DRAFT - Adit Discharge Engineering Evaluation/Cost Analysis

New World Mining District Response and Restoration Project

TETRA TECH

United States Department of Agriculture
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Gallatin National Forest

Draft

ADIT DISCHARGE
ENGINEERING EVALUATION/COST ANALYSIS
NEW WORLD MINING DISTRICT
RESPONSE AND RESTORATION PROJECT

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NEW WORLD MINING DISTRICT
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Prepared For:

USDA Forest Service
Gallatin National Forest
Bozeman, Montana

Prepared By:

Tetra Tech, Inc.
(formerly Maxim Technologies)
303 Irene Street
P.O. Box 4699
Helena, Montana 59604

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EXECUTIVE SUMMARY

Maxim Technologies (Maxim) developed this Engineering Evaluation/Cost Analysis (EE/CA) for the United States Department of Agriculture Forest Service (USDA-FS). This EE/CA presents an engineering evaluation and cost analysis of alternatives that were developed to mitigate human health and environmental risks associated with mining-related discharges in the New World Mining District (District), which is generally located north of Cooke City, Montana. These discharges result from historic gold, silver, copper, and lead mining activity that was active during the period from the 1864 to the early 1950's. Seepage from mining-related discharges is characterized by elevated metal concentrations and sometimes acidic pH values that contribute to degradation of receiving surface water streams and groundwater resources.

The purpose of this EE/CA is to develop, screen, and evaluate potential response alternatives that would reduce or eliminate impacts associated with adit discharge from historic mines and other mining-related discharges located in the District. This EE/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, and the updated National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Following receipt of public comment on the preferred response action alternative identified in this document, the USDA-FS will select a response alternative in an Action Memorandum.

Of the more than 150 historic mine sites located in the District, 27 adit openings with discharges were inventoried and monitored. Of these sites, only ten are perennial discharges with water quality that exceeds Montana's standards. In addition, a series of subsurface drains located at the reclaimed McLaren Pit site convey poor quality water from the reclaimed area to Daisy Creek; as such, these drains are included in the evaluation of mining-related discharges. The characterization of the nature and extent of the discharges indicates that some contribute significant loads to tributary streams while others have very minor impacts. Of the 11 discharges (ten adits and the McLaren Pit subsurface drains) that exceed aquatic water quality criteria, two are located on non-District property, which, according to the Consent Decree (the legal basis for response and restoration work), no work can be conducted at these sites until other criteria are met. Therefore, only nine discharges were carried through the screening and evaluation of potential response action alternatives in this EE/CA. A list of the discharges evaluated is presented in **Table ES-1**.

A streamlined risk evaluation was completed to determine if human health and environmental risks are present at the nine remaining discharge sites. This streamlined evaluation demonstrated that there is no human health risk associated with any of the discharges at the site and that ecological risks are likely associated with only four of the discharges: the McLaren Adit, McLaren Pit subsurface drains, Glengarry Millsite, and Henderson Mountain Dump 7. Ecological risks associated with these discharges appear in surface water tributaries that receive the discharges. Contaminants of concern -- aluminum, cadmium, copper, iron, lead, and zinc -- present ecological risks to aquatic life from ingestion and direct contact. In addition, wildlife species may be at risk from these discharges, although it is not possible to determine a site-specific assessment of exposure and risk due to the lack of site-specific knowledge of both species characteristics and exposure conditions.

For the five discharges where ecological risks are low, aquatic risk is mitigated because either there were no exceedances of aquatic water quality standards at the discharge point, or the discharge did not directly enter a receiving stream, or, if the discharge did enter a receiving water, no impact to the stream could be measured directly downgradient of the discharge. However, because water quality criteria were exceeded in these discharges either historically or currently, the sites were brought forward into the detailed analysis of alternatives so that a determination could be made on whether a response action could be implemented to meet applicable standards.

TABLE ES-1
DISCHARGE SITES REQUIRING RESPONSE ACTION EVALUATION

Site Name	Site No.	AIMSS Rank*	Discharge Flow Range (gpm)	Site Status**
Black Warrior	MCSI-96-2 (M-8)	2	0.1-10	Collapsed/Reclaimed 2005
Glengarry Millsite (includes middle adit)	F-8B	15	3.0-26.9	Open
McLaren Adit	D-18	17	1.8-29.6	Open
Little Daisy Adit and Dump	M-1	20	0.5-220	Collapsed/Reclaimed 2005
Gold Dust Adit	F-28	24	1.3-250	Closed/Reclaimed 2005
Lower Tredennic Adit	FCSI-96-5	26	0.6-5	Collapsed/Reclaimed 2001
Henderson Mountain Dump 7	AE-17	51	0.0-5	Collapsed/Reclaimed 2004
Henderson Mountain Adit	M-25	No rank	1.8-25	Collapsed
McLaren Pit Subsurface Drains	DCSW-101	No rank	6.8-32	Three drains under cap

Notes: * AIMSS - Abandoned and Inactive Mines Scoring System
** Reclaimed status indicates previous response action conducted at the site to remove waste rock and/or close the opening
gpm gallons per minute

General response technologies and process options that are potentially capable of achieving established goals and objectives related to the treatment or reduction of mining-related discharges were screened, and the most promising technologies were then used to develop a reasonable set of alternatives that would be evaluated in detail. Response technologies considered included no action, institutional controls, engineering controls, and water treatment controls. After screening, it was evident that the most promising response technologies were related to either emplacing engineering controls to reduce or eliminate flows from the discharges, or water treatment technologies to reduce or eliminate contaminants present in the discharges. Alternatives were then developed from the two types of technologies. These alternatives are listed in **Table ES-2**. Source control alternatives specifically focused on the McLaren Pit subsurface drains were identified in the screening process but were not further considered for alternative development and detailed evaluation due to effectiveness, implementability, and cost concerns.

Because multiple sites are being considered in this EE/CA, and because many of the sites share similar characteristics, it was evident that the detailed analysis of alternatives could be streamlined by grouping the sites according to similar characteristics and then evaluating the alternatives for each group of sites rather than for each site. To this end, the sites were placed into groups. One set of groupings was based on the physical characteristics of the discharges, and these groups were evaluated against potential engineering source control alternatives. Another set of groupings was based on the chemical characteristics of the discharges and these groups were evaluated against potential water treatment alternatives.

For engineering source control alternatives, there were two groups of sites: sites with open or recently closed adits and sites with collapsed adits. The engineering source control response technology retained from the screening evaluation was plugging, and the alternative evaluated for both types of sites (open and collapsed) consisted of placing two plugs within the underground workings. These two alternatives, EC-1 and EC-2, are further described in **Table ES-2**. A No Action alternative was also evaluated.

TABLE ES-2
RESPONSE ACTION ALTERNATIVES FOR MINING-RELATED DISCHARGES

Alternative		Process Option Description
NA-1	No Action	None
EC-1	Plug an Accessible Adit	Applicable for the McLaren and/or Gold Dust Adits. Place high strength, acid-resistant, cement plugs to block and seal workings at a location about 76 meters (250 feet) into the mine and another plug near the portal to reduce or eliminate adit discharge. Cement or conventional backfill placed around the plug for ground support and to further restrict water flow. Portal closure and site reclamation.
EC-2	Reopen and Plug an Inaccessible Adit	Applicable for the Little Daisy, Lower Tredennic and/or Black Warrior Adits. Reopen inaccessible adits by excavation of portals, water discharge through a sediment pond, and mucking workings to 76 meters (250 feet). Place high strength, acid-resistant, cement plugs to block and seal workings at a location about 76 meters (250 feet) into the mine and another plug near the portal to reduce or eliminate adit discharge. Cement or conventional backfill will be placed around the plug for ground support and to further restrict water flow. Portal closure and site reclamation.
WT-1	Infiltration and Natural Attenuation	Discharge directed to subsurface drain field. As discharge infiltrates ground, aeration, dispersion, precipitation, and other chemical and biological attenuation processes act to reduce contaminants of concern (COC) concentrations.
WT-2	Passive Chemical Adsorption/Ion Exchange	Synthetic and/or natural aluminum and iron oxyhydroxides and synthetic zeolites adsorb metal cations from water through ion exchange reactions.
WT-3	Anoxic Limestone Drain, Anaerobic Bioreactor (SSBR or LRBR), and Open Limestone Channel	Designs rely on metabolic activity of microorganisms to attenuate COCs primarily through precipitation as metal sulfide mineral phases in either a solid substrate (SSBR) or liquid substrate (LRBR) anaerobic reactant media. Used in series following an anoxic limestone drain and ahead of an open limestone channel that both add alkalinity to the waste stream thereby facilitating precipitation of metal hydroxides.
WT-4	Anaerobic Bioreactor (SSBR or LRBR), and Open Limestone Channel	Designs rely on metabolic activity of microorganisms to attenuate COCs primarily through precipitation as metal sulfide mineral phases in either a solid substrate (SSBR) or liquid substrate (LRBR) anaerobic reactant media. Used in series with open limestone channels that add alkalinity to the waste stream thereby facilitating precipitation of metal hydroxides.
WT-5	Manganese Removal Cell	Manganese removal cells are modifications of limestone drains that allow sufficient residence time for precipitation of manganese oxides.
WT-6	Chemical Addition, Precipitation, Micro-filtration	Chemical agents added to waste water stream to increase or decrease pH; facilitates precipitation of insoluble mineral phases. Residual suspended solids removed by micro-filtration.
WT-7	Ion Exchange	Inorganic zeolites or synthetic organic resins provide a solid immobile substrate to capture charged particles.

For water treatment control alternatives, the sites fell into five groups. For each group, seven water treatment alternatives were evaluated, including both passive treatment technologies and active treatment technologies. These alternatives are described in **Table ES-2**.

Engineering source controls were only considered for adit discharges that are amenable to this type of closure; these include two accessible mines (McLaren and Gold Dust) and three inaccessible mines (Little Daisy, Lower Tredennic, and Black Warrior). The remaining sites have underground workings that are too short to be considered for engineering source control measures. The two engineering source control alternatives evaluated (EC-1 and EC-2) use high strength, acid-resistant, watertight, cement plugs that block the flow of water and greatly reduce or eliminate a discharge. Watertight plugs have been shown to be effective in greatly reducing or eliminating water flow from mine sites. The effect of placing plugs will be immediate and permanent, and the mobility of metals will be permanently reduced or eliminated. The cost to implement the alternatives ranges from $370,000 to $500,000 at each site.

Passive, semi-passive, and conventional active treatment response alternatives were evaluated for each source under review. With many of the innovative or passive treatment approaches, it is unclear given available current literature if the technology can meet the stringent aquatic standards applied to the New World sites. This is due in part because, in many of the studies reported in the literature, the recorded detection limits are above the aquatic criteria set for Montana B-1 standards. It is therefore difficult to predict removal efficiencies by biological and/or other passive treatment technologies, and treatability testing with actual discharge waters would be necessary to define achievable removal efficiencies for each discharge. The cost to implement passive water treatment alternatives ranges from $20,000 to $4.8 million.

In contrast, conventional, active treatment technologies such as chemical addition-precipitation followed by micro- or nano-filtration, or reverse osmosis, typically have the best chance of consistently meeting effluent discharge standards from a proven technology standpoint. However, the remoteness of the location, limited access, and the severe winter climate in the District would make operation and maintenance of active technologies very difficult and expensive, and may also render these more proven technologies less efficient than would be expected with close monitoring in a very controlled environment. Typically, implementation of an active treatment technology could only be accomplished at a significant increase in cost over a passive treatment system. The cost to implement active water treatment alternatives ranges from $3.1 million to $4.8 million.

Following review of the detailed and comparative analysis of alternatives, and based on the results of the evaluation at each site for the three primary criteria, effectiveness, implementability, and cost, the USDA-FS selected a preferred alternative for each of the eight adit discharges and for the McLaren Pit subsurface drains. The preferred alternative for each site is to continue monitoring the discharges under the No Action alternative. Monitoring under no action will allow the USDA-FS to reassess whether an action is necessary depending on water quality changes that result from response actions taken to date. While water quality has improved as a result of capping, removal, and treatment actions that have been taken over the past six years, the full effect of these changes may take several additional years to be realized. Monitoring under No Action also allows the USDA-FS to conduct treatability studies of promising technologies that could lead to improving water quality. Such studies could be undertaken on technologies evaluated in this document or other appropriate technologies that hold promise in treating or controlling the discharges.

Monitoring under No Action is considered an appropriate and reasonable response to the mining-related discharges in the New World Mining District. In general, while a response action alternative could be implemented at each of the nine sites that would result in an improvement in water quality or a reduction of flow, the effectiveness of all alternatives is somewhat uncertain due either to unknowns associated with the underground workings, difficult site conditions, or difficult operating conditions, particularly for the water treatment alternatives. In addition, although the detailed analysis of alternatives demonstrated that several alternatives could reduce or eliminate the flow of a discharge or reduce concentrations in a discharge to lower levels (and in some cases to levels below applicable standards), a loading analysis performed for each discharge indicated that, except for the Glengarry Millsite Adit and the McLaren Pit subsurface drains, elimination of the discharge only resulted in a minor reduction in the total load of metals delivered to a stream.

At the Glengarry Millsite and the McLaren Pit subsurface drains where notable load reductions could be achieved if a response alternative was implemented, other factors were important in selecting Monitoring under No Action for these two sites. While iron loads could be reduced by about 10% by eliminating the Glengarry Millsite discharge in Fisher Creek, hydrogeologic conditions at the site are changing due to changes that are occurring as a result of the Glengarry Adit closure, and these changes may impact the Glengarry Millsite discharge. Therefore, it is premature to proceed with water treatment at this site when the quantity and quality of the millsite discharge may change.

For the McLaren Pit subsurface drains, active water treatment is the only alternative that could meet target goals, but at a very high cost (about $4,800,000) that comes with serious construction and operation problems. Considering the cost and that implementation issues are many and difficult, and considering the impacts that would occur to recreational use of the Daisy Pass Road by winter recreationists, Monitoring under No Action is the most desirable alternative, particularly while the results of longer term monitoring of the effectiveness of the McLaren Pit Cap are evaluated over the next few years.

Finally, as supported by other studies conducted in the District, there are other recognized sources of water quality degradation, including natural sources, that contribute metal concentrations to District drainages and thereby limit gains in water quality that might be realized from mitigating flows from mining-related discharges. While the loading analysis completed for the discharges evaluated in this EE/CA did not include an analysis that attempted to predict the contribution of metals to a receiving stream in terms of concentration, as such an evaluation would be complex and have a high level of uncertainty, none of the alternatives were expected to effect achievement of B-1 standards in the respective receiving stream (i.e. Daisy, Fisher, or Miller creeks) due to the high metals concentrations and associated loads that report to the streams from other sources.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIMSS	Abandoned and Inactive Mines Scoring System
ARARs	Applicable or Relevant and Appropriate Requirements
ALD	anoxic limestone drain
ARD	acid rock drainage
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	best available technology
BMP	best management practice
CaCO3	calcium carbonate
CBMI	Crown Butte Mines, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
COC	contaminant of concern
CFR	Code of Federal Regulations
cfs	cubic feet per second
District	New World Mining District
DNRC	Montana Department of Natural Resources and Conservation
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HHS	Human Health Standard
HI	Hazard Index
HQ	Hazard Quotient
IRIS	EPA's Integrated Risk Information System
kg/month	kilograms per month
Lpm	liters per minute
LRBR	liquid reactant bioreactor
MCL	maximum contaminant level
MDEQ	Montana Department of Environmental Quality
MPDES	Montana Pollutant Discharge Elimination System
MWCB	Mine Waste Cleanup Bureau
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimeter
µg/L	micrograms per liter
mmhos/cm	millimhos per centimeter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDP	non-District Property
NFS	National Forest System
OLC	open limestone channel
ppm	parts per million
PRSC	post-removal site control
RAOs	removal action objectives
RCRA	Resource Conservation and Recovery Act
SSBR	solid substrate bioreactor
s.u.	standard units
TDS	total dissolved solids
UOS	URS Operating Services
USDA-FS	United States Department of Agriculture Forest Service

1.0 INTRODUCTION

Maxim Technologies (Maxim) developed this Engineering Evaluation/Cost Analysis (EE/CA) for the United States Department of Agriculture Forest Service (USDA-FS). This EE/CA presents an engineering evaluation and cost analysis of alternatives for response and restoration work proposed for mining-related discharges in the New World Mining District (District). The District is located generally north of Cooke City, Montana (**Figure 1**). The discharges are related to historic gold, silver, copper, and lead mining activity.

Seepage from mining-related discharges is characterized by elevated metal concentrations and sometimes acidic pH values that contribute to degradation of receiving surface water streams and nearby groundwater resources. In this report, identified impacts related to these discharges are described and characterized, response alternatives are proposed, and the cost of implementing an alternative are estimated. The geographic area included for study in this EE/CA includes all mining-related discharges in the Daisy Creek, Fisher Creek, Miller Creek, and Soda Butte Creek watersheds (**Figure 1**).

1.1 PURPOSE AND APPROACH

The purpose of this EE/CA is to develop, screen, and evaluate potential response alternatives that would reduce or eliminate impacts associated with adit discharges from historic mines and other mining-related discharges located in the District. This EE/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, and the updated National Oil and Hazardous Substances Pollution Contingency Plan (NCP). **Figure 2** displays the non-time critical removal process as it applies to the New World Mining District Response and Restoration Project. A non-time-critical removal action is implemented by the lead agency to respond to "the clean-up 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). Following receipt of public comment on the preferred response action alternative identified in this document, the USDA-FS will select a response alternative in an Action Memorandum.

1.2 PROJECT BACKGROUND

On August 12, 1996, the United States signed a Settlement Agreement (Agreement) with Crown Butte Mines, Inc. (CBMI) to purchase CBMI's interests in the District. This transfer of property to the U.S. government effectively ended CBMI's proposed mine development plans and provided $22.5 million to cleanup historic mining impacts on certain properties in the District. In June 1998, a Consent Decree (Decree) was signed by all interested parties and was approved by the United States District Court for the District of Montana. The Decree finalized the terms of the Agreement and made available the funds that are being used for mine cleanup. Monies available for cleanup are to be first spent on District Property (**Figure 1**). District Property is defined in the Consent Decree as all property or interests in property that the mining company relinquished to the U.S. Government. If funds are available after District Property is cleaned up to the satisfaction of the United States, other mining disturbances in the District may be addressed.

In 1995, the Environmental Protection Agency (EPA) began a site investigation that involved installing monitoring wells, surface water sampling, groundwater monitoring, and completing a groundwater tracer study. The results of these studies were published in two technical reports (URS, 1996; 1998) and included a description of the following: a review of all previous surface water and groundwater data; an evaluation of the data collected during the 1996, 1997, and 1998 field seasons; and an overall evaluation of the complete data set with respect to adequacy for restoration and reclamation of historic abandoned mines.

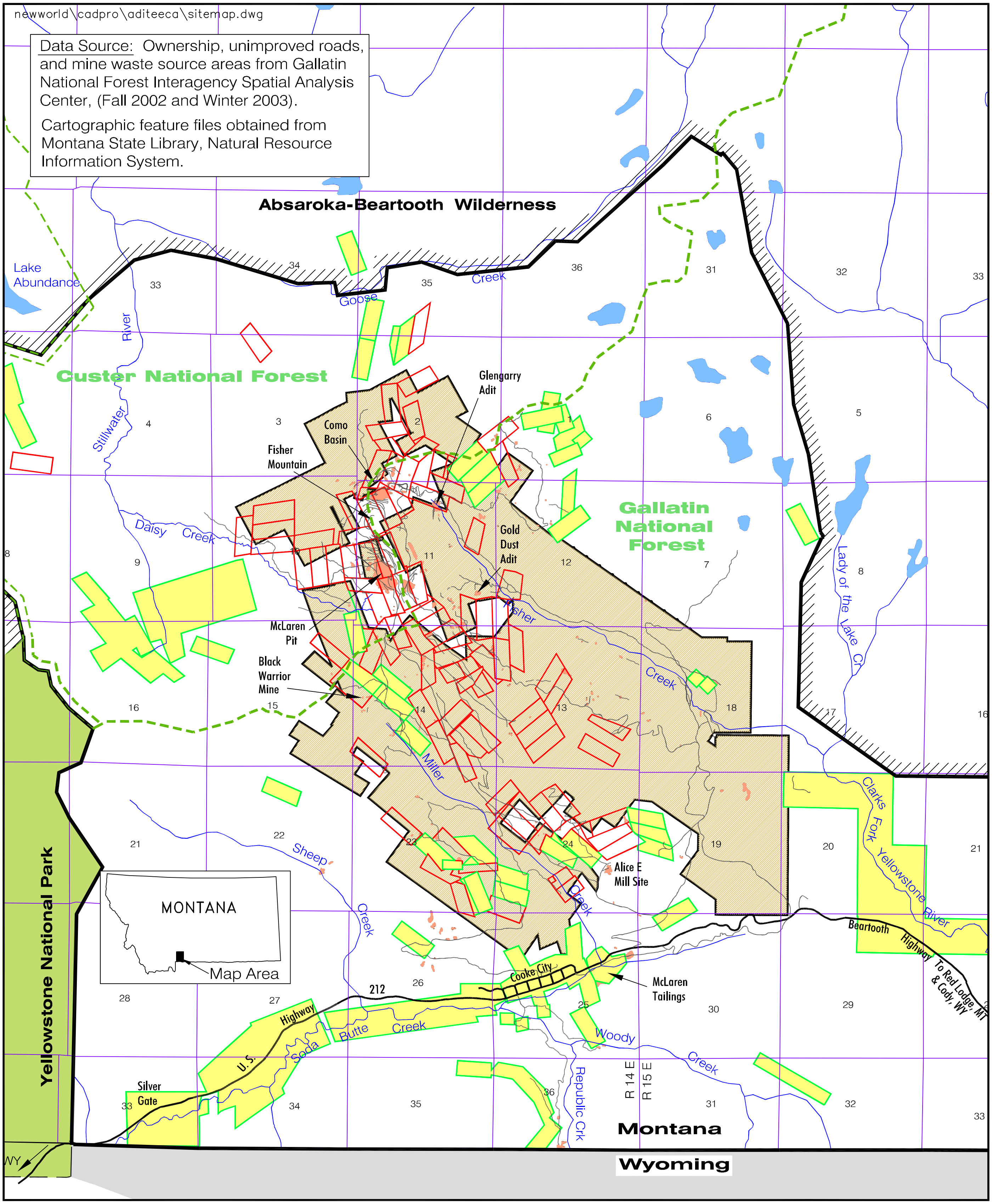
The USDA-FS assisted CBMI in October 1998 in completing and submitting a Support Document and Implementation Plan to support the CBMI petition for temporary modification of water quality standards, which was approved on June 4, 1999. The petition for temporary standards was necessary to temporarily modify surface water quality standards for Daisy and Fisher Creeks and a headwater portion of the Stillwater River so that improvements to water quality may be achieved by implementation of the response and restoration project.

Major work completed during the first three years of cleanup activity initiated by the USDA-FS was associated with the Selective Source Response Action (Maxim, 2001a). Construction activities associated with this response action were completed in 2002, and involved removing approximately 25,000 cubic meters (32,000 cubic yards) of mine waste and mill tailings from nine mine waste areas, disposing of these wastes in an engineered repository, and revegetating about 1.9 hectares (4.6 acres) of the former waste areas.

The second response action implemented by the USDA-FS in the District was the McLaren Pit Response Action (Maxim, 2001b). Construction activities were initiated in 2002 and were completed in October 2003. These activities included consolidation of waste rock dumps from the Daisy Creek headwaters area into the McLaren Pit, capping the consolidated wastes with a composite soil/geomembrane impermeable cap, and revegetating 4.5 hectares (11 acres).

The third response action implemented by the USDA-FS was the Como Basin/Glengarry Adit/Fisher Creek Response Action (Maxim, 2002a). Three separate source areas were evaluated in this study and include: the Como Basin Source Area, the Fisher Creek Source Area, and the Glengarry Adit Source Area. The Como Basin and Fisher Creek source areas are similar in that they both contain contaminated soils and/or mine waste rock deposits as a principal source of sulfide-bearing material that is oxidized to form an acid-rich, metal-laden leachate, which is in turn mobilized and impacts the quality of surface water and groundwater. These two areas differ in scale in that the Como Basin Source Area is a large area (2.23 hectares; 5.5 acres) underlain at shallow depths by a massive sulfide ore deposit, whereas the Fisher Creek Source Area contains a number of small scattered waste rock piles in the upper Fisher Creek drainage and other small, but locally severe erosional problems. The preferred alternative for the Como Basin Source Area uses a composite cover system (geomembrane liner overlain by amended soil) to confine and reduce the mobility of contaminants present in soils in the basin. Work was begun on this project in 2005 and completed in 2006. The preferred alternative for the Fisher Creek Source Area is the use of surface controls (regrading, drainage control, shallow soil lime amendment, and revegetation) for select waste rock dumps and the removal of other waste rock dumps to the Selective Source repository. The preferred alternative for the Fisher Creek source area was implemented in 2004.

Cleanup of the Glengarry Adit Source Area, where contaminated inflows into underground workings flowed through the workings before discharging contaminated water into Fisher Creek, involved grouting contaminated inflows and plugging outflows from the mine, thus minimizing or eliminating discharge from the mine workings. This project was initiated in 2003 and was completed in September 2005.



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District Property Boundary
District Boundary
Unimproved Road
National Forest Boundary
Wilderness Boundary
Mine Waste Source Area
District Property (Patented Claims)
District Property (Unpatented Claims)
Private Property

MAXIM TECHNOLOGIES

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Project Vicinity Map
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 1

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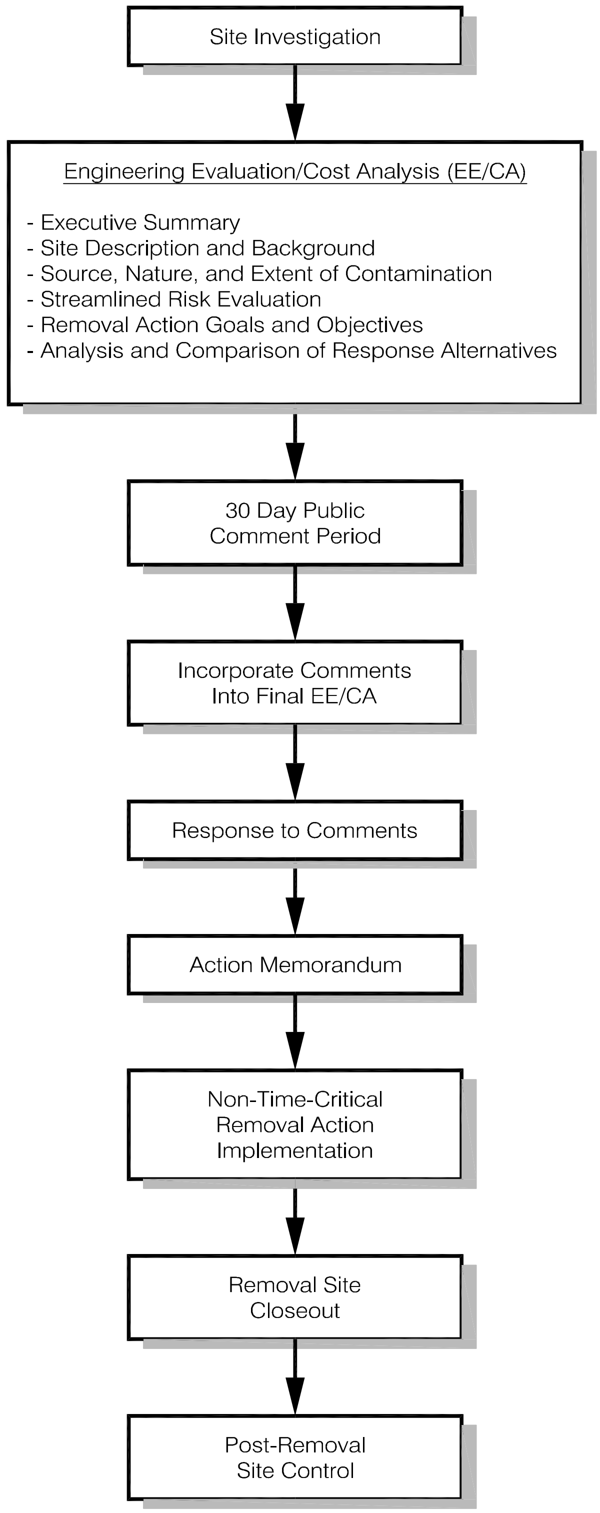

Non-Time-Critical Removal Action Process
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 2

MAXIM TECHNOLOGIES 4560831.100

1.3 REPORT ORGANIZATION

This EE/CA is arranged in eight sections. Following this introductory section, the history of the District and descriptions of the site's geologic, hydrologic, and climatic characteristics are presented in Section 2.0. Section 3.0 presents data pertinent to characterizing adit discharge sources within the Daisy, Fisher, and Miller Creek drainage basins. In particular, adit seepage chemistry and flow data are reviewed and compared to data from surface water monitoring stations to determine the relative contribution of each adit to the total metal load in receiving surface water. Section 4.0 summarizes human health and ecologic risks associated with discharges and recreational use of the sites. Section 5.0 outlines the response action scope, removal action objectives (RAOs), and goals for the site. The RAOs were developed by the USDA-FS, and goals were identified based on both applicable or relevant and appropriate requirements (ARARs) and representative cleanup guidelines for mine waste sites. In Section 6.0, response action technologies and process options are screened and potentially applicable removal alternatives are developed. Section 7.0 presents a detailed analysis of alternatives using NCP evaluation criteria. Section 8.0 presents a comparative analysis of the alternatives where a preferred alterative is selected.

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 water quality and flow data for adits and surface water monitoring stations, risk evaluation calculations, a list of ARARs, and detailed cost estimates for the alternatives discussed in Sections 7.0 and 8.0.

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2.0 SITE DESCRIPTION

The District includes both National Forest System (NFS) land and private land in a historic metal mining area located north of Cooke City, Montana (**Figure 1**). This historic mining district contains both mining-related and natural conditions that impact surface and groundwater resources and affect cleanup activities. These features include: massive sulfide deposits exposed at the surface; regionally distributed geologic units and deposits enriched in pyrite and chalcopyrite; abandoned mines; hard rock mining wastes; adit discharges from both mine wastes and abandoned mine workings; and natural acid rock drainage. Human health and environmental risk issues are related to elevated levels of metals present in various mineralized geologic units, mine wastes, acidic water discharging from mine openings, and contaminated stream sediments.

2.1 SITE LOCATION

The District falls within the boundaries of the Gallatin and Custer National Forests and lies adjacent to Yellowstone National Park's northeastern-most corner (**Figure 1).** The Absaroka-Beartooth Wilderness Area bounds the District to the north and east. To the south of the District is the Montana-Wyoming state line and NFS lands administered by the Shoshone National Forest. The District lies entirely within Park County, Montana. The communities of Cooke City and Silver Gate, Montana are the only population centers near the District.

The District is located at elevations ranging from 2,400 meters (7,900 feet) to over 3,200 meters (10,400 feet) above mean sea level. The site is snow-covered for much of the year. Only one route of travel is open on a year-round basis to the District, the highway between Mammoth and Cooke City. The Sunlight Basin road allows access to the District from northwestern Wyoming during the spring, summer, and fall, but only allows access to within a few miles of the District in winter. The Beartooth Highway is closed during winter, as is Highway 212 from Cooke City eastward to Pilot Creek near the Montana-Wyoming state line.

The District covers an area of about 100 square kilometers (40 square miles). Historic mining disturbances affect about 20 hectares (50 acres). The topography of the District is mountainous, with the dominant topographic features created by glacial erosion and glacial deposits. The stream valleys are U-shaped, broad, and underlain at shallow depths by bedrock, while the ridges are steep, rock covered, and narrow. Much of the District is located at or near tree line, especially in the vicinity of Fisher Mountain, where the major historic mining disturbances are located.

The District is situated at the headwaters of three tributaries of the Yellowstone River: the Clark's Fork of the Yellowstone, the Stillwater, and the Lamar. Headwaters tributaries that feed these three branches of the Yellowstone are named, respectively, Fisher Creek, Daisy Creek, and Miller Creek (**Figure 1**).

2.2 CLIMATE

The New World District has a continental climate modified by its mountain setting. It is characterized by large daily and annual temperature ranges and marked differences in precipitation, temperature, and wind patterns over distances of only a few kilometers.

Precipitation and temperature data have been collected periodically at Cooke City from 1967 through 1995 (EarthInfo, 1996). The average annual precipitation for the period of record is 645 millimeters (mm) (25.38 inches). Temperatures are coldest in January with an average minimum of -16.5°C (2.4°F) and an average maximum temperature of –4.8°C (23.3°F). Temperatures are warmest in July with an average minimum temperature of 3.3°C (37.9°F) and an average maximum temperature of 22.8°C (73.1°F).

Precipitation and temperature vary with elevation, and freezing conditions can occur any day of the year. Precipitation records from a Natural Resources Conservation Service SNOTEL Station TX06 at an elevation of 2,770 meters (9,100 feet) in the Fisher Creek drainage indicate that the average annual precipitation at this location is 1,500 mm (60 inches). Fifty percent of the annual precipitation occurs between October and February, with January having the highest average monthly precipitation (14.4 percent) and August having the lowest average monthly precipitation (3.9 percent) (URS, 1998). Average annual snowfall at higher elevations is about 13 meters (500 inches) (USDA, 1975).

A meteorological station was maintained in upper Fisher Creek and data collected from this site for the period May 1992 through August 1993 indicate an average wind speed of 2.4 meters/second (5.4 miles/hour) and a prevailing direction from the northwest (Gelhaus, 1993).

2.3 HYDROLOGY AND HYDROGEOLOGY

Surface water resources in the District are comprised of three separate watersheds: Daisy Creek (a tributary of the Stillwater River), Fisher Creek (a tributary of the Clarks Fork of the Yellowstone River), and Miller Creek (a tributary of Soda Butte Creek and the Lamar River) (**Figure 1**).

The Daisy Creek drainage basin collects water from the north side of Daisy Pass, the north flank of Crown Butte, the west flank of Fisher Mountain and Lulu Pass, the north flank of Bull of the Woods Pass and the east flanks of Wolverine Pass and Mount Abundance (**Figure 1**). Daisy Creek flows northward from its origin below Daisy Pass approximately three kilometers (two miles) to its confluence with the Stillwater River, which continues generally northward through the Absaroka-Beartooth Wilderness Area.

The upper portion of the Fisher Creek drainage basin collects water from the east side of Lulu Pass, the north and east flank of Fisher Mountain, the south flank of Scotch Bonnet and Sheep Mountains and from the Como Basin (**Figure 1**). Fisher Creek flows southeastward from its origin below Lulu Pass and is joined by a few small unnamed tributaries in the reach between the Glengarry Adit and the southern end of Henderson Mountain. Further downstream (southeast), Fisher Creek is joined by Lady of the Lake Creek and the Broadwater River, both of which flow from the north. Below the confluence with the Broadwater, the river becomes the Clarks Fork of the Yellowstone. From here, the Clarks Fork flows and joins the Yellowstone River near Laurel, Montana.

The Miller Creek drainage basin collects water from the south side of Daisy and Bull-of-the-Woods passes, the southwest flank of Henderson Mountain, and the east flank of Miller Mountain (**Figure 1**). Just east of Cooke City, Miller Creek flows into Soda Butte Creek, which flows westward into Yellowstone National Park.

Surface water discharge in the area is quite variable and seasonally dependent. All three of the principle watersheds within the District exhibit rapid flow response to snowmelt and summer precipitation events. Rain-on-snow events typically produce major spring and early summer peak runoff events. Significant diurnal variations in flow also occur, particularly during peak snowmelt periods. Although a substantial number of summer and fall flow measurements have been made in the three drainages, only a few winter and spring flow measurements have been made. Peak flows occur between mid May and early August and commonly in late June or early July.

Groundwater occurs in two hydro-stratigraphic units in the three drainage basins: 1) surficial unconsolidated alluvial and colluvial deposits localized along drainages, and 2) fractured bedrock. Unconsolidated deposits that host groundwater consist primarily of narrow strips of alluvial/colluvial material deposited parallel to tributary channels and the main stems of Daisy, Fisher, and Miller creeks. Groundwater within unconsolidated sediments is recharged by direct infiltration of surface runoff and in some areas by discharge from bedrock seeps, springs, and fractures. Groundwater flow within unconsolidated material is parallel to topographic slope.

The primary porosity of bedrock units throughout the District is very limited. Most porosity and permeability is secondary, and results from fractures and faults in bedrock. Recharge to bedrock occurs primarily as direct infiltration of snowmelt and runoff, particularly where fractures daylight.

Fractures in bedrock create a high degree of anisotropy that controls local and regional groundwater flow. Although the regional hydraulic gradient generally follows topography, anisotropy due to fracture orientation creates preferential flow paths that often cut across potentiometric gradients. Preferential groundwater flow along the Crown Butte Fault, which controls the location of the Miller Creek valley, has been demonstrated by pump testing.

2.4 MINING HISTORY

Mining exploration in the District began in 1864 when prospectors from the mining camp of Virginia City explored the area. The earliest placer and lode deposits were prospected in 1869. In 1876, the Eastern Montana Mining and Smelting Company constructed a smelter in the Cooke City area. In 1883, the Republic Smelter was built for the reduction of silver-lead ore. It was located on the western end of town, on the south side of Soda Butte Creek. During these early years of development, the District was a part of the Crow Reservation. When the U.S. government withdrew this land from the reservation and put it into public ownership in 1882, interest in mining in the District heightened with the filing of 1,450 claims (Wolle, 1963).

