAMATION PROJECT
MADISON COUNTY, MONTANA
January 30, 2009

ECOLOGICAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 1 - SITE SPECIFIC INFORMATION

SITE NAME: **Garnet Gold Mine, Madison County, Montana**

	Aquatic Life Maximum Surface Water Conc. ug/L	Surface Water Hardness* mg/L	Maximum Sediment Conc. mg/Kg	Deer Ingestion Water Conc. ug/L	Deer Ingestion Phytotoxicity Surface Conc. mg/Kg	Contaminant of Concern?
Arsenic						N
Cadmium	0.08	32		44		Y
Chromium III						N
Copper	7.0	41	239	4190	338	Y
Iron	140	33	7707	7750	28948	Y
Lead	7.3	40	915	1300	1047	Y
Mercury*	0.05	31	0	0.05	58.1	Y
Nickel						N
Silver						N
Zinc	10	43	79.4	2900	322	Y

Note: Minimum hardness=25 mg/L; Maximum=400 mg/L
nhd = not hardness dependent COCs
Mercury-all result less than detection limit; surface water values = 1/2 the detection limit

All site specific data are entered on page 1; pages 2 through 5 are lookup tables and page 6 presents the resultant EQs.

Enter media concentrations for the site, either areal averages or site maximum concentrations. If a contaminant does not meet the criteria for "contaminant of concern", enter 0 as the concentration or leave it blank (don't leave hardness blank). These criteria are listed below:

1) contaminants associated with and present at the site;
2) contaminants with concentrations significantly above background (generally 3 times higher);
3) contaminants with at least 20% of the measured concentrations above the detection limit; and,
4) contaminants with acceptable QA/QC results applied to the data.

Column B are surface water concentrations for comparison to aquatic life standards. Enter the maximum concentration measured in "real" surface water at the site (i.e. not adit discharges or intermittent water) that aquatic life might live in.

Column C are hardness measurements for the corresponding surface water concentration in column B in mg/L. Note that the minimum hardness for AWQC calculation is 25 mg/L and the maximum is 400 mg/L. Don't leave blank.

Column D are the maximum sediment concentrations measured at the site in "real" surface water (not adit discharges or intermittent drainages) for aquatic life impacts.

Column E are surface water concentrations that deer might drink at the site. This includes adit discharges, intermittent drainages, and ponded water, as long as it is accessible by deer.

Column F are surface waste concentrations for both the deer ingestion (salt) scenario and the phytotoxicity scenario. Enter the mean surface concentration of the highest concentration source at the site (generally tailings).

GARNET MINE RECLAMATION PROJECT
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ECOLOGICAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 2 - AQUATIC LIFE CRITERIA EQ

SITE NAME: **Garnet Gold Mine, Madison County, Montana**

	Acute Criteria ug/L	Chronic Criteria ug/L	Acute AWQC EQ	Chronic AWQC EQ
Arsenic				
Cadmium	0.7	0.1	0.1194	0.6876
Chromium III				
Copper	6.0	4.4	1.1583	1.6075
Iron		1000	0.0000	0.1400
Lead	25.4	1.0	0.2871	7.3664
Mercury	1.7	0.91	0.029412	0.0549
Nickel				
Silver				
Zinc	59	59	0.1706	0.1706
TOTAL			1.7649	10.0271

This page calculates AWQC for the hardness values supplied on page 1, column C. Both chronic and acute are calculated in the table; however, the chronic values are for reference only. Chronic criteria are not applicable unless surface water has been sampled over the entire range of hydrologic conditions at the site, and a statistically significant number of samples at each station are averaged to determine the chronic concentrations over time.

GARNET MINE RECLAMATION PROJECT
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ECOLOGICAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 3 - SEDIMENT QUALITY CRITERIA EQ

SITE NAME: Garnet Gold Mine, Madison County, Montana

	SQC Effect Range-Medium* mg/Kg	Sediment EQ
Arsenic	85	0.0000
Cadmium[a]	0.583	0.0000
Chromium III	145	0.0000
Copper	390	0.6128
Lead	110	8.3182
Nickel	50	0.0000
Mercury[a]	0.174	0.00000
Zinc	270	0.2941
TOTAL		9.2251

* from Long and Morgan, 1991
a - from NOAA SQuiRT, 1999

ECOLOGICAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 4 - DEER INGESTION EQ

SITE NAME: Garnet Gold Mine, Madison County, Montana

	Deer Intake Dose Est. Soil + water mg/Kg-day	Deer Ingestion EQ	
Arsenic	0.0000	0.0000	Toxicological effects from ATSDR, 1991a
Cadmium	0.0065	0.4655	Toxicological effects from ATSDR, 1991b
Copper	0.6217	0.0069	Toxicological effects from NAS, 1980
Lead	0.2079	41.5755	Toxicological effects from ATSDR, 1991c
Mercury	--	--	
Zinc	0.4317	0.0008	Toxicological effects from Maita et al, 1981
TOTAL		42.0486	

ECOLOGICAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 5 - PHYTOTOXICITY EQ

SITE NAME: **Garnet Gold Mine, Madison County, Montana**

	Phytotoxic Soil Conc.* mg/Kg	Phytotoxicity EQ
Arsenic	50	0.0000
Cadmium	8	0.0000
Copper	125	2.7040
Lead	400	2.6175
Mercury	0.3	193.5
Zinc	400	0.8045
TOTAL		199.6593

*Upper end of range, from Kabata-Pendias and Pendias, 1989

GARNET MINE RECLAMATION PROJECT
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ECOLOGICAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 6 - COMBINATION OF ECOLOGIC IMPACT QUOTIENTS (EQs)

SITE NAME: Garnet Gold Mine, Madison County, Montana

	Aquatic Life-Surface Water EQ (Acute)	Aquatic Life-Sediment EQ	Deer Ingestion EQ	Plant Phytotoxicity EQ	Total by COC
Arsenic	0.0000	0.0000	0.0000	0.0000	0.0000
Cadmium	0.1194	0.0000	0.4655	0.0000	0.5849
Chromium III	0.0000	0.0000			0.0000
Copper	1.1583	0.6128	0.0069	2.7040	4.4821
Iron	0.0000				0.0000
Lead	0.2871	8.3182	41.5755	2.6175	52.7982
Mercury	0.029412				0.029412
Nickel	0.0000	0.0000			0.0000
Silver	0.0000				0.0000
Zinc	0.1706	0.2941	0.0008	0.8045	1.2700
TOTAL	1.7649	9.2251	42.0486	6.1260	59.1645

GARNET MINE RECLAMATION PROJECT
MADISON COUNTY, MONTANA
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RECREATIONAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 1 - SITE SPECIFIC INFORMATION

SITE NAME: **Garnet Gold Mine, Madison County, Montana**

Recreational Use from AIMSS : **10** (10=High, 5=Mod., 2=Low)

Does surface water exceed any acute aquatic life criteria ? Y (Y or N)

	Surface Waste Rock Conc. mg/Kg	Surface Tailings Conc. mg/Kg	Surface Water Conc. ug/L	Contaminant of Concern?
Antimony				N
Arsenic				N
Barium				N
Cadmium				N
Chromium III				N
Cobalt				N
Copper	270	322	7.0	Y (SW only)
Cyanide				N
Iron				N
Lead	367	1,047	7.3	Y
Manganese				N
Mercury	58	5.9	0.05	Y (MW only)
Nickel				N
Silver				N
Zinc				N

Notes: For non-detects, one-half of the reporting limit was used for the calculations for the average values in the above table.
SW - surface water; MW - mine waste

All site specific data are entered on this page; pages 2 - 4 are lookup tables and page 6 present the resultant HQs and risk.

Enter "recreational use" value from site AIMSS data (10=high use, 5=moderate use, 2 or 0=low use).
If the AIMSS recreational use value is incorrect or changed, enter the appropriate value.

Answer question regarding acute exceedences. This determines whether the fish ingestion route is a viable exposure.

Enter media concentrations for the site, either areal averages or site maximum concentrations. If a contaminant does not meet the criteria for "contaminant of concern", enter 0 as the concentration or leave it blank.
These criteria are listed below:

1) contaminants associated with and present at the site;
2) contaminants with concentrations significantly above background (generally 3 times higher);
3) contaminants with at least 20% of the measured concentrations above the detection limit; and,
4) contaminants with acceptable QA/QC results applied to the data.

If no waste rock, tailings or surface water are present at a site, enter zeros for concentrations in that medium.

Column B are surficial waste rock concentrations for evaluation of the Rockhound/goldpanner scenario.
Enter the mean surface concentration of the highest concentration waste rock source area at the site.

Column C are surficial tailings concentrations for evaluation of the ATV/motorcyle rider scenario.
Enter the mean surface concentration of the highest concentration tailings source area at the site.

Column D are the maximum surface water concentrations measured at the site in "real" surface water (i.e. not adit discharges or intermittent drainages) that might reasonably used for drinking water and fish consumption by the recreational user.

Column E is a determination of contaminants of concern. It is not used for calculation, but is for reference by the user.

RECREATIONAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 2 - RECREATIONAL CLEANUP LEVELS (MAXIMUM)

Recreational Cleanup Levels for sites with Maximum Recreational Use Score [10]
Source: AMRB/TetraTech - 02/96

	50 Days RH/GP Soils Ing/Inh mg/Kg (max-50)	32 Days ATV/MR Soils Ing/Inh mg/Kg (max-32)	50 Days RH/GP Water Ing ug/L (max-50)	42 Days FISHERMAN Fish Ing ug/L water (max-42)
Antimony	586	1040	204	2150
Arsenic	323	569	153	36.7
Barium	103000	9950	35800	1000000
Cadmium	1750	3150	256	66.5
Chromium III	1470000	1000000	511000	337000
Cobalt	1000000	30500	1000000	1000000
Copper	54200	96600	18900	996
Cyanide	11100	19300	10200	1000000
Iron	1000000	1000000	1000000	1000000
Lead	2200	3920	220	165
Manganese	7330	1330	2560	33.7
Mercury	440	738	153	0.294
Nickel	29300	52200	10200	2290
Silver	1000000	1000000	1000000	1000000
Zinc	440000	784000	153000	34.4
Arsenic-Carc	1.39	2.17	0.662	0.158
Cadmium-Carc		38.9		

Non-Carcinogenic HQ @ 1.0
Carcinogenic Risk @ 1.0E-06

Noncarcinogenic CoCs with no available inhalation RfDs used oral RfDs instead for calculation.
CoCs with no cleanup level specified (e.g. Fe) were set to 1,000,000 mg/Kg (unity).

RfDs used by Tetra Tech are from EPA 1994; some of these have been changed or added since then.

RECREATIONAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 3 - RECREATIONAL CLEANUP LEVELS (Moderate)

Recreational Cleanup Levels for sites with Moderate Recreational Use Score [5]
Source: AMRB/TetraTech - 02/96

	25 Days RH/GP Soils Ing/Inh mg/Kg (max-50)	16 Days ATV/MR Soils Ing/Inh mg/Kg (max-32)	25 Days RH/GP Water Ing ug/L (max-50)	21 Days FISHERMAN Fish Ing ug/L water (max-42)
Antimony	1172	2080	408	4300
Arsenic	646	1138	306	73.4
Barium	206000	19900	71600	1000000
Cadmium	3500	6300	512	133
Chromium III	1000000	1000000	1000000	674000
Cobalt	1000000	61000	1000000	1000000
Copper	108400	193200	37800	1992
Cyanide	22200	38600	20400	1000000
Iron	1000000	1000000	1000000	1000000
Lead	4400	7840	440	330
Manganese	14660	2660	5120	67.4
Mercury	880	1476	306	0.588
Nickel	58600	104400	20400	4580
Silver	1000000	1000000	1000000	1000000
Zinc	880000	1000000	306000	68.8
Arsenic-Carc	2.78	4.34	1.324	0.316
Cadmium-Carc		77.8		

Non-Carcinogenic HQ @ 1.0
Carcinogenic Risk @ 1.0E-06

Noncarcinogenic CoCs with no available inhalation RfDs used oral RfDs instead for calculation.
CoCs with no cleanup level specified (e.g. Fe) were set to 1,000,000 mg/Kg (unity).

RfDs used by Tetra Tech are from EPA 1994; some of these have been changed or added since then.

RECREATIONAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 4 - RECREATIONAL CLEANUP LEVELS (Minimum)

Recreational Cleanup Levels for sites with Minimum Recreational Use Score [2 or 0]
Source: AMRB/TetraTech - 02/96

	7 Days RH/GP Soils Ing/Inh mg/Kg (max-50)	7 Days ATV/MR Soils Ing/Inh mg/Kg (max-32)	7 Days RH/GP Water Ing ug/L (max-50)	7 Days FISHERMAN Fish Ing ug/L water (max-42)
Antimony	4186	7429	1457	15357
Arsenic	2307	4064	1093	262
Barium	735714	71071	255714	1000000
Cadmium	12500	22500	1829	475
Chromium III	1000000	1000000	1000000	1000000
Cobalt	1000000	217857	1000000	1000000
Copper	387143	690000	135000	7114
Cyanide	79286	137857	72857	1000000
Iron	1000000	1000000	1000000	1000000
Lead	15714	28000	1571	1179
Manganese	52357	9500	18286	241
Mercury	3143	5271	1093	2
Nickel	209286	372857	72857	16357
Silver	1000000	1000000	1000000	1000000
Zinc	1000000	1000000	1000000	246
Arsenic-Carc	10	16	4.7	1.1
Cadmium-Carc		278		

Non-Carcinogenic HQ @ 1.0
Carcinogenic Risk @ 1.0E-06

Noncarcinogenic CoCs with no available inhalation RfDs used oral RfDs instead for calculation.
CoCs with no cleanup level specified (e.g. Fe) were set to 1,000,000 mg/Kg (unity).

RfDs used by Tetra Tech are from EPA 1994; some of these have been changed or added since then.

RECREATIONAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 5 - CALCULATION OF HQs AND RISK WITH RECREATIONAL USE VALUE OF 10

SITE NAME: **Garnet Gold Mine, Madison County, Montana**

	RH/GP Waste Rock	ATV/MR Tailings	RH/GP Water Ing	FISHERMAN Fish Ing
Antimony	0.0000	0.0000	0.0000	0.0000
Arsenic	0.0000	0.0000	0.0000	0.0000
Barium	0.0000	0.0000	0.0000	0.0000
Cadmium	0.0000	0.0000	0.0000	0.0000
Chromium III	0.0000	0.0000	0.0000	0.0000
Cobalt	0.0000	0.0000	0.0000	0.0000
Copper	0.0050	0.0033	0.0004	0.0070
Cyanide	0.0000	0.0000	0.0000	0.0000
Iron	0.0000	0.0000	0.0000	0.0000
Lead	0.1666	0.2671	0.0332	0.0442
Manganese	0.0000	0.0000	0.0000	0.0000
Mercury	0.1320	0.0080	0.0003	0.1701
Nickel	0.0000	0.0000	0.0000	0.0000
Silver	0.0000	0.0000	0.0000	0.0000
Zinc	0.0000	0.0000	0.0000	0.0000
Total Non-Carc	0.3036	0.2784	0.0339	0.2213
Arsenic-Carc	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium-Carc		0.00E+00		
TOTAL CARC	0.00E+00	0.00E+00	0.00E+00	0.00E+00

This page calculates soil and water HQs and risk for both the rockhound and ATV rider scenarios. The greater of the two values is reported on Page 6 as the site HQ/risk for that COC except where the fish consumption route is not possible.

GARNET MINE RECLAMATION PROJECT
MADISON COUNTY, MONTANA
January 30, 2009

RECREATIONAL RISK ASSESSMENT SPREADSHEET FOR ABANDONED MINE SITES

PAGE 6 - DETERMINATION OF SITE RECREATIONAL HQs AND RISK

SITE NAME: **Garnet Gold Mine, Madison County, Montana**

Recreational Use = 10 (High)

Non-Carc.	Soil routes Max. HQ	Water routes Max. HQ	Total HQ by COC
Antimony	0.0000	0.0000	0.0000
Arsenic	0.0000	0.0000	0.0000
Barium	0.0000	0.0000	0.0000
Cadmium	0.0000	0.0000	0.0000
Chromium III	0.0000	0.0000	0.0000
Cobalt	0.0000	0.0000	0.0000
Copper	0.0050	0.0004	0.0054
Cyanide	0.0000	0.0000	0.0000
Iron	0.0000	0.0000	0.0000
Lead	0.2671	0.0332	0.3003
Manganese	0.0000	0.0000	0.0000
Mercury	0.1320	0.0003	0.1323
Nickel	0.0000	0.0000	0.0000
Silver	0.0000	0.0000	0.0000
Zinc	0.0000	0.0000	0.0000
Total Non-Carc	0.4040	0.0339	**0.4379**
Carc.	Soil routes	Water routes	Total
Arsenic-Carc	0.00E+00	0.00E+00	0.00E+00
Cadmium-Carc	0.00E+00		0.00E+00
TOTAL CARC	0.00E+00	0.00E+00	**0.00E+00**

APPENDIX E

DETAILED COST ESTIMATE TABLES

Cost Analysis

COMMON ELEMENTS

Item	Rate ($/unit)	Unit	Number of Units	Total
Lower Access Road from Pony to Breached Dam	$1.00	sy	6000	$6,000
Lower Access Road Blasting	$20.00	cy	2500	$50,000
SUBTOTAL :				**$56,000**
Mobilization, Bonding, and Insurance (10%):				$5,600
Construction Staking and Survey (2%)				$1,120
Contingency (20%):				$11,200
Engineering Design (8%)				$5,914
Construction Oversight (6%)				$4,435
TOTAL ESTIMATE:				**$84,269**