Mining activity fluctuated greatly between 1882 and the late 1920's, hampered primarily by the lack of a railroad to ship ore and supplies, and the long and severe winters. Numerous smelters were built, although most only operated for a few years at a time. A portable smelter was reported to have been in operation in the Miller Creek drainage in the late 1880's. Gold was mined on Henderson Mountain beginning in 1888. During 1893 and 1894, gold was mined from underground workings and an open pit on Henderson Mountain (Reed, 1950). A road over Lulu Pass was built during 1905-1906 to reach a copper lode in the area of Goose Lake (URS, 1996).

A number of small mining companies operated underground mines that were developed in the early 1920's. The Glengarry Mining Company operated a flotation mill in the upper Fisher Creek drainage in the 1920's to process copper-gold ores from the Spalding Tunnels. The Spalding Tunnels were developed in a north-south fault structure (Crown Butte Fault) on the south side of Scotch Bonnet Mountain (Reed, 1950). Later, in the mid-1920's, the Glengarry Mining Company drove an adit, the Glengarry Adit (**Figure 3**), from the base of Lulu Pass in the Fisher Creek drainage to intercept ore at depth along the mineralized structure of the Spalding Tunnels. No ore-grade mineralization was encountered in this adit (Lovering, 1929). Prior to 1934, a southwest heading was driven from an underground location in the Glengarry Adit beneath the Como Basin, and a raise driven to surface in massive sulfide mineralization of the Como stratabound replacement deposit near Lulu Pass.

The Tredennic Mines were operated by the Tredennic Development Company on claims located on the southeast flank of Scotch Bonnet Mountain. The workings consist of three principal adits with about 419 meters (1,375 feet) of combined workings. The middle adit intercepted a narrow zone of copper-gold mineralization at the contact with Precambrian basement and the gabbro of the Scotch Bonnet intrusive complex. No significant production was recorded from any of the Tredennic workings (Lovering, 1929).

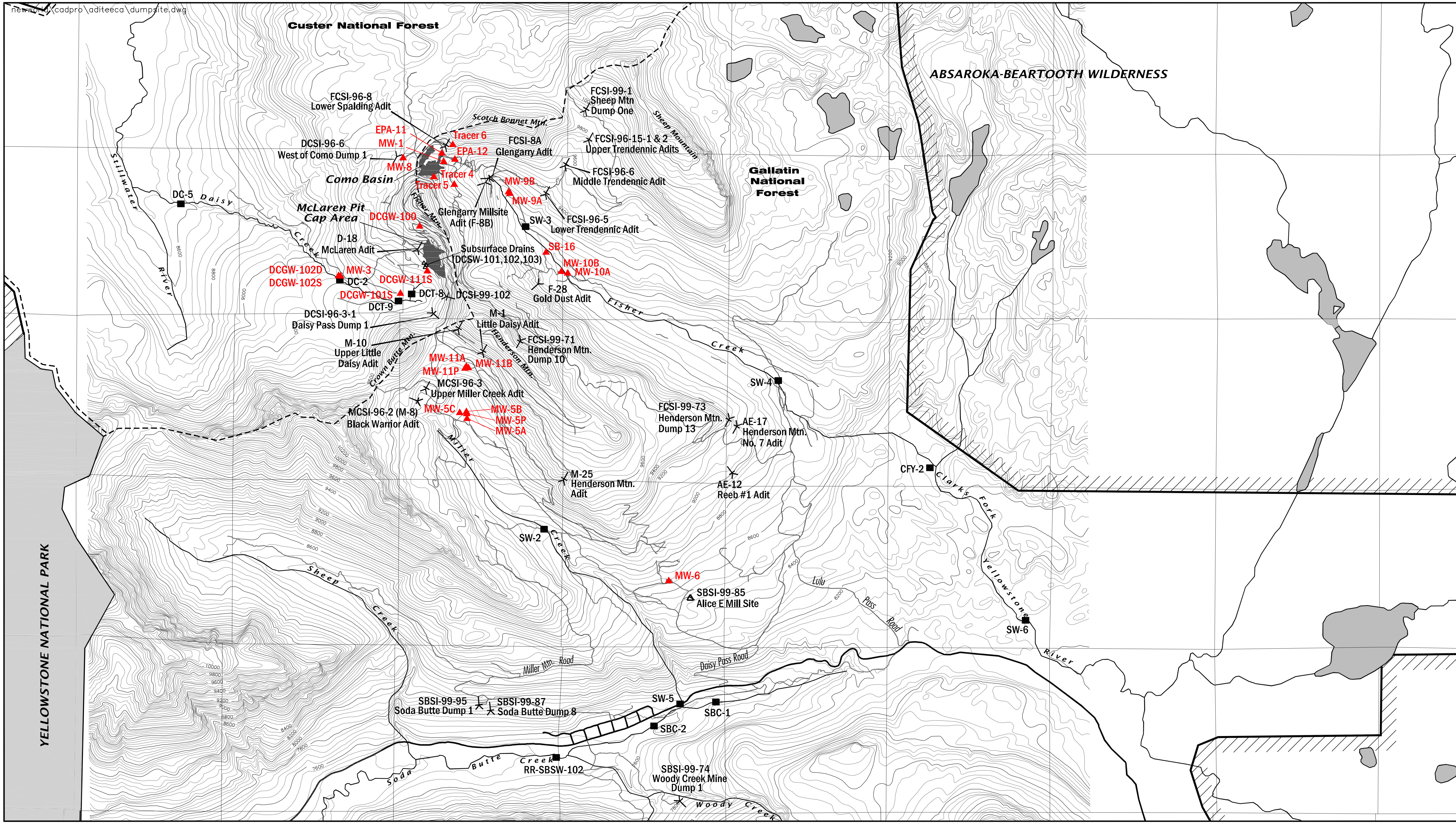
The Gold Dust Adit is located on the southwest side of the Fisher Creek Valley, near the break in slope forming the flank of Henderson Mountain (**Figure 3**). The adit was driven by Western Smelting and Power Company between 1920 and 1925 and drifts to the southwest for about 700 meters (2,300 feet). No production is recorded from the adit. By 1925, estimated production from the District was $215,000 in gold, silver, copper, and lead (Wolle, 1963).

Three mines were important in the early mining history of the Miller Creek area: the Little Daisy Mine (also known as the Daisy Mine), the Black Warrior Mine, and the Alice E Mine. In addition to these three mines, several small underground mines were operated on the west side of Miller Creek, on the mid- to lower-slopes of Miller Mountain (**Figure 3**). The Little Daisy Mine is located on the northwestern slope of Henderson Mountain southeast of Daisy Pass. Western Smelting and Power operated the mine intermittently from 1888 to about 1918. The Little Daisy Mine has approximately 2,385 feet of workings (Lovering, 1929) with portals on both the southwest (Little Daisy Adit) and northeast flanks (Homestake Adit) of Henderson Mountain (**Figure 3**). The Little Daisy Mine produced gold and copper ore from sulfide and oxide replacement mineralization in blocks of Pilgrim Limestone caught up in the Homestake Stock and the upper portion of the Homestake Breccia Pipe.

The Black Warrior Mine (**Figure 3**) lies southeast of Bull-of-the-Woods Pass, near the headwaters of Miller Creek. It consists of an underground adit about 130 meters (425 feet) in length and a 24-meter high (80-foot) raise to surface. The adit was driven to the north-northeast along fracture-controlled lead-zinc-silver mineralization in the Pilgrim Limestone along what may be a splay of the Crown Butte Fault zone.

The Alice E Mine (**Figure 3**) is located on the southwestern flank of Henderson Mountain. The mine was operated in the mid-1890's as an open-pit operation that mined oxidized gold from fracture-controlled mineralization in the brittle Flathead Formation (sandstone/quartzite). Some gold-bearing pyritic ore is exposed in these workings and contained in the waste rock; however, because the Alice E Mine recovered gold using cyanide it was not effective in treating sulfide-rich ores. The Alice E Mine proper is located on private property, although the mill site that contains both tailings and waste rock is located on NFS land (non-District Property).

In 1933, a gold-copper-silver mining operation, the McLaren Mine, was developed on the west side of Fisher Mountain. Milling of the ore produced from this mine was done in Cooke City at the Cooke City Mill. The Cooke City Mill was a gravity/flotation mill that produced a concentrate that was then shipped through Yellowstone National Park to a railhead in Gardiner, Montana. With the destruction of the McLaren Mill by fire in 1953, mining in the District ceased. Total metal production from the New World District is 62,311 ounces of gold; 692,386 ounces of silver; 1,963,800 pounds of copper; 3,242,615 pounds of lead; and 920,200 pounds of zinc (Lovering, 1929; Reed, 1950; Eyrich, 1969; Wolle, 1963; Krohn and Weist, 1977). Nearly all of the gold and copper came from the McLaren Mine. Most of the lead, zinc, and a large portion of the silver came from mines in the Republic District south of Cooke City.



Source: Topographic data from USGS 7.5 Cooke City Quad
Contour Interval = 40'

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District Boundary
Forest Boundary
Roads
SW-2 Surface Water Station
Collapsed Adit Discharge Site
Open Adit Discharge Site
Other Discharge Site
MW-3 Monitoring Well

Site Map
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 3

Figure 3 – back page

Extensive exploration of the area by a number of major mining companies for sediment-hosted, massive sulfide and porphyry copper and molybdenum deposits continued from 1974 until 1996, with CBMI as the last major company to hold an interest in the District. CBMI executed exploratory drilling programs for stratabound replacement and breccia pipe deposits containing gold, copper, and silver mineralization in the District from 1987 to 1993. This exploration work produced new subsurface deposit discoveries and led to extensive drilling in the Miller Creek and Homestake deposit areas located under the north end of Henderson Mountain in the upper Miller Creek drainage. In addition, the Homestake deposit was drilled from underground drill stations in the Gold Dust Adit in 1993.

2.5 DISTRICT GEOLOGY

The geology and mineral deposits of the District were mapped and described by Lovering (1929) and Elliott mapped the geology of the Cooke City Quadrangle in 1979 (Elliot 1979). Reed (1950) described many of the mines and summarized production from the District. Additional information on alteration and mineralization in the District is available from Eyrich (1969), Johnson (1991), Johnson and Meinert (1994), and guidebook articles by Johnson (1992) and Elliot, et al., (1992).

Precambrian basement rocks, predominantly granitic gneisses, are exposed over much of the northern and eastern part of the New World District, including the valley floor along lower Fisher Creek and scattered outcrops on the southern flank of Henderson Mountain (**Figure 4**). Paleozoic sedimentary rocks consisting of sandstone, siltstone, shale, limestone, and dolomite unconformably overlie these basement rocks and occur on the north and west flanks of Fisher Mountain, on the southwest flank of Sheep Mountain, and outcrop extensively in the Miller Creek area along the flanks of Henderson Mountain, Miller Mountain, and Crown Butte. These sedimentary rocks generally dip gently to the southwest and are intruded by Tertiary (Eocene) felsic calc-alkaline stocks, laccoliths, sills, and dikes. There are four principle plutons in the District. From north to south these are: Scotch Bonnet Diorite, Fisher Mountain Intrusive Complex, Homestake Stock, and the Henderson Mountain Stock. The Fisher Mountain and Homestake Intrusive complexes (**Figure 4**) exhibit concentrically zoned, porphyry-style alteration characterized by quartz-sericite-pyrite-chalcopyrite alteration assemblages. Both of these intrusive complexes were explored in the 1960s-1980s for porphyry copper and porphyry molybdenum deposits.

The Miller Creek drainage occurs along the southwest flank of Henderson Mountain, which is cored by the Homestake and Henderson Mountain Stocks. The location of the valley is controlled by Pleistocene (glacial) and recent erosion along the Crown Butte Fault that crosses Crown Butte and Daisy Pass and extends southward along the Miller Creek valley axis (**Figure 4**).

The gold-copper-silver deposits in the District are of three principal types: 1) tabular, stratabound, skarn and massive sulfide replacement deposits hosted by the Meagher Limestone Formation of Cambrian-age (i.e., Como, McLaren and Miller Creek deposits); 2) replacement (i.e., Fisher Mountain deposit) and vein-type mineralization along high angle faults and fractures (i.e., Little Daisy Mine, Spalding and Tredennic deposits); and 3) sulfide and oxide replacement deposits of limestone clasts in diatreme and intrusion breccias (i.e., Fisher Mountain Intrusive Complex and Homestake Breccia Pipe deposit). Late stage vein and replacement deposits of lead, zinc, and silver that occur more peripheral to the District, some of which occur in Miller Creek (Black Warrior Mine and some Miller Mountain deposits) are also genetically related to these two stocks.

Mineralization in the Daisy, Fisher, and Miller Creek areas is spatially, temporally, and genetically related to the emplacement and alteration of the Fisher Mountain Intrusive Complex and the Homestake and Henderson Mountain stocks. In addition, recent (1980's) exploration activities identified large areas of mineralization and alteration containing anomalous metal enrichment in intrusive rock and overlying soils on the southwest flank of Henderson Mountain. Detailed descriptions of mineralization in the District are presented in the Como Basin/Glengarry Adit/Fisher Creek Response Action EE/CA (Maxim, 2002a) and the Miller Creek Response Action EE/CA (Maxim, 2003a) and are not repeated here.

2.6 DESCRIPTION AND MINERALIZATION OF MINES IN THE DISTRICT

This section presents a description of the major mines in the District. With a few exceptions, most mines are underground and are entered through adit openings that have collapsed at all but two sites. Most of the major mines described below have adit discharges. **Figure 3** shows the location of all the discharging adits in the District.

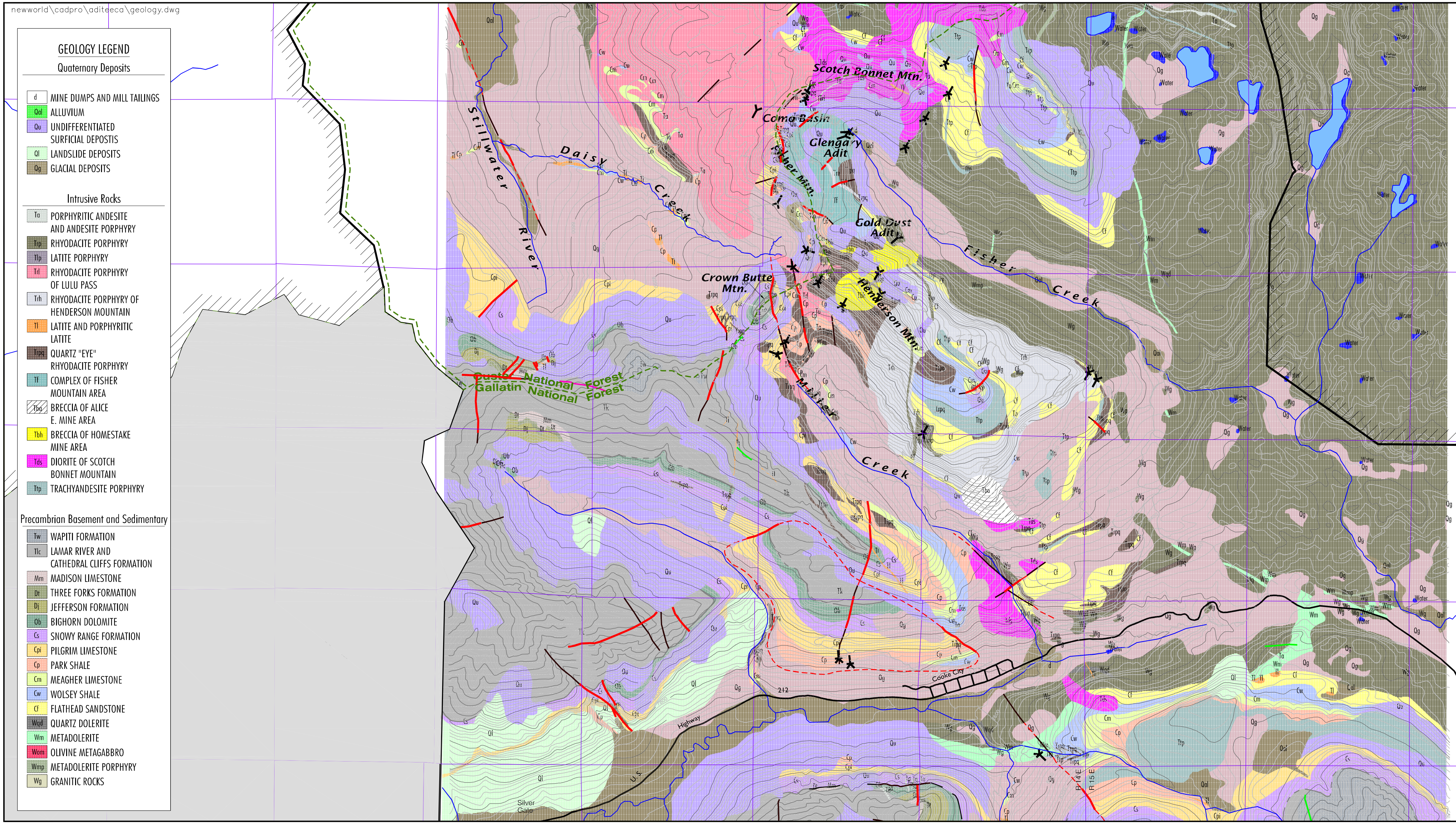
2.6.1 McLaren Adit

In 1933, The McLaren gold-copper-silver mining operation was developed on the west side of Fisher Mountain (**Figure 3**). Initial mining and exploration was conducted from a series of eight east-northeast trending adits of varying length (**Figure 5**). The geometry of the ore exposed in the exploration adits indicated that the ore deposit in the McLaren Mine area was aerially extensive, tabular and dipped gently to the southwest. It was determined that the McLaren gold-copper deposits could be most efficiently mined by open pit methods. In the subsequent open pit mining operations, waste rock was stripped from the underlying massive sulfide ore, and stockpiled to the north side of the pit. The massive sulfide ore was stripped down to its lower contact with an interformational dacitic intrusive sill. Presumably, these first eight adits were mined out during open pit mining operations, although this cannot be confirmed as these former adit levels are buried by waste rock.

Ore present beneath an interformational, Tertiary-age, dacitic intrusive sill occurring in the upper third of the Meagher Limestone at the McLaren Mine was not mined, and significant additional reserves were discovered by CBMI to lie beneath this intrusive sill. In addition, by recent and current economic standards, most waste rock placed as backfill into the open-pit is of ore-grade. CBMI drilled in the McLaren Mine area proper from 1987 through 1990 to evaluate the ore remaining in the lower portion of the Meagher Limestone and in mine backfill materials within the McLaren Pit (CBMI, 1990).

In addition to the eight adits consumed by the McLaren Pit, a ninth adit, called the McLaren Adit (or the Winter Tunnel), appeared on maps in 1952, one year prior to the cessation of open pit mining. The McLaren Adit was driven to the northeast from the northwest corner of the McLaren Pit. Due to a mill fire that ended mine operations, the McLaren Adit was not disturbed by historic open-pit mining activities and remains at the north end of the pit. It collars at about 2,938 meters (9,640 feet) in elevation near the junction of the main county road with the Lake Abundance road (**Figure 3**). Based on the size of a waste rock dump located near the portal and the dimensions of the adit, it is estimated that the length of workings would be approximately 540 meters (1,770) feet including crosscuts and drifts and/or stopes developed in the mine.

The USDA-FS reopened the McLaren Adit in September of 2001 using a track-mounted excavator to explore the workings and look for sources of the water inflow. **Figure 6** is a geologic map of the accessible portion of the workings and **Figure 7** shows the reconditioned adit portal. Altered and mineralized sedimentary rocks of the Meagher Limestone (pyrite, chalcopyrite, and abundant iron oxides) are complexly intruded by the Fisher Mountain porphyry over the accessible and visible portions of the mine. No water sources other than an occasional drip were observed in the first 107 meters (350 feet), but water was flowing over a meter (3.5 foot) high dam at a caved-in section of the mine at 130 meters (423 feet), and flowing down an exploration borehole drilled from the surface that had

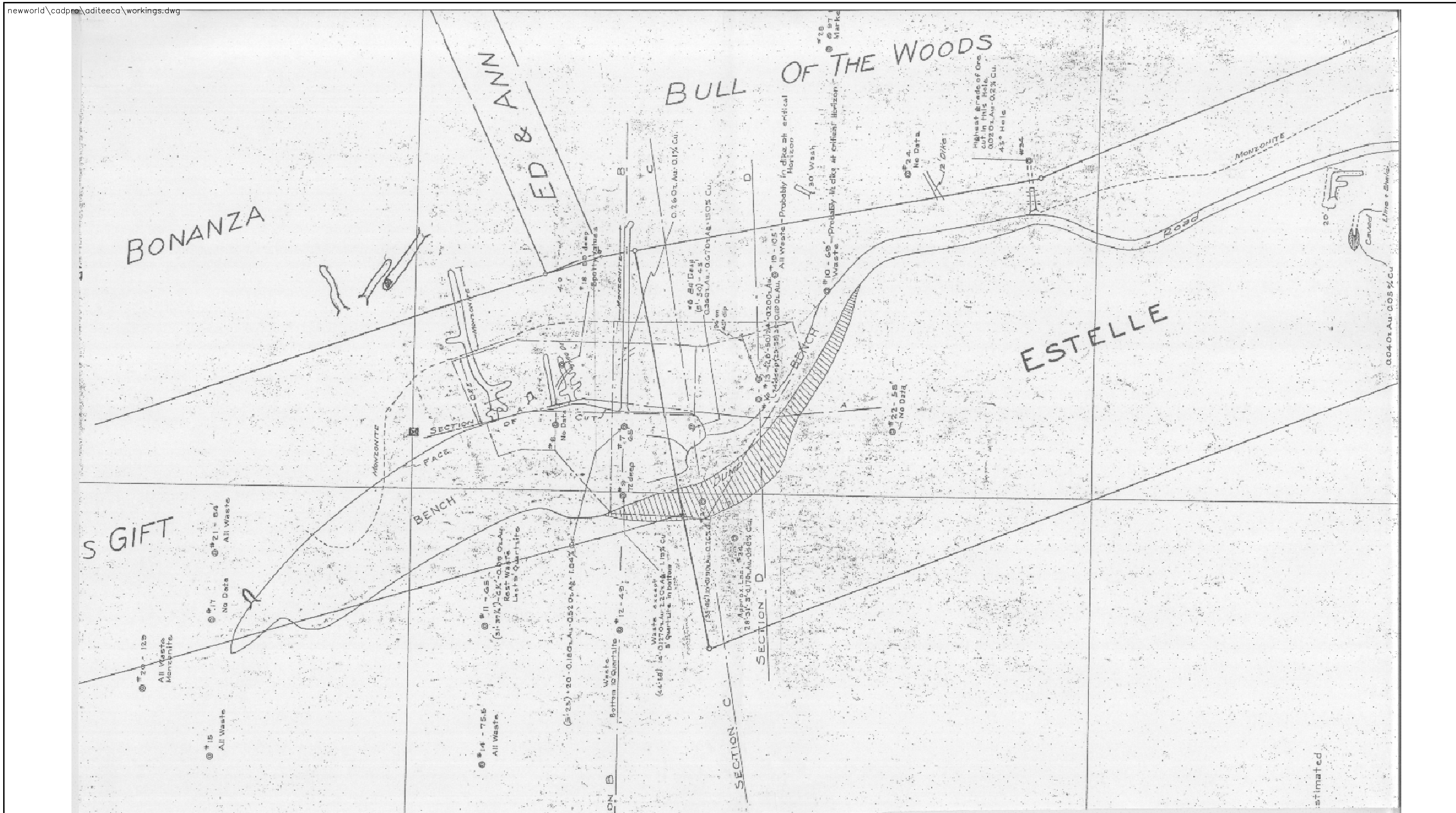


Source: Topographic data from USGS 7.5 Cooke City Quad
Contour Interval = 40'

Geology from USGS Miscellaneous Investigation Series Map I-1084, Geologic Map of the Southwest Part of the Cooke City Quadrangle, Montana and Wyoming, James E. Elliott, 1979.

MAXIM TECHNOLOGIES 4560831.112

Geologic Map of the New World District
New World Mining District
Response and Restoration Project
Cooke City Area, Montana
FIGURE 4



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Not To Scale

Source: Unpublished company report of McLaren Mines, 1937; Assay Plan Map of McLaren Mine, Cooke City, Montana.

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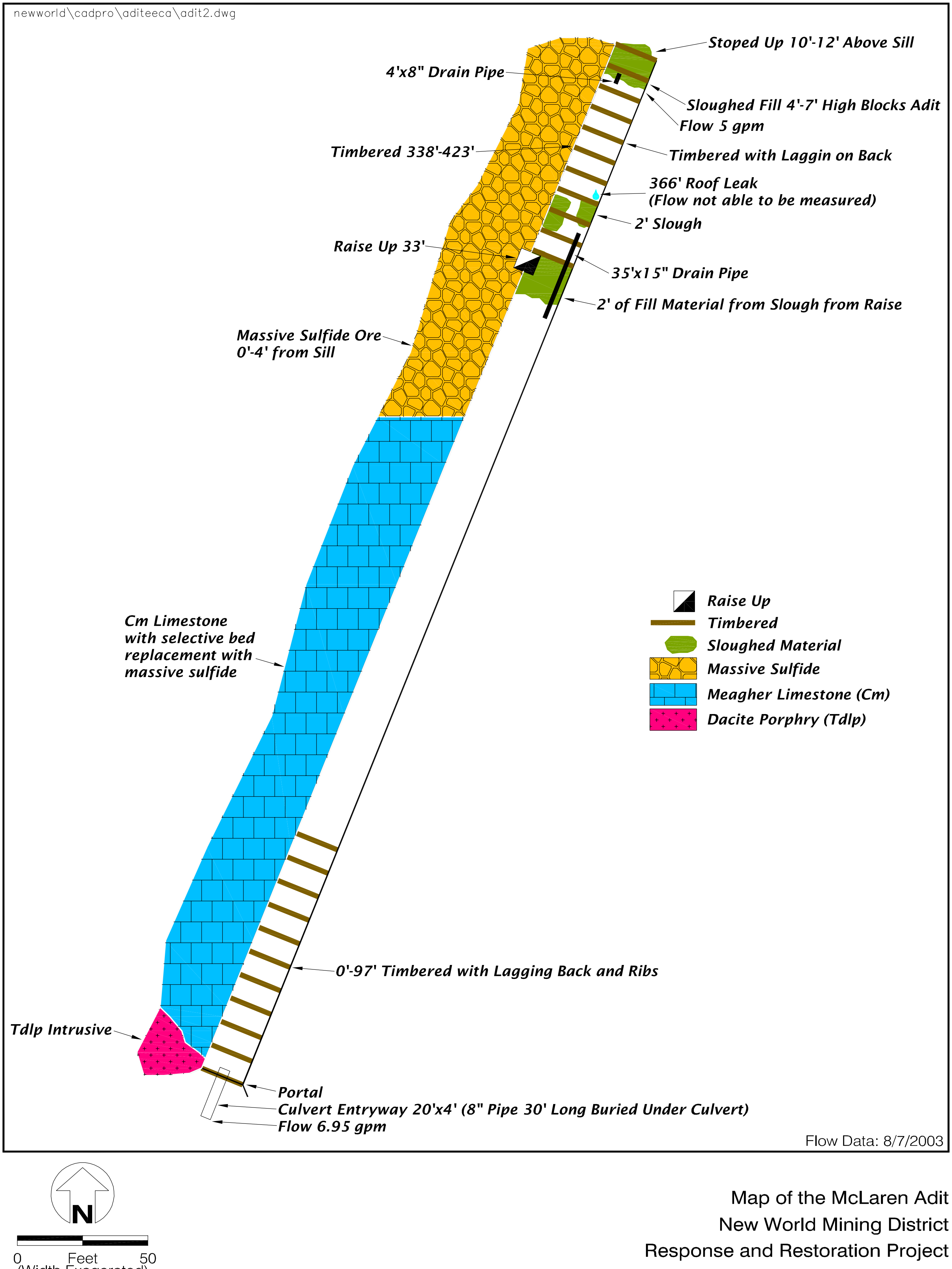
McLaren Mine Workings
New World Mining District
Response and Restoration Project
Cooke City, Montana
FIGURE 5



MAXIM TECHNOLOGIES 4560831.112

gpm = gallons per minute

Map of the McLaren Adit
New World Mining District
Response and Restoration Project
Cooke City, Montana
FIGURE 6

Figure 6 – back page

Figure 7. Reconditioned McLaren Mine Adit (also know as the Winter Tunnel)

intersected the adit at about 112 meters (366 feet). Because the mine flows year-round, it was assumed that a significant inflow must occur at some point further into the mine. In a successful effort to reduce flow into the adit, the drill hole that penetrated the adit from the surface was plugged in September 2003, reducing the flow from the borehole to zero and reducing the flow discharged at the portal to less than 12 liters per minute (Maxim, 2004a). This flow discharges by way of a tributary to Daisy Creek.

The McLaren open pit was regraded, capped with an impermeable liner, and covered with a drainage system and soil cover between July 2002 and October 2003 for the McLaren Pit Response Action. During waste rock regrading operations, several wet areas were encountered. One of these was a series of seeps originating from bedrock at the toe of the highwall. The others were point sources in bedrock that were found in the lower portion of the pit (Civil Consulting Services, 2006). These wet areas were excavated and filled with coarse drain rock, and a drain pipe was inserted in the rock to facilitate draining water from the wet areas so that regrading could proceed. There were four drains constructed, and the ends of these drains were terminated in a runoff channel downgradient of the pit. One of the drain pipes was covered in the channel with rock, but the terminal ends of three drain pipes are accessible. These sites are shown on **Figure 3** as sample sites DCSW-101, DCSW-102, and DCSW-103. Water quality from these three drains, collectively referred to as the McLaren Pit subsurface drains, is discussed in Section 3.0.

2.6.2 Glengarry Adit and Glengarry Millsite Adit

The Glengarry Adit (F8-A), located at an elevation of approximately 2,840 meters (9,320 feet) at the base of the eastern flank of Fisher Mountain, was actively being driven in 1925 (Lovering, 1929)(**Figure 3**). The adit was driven 701 meters (2,300 feet) towards Lulu Pass in an attempt to intercept mineralization beneath the Spalding Tunnels located on the south-facing flank of Scotch Bonnet Mountain. No mineralization was encountered at the level of the Glengarry Adit (Lovering, 1929). In the early 1930s, two nearly vertical raises were driven from an extended heading driven to the southwest from a "Y" intersection underground in the Glengarry adit. One of the raises extends 130 meters (425 feet) upward and surfaces in the Como Basin at the foot of the north flank of Fisher

Mountain. The top of this raise passes through the Meagher Limestone formation, and a massive sulfide deposit hosted in the Meagher.

A grout/plugging project to limit the inflow to and discharge from the Glengarry Adit was completed in 2005 as part of the Como Basin/Glengarry Adit/Fisher Creek Response Action (Maxim, 2002a). The Como Basin raise collar and a major fault system that was making water underground in the mine were grouted in 2003. In 2004, a watertight raise plug and two adit plugs were constructed and portions of the raise and adit were backfilled for ground support around the plugs. Two additional plugs and another cement backfilled portion of the adit were constructed in 2005. This action has resulted in a decrease of flow from as much as 144 liters per minute (Lpm) (38 gallons per minute [gpm]) prior to grouting and plugging to 7.9 Lpm (2.1 gpm) measured on October 27, 2005, 2.05 Lpm (0.54 gpm) measured on June 28, 2006, and 6 Lpm (1.6 gpm) measured on August 28, 2006. As a result of the success of the closure for the Glengarry Adit and Como Raise, no further response actions will be considered for the remaining Glengarry discharge under this EE/CA.

The Glengarry Millsite Adit (F8-B), located immediately south of the main Glengarry Adit, consists of a single horizontal adit extending approximately 40 feet from its portal. A small building, clearly designed for storage, sits at the portal of the adit (**Figure 8**). This adit appears to have been driven to serve as an extended storage area, possibly for explosives. The adit itself is in good condition and has a gate constructed of steel bars, which is buried by about 0.6 meters (2 feet) of ferrihydroxide mud. The ferrihydroxide mud extends to the back of the workings and is mixed with debris along the sill (floor). There is seepage from the Glengarry Millsite Adit with very low discharge rates, ranging from 3.0 to 19 Lpm (0.8 to 5.0 gpm) (average 15 Lpm [4 gpm]). However, a maximum flow of 102 Lpm (26.9 gpm) was measured in September 1989. Water from the adit flows over an extensive ferricrete bench outside of the portal, down across the mill site, and then infiltrates into colluvial materials below the mill site approximately 46 meters (150 feet) from Fisher Creek. This shallow groundwater likely surfaces in Fisher Creek.

Figure 8. Glengarry Millsite Adit.

The presence of significant depths of ferrihydroxide mud in the Glengarry Millsite adit and the extensive bench of ferricrete at the portal suggest that the seepage may be originating from bedrock fractures carrying reduced iron in solution. Once the reduced iron in solution comes in contact with the atmosphere, rapid deposition of iron hydroxides occurs. Iron deposition occurs because the solubility of reduced iron is about three times greater than oxidized iron, so contact of reduced, iron-bearing groundwater with atmospheric oxygen lowers the solubility, causing precipitation of ferrihydroxide mud. Where this material precipitates within colluvial materials, it cements the material into an indurated rock called ferricrete. The main Glengarry Adit also contained as much as one meter or more of ferrihydroxide mud along the sill. The fact that such an extensive bench of ferricrete exists in outcrop near the portal suggests that this process has been going on for a long time. This conclusion is supported by Furniss and Hinman (1998) who performed radiocarbon dating of ferricrete deposits located approximately 100 meters (110 yards) from the portal. They determined that these deposits range from about 6,000 to 8,800 years old. It further suggests that stemming the flow of this shallow adit may only divert water to other naturally occurring fractures along the exposed ferricrete bench.

2.6.3 Tredennic Mines

The Tredennic Mines were operated by the Tredennic Development Company on claims located on the southeast flank of Scotch Bonnet Mountain (**Figure 3**). The workings consist of three principal adits with about 419 meters (1,375 feet) of combined workings. **Figures 9, 10, and 11** are photographs of the three sites and **Figure 12** shows the historic underground workings of the Lower and Middle Tredennic mines. The upper adit is short and only drives about 38 meters (125 feet) to the northeast along a narrow pyrite-rich vein in Precambrian granite, beneath a topographic bench capped by Flathead Sandstone. The upper adit lies to the northeast of the lower two adits and was collared at about 9,800 feet in elevation. The middle adit (420 feet long), which is collared at about 2,926 meters (9,600 feet), intercepted a narrow zone of copper-gold mineralization at the contact with Precambrian basement and the gabbro of the Scotch Bonnet intrusive complex. The Lower Tredennic Dump # 1 Adit (FCSI-96-5) collared at 2,889 meters (9,480 feet) with more extensive workings (247 meters [810 feet]) was attempting to drive to the north-northeast to intercept mineralization beneath the middle adit workings at depth. The adit was not completed to its targeted distance and therefore drives for all of its length in unmineralized or weakly mineralized rock. A number of short adits lying at higher elevations on Scotch Bonnet Mountain were also affiliated with the Tredennic Mines. No significant production has occurred from any of the Tredennic workings.

Adit seeps have been observed or measured at all of the three Tredennic adit portals, although consistent discharge has only been measured at the Lower Tredennic Dump # 1 Adit, while the other adits are often dry or, when flowing, produce only very small volumes of seepage. Discharge from the Middle Tredennic Mine flows into Polar Star Creek, a tributary to Fisher Creek. Discharge from the Upper and Lower Tredennic mines infiltrates into the ground before reaching Polar Star Creek. Waste rock dumps were removed and the surface disturbances recontoured and revegetated in 2001. A mine drainage control system was constructed in front of the collapsed adits on the regraded former dump surfaces at each of these sites to allow capture and controlled discharge of the seasonal (less than 19 Lpm [5 gpm]) outflows from the Upper and Middle Tredennic adits, and the perennial discharge from the Lower Tredennic Adit (about 2.3 to 19 Lpm [0.6 to 5 gpm]). These mine drainage control systems consist of a small gravel basin placed at the mouth of the collapsed adit and a gravel-lined drainage channel.

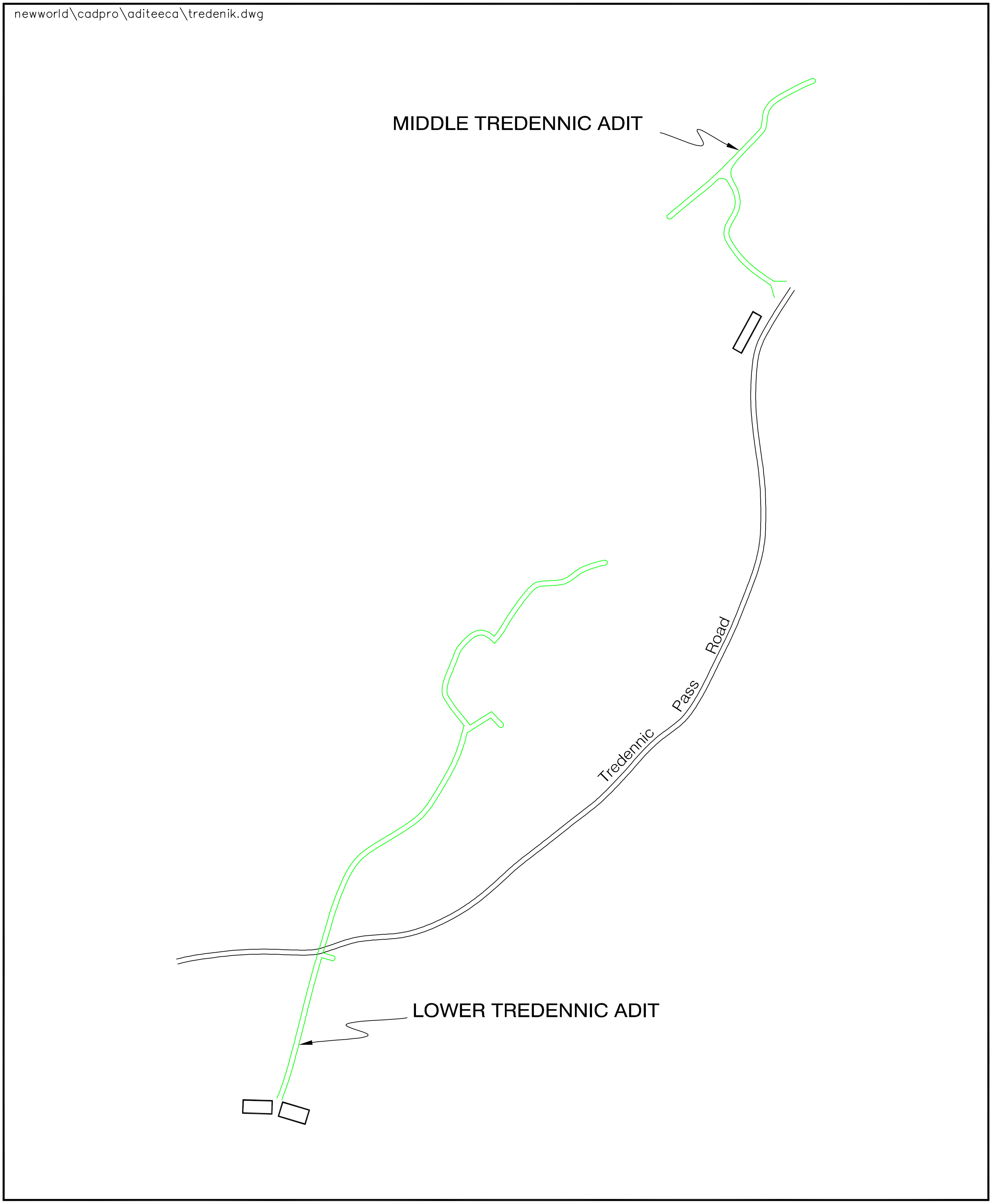
2.6.4 Gold Dust Adit

The Gold Dust Adit (F-28) is located on the southwest side of the Fisher Creek Valley, near the break in slope forming the flank of Henderson Mountain (elevation 2,810 meters [9,220 feet]) (**Figure 3**). Facilities associated with this mine include the Chicago (White) smelter, and aerial tram that connected the portal with the smelter (762 meters (2,500 feet) long), blacksmiths shop, boarding house, electric

Figure 9. Reclaimed Upper Tredennic Dumps 1 & 2

Figure 10. Reclaimed Middle Tredennic Dump

Figure 11. Collapsed Lower Tredennic Dump #1 Adit (above) and the mine drainage control system, gravel basin, and channel (left). Photos taken in August 2004, three years following reclamation.



(after Lovering, 1929)

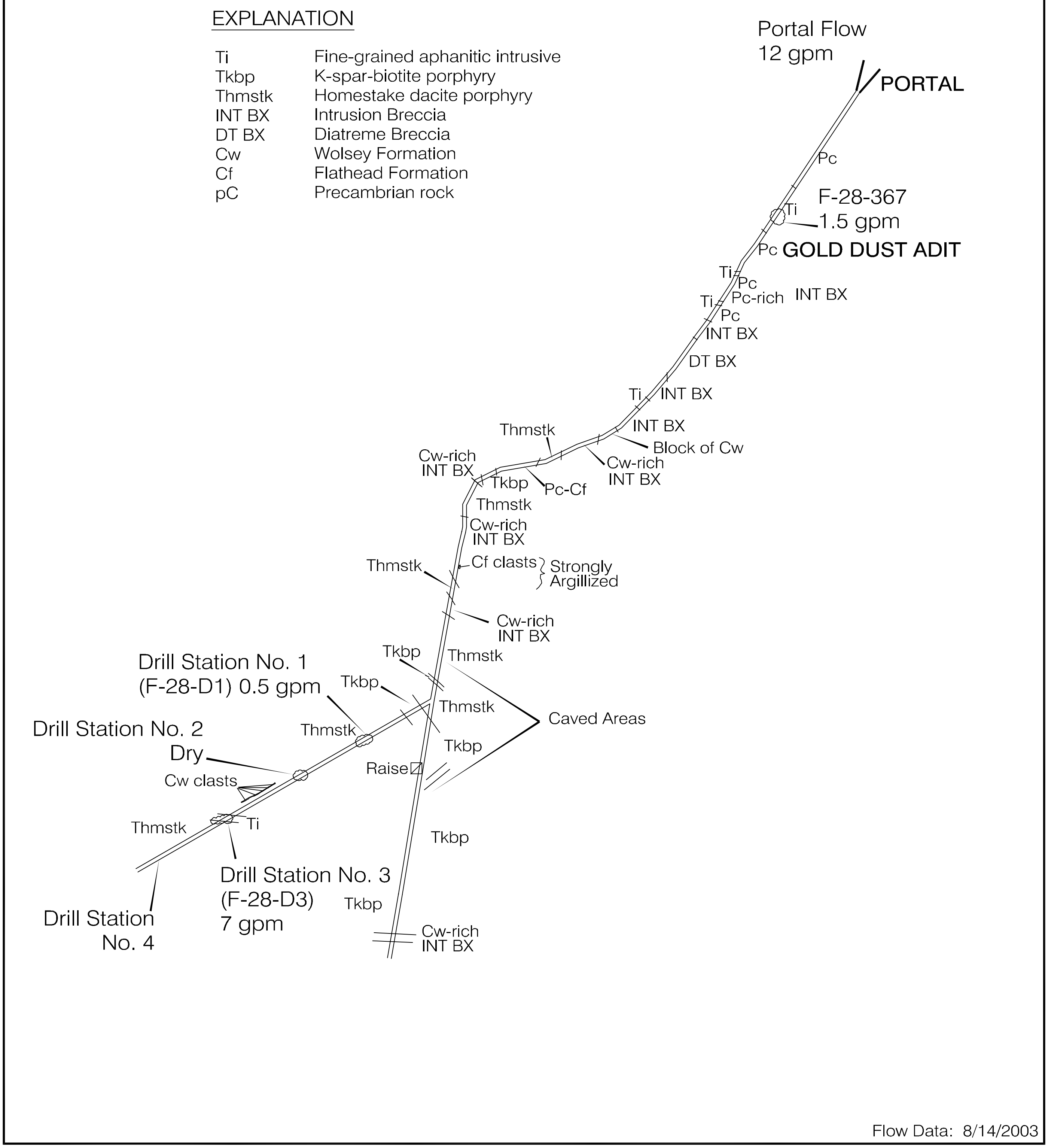
N

0 Feet 150

MAXIM TECHNOLOGIES 4560831.112

Plan Map Showing the Underground Workings
of the Middle and Lower Tredennic Mines
New World Mining District
Response and Restoration Project
FIGURE 12

newworld\cadpro\aditeeca\gdwater.dwg



(after Crown Butte Mines, 1993)

N

0 Feet 300

Flow in gallons per minute (gpm)

MAXIM TECHNOLOGIES 4560831.112

Geologic Map of the Gold Dust Adit
New World Mining District
Response and Restoration Project
FIGURE 13

compressor (still in building), and several cabins. The aerial tram was subsequently extended up the side of Henderson Mountain to the Homestake Adit. The Gold Dust Adit was driven between 1920 and 1925 and drifts to the southwest for about 701 meters (2,300 feet)(**Figure 13**). No production is recorded from the adit. The majority of the waste rock dump, which contained about 4,360 cubic meters (5,700 cubic yards) of material, was removed from the portal of the Gold Dust Adit in 2005 as part of the Fisher Creek Removal Action. A small portion of the waste was left for historic interpretation purposes. **Figure 14** shows the condition of the portal prior to waste removal.

Figure 14. Gold Dust Adit Portal

The adit is driven in Precambrian granite for the first 900 feet, and then crosses into monzonite porphyry intrusion breccia of the Homestake stock (**Figure 13**). The intrusion breccia contains varying amounts of subangular clasts of sedimentary rocks of predominantly Wolsey shale that range in size from a few centimeters to house size blocks. Inclusion free zones of monzonite porphyry also exist. Relatively fresh biotite-bearing monzonite gives way to strongly sericitized monzonite porphyry further into the mine. Mineralized specimens observed from the mine contained specular hematite, pyrite, ankerite, epidote, and quartz (Lovering, 1929).

After discovery of the Homestake Breccia Pipe in 1990 by surface drilling, CBMI executed an underground drilling program from the Gold Dust Adit to delineate mineralization in the middle and lower portion of the breccia pipe by drilling angle holes from four drill stations. The mine portal and underground workings were rehabilitated to gain access and to cut the four new drill stations. Approximately 7,111 meters (23,331 feet) of drilling were completed in 23 drill holes. Drill holes that were making water when drilled were closed with mechanical packers. The portal was closed with a series of timber sets, a locking steel gate, and a wooden door. The mine discharged water prior to being rehabilitated by CBMI, with an average discharge of about 49 Lpm (13 gpm) following exploration work. Since the time of drilling, at least two of the packers had failed and these holes were producing a combined flow of about 30 Lpm (8 gpm) when last measured in 2004 (Maxim, 2005c). Two or three other holes were also making small amounts of water (combined about 11 Lpm [3 gpm]). During August and September of 2005, the USDA-FS contracted with Denver Grouting to reenter the Gold Dust Adit, remove packers from drill holes, and grout and plug all drill holes producing water. After successful completion of this work, flow from the Gold Dust Adit portal was reduced to an estimated 15 Lpm (4.1 gpm) as measured on October 27, 2005 and 13.8 Lpm (3.7 gpm) on August 28, 2006. This decrease in flow represents a 68% reduction from the average flow.

2.6.5 Henderson Mountain Dump # 7 Adit

Two adits are located at the southeast terminus of Henderson Mountain at an elevation of approximately 2,780 meters (9,120 feet). Both of these adits were developed in stockwork fracture zones in the Cambrian Flathead Sandstone. The only obvious sulfide mineral present is pyrite, although abundant iron oxide occurs on fractured rock surfaces. Based on the size of the waste rock dumps, neither adit extended more than about 18 meters (60 feet) (and perhaps considerably less) into the side of Henderson Mountain. Numerous other similar small prospect pits occur throughout the immediate area. These adits were closed in August 2004 as part of the Fisher and Miller Creek Surface Controls Response Action. One of the adits was dry but the second adit, Henderson Mountain Dump # 7 (AE-17) (**Figure 3**), discharged less than 3 Lpm (1 gpm) of seepage. A mine drainage control system consisting of a small gravel basin placed at the mouth of the adit was constructed at this site as part of the response action. Drainage from the adit flows into a tributary to Fisher Creek.

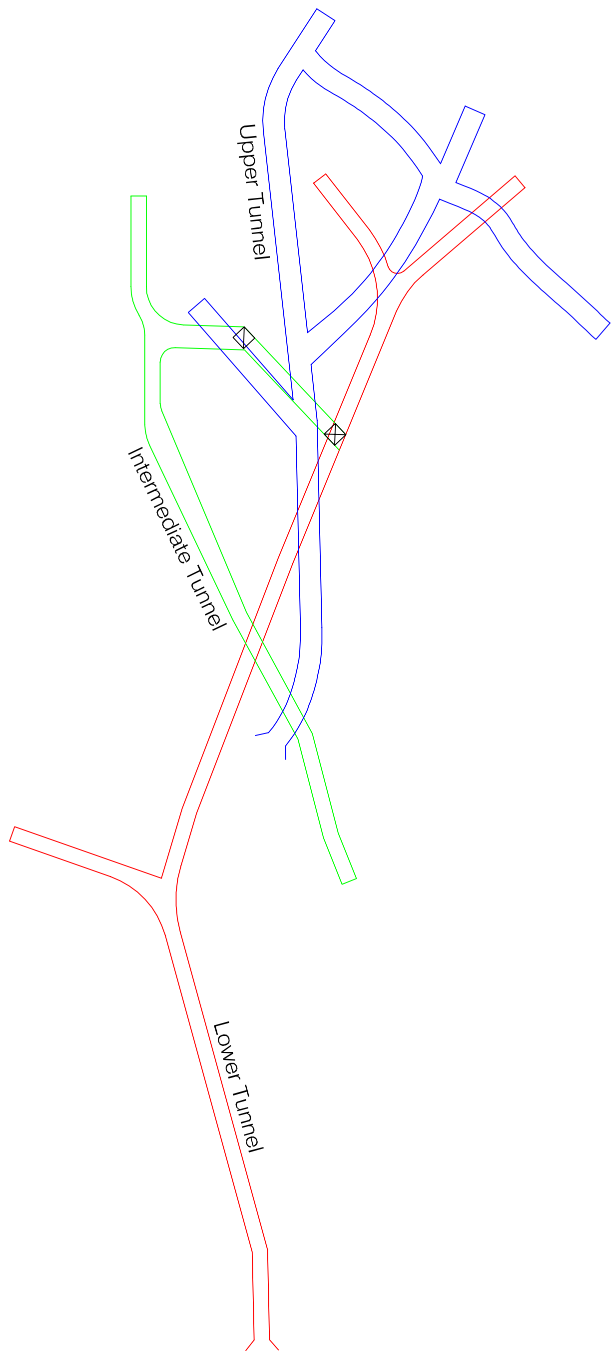
2.6.6 Sheep Mountain # 1 Adit

The Sheep Mountain # 1 Adit (FCSI-99-1 [**Figure 3**]) is located on the northwest flank of Sheep Mountain southeast of the saddle between Sheep and Scotch Bonnet Mountains and to the north and upgradient from the Upper Tredennic Mine area. The Sheep Mountain #1 site consists of a small waste rock dump (about 185 cubic yards) and an almost completely caved portal. Based on the size of the waste rock dump, the adit probably was driven somewhat less than 30 meters (100 feet) into Sheep Mountain. The adit itself seems to be driven in a porphyritic intrusive rock that is in contact with the Flathead Sandstone. The intrusive is highly sericitized and altered. Pyrite is the only obvious sulfide present although there is abundant iron oxide on fracture surfaces in the dump material. Although the adit seepage when observed has usually been low (<4 gpm, average 2 gpm) there is some evidence that higher flows occur as can be seen by iron-stained seepage channels at the toe of the waste rock dump. **The Sheep Mountain #1 adit is located on non-District Property**.

2.6.7 Spalding Tunnels

The Glengarry Mining Company initially had operations on the south-facing flank of Scotch Bonnet Mountain immediately northeast of Lulu Pass (2,957 meters [9,700 feet] in elevation) (**Figure 3**). On old historic mine maps these workings are called the Spalding Tunnels. The Spalding Tunnels consist of three short adits (60 to 96 meters long; 200 to 315 feet long) at different elevations, the lower two of which are connected by a winze (**Figure 15**). Prior to 2001, the upper and lower adit portals were closed with backfilled mine waste materials. The middle adit was accessible for about the first 50 feet, where a cave had blocked the workings.

Waste rock at the Upper, Middle, and Lower Spalding adits was removed during August 2001 for the Selective Source Response Action. Reopening of the lower Spalding Adit portal was attempted with a tracked-excavator in the summer of 2001 following waste rock removal. Before reclaiming the site, a low flow of adit seepage (0.38 to 7.6 Lpm; 0.1-2 gallons per minute) was present in the spring and early summer. Despite considerable effort using both a tracked excavator and a rubber-tired backhoe digging newworld\cadpro\aditeeca\glengary.dwg



(after Lovering, 1929)

N

0 Feet 40

MAXIM TECHNOLOGIES 4560831.112

Raise or Winze between Lower and Intermediate Tunnels
☐ Top
☒ Bottom

Map Showing the Location of Underground Workings in the Spalding Tunnels Area
New World Mining District
Response and Restoration Project
FIGURE 15

Figure 15. Back page.

Figure 16. Reclaimed Lower Spalding (August 2004; pole indicates former location of adit)

exploratory trenches in 2001, the portal could not be relocated for reopening. **Figure 16** shows the reclaimed dump in August 2004, three years after the dump was removed.

Reclamation of the upper and lower waste rock dump sites and their respective portal areas was accomplished by regrading of the slope following the removal of waste rock, lime amendment of surficial materials, and mixing topsoil with the lime-amended surface (**Figure 16**). The middle tunnel portal was backfilled with rock. A mine drainage control system consisting of a gravel basin and a gravel-lined drainage channel was constructed at the former location of the lower adit. No seepage from the Spalding reclaimed area has been observed since 2001.

2.6.8 <u>Little Daisy Adit</u>

The Little Daisy Mine (surface water station M-1) is located on the northwestern slope of Henderson Mountain southeast of Daisy Pass at an elevation of about 3,000 meters (9,840 feet) (**Figure 3**). The ruins of a stamp mill (only the foundation remains; the stamp mill was moved to Cooke City), boarding house, stable, and two cabins are located at the mine site just below the portal between the adit and the Daisy Pass road. A photograph of the Little Daisy dump and millsite is shown in **Figure 17**.

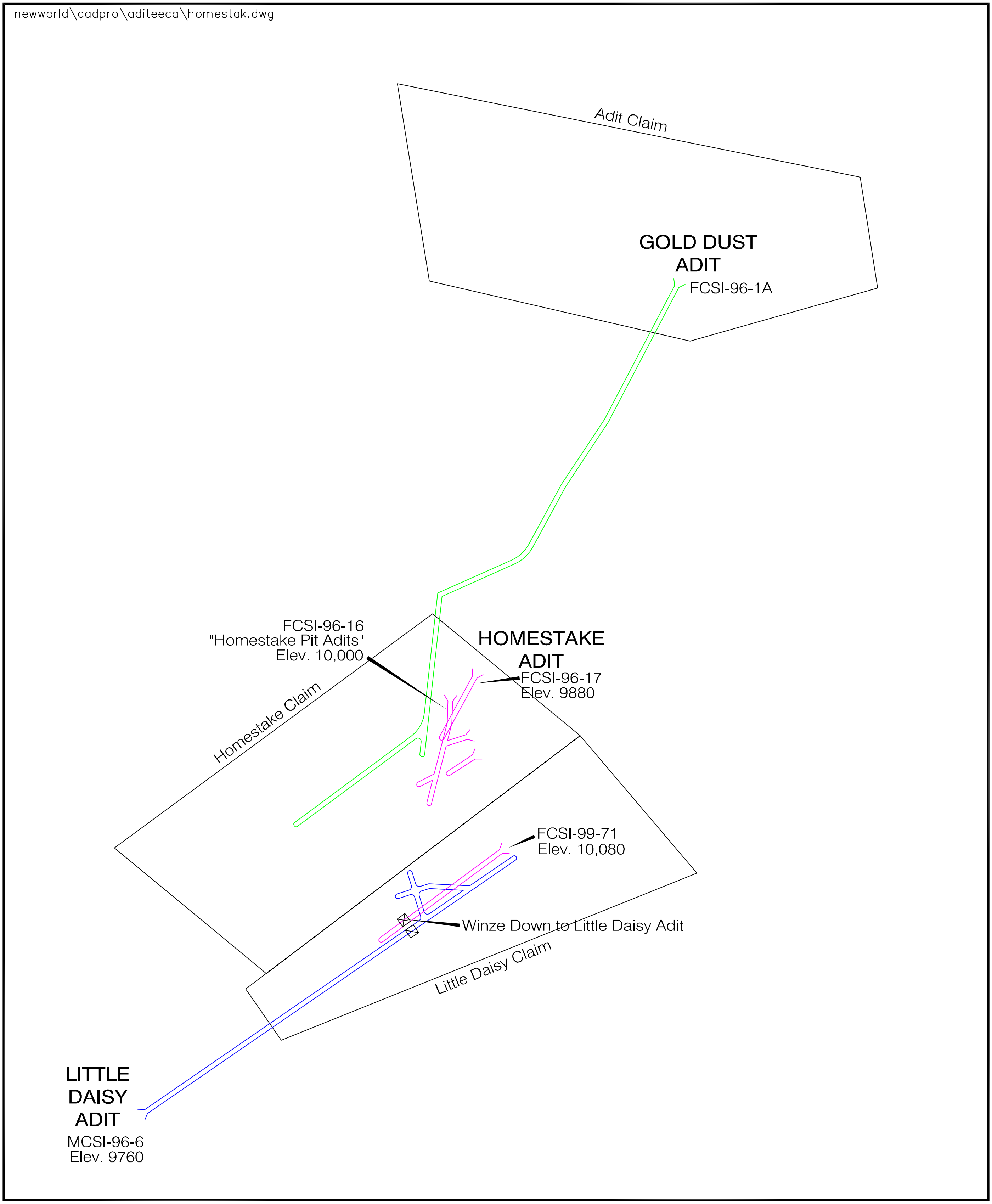
The Little Daisy Mine has approximately 726 meters (2,385 feet) of workings (Lovering, 1929) with portals on both the southwest and northeast facing flanks of Henderson Mountain (**Figure 18**). The longer of the two adits, the Little Daisy Adit, is collared just above the old stamp mill site. Its trend is east-northeast and the workings are approximately 427 meters (1,400 feet) in length. Only about 366 meters (1,200 feet) of these workings were accessible in the early 1920's (Lovering, 1929). This adit is connected by a raise of about 60 meters (200 feet) in height that connects with a shorter adit (Homestake Adit) that collars on the northeast flank of Henderson Mountain (elevation 3,036 meters; 9,960 feet). This adit was driven to the west-southwest, parallel to and slightly northwest of the main Daisy Adit; it is about 152 meters (500 feet) in length. The top of the raise is about 122 meters (400 feet) in from the portal of this adit.

Figure 17. Little Daisy Mine Dump (gray waste) and Millsite Dump (brown waste at center of photograph). Collapsed adit is located in road cut at top of gray dump.

Mineralization consists of blocks of Park Shale and Pilgrim Limestone caught up in an intrusive matrix (quartz monzonite of the Homestake Stock) to form an intrusion breccia. The sedimentary blocks have been skarn-altered and replaced by assemblages of garnet, epidote, magnetite, pyrite, and chalcopyrite. Although gold was recovered in the stamp mill at the Daisy Millsite, Lovering (1929) suggests that most of the ore's value must have been in copper. Drilling by CBMI between 1990 and 1993 identified ore grade mineralization in the Homestake Breccia Pipe (a phreatic explosion vent to the surface). The Daisy Adit penetrates Henderson Mountain about 18 meters (60 feet) above the elevation of ore-grade mineralization of the Homestake Breccia Pipe.

The Little Daisy Adit portal was backfilled and access blocked with mine wastes by CBMI in the 1990's, although seepage discharges from the adit through the backfill. In the early 1990's the portal was partially open, and CBMI pumped water from behind the portal berm for core drilling. This information suggests that there may be a considerable amount of water backed-up into the workings behind the portal backfill. Water from the adit discharged across the Henderson Mountain road and infiltrated into mine waste and talus below the road prior to 2005.

The waste rock dump for the Little Daisy Adit contains about 680 cubic meters (890 cubic yards) of material that is spreads out over a talus slope and tails downhill toward the millsite (**Figure 17**). Waste rock was removed from the site by the USDA-FS in 2005. The dump area was reclaimed and a mine drainage control system, which consists of a small gravel basin, was constructed at the mouth of the collapsed adit. The millsite dump and millsite features are considered historic features and were not removed or revegetated.



(after Lovering, 1929)

N

0 Feet 400

Raise or Winze
Bottom
Top

MAXIM TECHNOLOGIES 4560831.112

Map of Underground Workings in the Little Daisy Adit
Homestake Adit and Gold Dust Adit Mine Areas
New World Mining District
Response and Restoration Project
FIGURE 18

Figure 18 – back page

2.6.9 Henderson Mountain Adit

The Henderson Mountain Adit (M-25) (**Figure 3**) is located on the southwestern flank of Henderson Mountain above the Daisy Pass Road. This adit occurs in an area of anomalously high metal concentrations in soil and intrusive rock associated with the Henderson Mountain Stock. Soils in this area contain copper values as high as 500 parts per million.

The adit has a very small waste rock dump (less than a few cubic meters [10 to 20 cubic yards]) and a caved portal. It sits immediately adjacent to a small tributary of Miller Creek. Water discharging from the adit flows across mine waste and into the tributary. Late in the summer and early fall, the tributary stream above the adit is dry but flow becomes perennial below the adit. Discharge at this adit site ranges from 7.6 to 94.6 Lpm (2 to 25 gpm). Cleasby and Nimick (2002) suggest that three anomalous copper concentrations collected in small tributaries to Miller Creek located downhill of this adit might be attributable in part to flow from the adit.

2.6.10 Upper Miller Creek Dump Adit

The Upper Miller Creek Dump Adit (MCSI-96-3) (**Figure 3**) is located near the headwaters of Miller Creek about 200 meters (656 feet) to the northeast of the Black Warrior Adit. This is a very small caved adit with a small waste rock dump containing less than 60 cubic meters (80 cubic yards) of material. Based on the size of the dump, the adit is no more than 15 meters (50 feet) in length. The caved adit has a small seep that has always been less than 7.6 Lpm (2 gpm). Flow from the adit travels for a short distance across colluvial soils and infiltrates into the colluvium in a generally marshy area east of the Black Warrior Mine. **This adit is located on private land and is a non-District Property.**

2.6.11 Black Warrior Adit

The Black Warrior Mine lies near the headwaters of Miller Creek. It consists of an underground adit (surface water station M-8) about 130 meters (425 feet) in length and a 25 meter (80 feet) long raise to surface. The collar of the raise to surface occurs at an elevation of about 2,893 meters (9,490 feet) and lies just to the southeast of Bull-of–the-Woods Pass (**Figure 3**). The raise was closed by CBMI for safety reasons by backfilling with dolomitic waste rock. A soil cover was placed over the disturbed portion of the raise site and the site was seeded and fertilized. The adit was driven to the north-northeast along a high angle fracture or fault that is likely a splay of the Crown Butte Fault zone. Both vein and replacement type deposits of lead-zinc-silver mineralization occur in the Pilgrim Limestone host.

The area disturbed at the Black Warrior portal area is about 0.07 hectares (0.17 acres) and includes a small ore load-out structure. There is a small dump (610 cubic meters [800 cubic yards]) at the collapsed mine portal, which has been closed with backfilled mine wastes. Typically small rates of water flow, ranging from about 0.34 Lpm (0.09 gallons per minute) to 22.3 Lpm (5.9 gpm) have been measured at the adit portal. Flows up to 37.8 Lpm (10 gpm) have occasionally been measured. Water from the adit seep flowed around the east side of the waste rock dump and from there flowed on the surface for about 30.5 meters (100 feet) before joining a small tributary of Miller Creek. Waste rock was removed from the site in 2005 by the USDA-FS as part of the Miller Creek Removal Action, and a mine drainage control system, consisting of a gravel basin placed at the mouth of the collapsed adit was constructed in 2005. **Figure 19** shows the Black Warrior Dump before the dump was removed.

Figure 19. Photograph of the Black Warrior waste rock dump prior to waste removal.

2.6.12 Other Mines

There are many other small mines and prospects in the District for which little is known of the history of development or extent of underground workings. Most of these have very small waste rock dumps at the adit openings, indicating the workings are likely very limited as well. While little is known of these other mines, those with discharges have been inventoried and sampled and are included in the Site Characterization section of this EE/CA.

3.0 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

This section presents data that characterize the nature and extent of contamination associated with mining-related discharges in the District. A considerable amount of surface water flow and chemistry data, along with groundwater quality data from monitoring wells, have been collected in the Daisy Creek, Fisher Creek, and Miller Creek drainages. These data were collected from 1989 through fall 2006.

3.1 SITE RANKING AND LIST OF ADIT DISCHARGES

At the beginning of the New World Mining District Response and Restoration Project in 1999, all sites in the District were prioritized using the Abandoned and Inactive Mines Scoring System (AIMSS). This modified hazard ranking system (HRS) was developed for the MDEQ Mine Waste Cleanup Bureau (Pioneer, 1995; 1996) to prioritize abandoned mine sites in Montana. AIMSS scoring was completed on 132 source areas using data collected in 1999. AIMSS ranks waste sources relative to each other using site-specific data and the HRS scoring algorithm. In AIMSS, four exposure pathways are evaluated -- groundwater, surface water, air, and direct contact. For each exposure pathway, three factors are evaluated: 1) likelihood of release; 2) waste characteristics, and 3) potential receptors. The scores for the three factors are multiplied to derive a pathway score. Pathway scores are weighted more heavily toward certain situations and types of impacts. Higher weights are ascribed to the following: observed releases to groundwater and surface water, especially where an exceedance of a standard is documented; sources that are closer to a population base; and, higher contaminant concentrations, large contaminant quantities, and/or large areas of disturbance.

Table 3-1 lists the adit sites with discharges or historic discharges in the District in order of AIMSS rank. These sites are shown on **Figure 3**. It is important to note that waste dumps present at the sites contribute to the ranking score, and, for many of these sites, mine waste that was once present has been removed as part of a previous response action. Of the 27 adits in the District with discharges or historic discharges, six are on non-District Property; non-District Property includes both private lands that were not included in the Settlement Agreement or are located on National Forest System lands that lie outside the District Property boundary (**Figure 1**).

Table 3-2 presents a list of the 27 adit discharges in three categories: 1) Discharges with water quality exceedances; 2) Discharges without water quality exceedances, and 3) Discharges with seasonal flows. This third category includes a number of discharges that either have been dry for several years or have become recently dry (last few sampling events). **Table A-1 in Appendix A** lists the number of samples collected at each discharge, the last date sampled, and pH and flow characteristics for the 27 discharges.

The sites shown in the first group of discharges in **Table 3-2** are all perennial flows except for the Henderson Mountain Dump 7 discharge. Flows from group 1 discharges range from very low (less than 3.8 Lpm [1.0 gpm]) to more than several hundred Lpm. Exceedances of water quality criteria, as annotated in the table, are different for each site, ranging from exceedance of only the manganese human health guideline at the Gold Dust and Lower Tredennic sites, to exceedances of aluminum, copper, iron, and manganese at the Glengarry Adit Millsite seep.

Sites included in the second grouping shown in **Table 3-2** are perennial adit discharges with no water quality exceedances. As these sites currently meet human health and aquatic water quality criteria, a response action is not necessary; these sites will not be further discussed or evaluated in this EE/CA.

TABLE 3-1
AIMSS RANKING AND STATUS OF ADIT DISCHARGE SITES

Site Name	Site No.	AIMSS Rank*	Discharge Flow Range (gpm)	Site Status
Black Warrior	MCSI-96-2 (M-8)	2	0.1-10	Collapsed/Reclaimed 2005
Soda Butte Dump 1	SBSI-99-95	4	0.0-0.1	NDP
Woody Creek Mine Dump 1‡	SBSI-99-74	5	3.1-10	NDP
Alice E Millsite	SBSI-99-85	12	0.0-10.0	NDP
Soda Butte Dump 8	SBSI-99-87	13	3.0-100	NDP
Glengarry Millsite (includes middle adit)	F-8B	15	3.0-26.9	Open
McLaren Adit	D-18	17	1.8-29.6	Open
Little Daisy Adit and Dump	M-1	20	0.5-220	Collapsed/Reclaimed 2005
Sheep Mountain No. 1	FCSI-99-1	21	0.4-10	NDP
Lower Spalding Dump	FCSI-96-8	23	0-0.9	Backfilled/Reclaimed 2001
Gold Dust Adit	F-28	24	1.3-250	Closed/Reclaimed 2005
Lower Tredennic Dump 1	FCSI-96-5	26	0.6-5	Collapsed/Reclaimed 2001
Daisy Pass Dump 1	DCSI-96-3-1	30	<0.1-2	Collapsed
Henderson Mountain Dump 10	FCSI-99-71	32	0-12	Backfilled/Reclaimed 2004
Upper Tredennic Dump 2	FCSI-96-15-2	36	0-0.5	Reclaimed 2001
Upper Miller Creek Dump‡	MCSI-96-3	43	0.5-2	NDP
Middle Tredennic Dump 1	FCSI-96-6	45	0-10	Reclaimed 2001
Henderson Mountain Dump 7	AE-17	51	0.0-5	Collapsed/Reclaimed 2004
Henderson Mountain Dump 13	FCSI-99-73	66	5-15	Collapsed
Near McLaren Pit	DCSI-99-102	69	0	Dry
Upper Tredennic Dump 1	FCSI-96-15-1	70	0-1	Collapsed/Reclaimed 2001
West of Como Dump 1	DCSI-96-6	86	0	Dry
Henderson Mountain Adit	M-25	NR	1.8-25	Collapsed
Upper Little Daisy Adit	M-10	NR	0-5.8	Dry
Reeb No. 1 Adit	AE-12	NR	0	Dry

Notes: * AIMSS - Abandoned and Inactive Mines Scoring System
‡ Originally ranked with private property sites; rank shown for scoring with public sites.
NDP – non-District Property; NR – not ranked; gpm – gallons per minute

TABLE 3-2
ADIT DISCHARGES IN THE NEW WORLD MINING DISTRICT

Adit Station #	Site Name	Drainage	Status	Flow Type[1]	Flow (gpm)		Last pH (s.u.)	Water Quality[2]
					Range	Recent		
F-8B	Glengarry Millsite Adit	Fisher	Flowing	Perenn	3-26.9	5	3.3	Al Cu Fe Mn*
F-28	Gold Dust Adit	Fisher	Reclaimed 2005; Flowing	Perenn	1.3-250	3.6	6.8	Mn*
FCSI-96-5	Lower Tredennic Dump 1	Fisher	Reclaimed 2001	Perenn	0.6-5	1.4	6.1	Mn*
FCSI-99-1	Sheep Mountain #1 (NDP)	Fisher	Flowing	Perenn	0.4-10	4	6.1	Pb
D-18	McLaren Adit	Daisy	Flowing	Perenn	1.8-29.6	4.7	6.5	Cu Fe Mn*
M-8	Black Warrior Adit	Miller	Reclaimed 2005; Flowing	Perenn	0.1-10	8.1	7	Cd
MCSI-96-3	Upper Miller Creek Dump (NDP)	Miller	Flowing	Perenn	0.5-2	2	6.5	Cd
M-1	Little Daisy Adit	Miller	Reclaimed 2005; Flowing	Perenn	0.5-220	2.9	6.8	Cd Fe Mn* Zn*
M-25	Henderson Mt Adit	Miller	Flowing	Perenn	1.8-25	5	5.9	Al Cu Pb
AE-17	Henderson Mountain Dump 7	Fisher	Reclaimed 2004	Season	0-5	2.0	6.2	Al Cu Fe Mn*
FCSI-99-73	Henderson Mountain Dump 13	Fisher	Flowing	Perenn	5-15	15	6.6	None
DCSI-96-3-1	Daisy Pass Dump 1	Daisy	Flowing	Perenn	<0.1-2	1.0	6.8	None
SBSI-99-74	Woody Ck. Mine Dump 1 (NDP)	Woody	Flowing	Perenn	3.1-10	4.0	6.9	None
SBSI-99-85	Alice E. Millsite seep (NDP)	Soda Butte	Flowing	Perenn	0-10.0	4.0	5.4	None
SBSI-99-87	Soda Butte Dump 8 (NDP)	Soda Butte	Flowing	Perenn	3-100	3	6.9	None
FCSI-96-15-1	Upper Tredennic Dump 1	Fisher	Dry; reclaim 2001	Season	0-1.0	Dry	3.3	--
FCSI-96-15-2	Upper Tredennic Dump 2	Fisher	Dry; reclaim 2001	Season	0-0.5	Dry	2.9	--
FCSI-96-6	Middle Tredennic Dump 1	Fisher	Dry; reclaim 2001	Season	0-10	Dry	4.8	--
F-2	Lower Spalding Dump	Fisher	Dry; reclaim 2001	Season	0-0.9	Dry	2.6	--
FCSI-96-7	Middle Spalding	Fisher	Dry; reclaim 2001	Season	--	Dry	--	--
FCSI-99-71	Henderson Mountain Dump 10	Fisher	Dry; reclaim 2004	Season	0-12	Dry	7.5	--
F-8	Glengarry Middle Adit	Fisher	Dry	Season	0-1.4	Dry	3.5	--
DCSI-99-102	Near McLaren Pit	Daisy	Dry	Season	0	Dry	--	--
DCSI-96-6	West of Como Dump 1	Daisy	Dry	Season	0	Dry	--	--
M-10	Upper Little Daisy Adit	Miller	Dry	Season	0-5.8	--	7.84	--
AE-12	Reeb #1	Soda Butte	Dry	Season	0	Dry	3.3	--
SBSI-99-95	Soda Butte Dump 1 (NDP)	Soda Butte	Dry	Season	0-0.1	Dry	7.4	--

Notes: 1 Perenn = perennial flow; Season = seasonal flow
2 Exceeded chronic standard in most recent sampling event (hardness = 100 milligrams/liter where applicable); Al-aluminum; Cd-cadmium; Cu-copper; Fe-iron; Mn-manganese; Pb-lead; Zn-zinc; * indicates exceeds human health guideline for Mn (manganese has no aquatic standard)
NDP = non District Property; gpm = gallons per minute; s.u. = standard units

The seasonal discharges listed among the third grouping of sites shown in **Table 3-2** generally only flow for a month or so during the snowmelt period. In 2001, six of the sites in the third group were reclaimed by removing waste rock dumps, regrading removal areas, and revegetating the former dump sites. Flows from all these sites reclaimed in 2001 have diminished over the years, and have completely dried up at the Lower Spalding Mine. The remaining six sites in the third grouping were also dry when last visited (see Table A-1 in Appendix A). Due to the seasonal nature and very low flows measured at the group three sites, a response action is unwarranted; these discharges will not be further evaluated in this EE/CA.