Cost Analysis

Cataract Creek Tailings Deposit

Item		Rate ($/unit)	Unit	Number of Units	Total
T-1	**No Action**				**$0**
T-2	**Institutional Controls**				
	Fencing (3 wire)	$4	lf	$1,800	$7,200
	Signs	$120	ea	$10	$1,200
	SUBTOTAL:				**$8,400**
	Mobilization, Bonding, and Insurance (10%):				$840
	Construction Staking and Survey (2%)				$168
	Contingency (20%):				$1,680
	Engineering Design (8%)				$887
	Construction Oversight (6%)				$665
	TOTAL ESTIMATE:				**$12,640**
T-3	**Institutional Controls with Landuse Controls**				
	Fencing	$4	lf	$1,800	$7,200
	Signs	$120	ea	$10	$1,200
	Legal Process	$10,000	ls	$1	$10,000
	SUBTOTAL:				**$18,400**
	Mobilization, Bonding, and Insurance (10%):				$1,840
	Construction Staking and Survey (2%)				$368
	Contingency (20%):				$3,680
	Engineering Design (8%)				$1,943
	Construction Oversight (6%)				$1,457
	TOTAL ESTIMATE:				**$27,688**
T-4	**In-place Stabilization/Surface Controls**				
	Clearing and Grubbing dense brush including stumps	$3,900	ac	$2	$5,850
	Cut and Chip Medium Trees to 12" Diameter	$5,575	ac	$2	$8,363
	Riprap	$90	cy	$900	$81,000
	Step pools	$3,000	ea	$27	$81,000
	Soil Amendments (12 inches deep)	$10	sy	$600	$6,000
	Water Control	$50,000	ls	$1	$50,000
	Vegetative Backfill Material	$4	cy	$600	$2,400
	Erosion Control	$10,000	ls	$1	$10,000
	Revegetation	$2,500	ac	$2	$5,000
	SUBTOTAL:				**$235,400**
	Mobilization, Bonding, and Insurance (10%):				$23,540
	Construction Staking and Survey (2%)				$4,708
	Contingency (20%):				$47,080
	Engineering Design (8%)				$24,858
	Construction Oversight (6%)				$18,644
	TOTAL ESTIMATE:				**$354,230**

Cost Analysis

Cataract Creek Tailings Deposit (Continued)

Item		Rate ($/unit)	Unit	Number of Units	Total
T-5	**Partial Removal and Disposal in an On-Site Repository**				
	Clearing and Grubbing dense brush including stumps	$3,900	ac	$4	$14,040
	Cut and Chip Medium Trees to 12" Diameter	$5,575	ac	$4	$20,070
	Riprap	$90	cy	$900	$81,000
	Step Pools	$3,000	ea	$27	$81,000
	Water Control (Creek Relocate and Dewatering)	$50,000	ls	$1	$50,000
	Creek and Wetland Resoration Grading	$50	lf	$1,600	$80,000
	Vegetative Backfill Material	$4	cy	$6,000	$24,000
	Erosion Control	$20,000	ls	$1	$20,000
	Strip Repositoy Site (1ft)	$3	cy	$3,300	$9,900
	Haul Road Tailings to Repository	$4	sy	$2,700	$10,800
	Haul Tailings/Impacted Soil to Repository	$4	cy	$30,000	$120,000
	Drainage Controls at Repository	$1	lf	$1,200	$1,200
	Repository Cover Soil	$3	cy	$10,000	$25,000
	Wetland/Riparian Planting	$5	sy	$3,600	$18,000
	Revegetation	$2,500	ac	$6	$15,000
	SUBTOTAL:				**$570,010**
	Mobilization, Bonding, and Insurance (10%):				$57,001
	Construction Staking and Survey (2%)				$11,400
	Contingency (20%):				$114,002
	Engineering Design (8%)				$60,193
	Construction Oversight (6%)				$45,145
	TOTAL ESTIMATE:				**$857,751**
T-6	**Total Removal and Disposal in an On-Site Repository**				
	Clearing and Grubbing dense brush including stumps	$3,900	ac	$4	$14,040
	Cut and Chip Medium Trees to 12" Diameter	$5,575	ac	$4	$20,070
	Riprap	$90	cy	$900	$81,000
	Step Pools	$3,000	ea	$27	$81,000
	Water Control (Creek Relocate and Dewatering)	$50,000	ls	$1	$50,000
	Creek and Wetland Resoration Grading	$50	sy	$1,600	$80,000
	Vegetative Backfill Material	$4	cy	$7,800	$31,200
	Erosion Control	$25,000	ls	$1	$25,000
	Strip repositoy Site (1ft)	$3	cy	$5,000	$15,000
	Haul Road to Repository	$1	sy	$2,700	$2,700
	Haul Tailings/Impacted Soil to Repository	$4	cy	$50,000	$200,000
	Drainage Diversion Swales at Repository	$1	lf	$1,500	$1,500
	Repository Cover Soil	$3	cy	$14,965	$37,413
	Wetlatnd Riparian Planting	$5	sy	$3,600	$18,000
	Revegetation	$2,500	ac	$9	$22,500
	SUBTOTAL:				**$679,423**
	Mobilization, Bonding, and Insurance (10%):				$67,942
	Construction Staking and Survey (2%)				$13,588
	Contingency (20%):				$135,885
	Engineering Design (8%)				$71,747
	Construction Oversight (6%)				$53,810
	TOTAL ESTIMATE:				**$1,022,395**

Cost Analysis

Source Areas
Uphill from Oriole Adit Portal
(F-1, F-2, F-3, F-3A, and F-5)