For the reasons stated above, only the discharges in the first grouping shown in Table 3-2 will be further characterized and evaluated in this EE/CA. In addition, the collected discharge from the McLaren Pit subsurface drains (see Section 2.6.1) will also be considered as discharges that could be mitigated by a potential response action because the drains constitute a significant source of loading to Daisy Creek. All of the sources collected by the subsurface drains are from springs; two drains collect groundwater directly from bedrock fractures and the remaining water sources are suspected to originate in bedrock fractures. Flow measurements taken between 2004 and 2006 show an average combined flow rate of 83 Lpm (22 gpm) for the three drains.

3.2 SURFACE WATER QUALITY DATA EVALUATION APPROACH

A considerable amount of surface water flow and chemistry data has been collected for Daisy Creek, Fisher Creek, and Miller Creek. In conjunction with their application for a hard rock mining permit, CBMI began comprehensive surface and groundwater quality monitoring and discharge measurements in 1989 that continued through 1996. More recent work by the USGS (Cleasby and Nimick, 2001; Kimball *et al.* 1999; Nimick and Cleasby, 2000), EPA (1989), and the USDA Forest Service (1999 to present) continued to build on the database and understanding of surface water characteristics in the District. Water quality and flow data are available on the Internet from the New World project database at http://www.fs.fed.us/rl/gallatin. Additionally, **Appendix A** compiles data for selected parameters in samples collected from surface water and adit monitoring locations on all sample dates through October 2006, while summary statistics for surface water and adit discharge data are presented respectively in **Tables 3-3** and **3-4** and have been differentiated into all data, "high flow" data (samples collected in late May, June, and July during high flow), and "low flow" data (samples collected the other nine to ten months of the year). These data are discussed by drainage in subsequent sections.

Drainage specific temporary standards have been developed for both Daisy Creek and Fisher Creek (Maxim, 2005a). **Table 3-3** and the following discussion refer to Circular WQB-7 water quality standards as a point of reference for all water quality monitoring stations (MDEQ, 2004). **Figures 20** through **22, 24** through **26, 28,** and **29** show copper, iron, and zinc concentrations as a function of flow relative to Circular WQB-7 standards as well as the temporary standard for applicable monitoring stations. Companion graphs shown on these figures exhibit concentration data plotted chronologically.

Circular WQB-7 surface water standards are based on total recoverable metal concentrations with the exception of aluminum (standard based on dissolved concentration) (MDEQ, 2004). Most discussion in this EE/CA is thus based on total recoverable concentrations. However, it should be noted that total recoverable concentrations could be influenced by suspended sediment in water, thereby overestimating the concentration of metals actually dissolved in solution. Dissolved metal concentrations in surface water samples collected from District monitoring sites are often much lower compared to total recoverable concentrations when the pH of the water is in the neutral to alkaline range. For instance, Cleasby and Nimick (2002) reported total recoverable metal concentrations for Miller Creek that in many cases were 1.5 to 2 times greater than corresponding dissolved concentrations. This effect is

TABLE 3-3
SUMMARY OF SURFACE WATER FLOW AND QUALITY IN DAISY, FISHER, AND MILLER CREEKS

Station	Summary Statistic[1]	Flow (gpm) or %[2]	Concentration (total recoverable in milligrams per liter) or Percent						
			Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
Daisy Creek									
DC-2	Average of all data before Oct. 2003	1507	11.74	0.0037	2.94	12.75	0.006	1.72	0.45
	Average of all data after Oct. 2003	1036	8.09	0.0027	1.82	8.09	0.003	1.35	0.40
	% Change	**-31**	**-31**	**-28**	**-38**	**-37**	**-48**	**-22**	**-9.5**
	Average of high flow data before Oct. 2003	2842	6.97	0.0022	1.93	9.86	0.006	0.83	0.27
	Average of high flow data after Oct. 2003	3224	2.82	0.0007	0.53	3.65	0.002	0.32	0.11
	% Change	**13**	**-60**	**-70**	**-73**	**-63**	**-60**	**-62**	**-58**
	Average low flow data before Oct. 2003	244	11.78	0.0038	3.08	12.38	0.005	1.91	0.50
	Avg low flow data after Oct. 2003	98	10.34	0.0035	2.37	10.00	0.004	1.79	0.53
	% Change	**-60**	**-12**	**-6.8**	**-23**	**-19**	**-29**	**-6.3**	**4.7**
DC-5	Average of all data before Oct. 2003	3308	3.36	0.0013	1.07	3.18	0.0026	0.48	0.17
	Average of all data after Oct. 2003	2670	1.98	0.0007	0.50	1.62	0.0012	0.36	0.14
	% Change	**-19**	**-41**	**-42**	**-53**	**-49**	**-55**	**-25**	**-17**
	Average of high flow data before Oct. 2003	7686	1.93	0.0005	0.58	2.86	0.0016	0.21	0.08
	Average of high flow data after Oct. 2003	8116	0.85	0.0002	0.18	1.11	0.0008	0.10	0.06
	% Change	**5.6**	**-56**	**-69**	**-69**	**-61**	**-48**	**-52**	**-26**
	Average low flow data before Oct. 2003	277	4	0.0018	1.38	2.69	0.0022	0.63	0.22
	Avg low flow data after Oct. 2003	335	2.46	0.0010	0.63	1.83	0.0013	0.47	0.17
	% Change	**21**	**-41**	**-45**	**-54**	**-32**	**-41**	**-25**	**-22**
SW-7	Average of all data before Oct. 2003	22237	0.24	0.0001	0.064	0.49	0.0020	0.039	0.022
	Average of all data after Oct. 2003	14317	0.09	0.0001	0.015	0.30	0.0005	0.030	0.011
	% Change	**-36**	**-64**	**-63**	**-77**	**-38**	**-75**	**-23**	**-51**
	Average of high flow data before Oct. 2003	35965	0.38	0.0002	0.109	0.70	0.0031	0.039	0.024
	Average of high flow data after Oct. 2003	35751	0.16	0.0001	0.030	0.27	0.0005	0.019	0.005
	% Change	**-0.6**	**-57**	**-72**	**-72**	**-62**	**-84**	**-53**	**-79**
	Average low flow data before Oct. 2003	1241	0.08	0.0001	0.015	0.25	0.0011	0.039	0.021
	Avg low flow data after Oct. 2003	1456	0.05	0.0001	0.008	0.32	0.0005	0.036	0.014
	% Change	**17**	**-38**	**-51**	**-52**	**27**	**-55**	**-8.2**	**-33**
Chronic Aquatic Life Standard (Hardness = 50 mg/l)			**0.087[3]**	**0.00016**	**0.005**	**1**	**0.001**	**0.05[3]**	**0.07**
Chronic Aquatic Life Standard (Hardness = 100 mg/l)			**0.087**	**0.00027**	**0.009**	**1**	**0.003**	**0.05**	**0.12**

Notes: 1 Data collected between 1989 and 2006; high flow calculated using June and July sampling events; low flow calculated using all other data
2 gpm = gallons per minute; % change indicates increase (positive) or decrease (negative) in flow and concentration after October 2003.
3 Aluminum standard applies to dissolved concentrations in water with pH 6.6-9.0 s.u.; manganese standard is secondary MCL based on aesthetic qualities;

TABLE 3-3 (continued)
SUMMARY OF SURFACE WATER FLOW AND QUALITY IN DAISY, FISHER, AND MILLER CREEKS

Station	Summary Statistic[1]	Flow (gpm) or %[2]	Concentration (total recoverable in milligrams per liter) or Percent						
			Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
Fisher Creek									
SW-3	Average of all data before Oct. 2004	1794	2.58	0.0008	0.69	5.35	0.005	0.82	0.12
	Average of all data after Oct. 2004	838	1.95	0.0006	0.64	1.21	0.002	0.40	0.11
	% Change	**-53**	**-24**	**-27**	**-7.7**	**-77**	**-65**	**-51**	**-11**
	Average of high flow data before Oct. 2004	3130	1.96	0.0005	0.57	3.63	0.004	0.29	0.06
	Average of high flow data after Oct. 2004	3050	1.62	0.0001	0.38	1.33	0.002	0.16	0.03
	% Change	**-2.6**	**-17**	**-81**	**-35**	**-63**	**-44**	**-45**	**-53**
	Average low flow data before Oct. 2004	271	2.99	0.0010	0.80	6.68	0.007	1.12	0.17
	Avg low flow data after Oct. 2004	101	2.06	0.0007	0.73	1.17	0.002	0.48	0.13
	% Change	**-63**	**-31**	**-25**	**-8.7**	**-82**	**-72**	**-58**	**-22**
SW-4	Average of all data before Oct. 2004	10884	0.29	0.0003	0.092	0.49	0.0018	0.058	0.08
	Average of all data after Oct. 2004	5819	0.10	0.0002	0.048	0.10	0.0005	0.019	0.05
	% Change	**-47**	**-65**	**-47**	**-48**	**-81**	**-72**	**-67**	**-34**
	Average of high flow data before Oct. 2004	18793	0.45	0.0002	0.102	0.82	0.0020	0.056	0.10
	Average of high flow data after Oct. 2004	18837	0.22	0.0001	0.064	0.21	0.0005	0.031	0.01
	% Change	**0.2**	**-51**	**-78**	**-37**	**-75**	**-75**	**-45**	**-88**
	Average low flow data before Oct. 2004	705	0.14	0.0004	0.082	0.10	0.0016	0.061	0.06
	Avg low flow data after Oct. 2004	611	0.06	0.0002	0.042	0.05	0.0005	0.015	0.07
	% Change	**-13**	**-60**	**-45**	**-49**	**-49**	**-69**	**-76**	**20**
CFY-2	Average of all data before Oct. 2004	4792	0.11	0.00010	0.032	0.135	0.0009	0.018	0.017
	Average of all data after Oct. 2004	4626	0.07	0.00006	0.019	0.059	0.0006	0.008	0.020
	% Change	**-3.4**	**-37**	**-44**	**-42**	**-57**	**-41**	**-57**	**15**
	Average of high flow data before Oct. 2004	11001	0.21	0.00008	0.060	0.307	0.0010	0.0285	0.018
	Average of high flow data after Oct. 2004	20894	0.18	0.00005	0.045	0.185	0.0008	0.0230	0.013
	% Change	**90**	**-13**	**-38**	**-25**	**-40**	**-25**	**-19**	**-29**
	Average low flow data before Oct. 2004	356	0.05	0.00011	0.016	0.039	0.0009	0.0127	0.017
	Avg low flow data after Oct. 2004	667	0.04	0.00006	0.010	0.014	0.0005	0.0032	0.028
	% Change	**87**	**-32**	**-45**	**-40**	**-65**	**-44**	**-75**	**64**
Chronic Aquatic Life Standard (Hardness = 50 mg/l)			**0.087[3]**	**0.00016**	**0.005**	**1**	**0.001**	**0.05[3]**	**0.07**
Chronic Aquatic Life Standard (Hardness = 100 mg/l)			**0.087**	**0.00027**	**0.009**	**1**	**0.003**	**0.05**	**0.12**

Notes:
1 Data collected between 1989 and 2006; high flow calculated using June and July sampling events; low flow calculated using all other data
2 gpm = gallons per minute; % change indicates increase (positive) or decrease (negative) in flow and concentration after October 2003.
3 Aluminum standard applies to dissolved concentrations in water with pH 6.6-9.0 s.u.; manganese standard is secondary MCL based on aesthetic qualities;

TABLE 3-3 (continued)
SUMMARY OF SURFACE WATER FLOW AND QUALITY IN DAISY, FISHER, AND MILLER CREEKS

Station	Summary Statistic[1]	Flow (gpm) or %[2]	Concentration (total recoverable in milligrams per liter) or Percent						
			Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
Miller Creek									
SW-2	Average All Data	4884	0.157	0.00011	0.021	0.31	0.0027	0.014	0.027
	Average All High Flow Data	8853	0.279	0.00008	0.034	0.57	0.0044	0.026	0.025
	Recent High Flow 6-26-06	6975	0.060	0.00005	0.014	0.13	0.0005	0.014	0.005
	Average all Low Flow Data	280	0.039	0.00009	0.008	0.06	0.0009	0.005	0.031
	Recent Low Flow 9-25-06	328	0.025	0.00005	0.006	0.05	0.0005	0.002	0.005
SW-5	Average All Data	7382	0.207	0.00014	0.020	0.394	0.0023	0.016	0.038
	Average All High Flow Data	11219	0.292	0.00015	0.028	0.580	0.0027	0.023	0.026
	Recent High Flow 6-26-06	3842	0.025	0.00005	0.010	0.100	0.0005	0.005	0.010
	Average all Low Flow Data	256	0.045	0.00013	0.004	0.037	0.0016	0.007	0.061
	Recent Low Flow 9-28-05	36	0.025	0.00005	0.004	0.005	0.0005	0.004	0.010
Chronic Aquatic Life Standard (Hardness = 50 mg/l)			**0.087[3]**	**0.00016**	**0.005**	**1**	**0.001**	**0.05[3]**	**0.07**
Chronic Aquatic Life Standard (Hardness = 100 mg/l)			**0.087**	**0.00027**	**0.009**	**1**	**0.003**	**0.05**	**0.12**

Notes: 1 Data collected between 1989 and 2006; high flow calculated using June and July sampling events; low flow calculated using all other data
2 gpm = gallons per minute; % change indicates increase (positive) or decrease (negative) in flow and concentration after October 2003.
3 Aluminum standard applies to dissolved concentrations in water with pH 6.6-9.0 s.u.; manganese standard is secondary MCL based on aesthetic qualities;

TABLE 3-4
SUMMARY OF ADIT DISCHARGE FLOW AND WATER QUALITY DATA IN DAISY, FISHER, AND MILLER CREEK DRAINAGES

Adit Station Number and Name	Number of Samples[1]	Statistic	Flow (gpm)	Field pH (s.u.)	Field SC (umhos/cm)	Hardness (mg/L as CaCO3)	Concentration (total recoverable in milligrams per liter)[2]							
							Sulfate	Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
Daisy Creek Drainage														
Data through September 2006														
D-18 McLaren	27	Min	1.8	3.4	90	65	149	0.08	<0.0001	<0.001	3.6	<0.001	0.10	<0.01
		Mean	11.2	6.2	638	338	292	0.48	0.0008	0.026	17.2	0.003	0.85	0.04
		Max	29.6	7.1	904	449	379	4.95	0.0049	0.140	38.0	0.010	1.14	0.09
DCSW-101 McLaren Sub-Drain	7	Min	2.2	2.3	1120	114	515	26.0	0.008	13.2	105	0.005	2.74	1.50
		Mean	13.1		1283	149	667	30.0	0.011	15.2	146	0.010	3.38	1.92
		Max	24.6	4.4	1415	185	797	34.3	0.016	20.7	199	0.014	5.10	2.82
DCSW-102 McLaren Sub-Drain	7	Min	0.0	2.4	1537	155	641	23.2	0.011	13.8	90	0.001	3.47	1.95
		Mean	7.2		1723	215	876	31.4	0.017	18.4	154	0.003	4.87	2.72
		Max	18.8	4.2	1900	275	1160	42.2	0.029	27.7	265	0.009	6.31	4.29
DCSW-103 McLaren Sub-Drain	7	Min	0.3	2.3	2711	591	1910	76.6	0.022	29.0	315	0.002	11.80	4.07
		Mean	1.4		3213	680	2406	94.7	0.026	38.4	468	0.002	13.44	4.49
		Max	2.4	4.1	3700	750	3050	122.0	0.032	47.3	678	0.004	16.70	5.25
Data collected after plugging adit inflow (September 2003)														
D-18 McLaren	5	Min	3.6	6.5	750	348	363	0.08	<0.0001	0.018	19.1	<0.001	0.96	0.010
		Mean	5.6	6.7	783	400	371	0.09	<0.0001	0.022	19.6	<0.001	0.96	0.030
		Max	7.6	6.8	819	449	379	0.10	<0.0001	0.025	20.0	<0.001	0.97	0.050
Fisher Creek Drainage														
F-8B Glengarry Millsite	6	Min	0.8	3.1	176	23	54	0.32	0.0001	0.11	6.46	0.001	0.66	0.05
		Mean	7.0	3.4	234	31	83	0.32	0.0006	0.16	9.37	0.002	0.89	0.1
		Max	26.9	3.9	300	39	103	0.32	<0.0026	0.24	14.2	0.003	1.02	0.127
FCSI-96-5 Lower Tredennic Dump 1	5	Min	0.6	6.1	180	95	49	<0.05	0.0001	0.003	0.12	0.001	0.07	0.02
		Mean	2.6	6.6	189	99	53	<0.03	0.0001	0.003	0.16	0.001	0.11	0.03
		Max	5.0	7.1	210	102	58	<0.1	0.0002	0.004	0.21	<0.003	0.13	0.04
FSCI-99-1 Sheep Mt. # 1	5	Min	0.4	5.5	66	24	16	<0.05	<0.0001	0.005	0.1	0.004	<0.003	<0.01
		Mean	1.7	6.2	102	33	18	0.16	0.0004	0.017	0.4	0.009	0.03	0.04
		Max	4.0	6.9	173	45	21	0.40	0.0009	0.035	1.0	0.015	0.07	0.07

Notes: 1 Number of samples varies for each parameter; number shown is maximum number of samples for any one parameter.
2 A "<" value reported for the mean indicates parameter was below detection for all sampled dates, value shown is the greatest detection limit used.
gpm = gallons per minute; s.u. = standard units; mg/l = milligrams per liter; umhos/cm = micromhos per centimeter; SC = specific conductance

TABLE 3-4 (continued)
SUMMARY OF ADIT DISCHARGE FLOW AND WATER QUALITY DATA IN DAISY, FISHER, AND MILLER CREEK DRAINAGES

Adit Station Number and Name	Number of Samples(1)	Statistic	Flow (gpm)	Field pH (s.u.)	Field SC (umhos/cm)	Hardness (mg/L as CaCO3)	Concentration (total recoverable in milligrams per liter) (2)							
							Sulfate	Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
Fisher Creek Drainage (continued)														
AE-17 Henderson Mt. Dump # 7	7	Min	0	6.2	130	68	29	<0.1	0.0001	0.01	0.7	<0.001	0.08	0.0366
		Mean	1.2	6.7	162	79	42	0.07	0.0007	0.02	1.2	0.003	0.1	0.06
		Max	5.0	7.3	194	94	72	0.11	<0.0026	0.023	1.6	0.01	0.12	0.11
F-28 Gold Dust	16*	Min	4.9	6.3	423	376	163	<0.05	<0.0001	<0.001	0.09	<0.001	0.004	<0.01
		Mean	32.0	7.1	953	574	380	0.06	0.0003	0.004	0.46	0.001	0.063	0.02
		Max	246.9	7.6	1260	759	591	0.21	<0.005	0.012	2.23	0.015	0.152	0.05
	Samples collected after plugging boreholes in adit (August 2005)													
	3	9/22/05**	3.4	7.7	660	334	282	0.06	<0.0001	<0.001	<0.01	<0.001	NA	<0.01
		6/28/06†	18.9	6.1	357	181	142	0.35	<0.0001	0.01	2.64	0.005	0.25	0.03
		9/26/06	3.6	6.8	809	416	323	0.06	<0.0001	<0.001	0.62	0.001	0.13	0.04
Miller Creek Drainage														
M-1 Little Daisy	20	Min	0.5	5.9	107	215	156	<0.05	<0.0001	0.002	0.58	0.001	0.18	<0.01
		Mean	18.1	6.8	964	496	321	0.08	0.0004	0.013	6.17	0.026	1.30	0.11
		Max	179.5	7.3	1763	630	541	0.2	0.001	0.035	33.7	0.08	3.05	0.33
M-25 Henderson Mountain	8	Min	1.8	4.5	50	8	18	0.2	0.0001	0.29	<0.03	0.01	<0.02	<0.01
		Mean	11.3	5.8	73	10	19	0.4	0.0003	0.42	<0.05	0.01	<0.02	0.05
		Max	25.0	7.0	100	12	20	0.59	<0.001	0.56	<0.05	0.011	<0.02	0.1
M-8 Black Warrior	17	Min	0.1	7.0	167	106	23	<0.05	0.0005	<0.001	0.02	0.001	<0.003	0.1
		Mean	3.9	7.6	356	131	30	<0.1	0.0012	0.010	0.48	0.041	0.02	0.3
		Max	10.0	8.2	624	147	43	<0.1	0.0026	0.0234	1.32	0.090	0.065	0.43
MCSI-96-3 Upper Miller Creek Dump	5	Min	0.5	6.5	110	61	12	<0.05	0.0004	<0.001	0.02	<0.003	<0.02	0.11
		Mean	1.3	7.0	116	61	12	<0.05	0.0004	<0.001	0.02	<0.003	<0.02	0.11
		Max	2.0	7.6	122	61	12	<0.05	0.0004	<0.001	0.02	<0.003	<0.02	0.11

Notes:
1 Number of samples varies for each parameter; number shown is maximum number of samples for any one parameter.
2 A "<" value reported for the mean indicates parameter was below detection for all sampled dates, value shown is the greatest detection limit used.
* Gold Dust data are averages of sample measurements or concentrations from 1994 through 2004; during prior years, Crown Butte Mines, Inc. was conducting exploration activities underground, which resulted in elevated suspended sediment content measured in total recoverable fraction.
** Analytical metal results for sample collected at Gold Dust following borehole plugging are dissolved.
gpm = gallons per minute; s.u. = standard units; mg/l = milligrams per liter; umhos/cm = micromhos per centimeter; SC = specific conductance; NA = not analyzed

especially pronounced for total recoverable iron concentrations that tended to be much greater (by up to 200 times) compared to dissolved concentrations.

3.3 DAISY CREEK DRAINAGE BASIN

3.3.1 Daisy Creek Surface Water Quality and Flow

Water quality and flow data collected from 1989 through 2006 at three locations (DC-2, DC-5, and SW-7) in the Daisy Creek drainage provide a basis for assessing impacts to Daisy Creek. Surface water monitoring station DC-2 is located approximately 810 meters (2,660 feet) downstream of the headwaters of Daisy Creek and is the furthest upstream station influenced by discharge from the McLaren Adit. Station DC-5 is located approximately 3,025 meters (9,925 feet) downstream, and station SW-7 is located approximately 6 kilometers (3.7 miles) downstream from the headwaters of Daisy Creek.

At sampling station DC-2, aluminum, cadmium, copper, iron, lead, manganese and zinc exceeded water quality standards both before and after the McLaren Pit was capped in October 2003 even though concentrations have decreased considerably since the cap was constructed (**Table 3-3; Figure 20**). During the September 2006 sampling event, aluminum, cadmium, copper, iron, lead, and zinc concentrations were above aquatic life standards. The mean copper concentration measured after capping was 1.82 milligrams per liter (mg/L) (**Table 3.3**), a 38% reduction from concentrations measured prior to capping. Comparing copper concentrations measured during high flows before and after capping, a 70% reduction in concentration is evident (**Table 3.3**). This same result is seen for the other metals shown in Table 3.3, with the greatest reduction in concentrations measured during the high flow sampling period between late May and mid-July. Copper and zinc concentrations tend to increase during low flow periods, but are usually below the respective narrative standards for this station (**Figure 20**).

The pH of water in the stream at station DC-2, even after capping, is strongly acidic during low flows (**Table A-2, Appendix A**), although the pH has increased considerably during high flows since the cap was constructed. The most recent pH value measured after capping was 3.7 standard units (s.u.) in September 2006, although during high flow in June 2006 the pH was 6.2 s.u.

Flow versus concentration graphs of copper, iron, and zinc at station DC-2 (**Figure 20**) indicate that concentrations measured after capping during the high flow snowmelt period were either the lowest or among the lowest measured since 1990. These positive changes in water quality at station DC-2 is attributed to the emplacement of the McLaren Pit cap, which allows the melting snow to move off the cap without passing through the waste lying under the cap.

At sampling station DC-5, aluminum, cadmium, copper, iron, lead, manganese, and zinc concentrations were above Circular WQB-7 standards prior to capping the McLaren Pit (**Table A-2; Appendix A and Figure 21**). Subsequent to capping, lead and zinc concentrations at DC-5 have dropped to near or below the aquatic life standard (**Table A-2; Appendix A and Figure 21**). The historic average copper concentration prior to capping at this station was 1.07 mg/L (**Table 3-3)**; the average copper concentration after capping is less than half this value. When the data are separated into high and low flow regimes, the after capping mean copper concentrations are 69% and 54% lower, respectively, than the mean concentrations measured before capping. Neutral pH values were measured at DC-5 during all sample events occurring after capping the McLaren Pit (**Table 3-3**). A similar reduction was seen in concentrations of the other metals at this station as well.

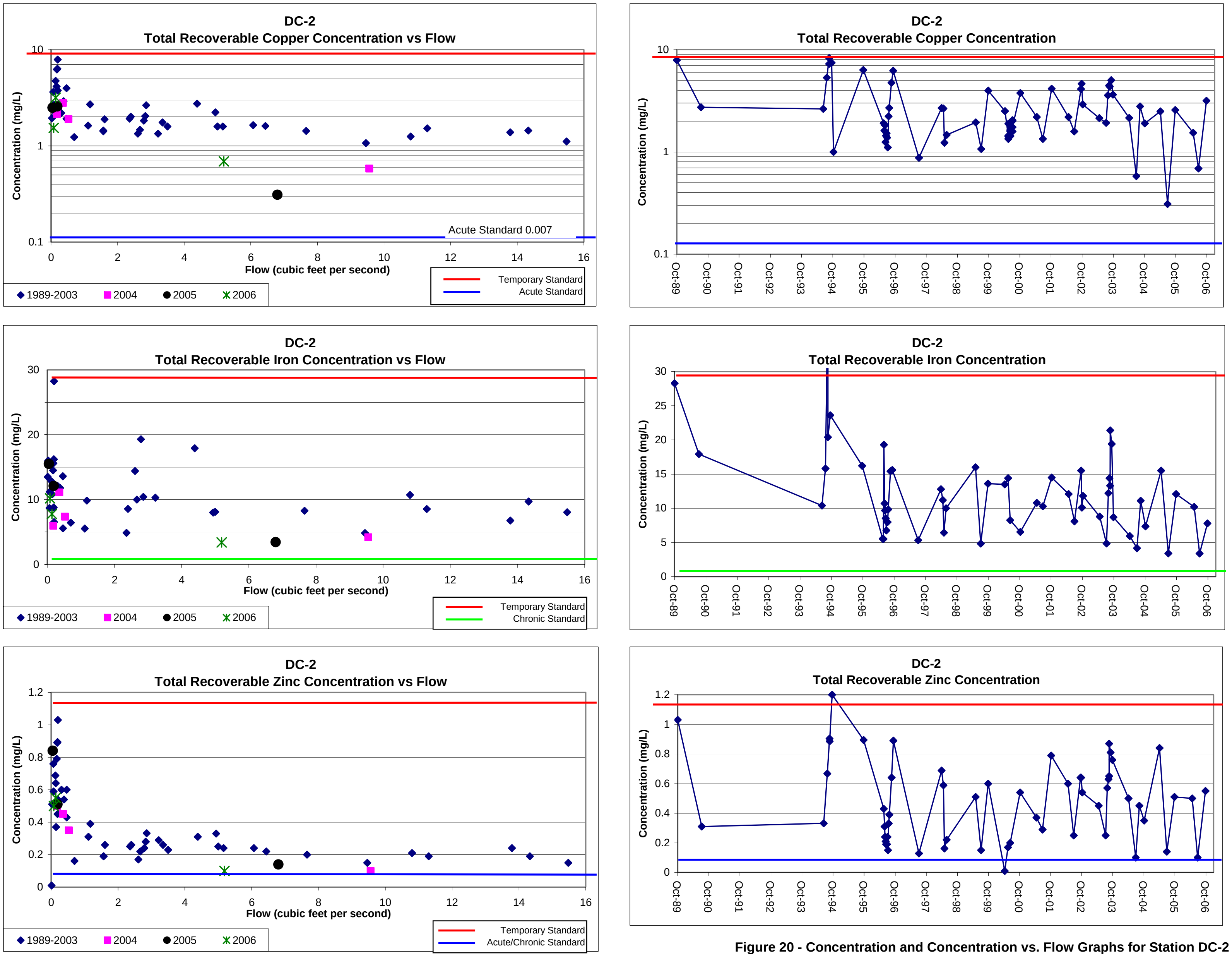
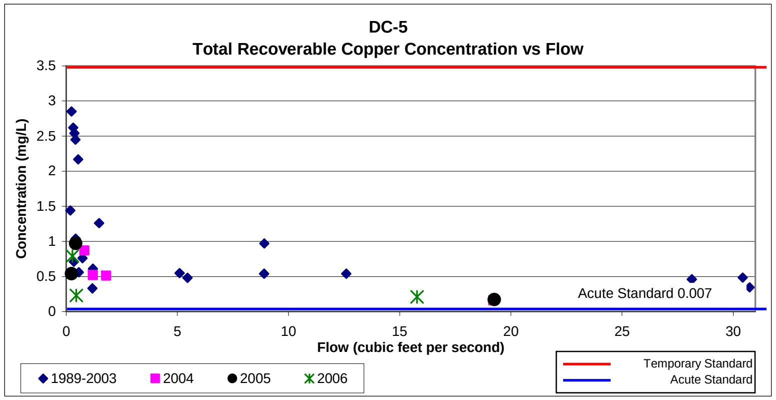
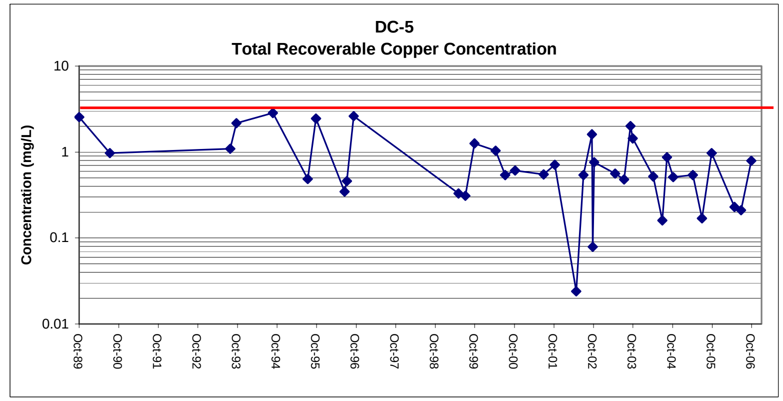
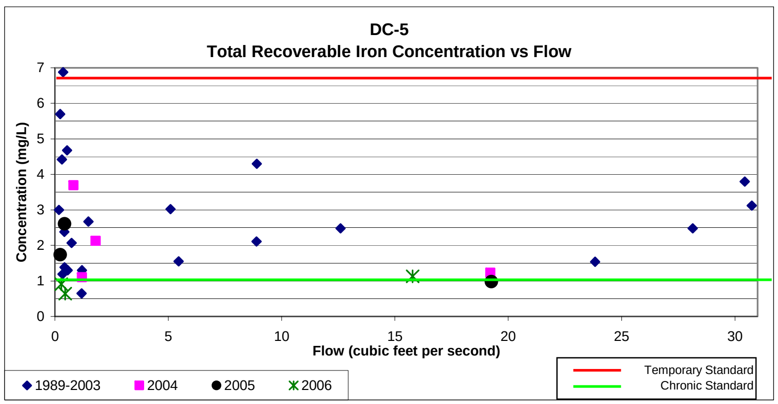
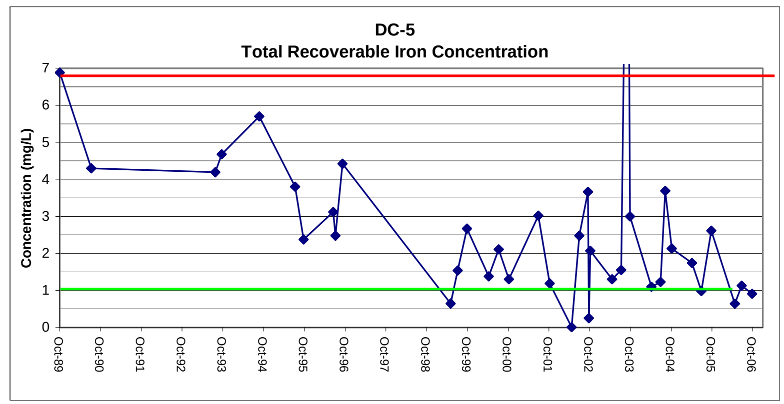


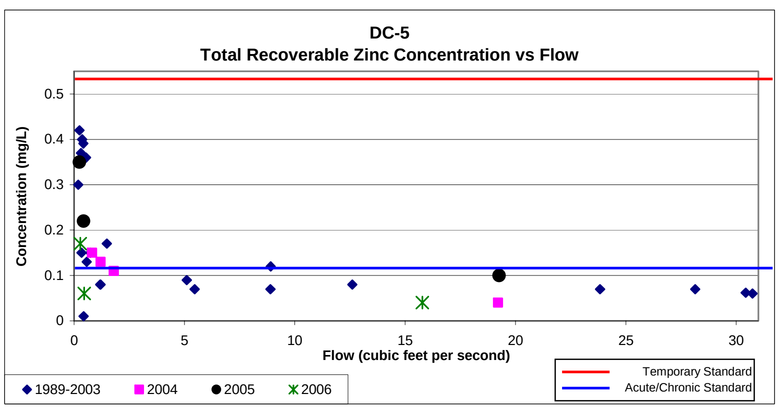
Figure 20 - Concentration and Concentration vs. Flow Graphs for Station DC-2











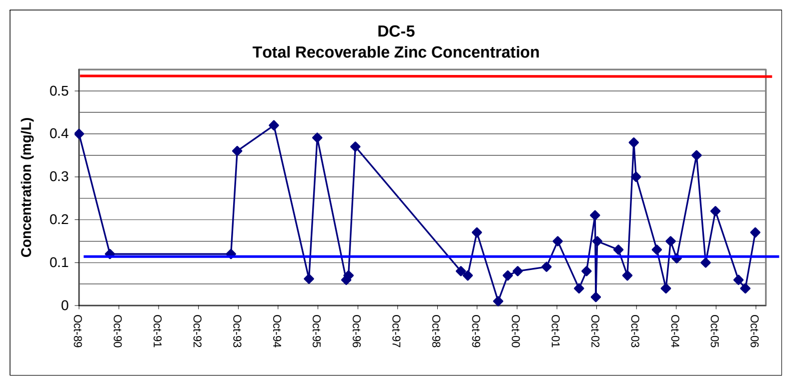


Figure 21 - Concentration and Concentration vs. Flow Graphs for Station DC-5

Average metal concentrations at sampling station SW-7 were considerably less than at sampling stations located above the confluence of Daisy Creek and the Stillwater River (**Table 3-3**). With the exception of aluminum and copper, metal concentrations generally met Circular WQB-7 water quality standards or occasionally exceeded the standards only slightly (**Figure 22**). Copper concentrations have decreased since capping the McLaren Pit, but exceeded the acute and chronic water quality standards in more than half of the sampling events conducted since the pit was capped (**Figure 22**). As stations DC-2 and DC-5, average metal concentrations were considerably lower at station SW-7 after capping compared to before capping the McLaren Pit. Reductions measured after capping during high flow ranged from 53 to 84% and 8.2 to 55% during low flow (**Table 3-3**). The average iron concentration was the only metal to show an increase in concentration in the post-capping period (**Table 3-3**).

3.3.2 McLaren Adit Discharge Water Quality and Flow

The McLaren Adit (or Winter Tunnel) (D-18) has been sampled on 27 occasions since 1989 for flow and/or metal concentrations. This period of record includes sampling performed before and after plugging an inflow from an exploration borehole within the adit in September 2003. Flow was measured once during the snowmelt period in July after the exploration boring was plugged, although no analytical data were collected at that time. Other samples taken after September 2003 were collected during lower flow conditions between August and October.

Flow from the adit decreased considerably after plugging the exploration borehole in September 2003. Flow rates have ranged between 13 and 29 Lpm (3.6 and 7.6) gpm during this time while mean flow prior to plugging the inflow was 42 Lpm (11.2 gpm) and reached rates as high as 112 Lpm (29.6 gpm) during high flow periods (**Table 3-4**).

Mean concentrations of aluminum, cadmium, copper, lead, and zinc have decreased since plugging the inflow, although the average concentrations of copper and zinc did not change appreciably (**Table 3-4**). In the last sample analyzed for metals in September 2004, copper and iron concentrations in the discharge exceeded Circular WQB-7 aquatic standards applicable to Daisy Creek. Aluminum, cadmium, lead, and zinc are typically present at relatively low concentrations. Circumneutral pH values have been measured during most sampling events since the first sample (pH of 3.4 s.u.) was collected during a very low flow period in 1989 (**Table A-2, Appendix A**).

3.3.3 McLaren Pit Subsurface Drains

Table 3-4 shows data collected from the McLaren Pit subsurface drains. Water from these drains exhibited very acidic pH values, ranging between 2.3 and 4.4 s.u., with generally poor water quality (copper and iron concentrations in the mg/L range). The combined flow from the three drains ranged from 25 to 121 Lpm (6.7 to 32 gpm) in 2004, 14 to 171 Lpm (3.7 to 45.2 gpm) in 2005, and 14 to 140 Lpm (3.6 to 37.3 gpm) in 2006.

3.3.4 Daisy Creek Loading Analysis

Mean metal concentration and flow data were used to calculate metal loads to determine the relative contribution of metals from the McLaren Adit and McLaren Pit subsurface drains to Daisy Creek (**Table 3-5, Table 3-6,** and **Figure 23**) as measured at DC-2 during the time following McLaren Pit capping. The load calculation at DC-2 was performed using the average base flow load measured between October 2003 and October 2006, which includes loads measured in April and September each year. The load determined for the McLaren Adit (**Table 3-5**) was is the average load calculated using data collected in October 2003 and September 2004 after a borehole leaking water into the adit was plugged.

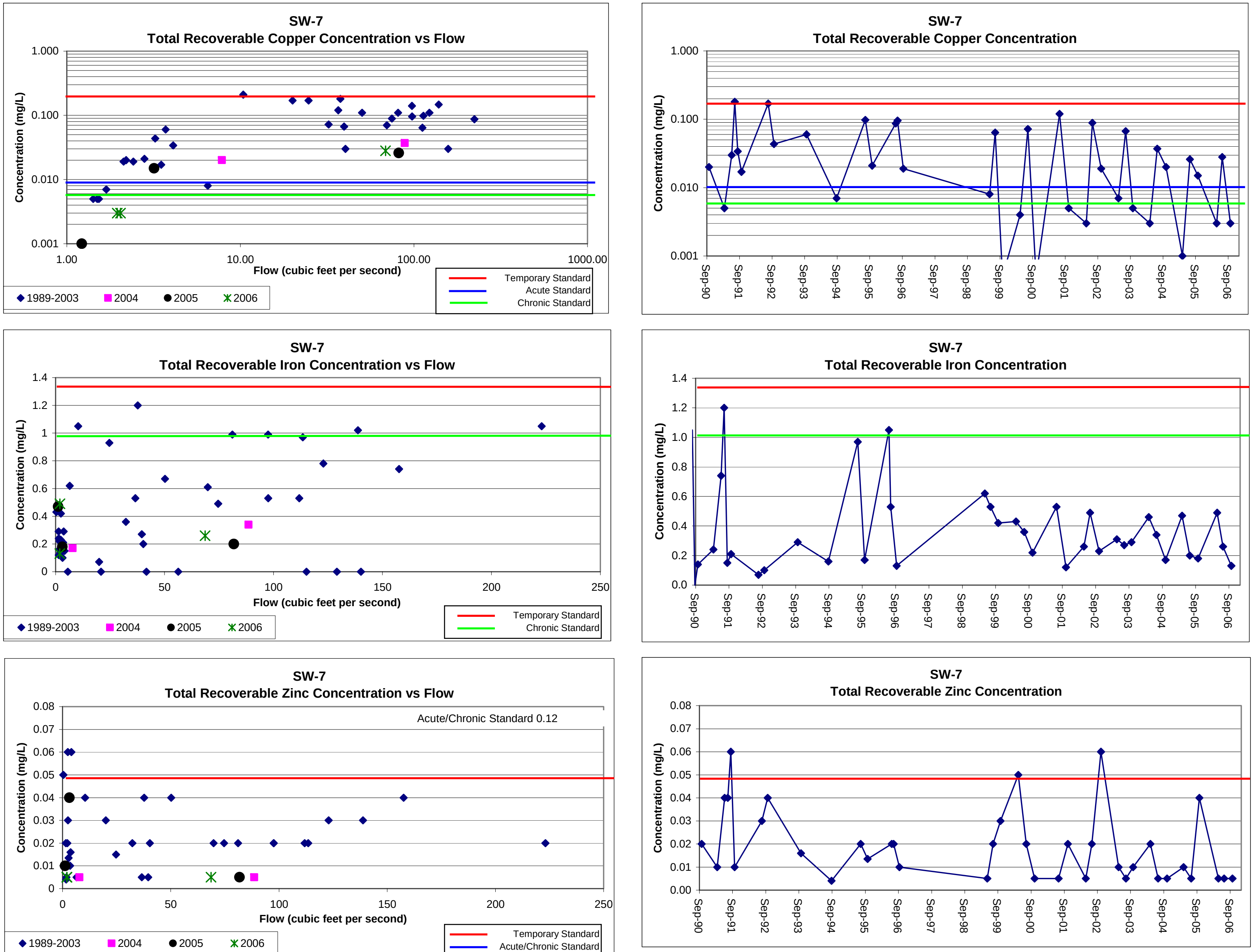


Figure 22 - Concentration and Concentration vs. Flow Graphs for Station SW-7

TABLE 3-5
PERCENT CONTRIBUTION OF MCLAREN ADIT (D-18) METALS LOADING AT DAISY CREEK STATION DC-2 AFTER CAPPING THE MCLAREN PIT

Station Number	Aluminum		Cadmium		Copper		Iron	
	Load kg/month	% Contribution at DC-2	Load kg/month	% Contribution at DC-2	Load kg/month	% Contribution at DC-2	Load kg/month	% Contribution at DC-2
D-18[1]	0.06	0.04	0.00003	0.07	0.014	0.04	13.3	9.1
DC-2[2]	149.4	100	0.05	100	37.5	100	146.3	100
Station Number	**Lead**		**Manganese**		**Zinc**			
	Load kg/month	**% Contribution at DC-2**	**Load kg/month**	**% Contribution at DC-2**	**Load kg/month**	**% Contribution at DC-2**		
D-18[1]	0.0003	0.6	0.655	2.6	0.019	0.25		
DC-2[2]	0.057	100	25.1	100	7.3	100		

Notes: 1 Reported loads are averages of data collected after plugging the adit borehole in September 2003 (n = 2).
2 Reported loads are average loads calculated for low flow data (August through April) collected after October 2003 (n = 7).
kg/month = kilograms per month

TABLE 3-6
PERCENT CONTRIBUTION OF METALS LOADING FROM MCLAREN PIT SUBSURFACE DRAINS AT DAISY CREEK STATION DC-2 AFTER CAPPING THE MCLAREN PIT

Data for 2006 Fall Low Flow

Station Number	Aluminum		Cadmium		Copper		Iron	
	Load[1] kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2
DCSW-101	10.6	8.4	0.004	8.3	4.84	14.9	65.3	81.7
DCSW-102	1.8	1.4	0.001	2.0	1.04	3.2	8.5	10.7
DCSW-103	11.3	8.9	0.003	7.3	4.26	13.1	46.2	57.8
Total Contribution[2]	23.8	18.7	0.008	17.6	10.14	31.1	120.1	150.2
DC-2 Post-Capping[3]	127	48.5	0.044	57.9	33	39.5	80	24.2
DC-2 Pre-Capping Low Flow	263		0.076		83		330	

	Lead		Manganese		Zinc		Flow (gallons per minute)
	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	Load Kg/month	Post-Capping % Contribution at DC-2	
DCSW-101	0.002	4.5	1.3	5.7	0.69	12.1	2.2
DCSW-102	0.000	0.4	0.3	1.3	0.14	2.6	0.45
DCSW-103	0.000	0.7	1.8	8.3	0.60	10.6	0.90
Total Contribution[2]	0.002	5.5	3.4	15.4	1.43	25.3	3.6
DC-2 Post-Capping[3]	0.04	22.7	22.0	60.4	5.65	44.3	63
DC-2 Pre-Capping Low Flow	0.18		36.4		12.75		244

Notes:
1 DC-2 post-capping and subsurface drain loads are September 2006 data; DC-2 pre-capping loads are average low flow loads measured prior to October 2003 (n varies).
2 Total Contribution is the total combined load from DSCW-101, 102, and 103.
3 Post Capping % for Station DC-2 is percent of Pre-Capping average low flow load.
kg/month = kilograms per month

TABLE 3-6 (continued)
PERCENT CONTRIBUTION OF METALS LOADING FROM MCLAREN PIT SUBSURFACE DRAINS AT DAISY CREEK STATION DC-2 AFTER CAPPING THE MCLAREN PIT

Data for June 2006 High Flow

Station Number	Aluminum		Cadmium		Copper		Iron	
	Load[1] kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2
DCSW-101	88	7.4	0.0277	14.5	45.58	17.3	354.5	27.5
DCSW-102	79	6.6	0.036	19.1	44.81	17.0	327.0	25.4
DCSW-103	24	2.0	0.007	3.7	10.60	4.0	127.4	9.9
Total Contribution[2]	191	16.0	0.071	37.3	100.99	38.4	808.9	62.8
DC-2 Post-Capping[3]	1189	49.1	0.19	26.9	263	36.7	1288	28.2
DC-2 Pre-Capping Low Flow	2418		0.71		717		4572	

Station Number	Lead		Manganese		Zinc		Flow (gallons per minute)
	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	Load kg/month	Post-Capping % Contribution at DC-2	
DCSW-101	0.041	5.3	9.3	7.1	5.06	13.3	20.6
DCSW-102	0.005	0.6	11.5	8.9	6.44	16.9	14.8
DCSW-103	0.001	0.1	3.8	3.0	1.30	3.4	1.8
Total Contribution[2]	0.046	6.0	24.6	19.0	12.81	33.6	37.3
DC-2 Post-Capping[3]	0.8	30.8	130	52.8	38	37.1	2329
DC-2 Pre-Capping Low Flow	2.5		245		103		2842

Notes: 1 DC-2 post-capping and subsurface drain loads are June 2006 data; DC-2 pre-capping loads are average high flow loads measured prior to October 2003 (n varies).
2 Total Contribution is the total combined load from DSCW-101, 102, and 103.
3 Post Capping % for Station DC-2 is percent of Pre-Capping average low flow load.
kg/month = kilograms per month

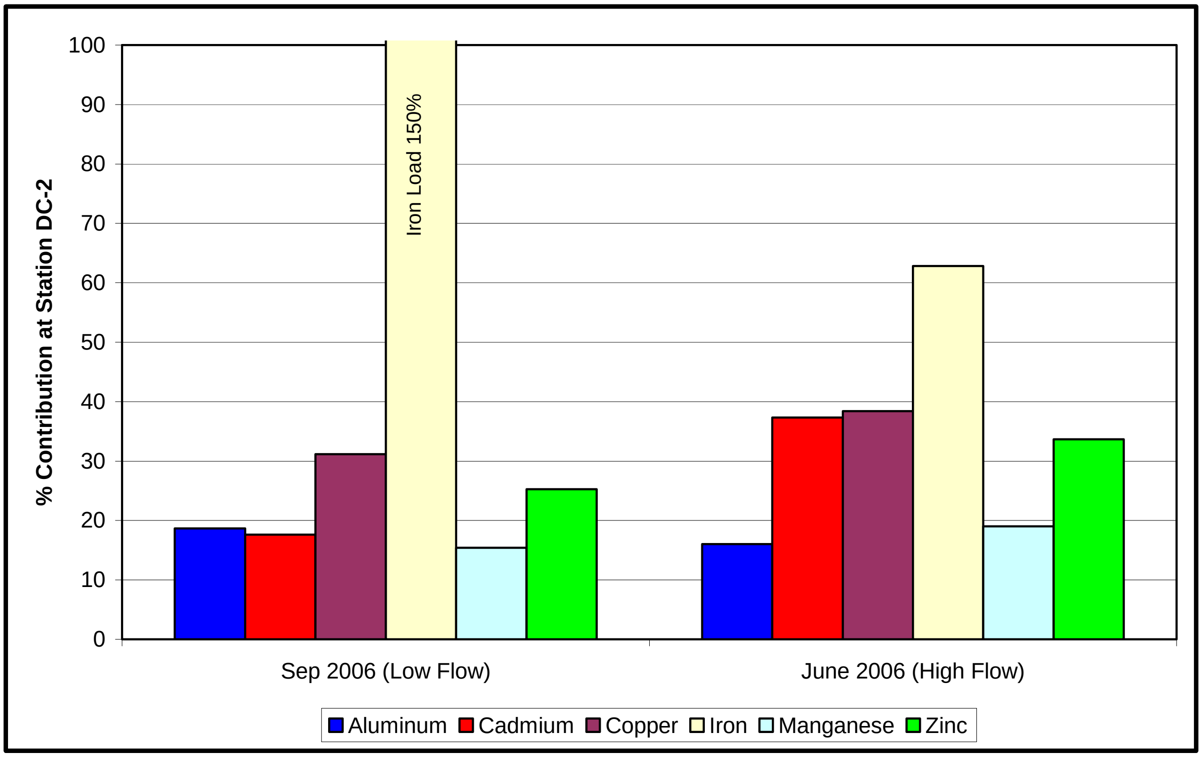


Figure 23 – Metal Loads calculated for McLaren Pit subsurface drains at Station DC-2

This analysis shows that the percent contribution of average metal loads from the McLaren Adit to base flow loads at DC-2 is less than 1.0% except for iron and manganese. The McLaren Adit contributes 9.1% of the total iron load and 2.6% of the total manganese load measured at DC-2.

Significant additional contributions to the upper reaches of Daisy Creek come from the McLaren Pit subsurface drains (DCSW-101, -102, and -103) as well as from other unidentified non-point sources. The subsurface drains were installed during the McLaren Pit Response Action to provide outlets for springs discharging from bedrock in the area of the highwall. In September 2006, the combined load from the three drains accounted for as much as 150% of the iron load and considerable contributions of aluminum (18.7%), cadmium (17.6%), copper (31%), manganese(15.4%), and zinc (25.3%) when compared to the loads measured at DC-2 (**Figure 23**). The low flow iron load (150% of the load measured at station DC-2) indicates that considerable iron precipitation occurs in the stream channel between the drain outlet and the DC-2 monitoring location.

Most of the combined load from the three subsurface drains is contributed by DCSW-101. During the 2006 high flow period, the relative contribution from the drains increased for each of the metals analyzed except for aluminum and iron, with the percent contribution of iron decreasing substantially when compared to the low flow percentage contribution (**Figure 23**).

Table 3-6 also shows average metal loads at DC-2 for the period prior to capping the McLaren Pit. Post-capping metal loads calculated for the average low flow periods sampled after October 2003 range from 22.7% 60.4% of those calculated for low flow sample events occurring before capping. A similar relationship occurred during post-capping high flow events with post-capping loads between 26.9% and 52.8% of the pre-capping high flow loads. These data indicate that capping the McLaren Pit was effective in reducing loads in Daisy Creek, although metal concentrations in Daisy Creek do not yet approach water quality standards.

Data plotted in **Figures 20** through **22** show metal concentrations for samples collected in 2004 through 2006 are in the lower range of values measured in samples collected previously at similar flow rates. As relatively few samples have been collected since pit capping was completed, continued sampling under variable flow conditions is required to confirm the effectiveness of the McLaren Pit cap.

3.4 FISHER CREEK DRAINAGE

3.4.1 Fisher Creek Surface Water Quality and Flow

Surface water quality in Fisher Creek is impacted by runoff from the Como Basin, discharges from adits, seeps, springs, and groundwater that carry high metal loads (Maxim 2002), and other sources such as natural soils. As a result, metal concentrations measured at Fisher Creek monitoring stations SW-3 and SW-4 (**Figure 3**) often exceed Circular WQB-7 water quality standards for aluminum, cadmium, copper, iron, lead, manganese, and zinc (**Table 3-3**). Water at station SW-3 is typically acidic, ranging from 3.6 to 5.0 s.u. since October 2004 (**Table A-2, Appendix A**); pH increases to between 5.6 and 7.2 s.u. at station SW-4 for the same period.

Data presented in **Table 3-3** and **Figures 24** and **25** indicate that metal concentrations are generally lower during periods of high flow than during low flow events at upstream station SW-3. At station SW-4, the opposite is generally true. These observations are consistent with those described by Maxim (2002) and suggest that dilution occurs near the headwaters of Fisher Creek during periods of high flow. **Table 3-3** also shows that concentrations of metals at both these stations have decreased considerably since the Glengarry Adit was closed in October 2004. When all data are averaged, iron concentrations decreased the most since the adit was closed with a reduction of 77% at SW-3 and 81% at SW-4. Average iron concentrations at SW-3 still exceed aquatic standards even with this reduction.

Water collected at monitoring station CFY-2, located downstream from SW-3 and SW-4 at the confluence of Fisher Creek and the Clarks Fork of the Yellowstone River (**Figure 3**), is of better quality yet generally exceeds aquatic standards for copper during certain flow periods each year (**Table A-2, Appendix A**. Metal concentrations at CFY-2 tend to increase during high flow conditions (**Figure 26**). An increase in metal loading at station CFY-2 during high flow is likely due to suspended fine-grained sediment present in the water.

3.4.2 Fisher Creek Adit Discharge Water Quality and Flow

Numerous adit discharge locations in the Fisher Creek drainage have been monitored. Flow from the Glengarry Adit (station F-8A, **Figure 3**) was measured most recently on June 26, 2006. Prior to plugging the adit, average flow from the portal was 210 Lpm (56 gpm) and ranged from 50 to 850 Lpm (15 to 224 gpm) (Maxim, 2002a). Flow was very low at about 2.0 Lpm (0.5 gpm) on June 26, although the discharge still exceeded aquatic water quality criteria for copper (0.038 mg/L) and iron (2.52 mg/L).

The Glengarry Millsite Adit (station F-8B, **Figure 3**) also has poor water quality, with pH ranging from 3.1 to 3.9 s.u. and elevated metal concentrations (**Table 3-4**). Water from this adit flows over a ferricrete bench outside of the portal, down across the millsite and infiltrates into colluvial materials below the millsite approximately 45 meters (150 feet) from Fisher Creek. Presumably, this shallow groundwater reports to Fisher Creek. Concentrations of cadmium, copper, iron, lead, manganese, and zinc from this adit regularly exceed aquatic life standards, although discharge rates are very low, ranging

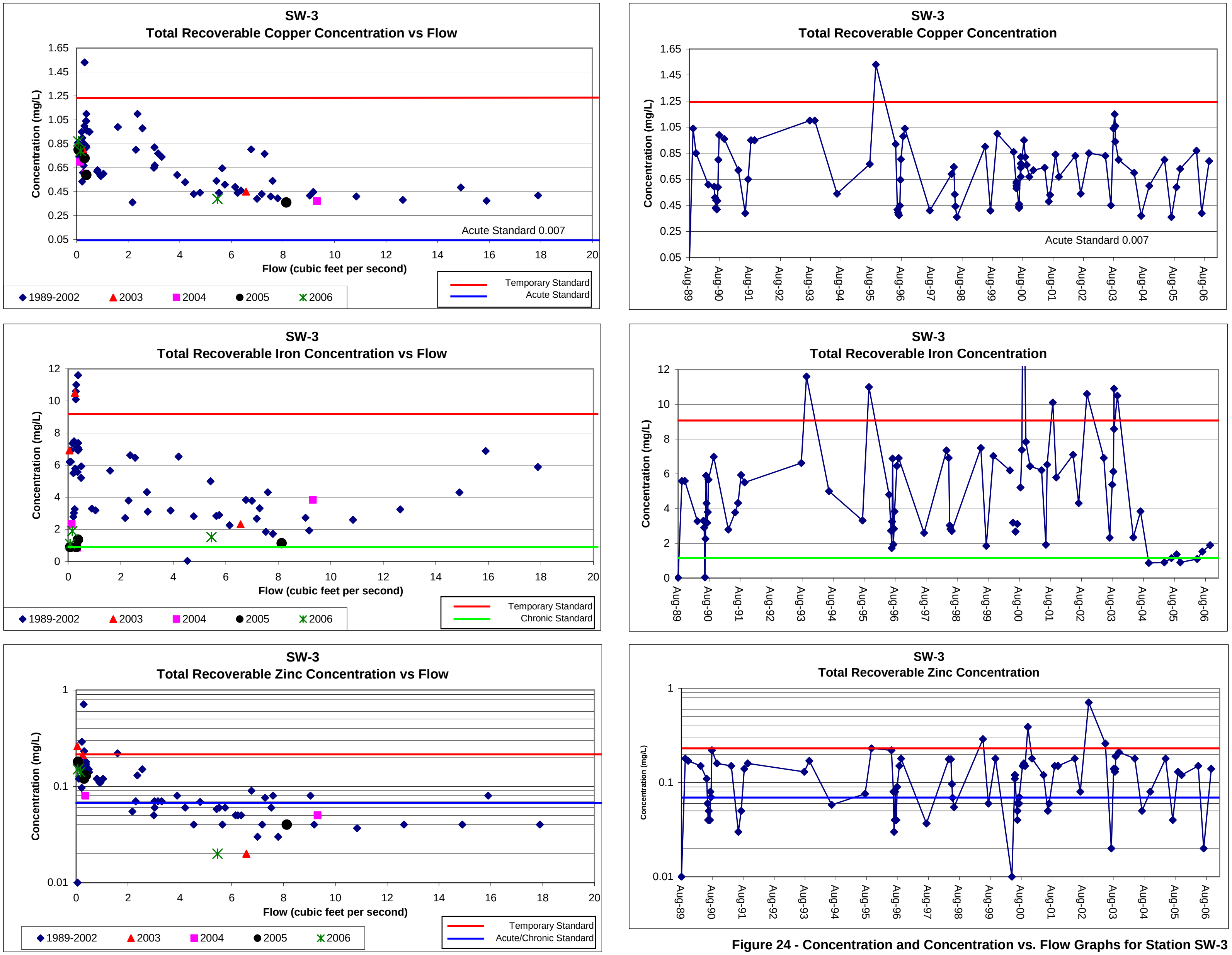


Figure 24 - Concentration and Concentration vs. Flow Graphs for Station SW-3

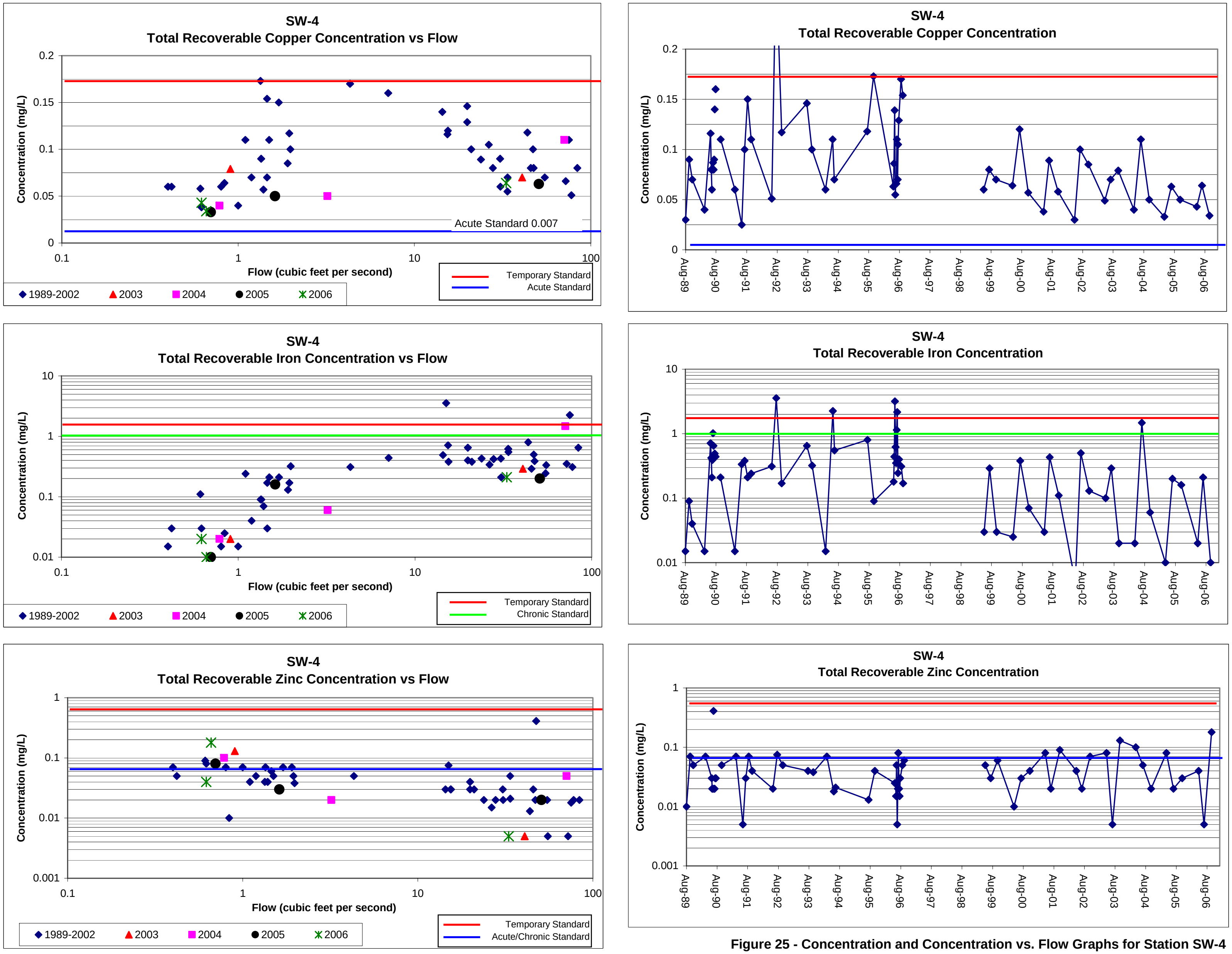


Figure 25 - Concentration and Concentration vs. Flow Graphs for Station SW-4

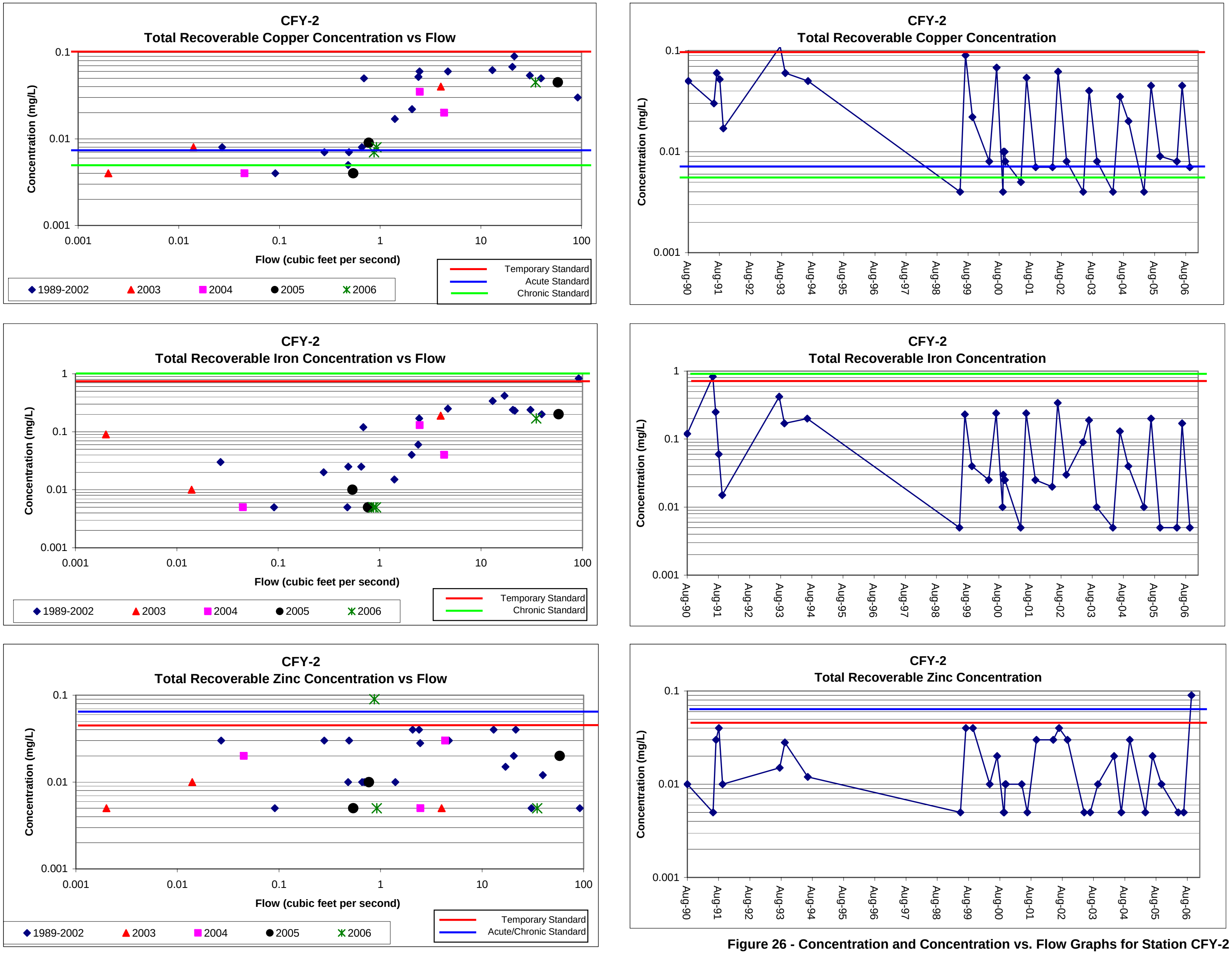


Figure 26 - Concentration and Concentration vs. Flow Graphs for Station CFY-2

from 3 to 20 Lpm (0.8 to 5.0 gpm) except for a maximum flow of 100 Lpm (26.9 gpm) measured in September 1989.

Water quality at monitoring stations FCSI-95-5 (Lower Tredennic Dump 1, **Figure 3**), FSCI-99-1 (Sheep Mountain # 1 Adit), AE-17 (Henderson Mountain Dump # 7), and F-28 (Gold Dust Adit) is somewhat better than the Glengarry stations with pH ranging from 5.5 to 7.6 s.u. and metal concentrations that are not as greatly elevated. However, each of these adits discharges water that would exceed applicable aquatic standards for one or more of the following elements: cadmium, copper, iron, lead, and manganese (**Table 3-3**). It should be noted that data collected prior to 1994 for the Gold Dust Adit were not included in this analysis. This is because these data are believed to have been influenced by drilling and other exploration activities that took place in the adit during this time.

3.4.3 Fisher Creek Loading Analysis

Previous studies have suggested that the Glengarry Adit contributed up to 65.3% of the load of certain metals to Fisher Creek at station SW-3 prior to the USDA's Glengarry Adit closure project (Amacher 1998; Kimball *et. al.* 1999). With closure of the adit complete in October 2004, discharge from the Glengarry Adit had decreased to about 2.0 Lpm (0.5 gpm) by June 2006, with concurrent decreases in metals concentrations. Metal loads from what remained of the adit discharge were less than 0.5% of the average low flow load measured at station SW-3 except for iron (1.1%) (**Table 3-7**).

With the dramatic reduction in loading from the Glengarry Adit, the loading analysis presented in **Table 3-7** was completed by comparing the mean flows and concentrations for the Fisher Creek adits (except for the Gold Dust) with the average low flow loads measures at the Fisher Creek monitoring stations between October 2004 and October 2006 (i.e. post-closure water quality). For the Gold Dust adit, only the most recent data (September 2006) are used in the loading calculation because previous water quality data may have been influenced by reclamation construction work conducted at the site in 2004, 2005, and 2006.

Aluminum, copper, iron, and manganese loads calculated for the three Fisher Creek main-stem stations (SW-3, SW-4, and CFY-2) decrease with distance downstream during the October 2004 to October 2006 low flow sampling events (**Table 3-7** and **Figure 27**). This indicates that attenuation mechanisms such as dilution, adsorption, and/or precipitation occur as metals travel downstream. Precipitation of dissolved metals is likely to occur as pH reaches circum-neutral values downstream of station SW-4 (**Table A-2, Appendix A**). On the other hand, cadmium, lead, and zinc loads increased between stations SW-3 and SW-4 (**Table 3-7**), suggesting that cumulative loading of these elements occurs from sources located below station SW-3.

As shown in **Table 3-7**, the mean discharge from the Glengarry Millsite Adit (station F-8B) contributed 11.4% of the iron, 1.4% of the lead, and 2.9% of the manganese loads at station SW-3 in the post-closure period. Sheep Mountain #1 Adit (station FSCI-99-1) contributed 3.8% of the lead load at this station (**Table 3-7**). Remaining metal loads at these two adit sites and all metal loads from the Lower Tredennic Adit contributed less than 1% of the total load for each metal measured at station SW-3. (It should be noted that the Lower Tredennic discharge does not directly enter a surface water stream; the discharge infiltrates into the ground a short distance from the adit.)

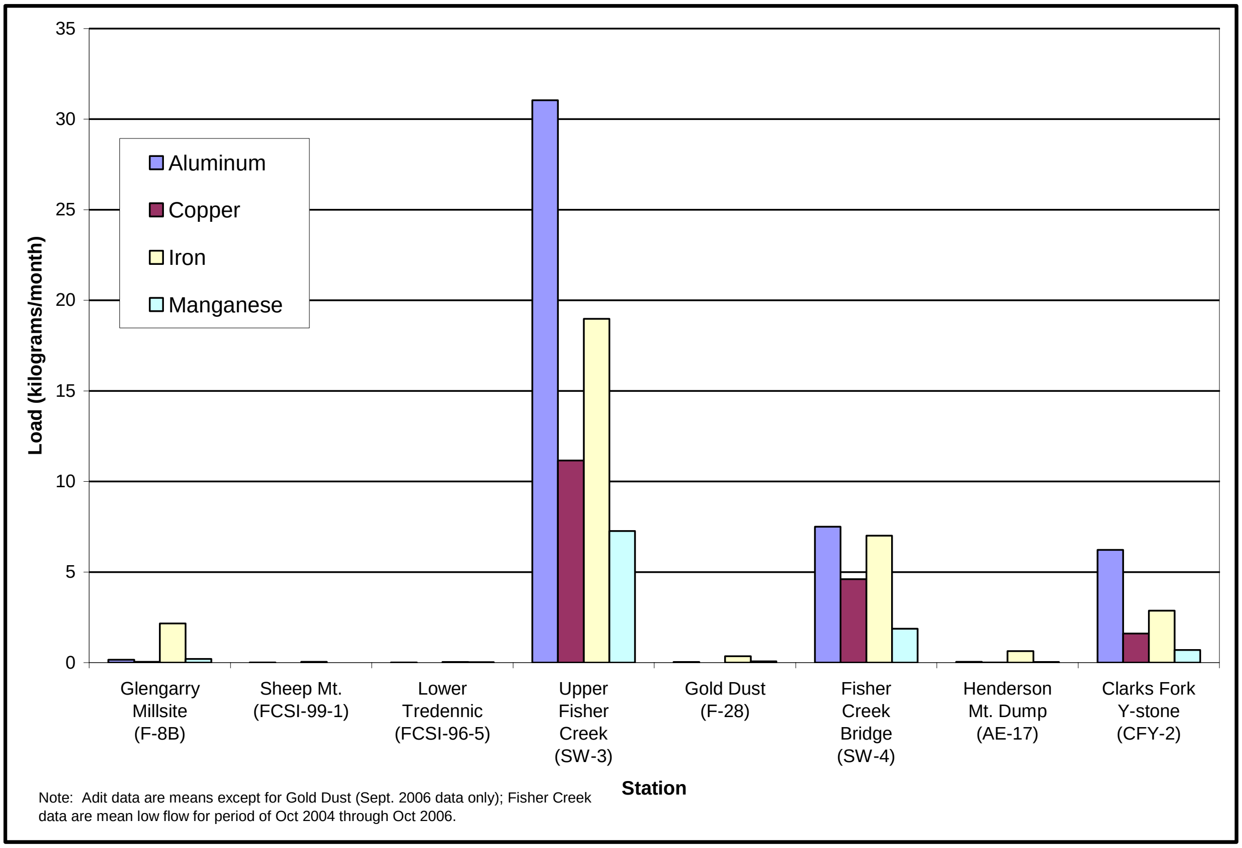


Figure 27 – Metal Loads in Fisher Creek and Fisher Creek Adit Discharges

Based on concentration and flow data measured at the Gold Dust Adit in the fall of 2006, the Gold Dust Adit, which discharges to Fisher Creek between stations SW-3 and SW-4, contributes less than 0.5% of the aluminum, cadmium, copper, lead, and zinc loads measured at station SW-4 and about 5%, 1%, and 4% of the iron, lead, and manganese load, respectively (**Table 3-7**). Discharge from the Henderson Mountain Dump 7 (station AE-17), which enters Fisher Creek between SW-4 and CFY-2 contributes 22.0% of the iron load and 4.8% of the manganese load measured at station CFY-2. Other metal loads from this adit were 1.1% or less of the load at station CFY-2 (**Table 3-7**).

3.5 MILLER CREEK DRAINAGE

3.5.1 Miller Creek Surface Water Quality and Flow

No temporary standards are in place for Miller Creek, as water quality in Miller Creek is generally of high quality with circumneutral pH and metals concentrations that tend to be low (Maxim 2003; Cleasby and Nimick 2002). Water quality data for Miller Creek monitoring stations SW-2 and SW-5 show cadmium, copper, iron, manganese, lead, and zinc have occasionally exceeded water quality standards, particularly under high flow conditions in June and July (**Table 3-3** and **Figures 28** and **29**). These exceedances likely result from the influence of suspended sediments on total recoverable metals analyses. It should be noted that cadmium and lead concentrations were usually below detection at both stations, and that the calculated mean values are biased by anomalously high concentrations recorded during a June 1990 high-flow sampling event (**Table A-2, Appendix A**). Flow at SW-2 and SW-5 ranges from about 240 to 151,000 Lpm (63 to 40,000 gpm).