Item		Rate ($/unit)	Unit	Number of Units	Total
WR-1	**No Action**				**$0**
WR-2	**Institutional Control**				
	Fence (chain link)	$50.00	lf	260	$13,000
	Signs	$120.00	ea	4	$480
	Drainage Diversion Swale	$1.00	lf	100	$100
	Haul Road from F8 to F2	$3.00	sy	5,900	$17,700
	SUBTOTAL:				**$31,280**
	Mobilization, Bonding, and Insurance (10%):				$3,128
	Construction Staking and Survey (2%)				$626
	Contingency (20%):				$6,256
	Engineering Design (8%)				$3,303
	Construction Oversight (6%)				$2,477
	TOTAL ESTIMATE:				**$47,070**
WR-3	**Surface Controls**				
	Regrade Waste Rock and Collapsed Adits F1, F3, F3A and F5	$1.50	cy	2,500	$3,750
	Regrade Stope/raise F2	$1.50	cy	2,000	$3,000
	Blasting Stope/raise F2	$20.00	cy	1,000	$20,000
	Vegetative Backfill Material	$4.00	cy	700	$2,800
	Revegetation	$2,500	ac	1.0	$2,500
	Haul Road from F-8 to F-1	$3.00	sy	5,900	$17,700
	Haul Road from Breached Dam to F-8	$1.00	sy	3,000	$3,000
	Reclaim Haul Road	$0.50	sy	8,900	$4,450
	Drainage Diversion Swales	$1.00	lf	100	$100
	Erosion Control	$10,000	ls	1	$10,000
	SUBTOTAL:				**$67,300**
	Mobilization, Bonding, and Insurance (10%):				$6,730
	Construction Staking and Survey (2%)				$1,346
	Contingency (20%):				$13,460
	Engineering Design (8%)				$7,107
	Construction Oversight (6%)				$5,330
	TOTAL ESTIMATE:				**$101,273**
WR-4	**Total Removal and Disposal in Raise/Stope F-2**				
	Remove and Haul Waste Rock from F3A and F5 to F2	$4.00	cy	4,000	$16,000
	Regrade Collapsed Adits F1 and F5	$1.50	cy	740	$1,110
	Vegetative Backfill Material	$4.00	cy	700	$2,800
	Revegetation	$2,500	ac	1.0	$2,500
	Haul Road from F-8 to F-1	$3.00	sy	5,900	$17,700
	Haul Road from Breached Dam to F-8	$1.00	sy	3,000	$3,000
	Reclaim Haul Road	$0.50	sy	8,900	$4,450
	Erosion Control	$10,000	ls	1	$10,000
	SUBTOTAL:				**$57,560**
	Mobilization, Bonding, and Insurance (10%):				$5,756
	Construction Staking and Survey (2%)				$1,151
	Contingency (20%):				$11,512
	Engineering Design (8%)				$6,078
	Construction Oversight (6%)				$4,559
	TOTAL ESTIMATE:				**$86,616**

Cost Analysis

Oriole Adit Waste Rock Pile F-8

Item		Rate ($/unit)	Unit	Number of Units	Total
WR-F8-1	**No Action**				**$0**
WR-F8-2	**Institutional Controls**				
	Drainage Diversion Swale	$1.00	lf	500	$500
	SUBTOTAL:				$500
	Mobilization, Bonding, and Insurance (10%):				$50
	Contingency (20%):				$100
	Engineering Design (8%)				$52
	Construction Oversight (6%)				$39
	TOTAL ESTIMATE:				**$741**
WR-F8-3	**Partial Removal to Oriole Tunnel (F7) and Surface Controls**				
	Partial Excavate and Haul Waste Rock to Oriole Tunnel F7	$8.00	cy	4,000	$32,000
	Regrade Remaining Waste Rock F8	$1.50	cy	600	$900
	Vegetative Backfill Material	$4.00	cy	300	$1,200
	Revegetation	$2,500.00	ac	0.5	$1,250
	Haul Road from F-8 to Oriole Adit	$2.00	sy	550	$1,100
	Haul Road from Breached Dam to F-8	$1.00	sy	2,700	$2,700
	Reclaim Haul Road	$0.50	sy	3,250	$1,625
	Erosion Control	$5,000.00	ls	1	$5,000
	Drainage Diversion Swale	$1.00	lf	500	$500
	SUBTOTAL:				**$46,275**
	Mobilization, Bonding, and Insurance (10%):				$4,628
	Contingency (20%):				$9,255
	Engineering Design (8%)				$4,813
	Construction Oversight (6%)				$3,609
	TOTAL ESTIMATE:				**$68,580**
WR-F8-4	**Total Removal and Disposal in Oriole Tunnel (F7)**				
	Total Excavate and Haul Waste Rock to Oriole Tunnel F7	$8.00	cy	8,000	$64,000
	Vegetative Backfill Material	$4.00	cy	300	$1,200
	Revegetation	$2,500.00	ac	0.5	$1,250
	Haul Road from F-8 to Oriole Adit	$2.00	sy	550	$1,100
	Haul Road from Breached Dam to F-8	$1.00	sy	2,700	$2,700
	Reclaim Haul Road	$0.50	lf	3,250	$1,625
	Erosion Control	$5,000.00	ls	1	$5,000
	SUBTOTAL:				**$76,875**
	Mobilization, Bonding, and Insurance (10%):				$7,688
	Construction Staking and Survey (2%)				$1,538
	Contingency (20%):				$15,375
	Engineering Design (8%)				$8,118
	Construction Oversight (6%)				$6,089
	TOTAL ESTIMATE:				**$115,682**
WR-F8-5	**Total Removal and Disposal in an On-site Repository**				
	Excavate and Haul All Waste Rock to Repository	$4.00	cy	8,000	$32,000
	Strip repositoy Site (1ft)	$3.00	cy	850	$2,550
	Repository Cover Soil	$2.50	cy	2,400	$6,000
	Vegetative Backfill Material	$4.00	cy	300	$1,200
	Revegetation	$2,500.00	ac	1.5	$3,750
	Haul Road from F-8 to Oriole Adit	$2.00	sy	550	$1,100
	Haul Road from Breached Dam to F-8	$1.00	sy	2,700	$2,700
	Reclaim Haul Road	$0.50	lf	3,250	$1,625
	Erosion Control	$5,000.00	ls	1	$5,000
	SUBTOTAL:				**$55,925**
	Mobilization, Bonding, and Insurance (10%):				$5,593
	Contingency (20%):				$11,185
	Engineering Design (8%)				$5,816
	Construction Oversight (6%)				$4,362
	TOTAL ESTIMATE:				**$82,881**

Cost Analysis

Oriole Adit Closure Alternatives
Garnet Mine Reclamation Area

Item		Rate ($/unit)	Unit	Number of Units	Total
OA-1	**No Action**				**$0**
OA-2	**Institutional Controls -Gate and Signs**				
	Signs	$120.00	ea	2	$240
	Gate (Labor)	$100.00	hr	32	$3,200
	Gate (materials)	$1,000.00	ls	1	$1,000
	SUBTOTAL:				**$4,440**
	Mobilization, Bonding, and Insurance (10%):				$444.0
	Contingency (20%):				$888
	TOTAL CONSTRUCTION:				**$5,772**
	Construction Oversight (6%)				$346.32
	TOTAL ESTIMATE:				**$6,118**
OA-3	**Access Control -Portal Closure**				$0
	Abandoned Bus Removal and Disposal	$3,000.00	ls	1	$3,000
	Gate and Timber Removal and Disposal	$1,500.00	ls	1	$1,500
	12-inchAdit Water Discharge Pipe	$15.90	lf	40	$636
	RipRap (18-24")	$90.00	cy	15	$1,350
	Infiltration Basin (Basin Excavation, Geotextile Fabric, Filter Gravel)	$5,500.00	ls	1	$5,500
	Reclaim Access Road	$0.50	sy	3,250	$1,625
	Vegetative Backfill Material	$4.00	cy	300	$1,200
	Erosion Control	$5,000.00	ls	1	$5,000
	Revegetation	$2,500.00	ac	1	$1,250
	SUBTOTAL:				**$21,061**
	Mobilization, Bonding, and Insurance (10%):				$2,106.1
	Construction Staking and Survey (2%)				$421
	Contingency (20%):				$4,212
	TOTAL CONSTRUCTION:				**$27,801**
	Engineering Design (4%)				$1,112
	Construction Oversight (6%)				$1,668.03
	TOTAL ESTIMATE:				**$30,581**
OA-4	**Packer Installation to Stem Flow from Borehole**				
	1.5 inch mechanical crank packers (18" depth, 3' length)	$335.00	ea	5	$1,675
	Labor (hole prep)	$100.00	hr	60	$6,000
	Travel	$0.50	mi	400	$200
	Per Deim	$100.00	da	2	$200
	SUBTOTAL:				**$8,075**
	Contingency (20%):				$1,615
	TOTAL CONSTRUCTION:				**$9,690**
	Engineering Design (8%)				$775
	Construction Oversight (6%)				$581.40
	TOTAL ESTIMATE:				**$11,047**