TABLE 3-7
PERCENT CONTRIBUTION OF ADIT METALS LOADING TO FISHER CREEK

Station	Aluminum				Cadmium				Copper			
	Load kg/month	% Contribution			Load kg/month	% Contribution			Load kg/month	% Contribution		
		at SW-3	at SW-4	at CFY-2		at SW-3	at SW-4	at CFY-2		at SW-3	at SW-4	at CFY-2
Glengarry (F-8A)	0.006	0.02			0.000004	0.04			0.003	0.03		
Glengarry Millsite (F-8B)	0.16	0.51			0.0001	1.00			0.05	0.45		
Sheep Mtn. #1 (FCSI-99-1)	0.014	0.04			0.00003	0.32			0.002	0.02		
L. Tredennic (FCSI-96-5)	0.008	0.02			0.00003	0.28			0.0007	0.01		
SW-3	31	100			0.01	100			11.2	100		
Gold Dust (F-28)	0.03		0.44		0.00003		0.14		0.0003		0.006	
SW-4	7.5		100		0.02		100		4.6		100	
Henderson Mtn. (AE-17)	0.05			0.73	0.00005			0.57	0.009			0.57
CFY-2	6.2			100	0.009			100	1.6			100

Station	Iron				Lead				Manganese			
	Load kg/month	% Contribution			Load kg/month	% Contribution			Load kg/month	% Contribution		
		at SW-3	at SW-4	at CFY-2		at SW-3	at SW-4	at CFY-2		at SW-3	at SW-4	at CFY-2
Glengarry (F-8A)	0.2	1.1			0.00004	0.14			0.03	0.35		
Glengarry Millsite (F-8B)	2.1	11.4			0.0004	1.38			0.2	2.9		
Sheep Mtn. #1 (FCSI-99-1)	0.05	0.25			0.001	3.85			0.003	0.04		
L. Tredennic (FCSI-96-5)	0.03	0.17			0.0002	0.69			0.02	0.29		
SW-3	19	100			0.03	100			7.3	100		
Gold Dust (F-28)	0.35		4.91		0.0006		1.1		0.07		3.88	
SW-4	7.0		100		0.05		100		1.9		100	
Henderson Mtn. (AE-17)	0.6			22.3	0.001			1.1	0.03			4.8
CFY-2	2.9			100	0.05			100	0.7			100

Station	Zinc			
	Load kg/month	% Contribution		
		at SW-3	at SW-4	at CFY-2
Glengarry (F-8A)	0.003	0.13		
Glengarry Millsite (F-8B)	0.02	1.03		
Sheep Mtn. #1 (FCSI-99-1)	0.004	0.19		
L. Tredennic (FCSI-96-5)	0.006	0.31		
SW-3	2	100		
Gold Dust (F-28)	0.02		0.48	
SW-4	4.6		100	
Henderson Mtn. (AE-17)	0.02			0.66
CFY-2	3.3			100

Notes: 1 Data for Fisher Creek monitoring stations SW-3, SW-4, and CFY-2 are the average low flow measured from Oct 04 through Oct 06 kg = kilograms
2 Glengarry and Gold Dust loads calculated using data collected in September 2006; remaining adit data is average for period of record.

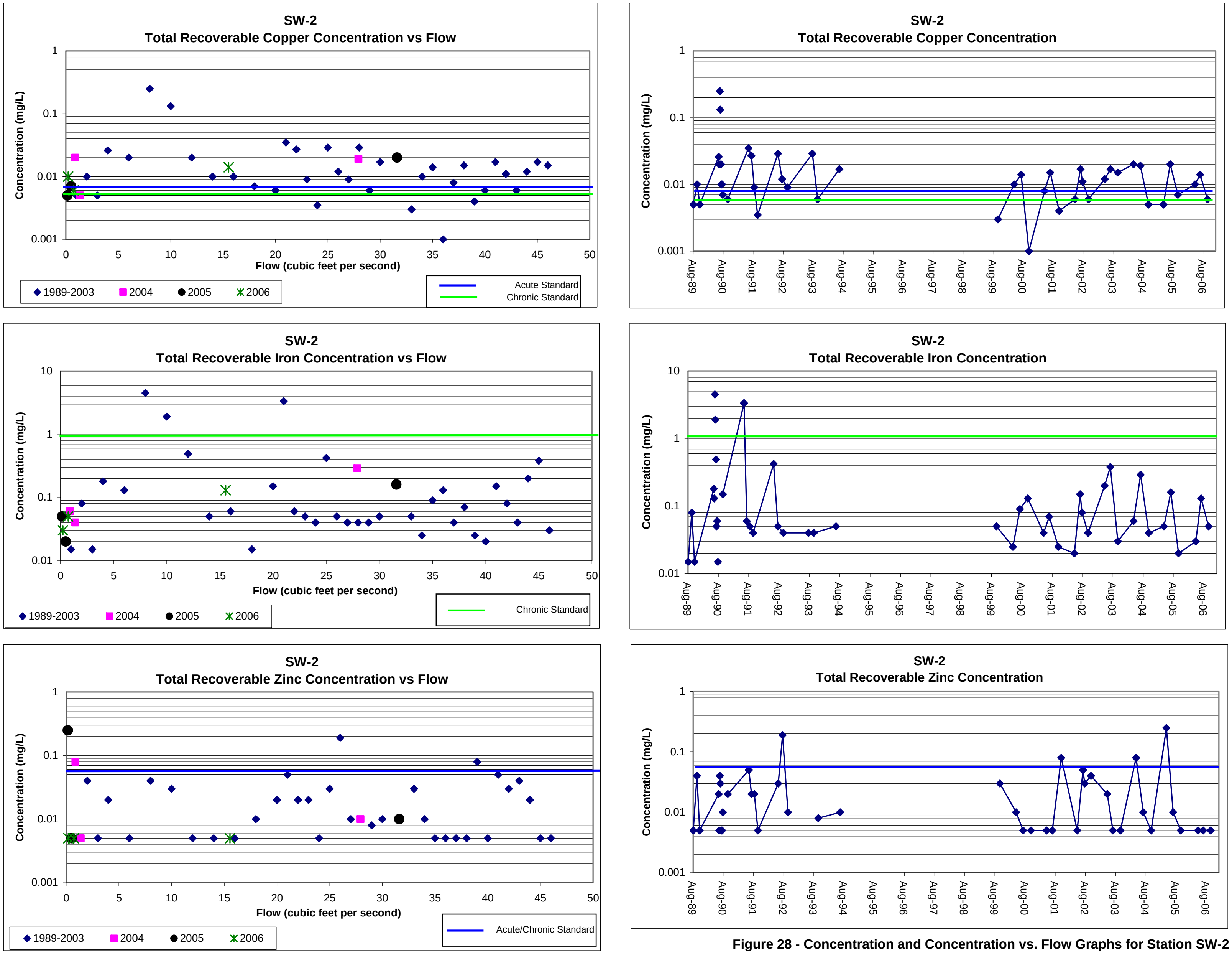
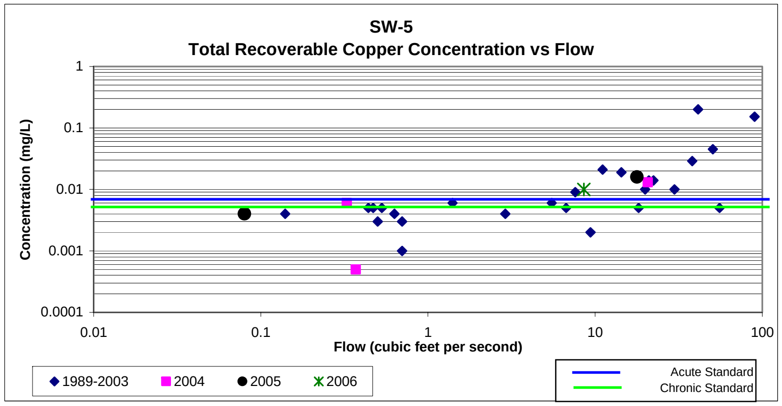
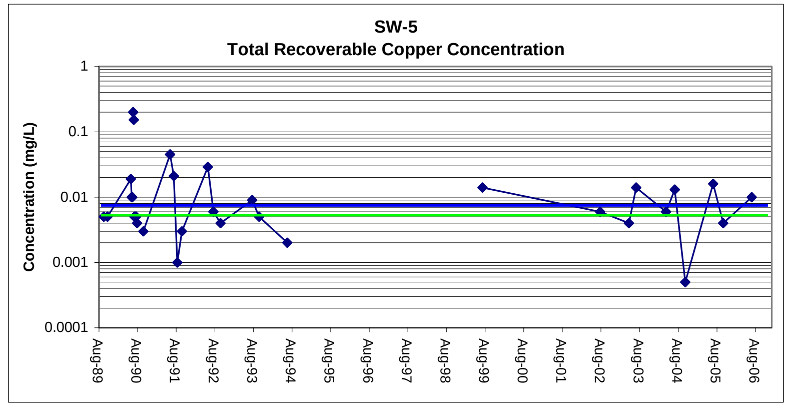
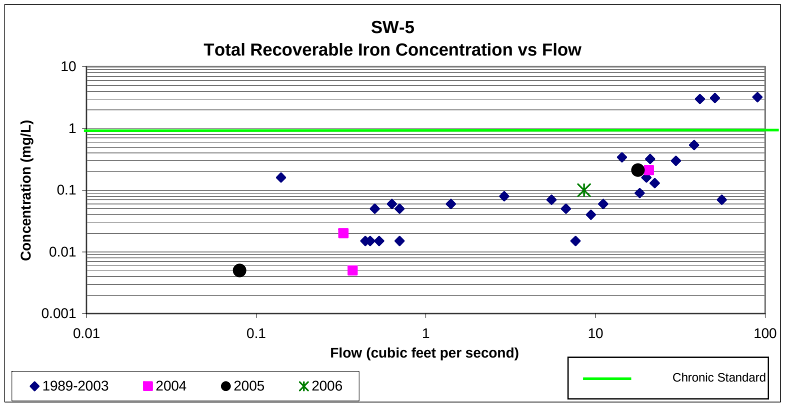
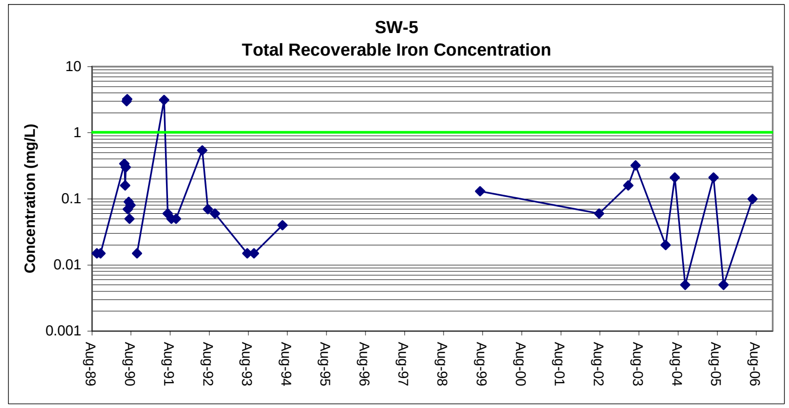


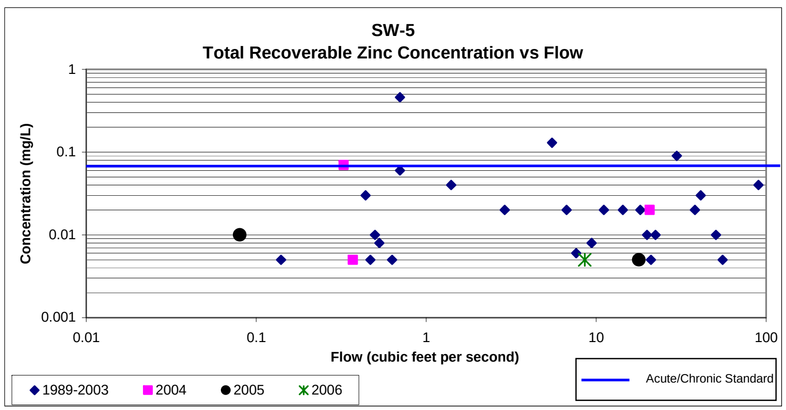
Figure 28 - Concentration and Concentration vs. Flow Graphs for Station SW-2











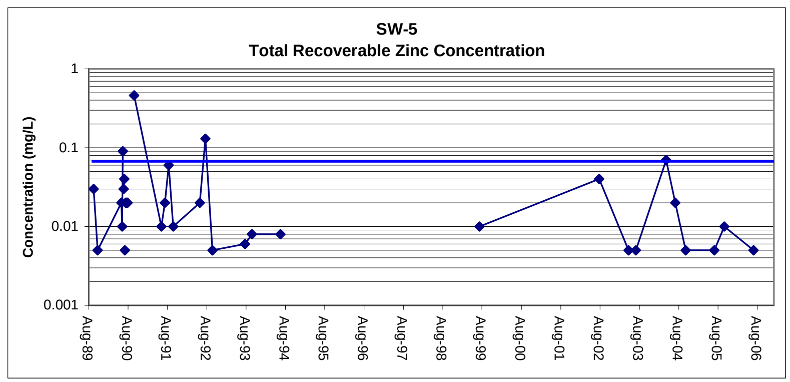


Figure 29 - Concentration and Concentration vs. Flow Graphs for Station SW-5

3.5.2 Miller Creek Adit Discharge Water Quality and Flow

There are several adit discharges in the Miller Creek drainage. The Little Daisy Adit (station M-1) has been sampled for flow and metal concentrations on ten dates between 1989 and 2004 (**Table A-5, Appendix A**). The Black Warrior Adit (station M-8) has been sampled about half as often over the same period. The Henderson Mountain Adit (station M-25) and the Upper Miller Creek Dump (station MCSI-96-3) have been sampled for flow and metal concentrations on one or two occasions, with the most recent event occurring in July 2003.

Adit discharge water quality tends to be poor compared to that of Miller Creek. Values of pH range from 4.5 to 8.2 s.u. and elevated metal concentrations have been recorded at most of the discharging adits in the drainage (**Table 3-4**). Most of the adit discharges display elevated concentrations of cadmium, copper, and lead, while a limited number also display elevated concentrations of iron, manganese, or zinc. Aluminum in adit discharges from M-10 and M-25 may exceed aquatic standards, although the standard is based on dissolved concentrations while only total recoverable aluminum data are available for these two sites. Dissolved aluminum was below the detection limit (0.1 mg/l) at the Little Daisy Adit, and total recoverable aluminum concentrations have been below the aquatic standard in the four samples collected since 1994.

Adits discharging to Miller Creek tend to have low flows, with average flows calculated for high flow periods that range from seven to 40 Lpm (2.0 to 10.7 gpm). The greatest flow rates occur at the Little Daisy Adit (M-1) and the Henderson Mountain Adit (M-25) with average flow around 40 Lpm (10 gpm) (**Table 3-4**). A mean flow of 70 Lpm (18.1 gpm) for the Little Daisy Adit is biased by an anomalously high flow rate of 680 Lpm (179.5 gpm) reported for September 1989 (**Table A-5, Appendix A**).

3.5.3 Miller Creek Loading Analysis

A loading analysis was performed to assess the relative contribution of metals from the discharging adits present in the Miller Creek watershed. As discussed in Section 3.2, differences in collection times for available data required multiple comparisons to be made in order to gain an understanding of the effect of loading from the adits. The loading analysis for Miller Creek examines adit discharge contributions based on the following four data sets:

1. Mean loads calculated for all available sampling events.
2. Mean loads calculated for available high flow sampling events (i.e., those occurring in June and July).
3. Most recent date(s) on which high flow samples were collected at station SW-2 (June 2006) and at the adit discharge sites (July 2003).
4. Most recent date(s) on which low flow samples were collected at Station SW-2 (September 2006) and at the adit discharge sites (September 2004) (Station SW-5 was dry in April and September 2006).

All the adits of interest described in this evaluation are located upstream of Station SW-2 (**Figure 3**). When averaged across all available sampling events or all available high flow events, load data show that adit contributions account for a minor amount of the total metal load to Miller Creek at station SW-2 (**Table 3-8**). The load in any adit discharge is most often less than 0.1% of the load in Miller Creek at this station and in no case is greater than 3.1%. As the metal load at SW-2 is less than the load at the downstream monitoring station SW-5 when using the average of all available data or all high flow data, sources of metal loading other than the identified adits contributes to metal loading in Miller Creek. As discussed by Cleasby and Nimick (2000) and Maxim (2003a), a possible source of metal loading is diffuse drainage across calcium poor rock and/or drainage originating in the metal-enriched soils derived from mineralization along the southwest flank of the Henderson Mountain stock.

Comparison of the most recent comparable high flow sampling events (i.e., late June 2006 for SW-2 and SW-5; mid-July 2003 for adit discharges) shows that relative contributions from adit discharges were higher compared to contributions calculated for just the high flow events measured during the period of record (**Table 3-8; Figure 30**). However, adit metal loads were still minor, usually accounting for less than 1.0% and never more than 5.4% of the load measured at SW-2.

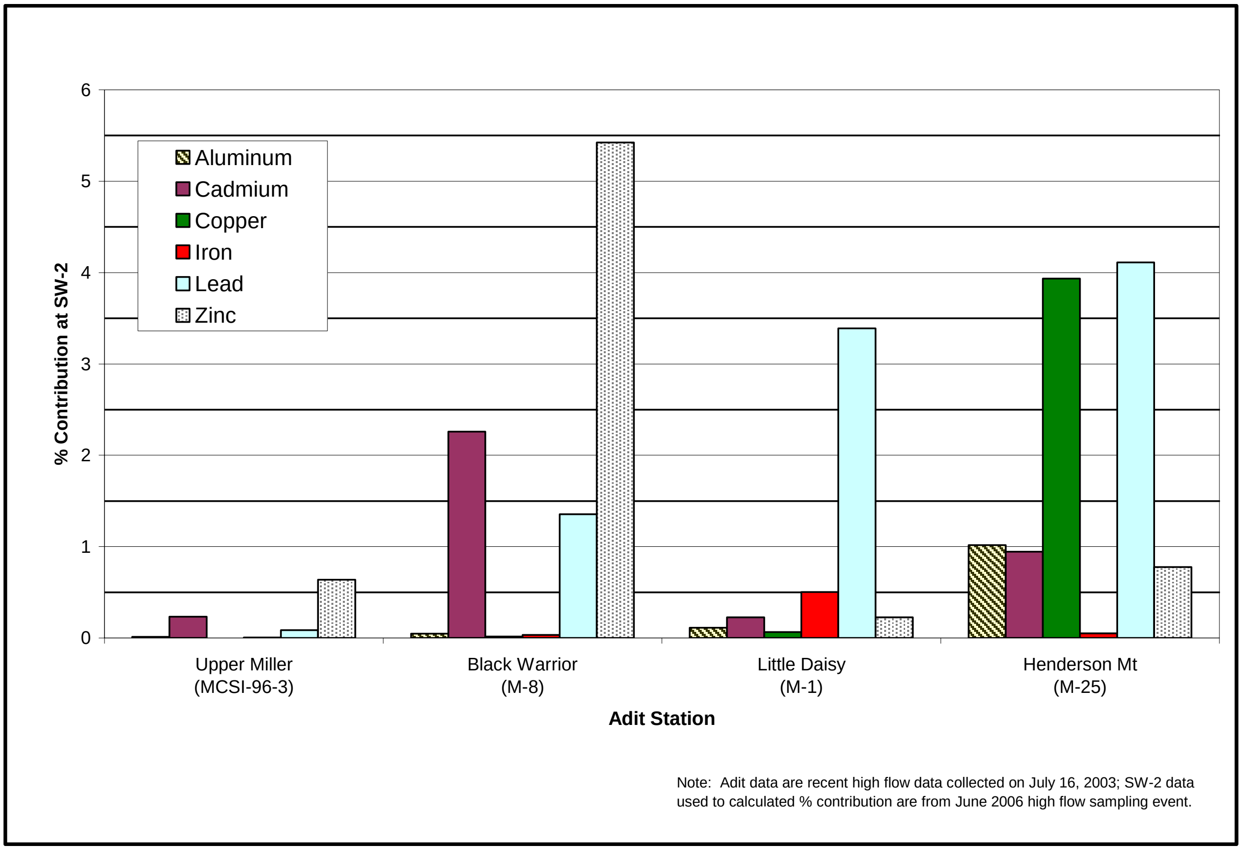


Figure 30 – % Contribution of Metal Loads at Station SW-2

The most recent sampling events from which loads in Miller Creek can be compared with the Little Daisy and Black Warrior adit discharge loads occurred during low flow conditions in the fall (i.e., SW-2, September 28, 2006; the Little Daisy and Black Warrior on September 23, 2004). The other two adits (Henderson Mountain and Upper Miller Creek) have only been sampled during high flow conditions. This comparison assumes that low flow discharges from the Little Daisy and Black Warrior adits remain relatively constant from year to year. During these recent low flow sampling events, loads in Miller Creek at SW-2 were one to two orders of magnitude lower compared to mean loads calculated for other periods due to lower concentrations and greatly reduced flows in 2006. While the adit discharge loads were lower in September 2004 compared to the high flow events, the relative contribution to loading from these two discharges is much greater than for other sampling periods. The Black Warrior Adit (a lead-zinc-silver mine) (station M-8) contributed 25% of the cadmium and 49% of the zinc loads measured at SW-2 (**Table 3-8**). Loading calculations indicate that the Little Daisy Adit (station M-1) contributed 71% of iron, 1,493% of manganese, and 25% of zinc loads measured at SW-2. As the Little

TABLE 3-8
PERCENT CONTRIBUTION OF ADIT METALS LOADING TO MILLER CREEK

Station ID	Aluminum		Cadmium		Copper		Iron		Lead		Manganese		Zinc	
	Load kg/mon	% At SW-2	Load kg/mon	% at SW-2	Load kg/mon	% at SW-2	Load kg/mon	% at SW-2	Load kg/mon	% at SW-2	Load kg/mon	% at SW-2	Load kg/mon	% at SW-2
Average of All Data														
MCSI-96-3	0.008	0.002	0.0001	0.2	0.0002	0.0005	0.007	0.001	0.0005	0.01	0.003	0.01	0.04	0.2
M-8	0.02	0.01	0.0006	0.9	0.003	0.01	0.1	0.02	0.01	0.2	0.009	0.03	0.1	1.0
M-1	0.04	0.01	0.0002	0.3	0.005	0.01	4.9	0.7	0.01	0.2	0.9	3.1	0.07	0.4
M-25	0.67	0.2	0.0007	1.0	0.8	2.2	0.08	0.01	0.02	0.5	0.04	0.1	0.08	0.5
SW-2	344	100	0.07	100	36	100	723	100	5.0	100	28	100	15	100
SW-5	715		0.19		66		1496		6.9		55		22	
Average of All High Flow Data														
MCSI-96-3	0.008	0.001	0.0001	0.09	0.00017	0.0002	0.007	0.0005	0.0005	0.004	0.003	0.005	0.04	0.1
M-8	0.02	0.002	0.0007	0.4	0.001	0.002	0.03	0.002	0.004	0.04	0.007	0.01	0.2	0.5
M-1	0.03	0.005	0.00003	0.02	0.004	0.01	0.5	0.04	0.007	0.1	0.1	0.2	0.01	0.04
M-25	0.7	0.1	0.0005	0.4	0.6	0.9	0.08	0.01	0.02	0.2	0.04	0.1	0.04	0.1
SW-2	686	100	0.15	100	71	100	1445	100	11.5	100	63	100	29.7	100
SW-5	1107		0.3		102		2318		12.3		99		37.5	
Recent High Flow Sampling Event*														
MCSI-96-3	0.008	0.012	0.0001	0.2	0.0002	0.0010	0.007	0.004	0.0005	0.087	0.003	0.02	0.04	0.6
M-8	0.03	0.05	0.001	2.3	0.003	0.016	0.05	0.03	0.01	1.36	0.01	0.08	0.3	5.4
M-1	0.08	0.11	0.0001	0.2	0.01	0.06	0.75	0.5	0.02	3.4	0.5	3.4	0.01	0.2
M-25	0.7	1.0	0.0005	0.9	0.6	3.9	0.08	0.05	0.02	4.1	0.04	0.2	0.04	0.8
SW-2	68	100	0.06	100	16.0	100	148	100	0.6	100	16.0	100	5.7	100
SW-5	16		0.03		6.3		63		0.3		3.1		6.3	
Most Recent Low Flow Sampling Event**														
M-8	0.03	2.5	0.001	25	0.001	0.3	0.03	1.0	0.001	4.9	0.002	2.5	0.1	49
M-1	0.01	0.9	0.0002	7	0.0009	0.4	1.9	71	0.0002	0.9	1.2	1493	0.07	25
SW-2	1.3	100	0.003	100	0.3	100	2.7	100	0.03	100	0.1	100	0.3	100

Notes: * Loads for recent high flow sampling event calculated using June 2006 data for SW-2 and SW-5; July 16, 2003 data used for adit discharges.
** Loads for most recent low flow sampling event calculated using September 2006 data for SW-2 (SW-5 was dry); September 23, 2004 data used for adit discharges.
kg/mon = kilograms per month

Daisy Adit discharges to talus below the adit with no direct connection to Miller Creek, this comparison of recent low flow data is only hypothetical.

In contrast to mean data for the entire period of record showing greater metal loads at SW-5 (**Table 3-8**), loads at SW-2 were much higher (182 to 508%) than those at SW-5 except for zinc (91%) during the most recent high flow sampling event (SW-5 was dry in April and September 2006). As the stream reach between SW-2 and SW-5 is a loosing reach under all but very high flow conditions, interpretation of loading data can be complicated. It is important to note that, despite high relative contributions from the Black Warrior and Little Daisy adit discharges shown in **Table 3-8** for the most recent sampling event, only copper exceeded aquatic standards at SW-2 or SW-5 in 2006.

3.6 LOADING ANALYSIS SUMMARY

Eight adit discharges have been identified in the District for which one or more COC is present at a concentration that exceeds the Circular WQB-7 aquatic standards and therefore may need either water treatment or some physical engineering means of source control to meet standards. In addition, three drains that convey water from upgradient of the McLaren Pit cap are also being evaluated for potential mitigation. Water quality data are summarized for these discharges in **Table 3-9** (median values); constituents that exceed the standards are in bold font.

There is significant variability in flow and water quality associated with the discharges listed in **Table 3-9** as illustrated in **Figures 31** and **32**. However, similarities in water quality between the sources allow for grouping the discharges based on similar water chemistries and/or other characteristics such as metals concentrations, flow rates, or COC mass loadings. To facilitate further evaluation of the discharges, five groups are identified in **Table 3-9** and shown in **Figure 31**.

Loading calculations show that contributions of metals from the McLaren Adit to Daisy Creek are minor except for iron (9.1%) and manganese (2.6%) at surface water monitoring station DC-2. These data indicate that there are other sources of metal loading contributing to Daisy Creek. One such source is the McLaren Pit drains (DCSW-101, -102, and - 103). During the 2006 fall low flow sampling event, the combined load from these drains contributes as much as 150% of the iron load and between 3.6 and 31.1% of the aluminum, cadmium, copper, manganese, and zinc loads at DC-2.

Comparison of water quality before and after initiation of Glengarry Adit closure and load contributions from adit drainage discharging into Fisher Creek indicate that water quality is improving in response to the grout/plugging project. Flow that discharged from the Glengarry Adit in September 2006 (2.0 Lpm; 0.5 gpm) still contributed 1% of the iron load measured at station SW-3, but all other metal loads were less than 0.5%. In April 2005, no discharge was present from the former Glengarry Adit portal. These data suggest that the closure project will be successful in reducing loads from the former adit.

The Glengarry Millsite Adit contributes 11.4% of the iron and 2.9% of the manganese loads measured at station SW-3. Following grouting of boreholes in the Gold Dust Adit, metal loads discharging from the adit in September 2006 were less than 0.5% as measured at station SW-4 except for iron, lead, and manganese (4.9%, 1.1%, and 3.8%, respectively). Relative contributions of metal loads from other adits discharging into Fisher Creek are minor.

Comparison of metal loads at adit discharge and Miller Creek monitoring stations indicates that the metal loading from adits is generally responsible for only very minor amounts of the total metal load at the nearest downstream monitoring station, SW-2. Despite metal contributions from adit discharges, only copper exceeded an aquatic standard at stations SW-2 or SW-5 in 2006.

TABLE 3-9
WATER QUALITY (MEDIAN VALUES), CONTAMINANTS OF CONCERN, AND WATER TREATMENT GOALS

Site Name by Adit Discharge Source Groupings	Flow (gpm)[1]	pH (s.u.)[2]	Acidity (mg/L as CaCO3)[3]	Concentration (milligrams per liter)									
				DO	SO_4^{2-}	HCO_3^-	Al	Cd	Cu	Fe	Pb	Mn	Zn
Group 1													
McLaren Pit Cap Subsurface Drains	23	**2.6**	631	4.4	840	0	**34.3**	**0.0126**	**16.8**	**166**	**0.007**	**4.2**	**2.23**
McLaren Adit	8	6.5	<2	6	311	64	**0.2**	**0.0005**	**0.018**	**16**	0.001	**0.92**	0.03
Glengarry Millsite Adit	4	**3.4**	38	7	88	0	**0.32**	0.0001	**0.121**	**7.45**	**0.002**	**1.0**	**0.12**
Group 2													
Little Daisy Adit	8	6.9	<2	5	294	210	**0.1**	**0.0004**	**0.016**	**3.05**	**0.02**	**1.02**	**0.095**
Group 3													
Gold Dust Adit [(4)]	3.6	6.8	<2	--	323	155	0.06	<0.0001	<0.001	0.62	0.001	**0.13**	0.04
Group 4													
Henderson Mt Adit	9	5.8	5	6	19	4	**0.395**	0.0001	**0.425**	*0.05*	**0.011**	*0.02*	0.055
Group 5													
Henderson Mountain Dump 7	1	6.7	<2	7	34	56	**0.105**	**0.0006**	**0.018**	**1.205**	**0.003**	**0.091**	0.045
Lower Tredennic Dump 1	2	6.6	<2	6	51	56	0.050	0.0001	0.003	0.15	0.0010	**0.120**	0.020
Sheep Mountain #1 (NDP)	2	6.2	<2	8	17	16	**0.100**	**0.0002**	**0.010**	0.19	**0.007**	0.020	0.050
Black Warrior Adit	3	7.5	<2	9	26	124	0.050	**0.0015**	**0.009**	0.30	**0.036**	0.022	**0.330**
Upper Miller Creek Dump	2	7.0	<2		12	59	0.050	**0.0004**	0.001	0.020	**0.003**	0.020	**0.110**
WQB-7 Chronic Aquatic Life Standard (Calculated for Hardness = 50 mg/l)							**0.087[5]**	**0.00016**	**0.005**	**1**	**0.001**	**0.05[6]**	**0.07**
WQB-7 Chronic Aquatic Life Standard (Calculated for Hardness = 100 mg/l)							**0.087**	**0.00027**	**0.009**	**1**	**0.003**	**0.05**	**0.12**

Notes
1 gpm = gallons per minute
2 s.u. = standard units
3 mg/L - milligrams per liter
4 Gold Dust data from September 2006 – post-borehole plugging.
5 Aluminum standard is based on dissolved concentrations and is applicable to water with pH between 6.6 to 9.0.
6 Manganese standard is a secondary MCL based on aesthetic qualities.
Bold indicates value exceeding WQB-7 chronic aquatic life standards at hardness adjusted 50 mg/L; actual hardness of receiving water varies

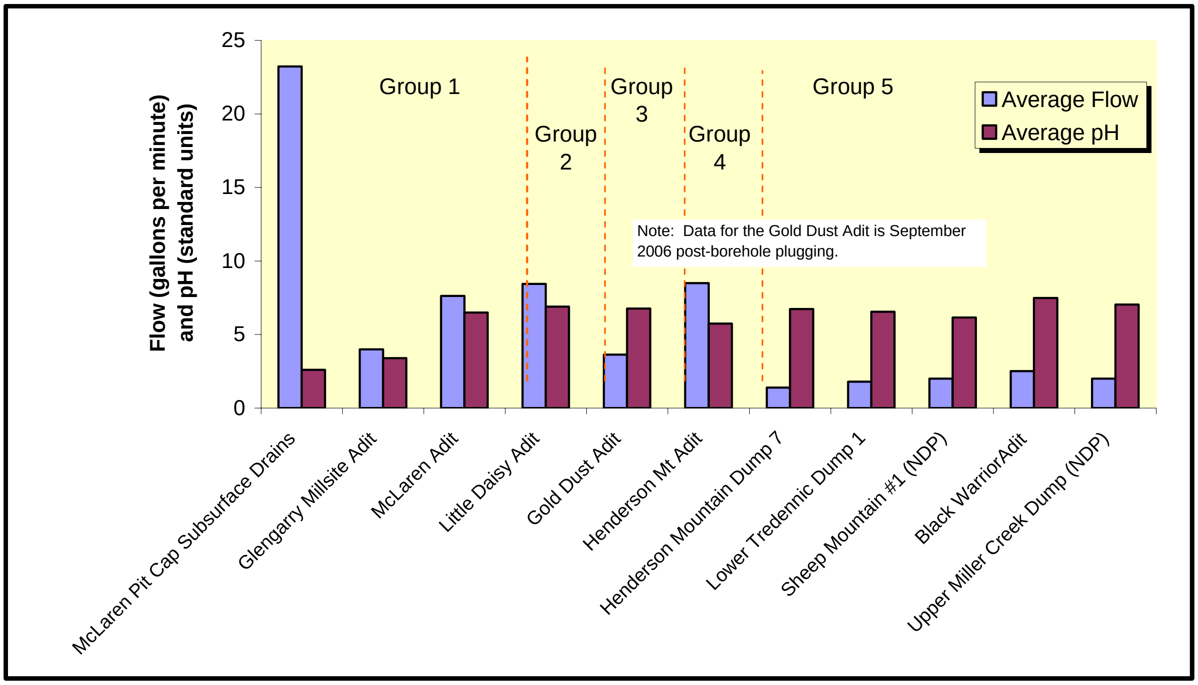


Figure 31. Comparison of average flow and pH from New World District adits being evaluated for water treatment.

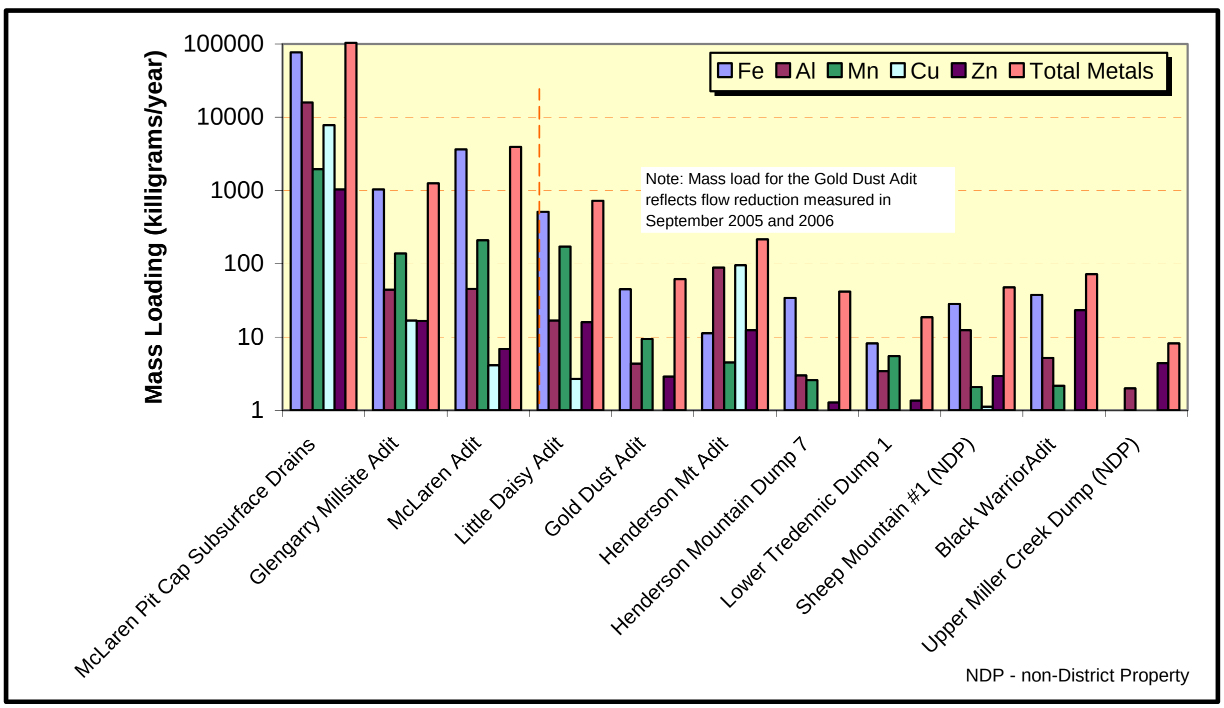


Figure 32. Comparison of annual metals loading from New World adits.

Recent analyses performed on samples collected during low flow conditions in fall 2004 indicate that M-1 (Little Daisy) and/or M-8 (Black Warrior) adit discharges contribute a considerable amount of the total cadmium, iron, manganese, and zinc loads measured at SW-2. Despite the high relative contribution from these two adits, concentrations of cadmium, iron, manganese, and zinc measured at SW-2 were well below applicable Circular WQB-7 surface water standards.

3.7 GROUNDWATER

Groundwater chemistry and flow characteristics vary widely in the District, predominantly influenced by geology. A summary of the extensive information present in project documents is presented here. Additional detail on groundwater flow and quality is presented in numerous reports available in the project library, a few of which are referenced in this report (Maxim, 2006; 2005b; 2004a; 2003b; 2001b; URS, 1998; 1997).

Groundwater occurs within two general hydrostratigraphic units in the area: unconsolidated sediments and consolidated bedrock. Unconsolidated sediments are thin relative to bedrock units and are primarily composed of colluvium, alluvium, and glacial deposits. Groundwater flow through unconsolidated material is diffuse, and the rate and direction of flow is usually more predictable than groundwater flow through bedrock units. The permeability and storage capacity of unconsolidated sediments are relatively very high compared to bedrock units.

Primary porosity and permeability within bedrock in the area is very low. As a result, groundwater flow in bedrock is primarily controlled by secondary permeability developed along fractures and joints. Bedrock permeability in the District is generally low (with a few exceptions) as evidenced by low sustained base flow from adits and springs, and low yields to wells and borings drilled in the District. Throughout the area, groundwater typically flows from mountain ridges to valley bottoms, but flow can be locally controlled by fracture orientation, geologic structures, and mine workings.