Cost Analysis

Oriole Adit Closure Alternatives
Garnet Mine Reclamation Area

Item		Rate ($/unit)	Unit	Number of Units	Total
OA-5	**Grout Curtain Installation to Stem Flow from Borehole**				
	Mobilization and Demobilization				
	Mobilization	$25,000.00	ls	1	$25,000
	Demobilization	$25,000.00	ls	1	$25,000
	Equipment				
	Mucker	$325.00	da	35	$11,375
	Compressor	$85.00	da	35	$2,975
	Generator	$25.00	da	35	$875
	Jackleg Drill	$35.00	da	70	$2,450
	Bobcat	$90.00	hr	60	$5,400
	Fuel tanks and pump	$20.00	da	35	$700
	Core Drill	$625.00	da	6	$3,750
	Water Storage	$10.00	da	35	$350
	Grout Plant	$300.00	da	35	$10,500
	Pick-up Trucks	$75.00	da	105	$7,875
	Misc (fan, pumps,elders, tools, etc)	$250.00	da	35	$8,750
	Materials, Supplies and Fuel				
	Fuel	$200.00	da	35	$7,000
	4" Victaulic Pipe, fittings and hangers	$13.80	lf	900	$12,420
	1.5" Poly Pipe	$2.63	lf	1200	$3,156
	Packers	$425.00	ea	18	$7,650
	Vent Bag	$3.69	lf	1200	$4,428
	Explosives	$9.25	ft	200	$1,850
	Ground Support	$2,000.00	ls	1	$2,000
	Electric Cable	$7.90	ft	1200	$9,480
	Bentonite Grout	$220.00	tn	20	$4,400
	Type II Portland Cement	$11.78	bg	500	$5,890
	Miscellaneous	$5,000.00	ls	1	$5,000
	Labor				
	Drilling/grouting (2 man crew)	$1,800.00	da	15	$27,000
	Mining Contractor (3 man crew)	$2,960.00	da	35	$103,600
	SUBTOTAL:				**$298,874**
	Bonding,and Insurance (5%):				$14,943.7
	Contingency (20%):				$59,775
	TOTAL CONSTRUCTION:				**$373,593**
	Engineering Design (4%)				$7,472
	Construction Oversight (6%)				$22,415.55
	TOTAL ESTIMATE:				**$403,480**

Cost Analysis

Oriole Adit Closure Alternatives
Garnet Mine Reclamation Area

Item		Rate ($/unit)	Unit	Number of Units	Total
OA-6	**Plug Oriole Adit - two hydraulic plugs**				
	Mobilization and Demobilization				
	Mobilization	$40,000.00	ls	1	$40,000
	Site Clean-up	$15,000.00	ls	1	$15,000
	Demobilization	$40,000.00	ls	1	$40,000
	Equipment				
	Mucker	$325.00	da	61	$19,825
	Compressor	$85.00	da	61	$5,185
	Generator	$25.00	da	61	$1,525
	Jackleg Drill	$35.00	da	122	$4,270
	Fuel tanks and pump	$20.00	da	61	$1,220
	Excavator	$120.00	hr	30	$3,600
	Bobcat	$90.00	hr	200	$18,000
	Front End Loader	$92.50	hr	100	$9,250
	Ready Mix Truck	$700.00	da	12	$8,400
	Concrete Pump	$1,000.00	da	14	$14,000
	Core Drill	$625.00	da	14	$8,750
	Water Storage	$10.00	da	61	$610
	Grout Plant	$300.00	da	26	$7,800
	Pick-up Trucks	$75.00	da	183	$13,725
	Misccellaneous (fan, pumps, welder, tools, etc)	$250.00	da	61	$15,250
	Materials, Supplies and Fuel				
	Fuel	$200.00	da	61	$12,200
	4" Victaulic Pipe, fittings and hangers	$13.80	lf	600	$8,280
	1.5" Poly Pipe	$2.63	lf	600	$1,578
	Vent Bag	$3.69	lf	600	$2,214
	Form Materials	$7,200.00	ls	1	$7,200
	Explosives	$9.25	ft	600	$5,550
	Ground Support	$4,000.00	ls	1	$4,000
	Electric Cable	$7.90	ft	600	$4,740
	Bentonite Grout	$220.00	tn	20	$4,400
	Pre Mix	$196.00	cy	124	$24,304
	Type II Portland Cement	$11.78	bg	650	$7,657
	Aggregate	$32.00	yd	120	$3,840
	Cement Admixtures	$22.50	tn	150	$3,375
	Miscellaneous	$15,000.00	ls	1	$15,000
	Labor				
	Drilling (2 man crew)	$1,800.00	da	14	$25,200
	Mining Contractor (4 man crew)	$4,000.00	da	61	$244,000
	SUBTOTAL:				**$599,948**
	Bonding, and Insurance (5%):				$29,997
	Contingency (20%):				$119,990
	TOTAL CONSTRUCTION:				**$749,935**
	Engineering Design (2%)				$14,999
	Construction Oversight (4%)				$29,997
	TOTAL ESTIMATE:				**$794,931**