Water levels fluctuate widely in response to snowmelt and precipitation, with the greatest changes in water levels occurring in late June/early July in the headwaters areas of the District. Water level changes are greatest in bedrock, in some cases as much as 20 meters (65 feet) or more over the hydrograph year (Maxim, 2000). These water level changes may lag behind snowmelt and maximum surface water flows by as little as two to three weeks. Water levels typically fall as the summer progresses into autumn, but levels in shallow aquifers can rise in response to heavy rain or snow events.

Springs and seeps occur where groundwater intersects the topographic surface, and these features are often localized near the surface expression of fractures and/or geologic structures. As with surface flows, discharge rates from seeps and springs are variable and exhibit large seasonal variations.

A discussion of groundwater characteristics is presented in the following sections. The discussion is separated into the major geographic areas of the District, and includes a discussion of the potential impacts that adit discharges may have on groundwater quality.

3.7.1 McLaren Pit Area

Groundwater information for the McLaren Pit area has been assembled from data collected since 1989 when the first monitoring wells were installed by CBMI. The EPA conducted very detailed studies in the pit by drilling a number of waste rock, bedrock, and dye tracer injection wells in 1996 and 1997. The USDA-FS conducted further studies in the area below the pit between 2000 and 2006 with the drilling and sampling of additional monitoring wells.

Groundwater levels fluctuate widely in the McLaren Pit area as described in the previous section. Highest water levels are associated with the annual spring snowmelt period, with water levels in the waste rock beginning to rise in mid to late May as snowmelt percolates into the subsurface. Water levels in the waste rock peaked in early July in 1997 (URS, 1998) and in early to mid-June in 2005 and 2006 (Maxim, 2006). Water levels in bedrock wells trail those in the shallower waste rock wells by a week or two, but all wells reach peak water level elevation in June or July and then slowly decline until the following May (URS, 1998).

Groundwater flow in shallow bedrock units underlying the McLaren Pit is generally south to southeast (URS, 1998), and primarily moves through faults and fractures, as mentioned above. While this flow is complicated by fracture orientation, fracture density, and the geologic unit where fractures are present, it is evident from potentiometric surface elevations that groundwater in shallow bedrock beneath the pit has a vertical component of flow both downward and upward. Water level data collected from October 1996 through October 1997 show that vertical gradients are downward when water levels in the shallow waste rock are lowest to dry (October through May) and switch from downward to upward during the peak snowmelt period in late June and early July. This phenomenon is illustrated by higher water elevations measured in a shallow well completed in the Meagher Limestone (EPA-10) and a nearby companion well completed in waste rock in the pit (EPA-4) (URS, 1998). Other shallow bedrock wells in the McLaren Pit that are completed in the Meagher Limestone and Wolsey Shale exhibited water levels that rise above the elevation of the base of the pit.

Due to the complex geology, it is difficult to determine the degree of upward or downward movement of groundwater pit and therefore there is some uncertainty on whether groundwater in the waste rock in the pit is largely influenced by groundwater flow from bedrock. The EPA attempted to answer this question using groundwater tracing studies. Two tracing studies were completed by URS in 1997 and 1998 in the pit area, which involved injecting several different fluorescent dyes in tracer wells and then sampling nearby monitoring wells to determine the tracer flow path. Dye was injected during low water levels in August 1997. Two different dyes were used, and dye was injected into two wells located upgradient of the pit and completed in the Fisher Mountain Intrusive (Tracer 1 and 2). Dye from Tracer 1 was detected in a well located in Miller Creek and another well located in Fisher Creek, but this dye was not detected in any of the wells completed in the McLaren Pit. About six months following dye injection, dye injected in Tracer 2 was first detected in McLaren Pit wells completed in the Meagher Limestone and Wolsey Shale, and in a well in Miller Creek.

In May 1998, when water levels were considerably higher than during dye injection the previous year, two dyes were injected in Tracer 2 and monitoring well EPA-5, which is also completed in the Fisher Mountain Intrusive. Dye from these wells was detected shortly after injection in several of the bedrock wells completed in rock formations beneath the pit, in one of the waste rock wells in the pit, in several surface water tributaries draining the pit, in several locations in Fisher Creek, and in Miller Creek. The conclusion reached following the results of the two dye investigations completed in the McLaren Pit (URS, 1998) was that there was clear evidence to support a model where flow is beneath the McLaren Pit in bedrock and probably not via a pathway through the waste rock. This conclusion was based on the limited permeability of the waste rock and the higher permeability of the fractured bedrock system.

While the two dye studies focused on the interaction of groundwater in bedrock beneath the pit, the USDA-FS focused its investigation on the flow and quality of water in shallow colluvium and shallow bedrock in the area downgradient of the pit to the headwaters of Daisy Creek. Groundwater flow in the shallow groundwater system in this area is generally perpendicular to slope and toward Daisy Creek. Vertical hydraulic gradients are both downward and upward depending on where along the slope the wells are placed, and groundwater flow is likely influenced to some extent by the Crown Butte Fault

(**Figure 4**). URS (1998) noted the importance of the Crown Butte Fault in the transmission of dye into the Miller Creek drainage.

Groundwater quality in the McLaren Pit area is distinctly different depending on location relative to the pit, the Crown Butte Fault, and the geologic formation associated with the water. Background water quality varies considerably depending on the geologic formation, as shown in **Table 3-10,** where metals concentrations in well DCGW-100, which is completed in the Meagher Limestone at a depth of 235 feet upgradient of the McLaren Pit, are relatively low compared to metals concentrations in well Tracer 2, which is completed in the Fisher Mountain Intrusive upgradient of the McLaren Pit at a depth of 135 feet. Water in Tracer 2 is acidic and contains substantially higher concentrations of aluminum, cadmium, copper, and iron concentrations than the more neutral water intercepted by well DCGW-100.

TABLE 3-10
CONCENTRATIONS OF SELECTED PARAMETERS IN GROUNDWATER IN MCLAREN PIT AREA

Well Designation	pH (standard units)	Dissolved Metals (milligrams per liter) (1)						
		Al	Cd	Cu	Fe	Mn	Pb	Zn
Colluvial Wells								
DCGW-111S	5.26	5.72	0.024	7.44	0.97	5.56	0.011	2.96
DCGW-133	3.0	17.2	0.0068	6.6	16.5	2.24	0.005	0.82
DCGW-101S	4.07	1.81	0.0003	0.12	<0.01	0.18	0.002	0.06
DCGW-102S(2)	7.5	0.22	0.0002	0.005	0.81	0.4	0.01	<0.01
Bedrock Wells								
DCGW-101D	5.58	<0.05	<0.0001	< 0.001	< 0.01	0.34	<0.001	<0.01
DCGW-102D(2)	7.7	0.1	<0.0001	<0.001	0.1	0.3	<0.001	<0.01
MW-3	7.61	<0.05	<0.0001	<0.001	<0.01	0.26	<0.001	<0.01
Background Wells								
Tracer 2	3.96	63.8	0.0012	3.64	85.9	0.46	<0.001	0.17
DCGW-100	7.1	<0.05	0.0003	0.017	0.22	0.94	<0.001	0.04
Standard(3)	--	--	0.005	1.3	0.3	0.05	0.015	2.1

Notes: (1) Data from July 2006 sampling event unless otherwise noted (Maxim, 2006)
(2) Data from July 2003 sampling event (Maxim, 2004b)
(3) Montana DEQ human health standard, Circular WQB-7 (MDEQ, 2004); shading indicates exceedance of standard
-- Indicates not measured or not applicable

Downhill and downgradient of the former McLaren Pit, a zone of shallow groundwater exhibiting relatively low pH and high conductivity, sulfate, and metals concentrations extends toward the Crown Butte fault (wells DCGW-111S and -133; **Figures 3 and 4; Table 3-10**)(Maxim, 2006; 2004a; 2005b). This zone then parallels the fault and continues to Daisy Creek. The McLaren Pit is the source of acidic and metals laden groundwater in this zone that is caused by oxidation of pyrite and other sulfide minerals (Maxim, 2001b). Further downstream of where the fault intersects Daisy Creek, pH rises in groundwater as more carbonate rocks become dominant (wells DCGW-102S and MW-3; **Figure 3**), and metal concentrations fall below human health standards, except for iron and manganese concentrations (**Table 3-10**). Iron and manganese concentrations are ubiquitous in the District, as reflected in concentrations of these parameters measured in background wells (**Table 3-10**).

Work completed in 2002 and 2003 led to the conclusion that significant contaminant loading to Daisy Creek comes from contaminated surface water tributaries originating in the McLaren Pit area, and discrete zones of preferential flow of contaminated groundwater through shallow colluvial material. Tributary DCT-8 and a zone of more transmissive colluvium and fractured shallow bedrock associated with the Crown Butte Fault appear to be the primary conduits controlling transport of metals from the McLaren Pit to groundwater and ultimately to the manganese bog and Daisy Creek. Impacted shallow groundwater flowing downgradient in colluvium is believed to be redirected along the Crown Butte Fault, which seems to serve as a preferential pathway transporting contaminants to Daisy Creek. Tributary DCT-8 drains impacted water from the capped McLaren Pit area, including the McLaren subsurface drains (DCSW-101, -102, and -103). The McLaren Adit also eventually drains into Daisy Creek via tributary DCT-9 (**Figure 3**), which flows through the shallow groundwater area containing low pH and high metals.

3.7.2 Fisher Creek

Comparison of groundwater chemistry for wells completed in various bedrock units in Fisher Creek (**Table 3-11**) suggest several types of water quality depending on the host aquifer. **Figure 3** shows the locations of these wells. Water quality is most degraded in wells completed in sedimentary rock within the Como Basin and in rocks of the mineralized Fisher Mountain Intrusive Complex (**Table 3-11**).

Groundwater quality and water level data collected in the Como Basin indicate groundwater flow is controlled primarily by near vertical fractures, joints, and faults (Maxim, 2002a). Interconnectedness between fractures and joints appears moderate to minimal. Dissolved metals concentrations in groundwater appear to be highest in Como Basin wells during July, when groundwater levels are at their seasonal peak. However, in the Como Basin area, water quality trends with respect to well depth and formation completion are not evident (Maxim, 2002a). The poorest water quality is intercepted by wells located near the Glengarry adit underground workings (wells MW-1, EPA-11, and EPA-12). Except for iron and manganese, wells in Fisher Creek that are downstream of the Glengarry Millsite (MW-9A and -9B) and the Gold Dust (MW-10A and -10B), groundwater quality is in compliance with groundwater standards. Groundwater in lower Fisher Creek (MW-11) meets human health standards.

3.7.3 Miller Creek

There are several groups of wells in the Miller Creek drainage. Two groups of wells were installed to determine hydraulic characteristics of specific formations; MW-5P, a pumping well, and MW-5A, MW-5B, and MW-5C (observation wells) are located along and near the Crown Butte Fault zone in upper Miller Creek (**Figure 3**); MW-11A and -11P are located along the Daisy Pass Road near the Little Daisy Mine. The last well, MW-6, is located on non-District Property on the southwest flank of Henderson Mountain near the Alice E Mine. These wells have been monitored intermittently since 1989.

There is no water quality data for well MW-11P, as this well was only used for pump testing. For the MW-5 nest of wells in upper Miller Creek, groundwater is nearly neutral in pH and there are no exceedances of MDEQ's Circular WQB-7 human health standards (**Table 3-12**). These wells are the nearest wells downgradient of the Little Daisy Adit. Groundwater in well MW-6, located downgradient of the Alice E Mine, is acidic, and human health standards are exceeded for iron, manganese, and lead. There is no adit discharge from the Alice E. Mine, but downgradient of the mine and well MW-6 is the Alice E. Millsite seep. (This seep is a non-District Property). Water from the seep does not exceed surface water standards (see **Table 3-2**).

TABLE 3-11
CONCENTRATIONS OF SELECTED PARAMETERS IN GROUNDWATER IN FISHER CREEK

Well Designation	pH[(1)] (standard units)	Dissolved Metals (milligrams per liter) [(1)]						
		Al	Cd	Cu	Fe	Mn	Pb	Zn
Como Basin and Upper Fisher Creek								
EPA-11[(3)]	4.94	1.07	0.0032	0.005	233	10.1	0.035	0.75
Tracer-4[(2, 3)]	3.4	1.2	0.0005	0.295	105.5	8.46	0.010	1.76
Tracer-5[(2, 3)]	3.5	22.4	0.0017	5.07	54.95	0.86	0.004	0.38
MW-1[(4)]	5.02	0.36	0.0002	0.008	60	4.46	0.003	0.11
EPA-12[(5)]	6.46	<0.05	<0.0001	<0.001	34.3	1.88	<0.001	0.05
Glengarry Millsite Area Wells								
MW-9A[(6)]	5.11	<0.05	<0.0001	0.004	<0.01	<0.003	0.001	<0.01
MW-9B[(7)]	5.45	<0.05	<0.0001	<0.001	1.02	0.091	<0.001	<0.01
Gold Dust Area Wells								
SB-16[(7)]	4.8	<0.05	<0.0001	<0.001	0.54	0.18	<0.001	<0.01
MW-10A[(6)]	5.16	<0.05	<0.0001	0.017	<0.01	<0.003	<0.001	<0.01
MW-10B[(7)]	6.7	<0.05	<0.0001	0.002	2.33	0.2	<0.001	<0.01
Lower Fisher Creek								
MW-11[(7)]	5.31	<0.05	<0.0001	0.003	<0.01	<0.003	<0.001	<0.01
Background Wells								
Tracer-6[(2, 5)]	5.9	0.3	0.0008	0.150	19.3	3.09	0.001	0.06
MW-8[(2, 8)]	--	<0.1	0.0004	<0.001	0.03	0.005	<0.001	0.04
Standard[(9)]	--	--	0.005	1.3	0.3	0.05	0.015	2.1

Notes:
(1) Data from July 2006 sampling event unless noted otherwise
(2) Average data from Maxim, 2002c; pH is minimum value
(3) Well completed in Fisher Mountain Intrusive
(4) Well completed in Wolsey Shale
(5) Well completed in Scotch Bonnet Diorite
(6) Well completed in alluvium
(7) Well completed in Precambrian granite
(8) Well completed in Lulu Pass Rhyodacite
(9) MT WQB-7 (MDEQ, 2004); shaded cells exceed standard
-- Indicates not measured or not applicable
J Indicates value is estimated

TABLE 3-12
CONCENTRATIONS OF SELECTED PARAMETERS IN GROUNDWATER IN MILLER CREEK

Well Designation	pH (standard units)	Dissolved Metals (milligrams per liter) [(1)]						
		Al	Cd	Cu	Fe	Mn	Pb	Zn
MW-5A	7.2	<0.05	<0.0001	<0.001	<0.01	<0.003	<0.001	<0.01
MW-5P	7.3	<0.05	<0.0001	<0.001	<0.01	<0.003	<0.001	0.02
MW-6	4.2	5.49	0.0007	0.1	18.9	0.37	0.072	0.15
Standard[(2)]	--	--	0.005	1.3	0.3	0.05	0.015	2.1

Notes:
(1) Data from July 2004 sampling event (Maxim, 2005c); -- indicates not applicable
(2) Montana DEQ human health standard, Circular WQB-7 (MDEQ, 2004); shading indicates exceedance of standard

Spring data is often used as an indicator of groundwater quality and flow. More than 60 springs have been located, characterized, and sparingly sampled in the Miller Creek drainage since 1989. Analysis of spring data by Hydrometrics (1990) showed Miller Creek water belonged to one type of water (Type III), with water chemistry dominated by calcium, bicarbonate, and sulfate ions. This groundwater type contained low metal concentrations with a near neutral pH. Durst (1999) performed another study of springs in Miller Creek. Springs were divided into groups based on association with geologic formations, lineaments (e.g., faults), and those of unknown origin. Springs associated with geologic formations tended to have higher SC values than the other groups of springs. Four springs included in his analysis were from adits; thirteen springs produced iron staining on substrate below the spring discharge.

3.8 CONCEPTUAL MODEL

The majority of underground mines in the District were developed using adit entries. Adits were driven into mineralized and non-mineralized bedrock, including massive sulfide deposits. As an adit advances into mineralized rock, oxygen in the atmosphere reacts with certain minerals in the surrounding rock, accelerating acid-generating, oxidation reactions in the mine workings. These reactions produce acid, and, due to the resulting low pH associated with acid production, cause metals such as aluminum, copper, and iron to become soluble. As rain and snowmelt enter the mine workings through fractures, faults, and abandoned exploration borings, water becomes acidified and transports dissolved metals from the adit to surface water and groundwater.

Many adit discharges are greatly influenced by annual recharge from the melting snowpack. This is reflected by large variations in flow during the spring, and the tendency for these flows to diminish through the summer, to the point that several adits dry up in late August and September.

3.9 ADIT DISCHARGES REQUIRING RESPONSE ACTION EVALUATION

The characterization of the nature and extent of mining impacts related to adit discharges in the District indicates that some of the discharges present in the District contribute significant loads to tributary streams, while others have very minor impacts. Of the 11 discharges that exceed aquatic water quality criteria, two are located on non-District property. Regardless of the relative impacts of the Sheep Mountain No. 1 and Upper Miller Creek Dump discharges, no work can be conducted at these sites until a Certificate of Completion is received from the U.S. Government for District Property sites. Therefore, these two sites will be dropped from further evaluation in this EE/CA. **Table 3-13** lists the discharges that will be carried through the screening and evaluation of potential response action alternatives.

TABLE 3-13
DISCHARGE SITES REQUIRING RESPONSE ACTION EVALUATION

Site Name	Site No.	AIMSS Rank*	Discharge Flow Range (gpm)	Site Status**
Black Warrior	MCSI-96-2	2	0.1-10	Collapsed/Reclaimed 2005
Glengarry Millsite (includes middle adit)	F-8B	15	3.0-26.9	Open
McLaren Adit	D-18	17	1.8-29.6	Open
Little Daisy Adit and Dump	M-1	20	0.5-220	Collapsed/Reclaimed 2005
Gold Dust Adit	F-28	24	1.3-250	Closed/Reclaimed 2005
Lower Tredennic Adit	FCSI-96-5	26	0.6-5	Collapsed/Reclaimed 2001
Henderson Mountain Dump 7	AE-17	51	0.0-5	Collapsed/Reclaimed 2004
Henderson Mountain Adit	M-25	No rank	1.8-25	Collapsed
McLaren Pit Subsurface Drains	DCSW-101	No rank	6.8-32	Three drains under cap

Notes: * AIMSS - Abandoned and Inactive Mines Scoring System
** Reclaimed status indicates previous response action conducted at the site to remove waste rock or close the opening
gpm gallons per minute

4.0 RISK EVALUATION

A streamlined risk evaluation process is used to assess threats to human health and the environment associated with exposure to discharges in the District that were described in previous sections of this EE/CA. Risks are evaluated using site-specific chemical concentration data to provide an estimate of how and to what extent people, flora, and fauna might be exposed to the contaminants of concern using reasonable exposure scenarios. This streamlined risk evaluation examines risks under existing site conditions, assuming no cleanup activities are performed at the site. This streamlined risk evaluation was completed in accordance with EPA guidance for non-time-critical removal actions (EPA. 1993).

4.1 STREAMLINED HUMAN HEALTH RISK EVALUATION

The streamlined human health risk evaluation involves identifying contaminants of concern (COCs), determining the nature of exposures to COCs, and determining the toxicity of COCs. The evaluation is accomplished by evaluating available site data, identifying applicable human populations and exposure routes, reviewing toxicity data, and characterizing overall risk by comparing COC concentrations in water to previously derived risk-based cleanup guidelines. Human health risk-based cleanup guidelines were developed for abandoned mine sites by Montana's Mine Waste Cleanup Bureau (MWCB) using site data that was combined from over 200 abandoned mine sites in Montana (Tetra Tech, 1996).

4.1.1 Contaminants of Concern

COCs are contaminants that pose significant potential risks to human health. Standard EPA criteria that must be collectively satisfied to establish a COC are the following: (1) the contaminant is associated with mining wastes present at the site; (2) has an average concentration at least three times average background levels; and (3) has been measured at concentrations above the detection limit in at least 20% of the samples analyzed. The data used to determine if the discharges meet these criteria is presented in **Appendix A**.

For all the sites, trace metals that satisfy the first criteria include aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, manganese, nickel, silver, and zinc. Collectively, except for arsenic, chromium, mercury, nickel, and silver, these metals have been detected in more than 20% of the samples analyzed. The second criterion is more difficult to apply, since background levels in surface water range widely across the site, primarily as a function of surface water flow conditions and geology. Background conditions may not be as meaningful, then, in determining whether specific trace metals are associated with background conditions or historic mining disturbances.

Therefore, for the purposes of the human health risk assessment, those metals detected in more than 20% of the samples collected, cadmium, copper, lead, manganese, and zinc, are considered potential COCs. Aluminum in surface water is not considered a risk to human health, as there are no human health standards for aluminum in MDEQ's list of numeric water quality standards (MDEQ Circular WQB-7, 2004). Iron is generally considered nontoxic as well, and human health guidelines for iron are based on aesthetic properties such as taste, odor, and staining. Therefore, iron is not considered a COC for the adit discharge sites, as these sites are not used as a source of drinking water.

4.1.2 Exposure Assessment

An exposure assessment identifies potentially exposed human populations, exposure pathways, and typical exposure durations. Analytical results for adit discharge water samples are then used to estimate COC concentrations at exposure points and the potential intake of contaminants.

There is no residential use of District Property in or around any of the discharges considered in this EE/CA. Current human exposure to site-related contaminants in adit discharge water is via seasonal recreational activities that occur during the snow-free period in the District, which generally falls between the months of June and October. From late fall through the spring, access to the discharge sites is exclusively over snow, and during this period the adit discharge sites are covered with snow and do not pose a risk to humans.

Exposure pathways are limited to direct contact (dermal exposure) with discharge water and ingestion of water. Instances of direct contact might occur from wading through or in discharges, washing in discharge water, or using discharge water for other recreational pursuits such as gold panning. Ingestion would likely occur from incidental ingestion rather than purposeful drinking of water, since most of the discharges are non-palatable due to unpleasant odor and taste attributes that are mainly associated with iron and manganese staining and coloring. Both of the exposure pathways are likely to be minor, as relatively few people are exposed to the adit discharges during their recreational pursuits and because the majority of people recreating in the District are generally in the area for only a few days to a couple of weeks. Exposures on any one day are believed to be of very short duration, on the order of minutes.

Because there are no site specific data on exposure, the risk evaluation completed by MDEQ for abandoned mine sites (Tetra Tech, 1996) is used as a benchmark for human exposure to contaminated water. The MDEQ risk evaluation assumed four types of recreation populations: fishermen, hunters, gold panners/rock-hounds, and ATV/motorcycle riders. Evaluated exposure pathways included soil and water ingestion, dermal contact, dust inhalation, and fish consumption. For a risk evaluation that would be pertinent to the adit discharge sites, only the exposure scenario for the gold panner/rock-hounds would be similar to the potential exposure of humans to COCs in the District.

Exposure pathways for Gold panners/rock-hounds in the Tetra Tech analysis included dermal exposure to adit discharge water and consumption of adit discharge water. Exposure to contaminants involved an estimation of contaminant intake, contaminant concentration, contact rate with water, exposure frequency, exposure duration, body weight, and average time for pathway-specific exposures. For the water ingestion rate, the gold panner/rock hound was assumed to be more than 18 years of age and would consume 1 liter of water per day for 50 days per year. For dermal exposure, hands and forearms were considered to be the surfaces exposed for an exposure time that lasted 6 hours per day. A body weight of 70 kilograms (154 pounds) was assumed for an adult gold panner/rock hound and 15 kilograms (33 pounds) for a child gold panner. The exposure duration period was 30 years. The exposure point concentrations used in the calculations were the median values measured for each media.

4.1.3 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.

Toxicity is generally broken into two classes, carcinogenic and non-carcinogenic. For carcinogens, specific toxicity values are obtained from cancer slope factors; for non-carcinogens, chronic reference doses are used. For the District adit discharges, the only potential carcinogen of the COCs is cadmium. Cadmium is considered carcinogenic when it is inhaled in sufficient quantities to cause tumors in the trachea and lungs. Since cadmium present in water is not inhaled, it is not considered a carcinogen for this risk evaluation.

Chronic reference doses were determined in the Tetra Tech study for each of the COCs present at the adit discharge sites. These chronic reference doses represent the dose above that which would be expected to adversely affect human health. Chronic reference doses are measured in milligrams per kilogram per day.

4.1.4 <u>Risk Characterization</u>

Findings of the recreational scenario exposure assessment were combined with toxicity data for the COCs to characterize health risks posed to a gold panner/rock hound for the ingestion and dermal exposure routes (Tetra Tech, 1996). Risks were determined for individual routes of exposure and additive effects. The results of risk characterization provide a basis for decisions about the necessity to mitigate contaminant exposures at the site. For non-carcinogens, a critical chemical dose must be exceeded before a health effect is observed. The likelihood of an adverse health effect is represented by the ratio of a chemical exposure level and the chronic reference dose. This ratio is referred to as a hazard quotient (HQ), with any value greater than one indicating an adverse health effect may occur due to a chemical exposure. Hazard quotient values are summed across exposure pathways and for all chemical exposures to develop Hazard Index (HI) values.

Using the methodology and formulas developed in the Tetra Tech document, hazard indexes were calculated for each of the 8 adit discharges and McLaren Pit subsurface drains considered in this EE/CA. The exposure point concentration used in the calculation was the mean value measured at each site. A summary of the results is presented in **Table 4-1.** Supporting data is presented in **Appendix B,** with pertinent formulas and values used in this risk evaluation referenced from the following pages in the Tetra Tech document: page 34, Figure 4-2, Pathway Specific Formulas Used for Chemical Exposure Calculations; page 48, Table 4-6, Dermal Permeability Constants; Appendix A, page A-82, Estimated Noncarcinogenic HI for Gold Panner/Rock Hound (Adult Only – Ingestion – T/Weighted-Dermal) Exposures to Adit Discharges at Montana Abandoned Mines.

As shown in the table, only one site has a Hazard Index value greater than 1.0, the McLaren Pit subsurface drains. The HIs for the rest of the adit sites are less than one, indicating that these adit discharges do not pose a risk to human health. For the McLaren Pit subsurface drains, 98% of the HI score is due to ingestion of this water. The assumptions used for ingestion (Section 4.1.2) for the gold panner/rock hound include drinking one liter of water per day, 50 days per year, for 30 years. Since such a scenario is highly unlikely, the HI score for the McLaren Pit subsurface drains was recalculated for 0.25 liters of water (incidental ingestion) for 10 days per year for 30 years. The recalculation of the HI using this scenario is 0.20 (**Appendix B**). Because the exposure scenario under the second set of assumptions is also conservative, in that it is highly unlikely that a person would drink the water coming from the drains more than incidentally, water discharging from the McLaren Pit subsurface drains is not considered to present any risk to human health.

Table 4-1
HAZARD INDEX CALCULATIONS FOR ADIT DISCHARGES

Adit Name	Flow (gpm)	pH field (s.u.)	Total Recoverable Mean Concentration (milligrams per liter)					Hazard Quotient [1]		Hazard Index [2]
			Cadmium	Copper	Lead	Manganese	Zinc	Ingestion	Dermal	
D-18 McLaren	11.5	6.2	0.0008	0.026	0.002	0.85	0.04	0.3466	0.00756	0.35411
McLaren Pit Drains	21.7	2.6	0.014	17.7	0.007	4.5	2.3	2.7991	0.06152	2.86059
F-8B Glengarry Millsite	7.0	3.4	0.0006	0.16	0.002	0.89	0.1	0.3689	0.00806	0.37697
FCSI-96-5 Lower Tredennic	2.6	6.6	0.0001	0.003	0.002	0.11	0.03	0.0529	0.00098	0.05388
AE-17 Henderson Mt. Dump # 7	1.2	6.7	0.0007	0.017	0.003	0.1	0.06	0.0568	0.00094	0.05777
F-28[4] Gold Dust	3.63	6.8	0.00005	0.0005	0.001	0.13	0.04	0.0559	0.00115	0.05706
M-1 Little Daisy	18.1	6.8	0.0004	0.013	0.026	1.30	0.11	0.6301	0.01149	0.64160
M-25 Henderson Mountain	11.3	5.8	0.0003	0.43	0.008	<0.02 [3]	0.06	0.0646	0.00062	0.06525
M-8 Black Warrior	3.9	7.6	0.0012	0.01	0.041	0.03	0.3	0.2055	0.00036	0.20587

Notes:
1 Hazard Quotient (HQ) calculated by dividing site-specific dose for each chemical by a reference dose; formulas and calculations shown in Appendix B.
2 Hazard Index (HI) equal to the sum of the ingestion and dermal hazard quotients; a sum greater than 1 indicates a potential health hazard.
3 "<" value reported for the mean indicates parameter was below detection for all sampled dates, value shown is the greatest detection limit used.
4 Gold Dust data are September 2006 fall low flow sampling event post-borehole closure.
NDP = non-District Property; gpm = gallons per minute; s.u. = standard units.

4.2 STREAMLINED ECOLOGICAL RISK EVALUATION

The streamlined ecological risk evaluation was completed to assess the potential risk that adit discharges pose to wildlife and aquatic ecosystems. The evaluation was performed by comparing concentrations of COCs in the discharges 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 streamlined ecological risk evaluation is only intended to be qualitative.

The streamlined 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.

4.2.1 Contaminants of Concern

Using the same EPA criteria as discussed in Section 4.1.1, COCs that present a potential risk to wildlife and aquatic systems at the site are aluminum, cadmium, copper, iron, lead, manganese, and zinc. These elements are detected in more than 20% of the adit discharge samples and are associated with mining disturbances. As with the human health risk assessment, background levels in surface water range widely across the site, primarily as a function of surface water flow conditions and geology. Background conditions may not be as meaningful, then, in determining whether specific trace metals are associated with background conditions or historic mining disturbances. Therefore, for the purposes of this streamlined ecological risk assessment, aluminum, cadmium, copper, iron, lead, manganese, and zinc are considered potential COCs.

4.2.2 Exposure Assessment

Two groups of ecological receptors have been identified as potentially being affected by site contamination. The first group includes aquatic life residing in streams downstream of where discharges enter a surface water course. This population may be affected by concentrations of COCs that directly enter the receiving stream. The second group of receptors is wildlife that may utilize the discharge water for consumption.

Potentially adverse exposures of elevated metals to aquatic life and wildlife can be quasi-quantitatively assessed by comparing site-specific water quality criteria to toxicity-based criteria and standards. Exposure pathways for aquatic life include: 1) direct exposure of aquatic organisms to metals in surface water that exceed toxicity thresholds; and 2) ingestion of aquatic species (e.g., insects) that have accumulated contaminants by predators to the extent that they are toxic to predators (e.g., fish). Exposure pathways for wildlife include direct contact (dermal exposure) with discharge water and ingestion of discharge water. Instances of direct contact might occur from wading or swimming through discharges. Ingestion would likely occur from incidental ingestion rather than purposeful drinking, since most of the discharges would likely be avoided in preference to other easily obtainable sources of water, as the odor and taste attributes of adit discharges are likely less desirable.

Exposure pathways for aquatic species apply only for those adit discharges that reach a surface water body where aquatic species reside. The Lower Tredennic and Little Daisy percolate into the ground after leaving the collapsed adits and do not flow to surface water. The Black Warrior and Henderson Mountain Adit (M-25) discharge into Miller Creek. The Glengarry Millsite, Henderson Mountain No.7 (AE-17), and Gold Dust adits flow into Fisher Creek or into tributaries to Fisher Creek. The McLaren Adit and McLaren Pit subsurface drains flow into tributaries to Daisy Creek.

Exposure pathways for wildlife are likely to be minor as the adit discharges constitute only a small portion of the water available in the District, and, based on cursory observations of the sites, wildlife are not known to favor any discharge over other sources of water. Exposure to discharge waters on any day is thought to likely be of very short duration. The exposure period for wildlife, as with humans, would be limited to the snow-free period between the months of June and October. From late fall through the spring, the adit discharge sites are covered with snow.

4.2.3 *Ecological Effects Assessment*

The COCs are known to have toxic effects on aquatic species, which have led to the adoption of acute and chronic water quality criteria promulgated by the State of Montana (MDEQ, 2004). Criteria for cadmium, copper, lead, and zinc are calculated as a function of water hardness while aluminum and iron criteria are fixed numerical standards. An average hardness of 100 mg/L was used to calculate applicable hardness based standards for these elements. Manganese is not considered a risk to aquatic life according to MDEQ Circular WQB-7 standards.

There are many different wildlife species that could be exposed to COCs. These include birds, many species of mammals (including rodents, ungulates, shrews, rabbits, pikas, mountain lion, and bears), reptiles, and amphibians. For wildlife, many factors would influence the toxicity of COCs. These include body weight, growth rate, metabolic rate, ingestion rate, surface area of exposed skin, habitat characteristics, and population dynamics (e.g., habitat range, population density, and mating season). Unlike the human health toxicity assessment, toxicity of contaminants will range widely by species; for instance, toxicity to a meadow vol would be different than toxicity to elk, deer, or bear. Additional complications with assessing ecological effects include a lack of toxicity information on many species, especially species that inhabit the subalpine ecosystem that dominates the New World District. Because there are potentially a large number of wildlife species that could be exposed to the COCs, and because there are no site-specific exposure data available to make a generalized effects assessment, the effects assessment will focus on aquatic species rather than wildlife.

4.2.4 *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. This was accomplished by comparing mean concentrations of adit discharge water quality to acute and chronic aquatic standards. This comparison is somewhat limited because EPA 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 the District. In addition, toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, aquatic ecosystem. **Table 4-2** lists the adit discharge sites' water quality compared to aquatic standards.

Table 4-2
AQUATIC ECOSYSTEM RISK CHARACTERIZATION SUMMARY

Adit Name	Flow (gpm)	pH field (s.u.)	Total Recoverable Mean Concentration (milligrams per liter)						Direct Discharge?[1]	Impact Measured In Stream?[2]	Potential Risk Present?[3]
			Aluminum	Cadmium	Copper	Iron	Lead	Zinc			
McLaren (D-18)	11.5	6.2	**0.48**	**0.0008**	**0.026**	**17.2**	0.002	0.04	Yes	Yes	**Yes**
McLaren Pit Drains	20.8	2.6	**36.6**	**0.014**	**19.4**	**167**	**0.007**	**2.4**	Yes	Yes	**Yes**
Glengarry Millsite (F-8B)	7.0	3.4	**0.32**	**0.0006**	**0.16**	**9.37**	0.002	0.09	Yes	Yes	**Yes**
Lower Tredennic	2.6	6.6	<0.1[4]	0.0001	0.003	0.16	0.001	0.03	No	No	No
Henderson Mt. Dump # 7	1.2	6.7	0.07	**0.0007**	**0.017**	**1.17**	0.003	0.06	Yes	Yes	**Yes**
Gold Dust (F-28)*	3.6	6.8	0.06	0.00005	0.0005	0.62	0.001	0.04	Yes	No	**No**
Little Daisy (M-1)	18.1	6.8	0.083	**0.0004**	**0.013**	**6.17**	**0.026**	0.11	No	No	No
M-25	11.3	5.8	**0.4**	**0.0003**	**0.43**	<0.05[4]	**0.008**	0.06	Yes	No	No
Black Warrior (M-8)	3.9	7.6	<0.1[4]	**0.0012**	**0.010**	0.48	**0.041**	**0.3**	Yes	No	No
Acute Criteria			**0.75**	**0.00213**	**0.014**	**NA**	**0.082**	**0.1198**			
Chronic Criteria			**0.087**	**0.00027**	**0.0093**	**1**	**0.0032**	**0.1198**			

Notes:
1 A yes indicates discharge directly enters tributary or stream; a no indicates discharge infiltrates into ground and does not discharge to a stream.
2 A yes indicates surface water sampling downstream of discharge exceeds aquatic criteria (see Section 3.0); no indicates no impact measured in downstream sample.
3 Risk assumed to be present if 1 and 2 are both yes.
4 "<" value reported for the mean indicates parameter was below detection for all sampled dates, value shown is the greatest detection limit used.
* Gold Dust data are September 2006 low flow sampling event post-borehole closure.
NDP = non-District Property; gpm = gallons per minute; s.u. = standard units.

Table 4-2 shows that aquatic water quality standards are exceeded in all discharges except the Lower Tredennic Dump #1 Adit and the Gold Dust Adit. However, impacts to receiving waters immediately downstream of the adit discharges are not measured for the Black Warrior, Little Daisy, or the Henderson Mountain Adit (M-25), which means that these sites pose little to no risk to the aquatic environment. Impacts to receiving waters are evident as a result of discharges from the McLaren Adit, McLaren Pit drains, and Glengarry Millsite. Impacts from the Henderson Mountain Dump 7 adit in Fisher Creek are less clear, even though the criteria for aquatic risks are met (**Table 4-2**), primarily because the flow from this adit are relatively low compared to flows in Fisher Creek, and because the adit is a considerable distance from Fisher Creek.

5.0 RESPONSE ACTION SCOPE, GOALS, AND OBJECTIVES

The risk evaluation demonstrated that there is no human health risk associated with any of the discharges at the site and that ecological risks are likely associated with the McLaren Adit, McLaren Pit subsurface drains, Glengarry Millsite, and Henderson Mountain Dump 7. Environmental risks associated with these discharges appear in surface water tributaries that receive the discharges. Contaminants (aluminum, cadmium, copper, iron, lead, and zinc) present ecological risks to aquatic life from ingestion and direct contact. In addition, wildlife species may be at risk from these discharges, although a meaningful exposure assessment and risk characterization is difficult due to the lack of site-specific knowledge of both species characteristics and exposure conditions.

Twenty-eight discharges were inventoried in the District and identified in Section 3.0. Of these, 12 discharges were dry or only flowed for a brief period in 2004, and five discharges did not exceed water quality criteria for identified COCs. Of the remaining discharges, only four constitute a risk to the environment, as discussed above. The Gold Dust discharge does not pose any risk to human health or the environment, but the discharge still exceeds the Circular WQB-7 water quality guideline for manganese.

This section of the EE/CA presents the scope of the Adit Discharge Response Action and Response Action Objectives (RAOs) to meet project goals and applicable or relevant and appropriate requirements (ARARs).

5.1 SCOPE AND OBJECTIVES

The scope of this response action is directed at eliminating or reducing uncontrolled releases of metals from mining-related discharges. Reducing or eliminating contaminated discharges or treatment of acidic and/or metal-laden waters from the identified discharges will lead to a direct improvement in surface water quality in receiving streams. Improvements in surface water and groundwater quality are expected to result from implementation of all of the other response actions; however, the absolute amount of improvement is difficult to quantify and is expected to be quite variable between specific response actions.

As outlined in the Overall Project Work Plan (Maxim, 1999b), the overall goals for the response and restoration project are: 1) assure the achievement of the highest and best water quality practicably attainable on District Property, considering the natural geology, hydrology, and background conditions in the District; and 2) mitigate environmental impacts that are a result of historic mining. To meet these goals within the scope of the Adit Discharge Response Action, project-specific RAOs are:

- Prevent potential exposure through the food chain to metal contaminants from acid discharges to the extent practicable.
- Prevent or limit future releases of hazardous substances, pollutants, or contaminants.
- Comply with applicable or relevant and appropriate requirements (ARARs) to the extent practicable, considering the exigencies of the circumstances.

5.2 ARAR-BASED RESPONSE GOALS

Response action goals are primarily contaminant-based concentrations that are set by federal or state laws and regulations. For this project overall, the primary contaminant-specific ARARs apply to groundwater and surface water. A list of ARARs is presented in **Appendix C**.

5.2.1 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 this site, aquatic standards represent the surface water ARARs for this site. These goals are presented in **Table 5-1**. Enforcement of cleanup goals may be executed at specific water quality stations, in which case the cleanup goal for hardness dependent contaminants should be calculated based on the hardness at a specific stream station. The hardness-dependent goals shown in the table are based on a hardness of 100 mg/L.

TABLE 5-1
ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER

	Total Recoverable Metals (micrograms/liter)[(1)]						
	Aluminum	**Cadmium**	**Copper**	**Iron**	**Lead**	**Manganese**	**Zinc**
Goal	87	0.27	9.3	300	3.2	50	119.8

Notes: (1) Standards are in terms of total recoverable concentrations. Hardness based criteria are calculated for hardness = 100 milligrams/liter.

CBMI, with the support of the USDA-FS, petitioned the State of Montana Board of Environmental Review (Board) for temporary modification of water quality standards for certain stream segments in the District. The temporary standards are necessary so that improvements to water quality may be achieved by implementation of the response and restoration project. The Board approved a rule allowing temporary standards on specific reaches of Fisher Creek, Daisy Creek, and the headwaters of the Stillwater River on June 4, 1999. No temporary standards have been established for Miller Creek.

5.2.2 Groundwater

ARAR-based reclamation goals for groundwater are Montana Human Health Standards. Using these standards, ARAR-based goals for COCs in groundwater are shown in **Table 5-2**.

TABLE 5-2
ARAR-BASED RECLAMATION GOALS FOR GROUNDWATER

Chemical	Type [(1)]	Concentration (μg/L)
Arsenic	HHS (MCL)	20 (50)
Cadmium	HHS/MCL	5
Copper	HHS/MCL	1,300
Iron	MCL	300[(2)]
Lead	HHS/MCL	15
Manganese	MCL	50[(2)]
Zinc	HHS (MCL)	2,000 (5,000)

Notes: (1) HHS = Human Health Standard (MDEQ, 2004); MCL = Maximum Contaminant Level (EPA, 1996)
(2) Human health guideline for taste, odor, color.
μg/L = micrograms per liter

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6.0 IDENTIFICATION AND SCREENING OF RESPONSE TECHNOLOGIES

The description of the source, nature, and extent of contamination (Section 3.0) and the RAOs developed for mining-related discharges in the District (Section 5.0) provide the basis for development and screening of response alternatives for the Adit Discharge EE/CA. 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 defining response alternatives. The EPA guidance suggests that only the most qualified technologies that apply to the source of contamination be evaluated in detail in the EE/CA. Using this guidance, removal action activities were grouped into general response technologies that are considered reasonable approaches to mitigating identified risks and that are implementable.

This section of the report presents the potential response technologies, screens the technologies, and then develops alternatives. The alternatives are then evaluated in detail against three principal criteria in Section 7.0.

6.1 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 response actions and process options are specifically applied to either treatment of contaminated discharges or reducing or eliminating the flow of contaminants from mining-related discharges to surface water in the Daisy, Miller, and Fisher Creek drainages.

General response actions potentially capable of achieving RAOs and goals related to the treatment or reduction of mining-related discharges are screened for applicability in **Table 6-1**. Response actions include no action, institutional controls, engineering controls, and water treatment controls. The general response actions, technology types, and process options are also discussed in the following text. Screening comments are found in **Table 6-1**, and the logic and reasons for removing technologies or process options by screening are discussed in the text. Technologies and options retained for alternative development are shaded in **Table 6-1** and highlighted in the text.

6.1.1 No Action

No action means that there is no active response action implemented at a site. No action does include monitoring water quality and assessing site conditions on a regular annual basis. No action is generally used as a baseline against which other response options are compared; therefore, ***the no action alternative is retained*** for consideration in the detailed analysis of alternatives.

6.1.2 Institutional Controls

Institutional controls are used to restrict or control access to or use of a site (**Table 6-1**). Land use and access restrictions are potentially applicable institutional controls. Land use restrictions would limit the possible future uses of the land through the local forest management plan. 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-

TABLE 6-1
RESPONSE TECHNOLOGY SCREENING SUMMARY

General Response Action	Response Technology	Treatment or Process Technology	Description	Screening Comment
NO ACTION	None	Not Applicable	Includes water quality monitoring to assess site conditions on an annual basis.	Retained for comparison to other options. Allows on-going evaluation of site conditions.
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 barred 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	Near Surface Grout Curtain (portal or collar)	Drilling unconsolidated surficial material and or near surface fractured rock and filling fractures and porous voids using high or low pressure cement or bentonite grouting techniques to prevent infiltration or seepage.	Reduces surface water infiltration into near-surface fractures and workings, or may minimize seepage of water from workings into adjacent fractures. Effective in isolating near surface workings from surface water infiltration; readily implementable; best when used in conjunction with backfill of workings for optimum support.
		Flowing Fracture Grout Curtain	Drilling fractured rock zones and filling fractures using high-pressure cement or bentonite grouting techniques to stem or divert water flow.	Effective in stopping or reducing flow through fractures adjacent to workings. Diverts flow around workings. Readily implementable; best when used in conjunction with backfill of workings for optimum structural support.
		Cemented Backfill of Workings	Placing an aggregate based cemented backfill along sections of raise or tunnel for structural support and strength, and to restrict flow along the workings.	Effective in support of working to prevent collapse and protection of grout curtains; significantly restricts flow when installed tight to back; readily implementable.

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

TABLE 6-1 (continued)
RESPONSE TECHNOLOGY SCREENING SUMMARY

General Response Action	Response Technology	Treatment or Process Technology	Description	Screening Comment
ENGINEERING CONTROLS (continued)	Underground Flow Control (continued)	Acid Resistant Cement Tunnel Plugs	Placing a high strength, acid-resistant cement plug to block and seal workings in raises or tunnels to act as a seal or barrier to groundwater flow	Effective as a barrier or seal to water flow along workings or isolating select areas of underground workings in order to prevent the mixing of groundwater; readily implementable, most effective when used with backfill (but not required);.
	Containment (McLaren Subsurface Drains)	Cut-off Trench	Excavation of a trench upgradient of mine waste to intercept groundwater flow. Intercepted water is routed around the waste in an open channel.	Appropriate for interception of near-surface groundwater (generally less than 5 to 20 m) using conventional construction equipment. Effective in porous media but use in fractured bedrock makes uncertainty level high; not effective where upward vertical flow present. Generally implementable in unconsolidated materials; very difficult to construct in bedrock, especially at depths greater than 5 m. Trench stability would be a priority consideration. Cost expected to be high due to difficulty excavating to desired depth.
		Slurry Wall	Excavation of a trench upgradient of mine waste and emplacement of low permeable material in the trench that forces groundwater to move laterally around the waste.	Similar to cut-off trench except clay or cement used to provide a physical barrier to flow; uses conventional construction equipment. Effective in porous media but used in fractured bedrock makes uncertainty level high; not effective where upward vertical flow present. Generally implementable in unconsolidated materials; very difficult to construct in bedrock. Cost expected to be high
		Grout Curtain (linear emplacement)	Involves drilling closely spaced boreholes upgradient of mine waste into unconsolidated surface material and bedrock, and injecting cement or bentonite grout under high or low pressure to prevent lateral movement of groundwater.	Pressure grouting reduces permeability in materials near borehole; overlapping boreholes create grout curtain that provides a physical barrier to groundwater flow; uncertainty lies in knowledge of groundwater flow paths and how flows will adjust after grouting. Implementable with conventional drilling and grouting equipment. Cost expected to be very high.

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

TABLE 6-1 (continued)
RESPONSE TECHNOLOGY SCREENING SUMMARY

General Response Action	Response Technology	Treatment or Process Technology	Description	Screening Comment
WATER TREATMENT CONTROLS	Passive Treatment Technologies	Infiltration/Natural Attenuation	Discharges directed to sub-surface drain field. As discharge infiltrates into the ground, aeration, dispersion, precipitation, and other chemical and biological attenuation processes act to reduce COC concentrations.	Appropriate only for sites that have low potential for contaminant impacts, such as sites with very low flows and/or very low metal loads.
		Aerobic and/or Anaerobic Bioreactors	Various designs rely on metabolic activity of microorganisms to attenuate COCs primarily through precipitation as metal sulfide mineral phases.	Not all metals are amenable to formation of sulfide minerals (e.g., aluminum and manganese). In such cases, it may be necessary to couple a bioreactor with other treatment technologies.
		Constructed Wetlands	Reduce COC concentrations through biological attenuation/reduction.	Unlikely to function for more than a few months per year due to long, harsh winters in the New World District.
		Passive Chemical Adsorption/Ion Exchange	Synthetic and/or natural aluminum and iron oxyhydroxides and synthetic zeolites adsorb metal cations from water through ion exchange reactions.	Treatment is most applicable to low flows and low concentrations of dissolved metals or as a polishing step following other treatments. Adsorbing substrate would need to be removed and replaced periodically when retention capacity is exceeded.
		Limestone Drains and Manganese Removal Cells	Limestone drains add alkalinity to waste streams thereby facilitating precipitation of metal hydroxide mineral phases. Manganese removal cells are modifications of limestone drains that allow sufficient residence time for precipitation of manganese oxides.	Open limestone channels and sequential alkalinity producing systems would be applicable for some discharges but anoxic limestone drains would not be applicable as a stand-alone technology. Limestone drains would need to be cleaned periodically.

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

TABLE 6-1 (continued)
RESPONSE TECHNOLOGY SCREENING SUMMARY

General Response Action	Response Technology	Treatment or Process Technology	Description	Screening Comment
WATER TREATMENT CONTROLS (continued)	Active Treatment Technologies	Ion Exchange	Inorganic zeolites or synthetic organic resins provide a solid immobile substrate to capture charged particles.	Typically involves use of multiple treatment vessels to ensure continuous treatment. Susceptible to interference by calcium, sodium, chloride, and sulfate. Easily clogged by suspended solids.
		Reverse Osmosis	Pumps used to force water through a semi-permeable membrane / filter.	Requires reliable power supply, heated facility, and regularly scheduled maintenance.
		Chemical Addition, Precipitation, and Micro-filtration	Chemical agents added to waste water stream to increase and/or decrease pH facilitating precipitation of insoluble mineral phases. Residual suspended solids removed by micro-filtration.	Packaged, skid-mounted systems are commercially available. Year-round access required for routine monitoring and maintenance.
		Coagulation/Flocculation	Metal salts added to waste water dissolve and form precipitates to which oppositely charged COC particles and molecules adsorb. The adsorbed compounds are then removed by sedimentation and/or filtration.	Because of the excess of iron and/or aluminum compared to other trace metals in many adit discharges it is unlikely that addition of extra metal salts would be required for treatment.
		Thermal Evaporation	Contaminated water is evaporated, which generates solid wastes that require disposal at an appropriate facility.	Significant energy is required and evaporation removes water from the watershed.

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

term public safety. These options are ***retained*** to complement clean up and safety actions and will be combined with other process options.

6.1.3 Engineering Source Controls

Engineering source controls are used to reduce the mobility of contaminants by reducing or eliminating the flow of a contaminated adit discharge. In an underground mine application, engineering controls are used to stem water inflow or outflow from the mine or to provide structural support or strength to materials or mine workings. Underground engineering controls may include grout curtains, cemented backfill, or watertight cement plugs (**Table 6-1**). Engineering controls generally do not reduce the volume or toxicity of hazardous materials.

6.1.3.1 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, these controls minimize the impacts of discharging contaminated water to surface water. Typically, these flow controls do not reduce the toxicity or volume of the water because underground flows are usually diverted to other pathways, typically the pathways used before the underground workings were constructed.

Methods such as near-surface grout curtains in unconsolidated materials or fractured bedrock around shallow near-surface workings are often accomplished by drilling these materials and filling fractures and porous voids using high- or low-pressure cement or bentonite grouting techniques to prevent infiltration or seepage into the mine. Near-surface grouting is typically used around portals or raise or shaft collars and is typically used in conjunction with plugs or backfill. These techniques can also be used to structurally stabilize near-surface workings. The objective of grouting is to reduce surface water infiltration into near-surface fractures and workings, or to minimize seepage of water from workings into adjacent bedrock fractures. Grouting often works best when used in conjunction with backfilling of adjacent workings for optimum ground support and or with a portal plug. For these reasons, a near-surface grout curtain is generally not used as a "stand-alone" technique to stem water inflows or outflows from mines, but rather is typically used in conjunction with ground stabilization around a portal plug or portal backfill.

Grout curtains placed into fracture systems that act as pathways for water flowing into mine workings are usually constructed by drilling fractured rock or fault zones and filling fractures using high-pressure cement or bentonite grouting techniques. These grout curtains are very effective at stemming or diverting water flow into the mine workings. Water is typically diverted into pre-mining flow path fractures. As with shallow grout curtains, flowing fracture grout curtains function best when used in conjunction with adjacent backfill in the workings to provide long-term structural support of the grouted fracture system and the surrounding ground.

Cemented backfills are constructed by placing aggregate-based, cemented backfill along sections of raises or tunnels for structural support and strength, and to restrict water flow along the workings. Cemented backfills are often used to support workings to prevent collapse, thereby providing protection of grout curtains or adit plugs. Cemented backfills significantly restrict water flow when installed tight to the back of the workings. When used in this manner, these fills effectively become elongated "watertight" plugs.

Cement plugs that act as watertight barriers or seals to groundwater flow are appropriate technologies when underground flows need to be controlled, diverted, or eliminated. Cemented plugs are constructed by placing a high strength, sometimes acid-resistant, cement plug to block and seal workings in raises or tunnels, thus acting as a seal or barrier to groundwater flow. Cement plugs are also effective as a barrier or seal to water flow along workings or isolating select areas of underground workings in order to prevent mixing of groundwater. Cement plugs are most effective when used with a backfill for ground support to prevent damage to the plug should that portion of the mine collapse; however, this is not always required. Cement plugs are also more effective when used in pairs; one plug is placed outboard of the inflow to stop the flow of water toward the portal and hold back most of the hydrostatic head; a second plug is placed closer to the portal to act as a backup to block any water that bypasses the first plug.

One of the most important underlying characteristics in understanding water movement through rock in the New World District is that all of the bedrock flow is the result of secondary porosity and permeability, or flow in fractures or along faults. There are no true porous media bedrock aquifers in the District. The degree of interconnection of fractures appears to be fair to poor with overall hydraulic conductivities ranging from 10^{-4} to 10^{-5} centimeters per second (cm/sec). Hydraulic conductivities in fault zones can be much higher. Cement plugs and fracture fill grout curtains can be designed to yield hydraulic conductivities in the range of 10^{-6} to 10^{-8} cm/sec. Therefore, once a cement plug or grout curtain is used to effectively seal the adit or fracture system, flow will preferentially occur in the higher transmissivity rock adjacent to the plug. This likely diverts water into flow paths along pre-mining fractures.

Each of these alternatives uses common underground mining practices, with equipment that is readily available, and site- or application-specific designs. Shallow, surface grout curtains are typically only used in combination with watertight cement plugs installed in adit portals and shaft or raise collar areas where the plugs are used to shut off flow to underground workings. Likewise, cement backfills are most typically used as ground support around underground grouted fracture systems or surrounding tunnel plugs. For these reasons, ***underground flow control techniques are retained*** as a possible response action.

6.1.3.2 CONTAINMENT

The containment options listed in **Table 6-1** focus on solving the unique problems associated with the McLaren Pit subsurface drains. Containment technologies, other than those discussed in the previous section, are not appropriate for the other adit discharges. As described in Section 2.6.1, the subsurface drains were constructed underneath the McLaren Pit cap to drain off water seeping from bedrock near the McLaren Pit highwall. While there is some evidence that the source of water in the drains is from deeper bedrock sources (see Groundwater discussion in Section 3.7.1), some component of flow may be moving laterally into the waste rock through fractures intercepted by open pit. In an attempt to prevent groundwater from moving laterally through the capped waste rock, containment would try to isolate the wastes from upgradient sources of groundwater by constructing a physical barrier to groundwater flow. Containment of wastes at contaminated sites is a fairly common and effective technique that has been employed for decades in the United States, United Kingdom, and Europe, as well as other countries. While the term containment usually means contaminants are isolated on a site, the containment options discussed here for the McLaren Pit would intercept or block lateral migration of groundwater through the capped waste rock. These options would not affect the component of flow that is vertically upward. The physical containment barriers considered for the McLaren Pit include a cut-off trench, slurry wall, and grout curtain.

A cut-off trench is a shallow trench that would be excavated upgradient of the McLaren Pit cover. The depth of excavation would be determined by the elevation of the base of the waste rock in the pit so that the trench intercepts any groundwater that could move laterally between the cover and the base of the waste rock. Excavation would be done with conventional excavators that have the capacity to reach design depths. Typically, a cut-off trench would be constructed one to two meters wide, and about 430 meters (1410 feet) long upgradient of the McLaren Pit. Excavated materials would be sidecast along the trench margin. The trench has to have self-supporting walls; if not, another option such as a slurry wall would have to be considered, Groundwater that collects in the trench would be routed to a point at either end of the trench and discharged to the surface.

The effectiveness of a cut-off trench in intercepting groundwater would be considered poor to fair, as the trench is unlined and cannot prevent water from flowing through the bottom or downgradient side of the trench. Constructing a trench (implementability) upgradient of the McLaren Pit to a sufficient depth (estimated to be as much as 35 meters) would be extremely difficult and would be expected to become more difficult with depth due to the nature of excavating fractured bedrock. In addition, the site of the excavation in the area of the highwall will have very limited space for both equipment and the sidecast spoils. Costs are expected to be moderate to high due to the depth of excavation required and would depend on the difficulty of excavating bedrock.

A slurry wall is constructed in the same manner as a cut-off trench except that a structural liquid containing bentonite clay, cement-bentonite mixture, or cement earth mixture would be used to backfill the trench. The slurry hydraulically shores the trench to prevent collapse and forms a filter cake to reduce ground water flow. Slurry walls have been effectively constructed at hundreds of sites in the United States, typically to depths of up to 30 meters. Excavating to depths greater than 30 m would be accomplished with a clam shell bucket and crane, but this technology is only practical in unconsolidated materials. The most effective design for a slurry wall is to key the wall into a low permeability layer at the bottom of the trench so that groundwater cannot flow under the wall.

Slurry walls are more effective in preventing lateral flow of groundwater than cut-off trenches because the trench is sealed, especially where it can be keyed into an impermeable layer at depth. As the trench walls are supported, the ability to excavate to greater depths is improved. The same constructability issue described above for a cut-off trench applies. Costs for this technology are expected to be high with much of the added expense over a cut-off trench associated with procuring, delivering, and mixing slurry materials.

Grout curtains provide a similar barrier to groundwater flow as slurry walls except that, rather than excavating a trench, grout is injected into the subsurface through drilled boreholes. Injection is achieved using a variety of equipment and methods, but all systems use pressure to force grout into rock fractures and openings. Conventional drilling equipment is used to drill boreholes. Borehole spacing is dependent on fracture density and orientation and is done in phases such that primary holes are bracketed by secondary holes, and secondary holes are bracketed by tertiary holes until the desired permeability is reached. For the McLaren Pit, a curtain more than 430 meters (1,400 feet) long would be required, resulting in hundreds of holes and thousands to tens of thousands of meters of hole drilled. The most common grouts used in this application are bentonite and cement mixtures, similar to those used to plug the Glengarry Adit, Como Raise, and boreholes in the McLaren and Gold Dust adits. Grout would be selected to have long-term performance under acidic conditions.

A grout curtain would be more effective than a slurry wall or cut-off trench because the maximum depth of the curtain (35 meters) could be attained. There would be some uncertainty and unpredictability in how groundwater flow paths would adjust to the grout curtain. The technology is implementable, although it would require several hundred boreholes and considerable quantities of grout to produce an effective curtain. However, the cost to install a grout curtain is expected to be very high, as drilling closely spaced holes is expensive and material transport costs would be high.

One overriding consideration for containment options at the McLaren Pit is the uncertainty of the portion of flow that moves laterally through the capped pit area and the portion of flow that moves vertically into the capped waste from bedrock below. Dye tracer results and potentiometric heads in bedrock monitoring wells in the pit indicate that some portion of flow is upward from bedrock. As containment options described above do not affect this portion of flow, the overall effectiveness of each of the three options will be negatively impacted. For this reason, as well as for effectiveness and implementability issues associated with cut-off trenches and slurry walls, and the very high costs associated with grout curtains ***containment technologies are not retained*** for the McLaren Pit subsurface drains.

6.1.3.3 Adit Groups by Site and Engineering Characteristics

There are a number of physical characteristics that the adit sites and associated underground workings share that allow the sites to be divided into groups based on the kinds of engineering underground flow controls that might be applicable. **Table 6-2** shows the eight adits under consideration for stemming water flow using an engineering response action grouped by site and engineering characteristics.

Before implementing underground flow controls, underground workings need to be reconditioned such that safe access can be gained. With safe access to the underground workings established, an assessment of the condition and suitability of the workings can be made relative to the application of Engineering Source Controls. Source controls would be used to stem inflows to underground workings or to reduce or eliminate mine outflows. Currently, only three of the eight mine adits being examined in this EE/CA are accessible (**Table 6-2**). (The Gold Dust Adit was blocked with an earthen closure to exclude access to the workings in 2005, but the workings are still considered accessible for this evaluation as the earthen plug can easily be removed).

The goal of stemming or eliminating flow from adits requires sufficient length to the workings to be able to construct an engineering barrier. In addition, it is important that the source of water inflow to the mine be a sufficient distance in the mine to allow constructing a barrier outboard of the inflow and not too close to the surface or adit opening. Plugs placed too close to the surface or portal redirect flow into fractures in adjacent rock, which in turn will likely discharge to the surface. This may eliminate a point source discharge, but does little to remedy the underlying problem of contaminated water discharge. Watertight plugs are also known to work better in pairs, so it is best if there is enough length in the adit to construct two plugs. Therefore, short or shallow adits are generally not suitable for closure by engineering source control methods. Adits listed in Group C in **Table 6-2** are deemed too short to effectively stem outflows with any of the Engineering Source Control technologies identified in **Table 6-1**. These adits include Henderson Mountain Dump 7, Glengarry Millsite Adit, and Henderson Mountain Adit.

Flowing fracture grout curtains are not needed in either the McLaren Adit or the Gold Dust Adit, the only two mines that are accessible and were previously assessed for a potential engineering closure (**Table 6-2**). Both of these mines have underground workings that are suitable for constructing a two plug closure system. These sites may also require the use of cemented backfill in the workings to provide ground support for the plugs. These mines are assigned to Group A (**Table 6-2**). Other mines with workings of sufficient length for flowing fracture grout curtains or tunnel and portal plugs are assigned to Group B and include the Little Daisy, Lower Tredennic, and Black Warrior mines

TABLE 6-2
ADIT GROUPS BY SITE AND ENGINEERING CHARACTERISTICS

Adit Groups	Workings Accessible	Likelihood of Inaccessible Workings Being Open	Length of Workings Mined (feet)	Fracture Grout Curtain	Suitable for Tunnel Plug	Amenable to Flow Control Technology
Group A						
McLaren Adit	✓	Poor	423 open 1,770 mined	None Needed	✓	Yes
Gold Dust Adit	✓	✓	2,300	None Needed	✓	Yes
Group B						
Little Daisy Adit		Fair to Poor	2,385	Unknown	Possible Unknown	Unknown Reopen
Lower Tredennic		Poor	821	Unknown	Possible Unknown	Unknown Reopen
Black Warrior		Fair	425	Unknown	Possible Unknown	Unknown Reopen
Group C						
Henderson Mtn. Dump 7		Fair	25-60	Short Adit	Short Adit	No
Glengarry Mill Site Adit	✓	✓	40	Short Adit	Short Adit	No
Henderson Mountain Adit		Poor	20-40?	Short Adit	Short Adit	No

(**Table 6-2**). However, as these mines are inaccessible, the workings would require reopening and assessment before the appropriateness of using and Engineering Source Control alternatives to reduce or eliminate the discharge could be fully evaluated.

6.1.3.4 Reopening Inaccessible Mines

Reopening inaccessible mines is generally costly, is entered into with no guarantee of success, and is potentially rife with uncertainty. Rock quality and the age of a mine are two attributes that can be used to provide some estimate of reopening success, however. For example, the Glengarry Mine, although old (1920s-1934), was driven in fractured but fairly solid intrusive rock, and was known to have been reopened by the Montana Department of Natural Resources and Conservation (DNRC) in 1974. It was likely, then, that it could be successfully reopened again, as it was in 2001. A different example is the Little Daisy Adit, which was probably last mined in about 1918. In the late 1920's, Lovering, a geologist with the US Geological Survey, could only access the first 427 meters (1,400 feet) of the 701 meters (2,300 feet) of workings (Lovering 1929). Presumably, the workings behind the backfilled portal would be much less likely to have remained open without caving since that time.

Table 6-2 identifies those sites (Group B) that, if reopened, might be amenable to stemming flow using one or more of the response action technologies identified in **Table 6-1.** These sites include the Little Daisy, the Lower Tredennic, and the Black Warrior. The workings at these mine range in length from 130 to 701 meters (425 to 2,300 feet)(**Table 6-2**). **Table 6-2** also qualitatively assesses the likelihood of inaccessible workings being open based on age and estimates of rock quality. The likelihood of inaccessible workings being open in the Little Daisy Mine is rated as "fair to poor" for the reasons discussed in the paragraph above. The Lower Tredennic is rated as "poor" because the mine was only most recently operated in the early 1900's and the collar of the portal occurs in a relatively gently sloping area subject to near-surface fracturing and weathering. The Black Warrior Mine is rated as "fair", despite the fact that it was last mined 85 years ago, because the mine is driven in dolomite, which is a massive, dense, geologic unit with excellent rock quality properties. In addition, the raise to surface from the Black Warrior Adit was open to depth as late as 1993, when it was backfilled by CBMI.

6.1.4 <u>Water Treatment Controls</u>

Water treatment control technologies use either active or passive treatment technologies (**Table 6-1**) to treat contaminated discharge once it has left the adit portal. Numerous water treatment technologies are presently available for removing contaminating compounds from aqueous media. Treatment technologies considered here are not an exhaustive listing of all potentially applicable water treatment processes, but rather represent a range of processes that are potentially suitable for the water type and the goals for treated effluent quality. Water treatment technologies evaluated include a range of conventional, innovative, and industry-specific methods that span the expected range of process effectiveness, implementability, complexity, and cost.

Median water quality data for discharges, initially discussed in Section 3.0, are presented again in **Table 6-3**. **Table 6-3** groups the discharges by discharge chemistry type and lists the Circular WQB-7 aquatic water quality standards that are the goals for treated water. Highlighted cells in **Table 6-3** indicate constituents whose median concentration values exceed Circular WQB-7 standards. The constituents of concern (COCs) identified at the discharge sites are divalent (Cd^{2+}, Cu^{2+}, Fe^{2+}, Pb^{2+}, Mn^{2+}, and Zn^{2+}) and/or trivalent (Al^{3+}, and Fe^{3+}) metal ions. Therefore, only treatment technologies that are applicable to metals removal are included in the preliminary technology screening.

TABLE 6-3
WATER QUALITY (MEDIAN VALUES), CONTAMINANTS OF CONCERN, AND WATER TREATMENT GOALS

Site Name by Adit Discharge Source Groupings	Flow (gpm)[1]	pH (s.u.)[2]	Acidity (mg/L as CaCO3)[3]	Concentration (milligrams per liter)									
				DO	SO_4^{2-}	HCO_3^-	Al	Cd	Cu	Fe	Pb	Mn	Zn
Group 1													
McLaren Pit Cap Subsurface Drains	23	**2.6**	631	4.4	840	0	**34.3**	**0.0126**	**16.8**	**166**	**0.007**	**4.2**	**2.23**
McLaren Adit	8	6.5	<2	6	311	64	**0.2**	**0.0005**	**0.018**	**16**	0.001	**0.92**	0.03
Glengarry Millsite Adit	4	**3.4**	38	7	88	0	**0.32**	0.0001	**0.121**	**7.45**	**0.002**	**1.0**	**0.12**
Group 2													
Little Daisy Adit	8	6.9	<2	5	294	210	**0.1**	**0.0004**	**0.016**	**3.05**	**0.02**	**1.02**	**0.095**
Group 3													
Gold Dust Adit [4]	3.6	6.8	<2	--	323	155	0.06	<0.0001	<0.001	0.62	0.001	**0.13**	0.04
Group 4													
Henderson Mt Adit	9	5.8	5	6	19	4	**0.395**	0.0001	**0.425**	*0.05*	**0.011**	*0.02*	0.055
Group 5													
Henderson Mountain Dump 7	1	6.7	<2	7	34	56	**0.105**	**0.0006**	**0.018**	**1.205**	**0.003**	**0.091**	0.045
Lower Tredennic Dump 1	2	6.6	<2	6	51	56	0.050	0.0001	0.003	0.15	0.0010	**0.120**	0.020
Sheep Mountain #1 (NDP)	2	6.2	<2	8	17	16	**0.100**	**0.0002**	**0.010**	0.19	**0.007**	0.020	0.050
Black Warrior Adit	3	7.5	<2	9	26	124	0.050	**0.0015**	**0.009**	0.30	**0.036**	0.022	**0.330**
Upper Miller Creek Dump	2	7.0	<2		12	59	0.050	**0.0004**	0.001	0.020	**0.003**	0.020	**0.110**
WQB-7 Chronic Aquatic Life Standard (Calculated for Hardness = 50 mg/l)							**0.087[5]**	**0.00016**	**0.005**	**1**	**0.001**	**0.05[6]**	**0.07**
WQB-7 Chronic Aquatic Life Standard (Calculated for Hardness = 100 mg/l)							**0.087**	**0.00027**	**0.009**	**1**	**0.003**	**0.05**	**0.12**

Notes
1 gpm = gallons per minute
2 s.u. = standard units
3 mg/L - milligrams per liter
4 Gold Dust data from September 2006 – post-borehole plugging.
5 Aluminum standard is based on dissolved concentrations and is applicable to water with pH between 6.6 to 9.0.
6 Manganese standard is a secondary MCL based on aesthetic qualities.
Bold indicates value exceeding WQB-7 chronic aquatic life standards at hardness adjusted 50 mg/L; actual hardness of receiving water varies

A brief description of each water treatment control technology is presented below, along with general operational information and comments regarding applicability for implementation within the New World District. A preliminary analysis of each identified treatment technology is also provided to facilitate screening. Those technologies that meet identified goals and objectives and are potentially applicable to District discharges are retained for detailed analysis (shaded rows in **Table 6-1**). Technologies deemed infeasible and/or ineffective based on preliminary evaluation are dropped from further consideration.

6.1.4.1 EVALUATION AND SCREENING APPROACH

Evaluation and selection of the appropriate water treatment technologies for contaminated water sources is often a complex process. There are numerous technologies available and many are only effective against a small subset of potential constituents. Selection of a water treatment technology for application in the New World District is additionally complicated by several factors including:

- Numerous sources that have varied flow rates and contaminant concentrations
- Inability to combine water sources for treatment due to geographical constraints
- Very low treatment goals (Circular WQB-7) and target levels for several constituents
- The remoteness and limited physical and seasonal accessibility of the sites
- The lack of a power source to identified discharges
- The extremely high elevations and harsh climate of the sites
- The pristine nature of areas surrounding the District

In general terms, water treatment processes can be divided into two groups based on infrastructure requirements and the level of activity required to operate the systems. Passive and/or semi-passive technologies require limited infrastructure and, once installed, require no or very limited human involvement to maintain and operate. These technologies offer significant advantages over conventional active treatment approaches at remote sites like those in the New World District. The use of chemical addition and energy consuming treatment processes are virtually eliminated with passive treatment systems. In addition, the requirement for constant site access for process monitoring and equipment maintenance is removed. However, for many of these technologies, it is unclear if the technology can treat the discharge water to the stringent aquatic water quality standards required and/or how long a particular technology will function before needing replacement.

In contrast, active treatment requires a supporting infrastructure, some form of power, and periodic routine maintenance. While active technologies can potentially be very effective at removing metals to the low aquatic standards imposed in the New World District, the remoteness of the sites and inaccessibility to the sites for much of the year suggests that the successful implementation of these technologies could be difficult and expensive. Thus, implementation of active treatment technologies with the greatest likelihood of meeting all water quality standards would require major road improvements, a reliable source of power provided by construction of new electrical power lines and/or on-site diesel generators, construction of numerous structures to house equipment, and increased vehicular traffic necessary to move personnel and supplies. These types of infrastructure improvements would have long-term affects on the local environment and would likely impact the pristine nature of the surrounding area. During the evaluation process, these factors were carefully considered such that a retained technology would have a high likelihood of meeting water quality standards while having a minimal impact on the natural qualities of the area.

Applicable response technologies and process options summarized in **Table 6-1** are further described and screened in the following sections. Water treatment technologies have been divided into two groups: active and passive or semi-passive. The treatment technologies evaluated in this EE/CA include:

- Passive Systems
  - Infiltration
  - Anaerobic bioreactors
  - Constructed wetlands
  - Passive chemical adsorption or ion exchange
  - Limestone drains

- Active Systems:
  - Ion exchange
  - Reverse osmosis
  - Chemical addition, precipitation, and micro-filtration
  - Coagulation/Flocculation
  - Evaporation

6.1.4.2 Passive Treatment Technologies

❖ *Infiltration-Natural Attenuation*

Infiltration would convert discharges from surface flows to subsurface flows where natural attenuation process (e.g., adsorption, precipitation, and dilution) would be more likely to occur. Discharges would be collected and directed to a subsurface drain field from which it would infiltrate the ground. The infiltration system would rely on gravity flows; there would be no power or ongoing maintenance requirements. The infiltration system would aerate the discharge resulting in the precipitation of iron and co-precipitation of other metals. Infiltration would also tend to enhance dispersion and dilution of the discharges.

The term "natural attenuation" describes a set of processes that include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.

Natural attenuation processes are typically occurring at all sites, but to varying degrees of effectiveness depending on the types and concentrations of contaminants present and the physical, chemical, and biological characteristics of the soil and groundwater. Natural attenuation processes may reduce the potential risk posed by site contaminants in three ways:

1. Transformation of contaminant(s) to a less toxic form through destructive processes such as biodegradation or abiotic transformations;
2. Reduction of contaminant concentrations whereby potential exposure levels may be reduced; and
3. Reduction of contaminant mobility and bioavailability through sorption onto the soil or rock matrix.

Generally, infiltration-natural attenuation would only be appropriate for sites that have a low potential for contaminant migration, such as when flows and/or contaminant loads are low and/or when the attenuation capacity of the soil matrix is very high. Discharges in the New World district that may be amenable to treatment by infiltration include those in Group 5, which have low flow rates (less than 11

Lpm [3 gpm]) and low metals concentrations (on average approximately 1 x 10^{-5} moles/L). ***Infiltration-Natural Attenuation processes are retained*** for future consideration.

- BIOREACTORS (AEROBIC AND/OR ANAEROBIC)

Bioreactors rely on the metabolic activity of microorganisms to transform contaminants to less toxic and/or immobile species. Microorganisms can accelerate metal oxidation reactions and thereby promote the precipitation of metal oxyhydroxides. Conversely, many bacterial species can facilitate metal and sulfate reduction and promote the removal of metals from the aqueous phase by the precipitation of metal sulfide solids.

Various design configurations are employed for bioremediation including horizontal flow aerobic wetlands, horizontal flow anaerobic wetlands, vertical flow wetlands (see Section 6.2.3), and anaerobic bioreactors (also known as sulfate-reducing bacteria bioreactors).

Subsurface bioreactors have been employed successfully for metal removal at numerous sites including those at high elevations with a climate similar to that of the New World District (Christensen, Laake et al., 1996; Gusek, 1998; Skousen, Rose et al., 1998; URS, 2003). Due to the reactions that occur within the bioreactors, soluble organics, nitrogen compounds, and residual sulfides that are produced need to be removed from the effluent prior to release. This is typically accomplished by placing an aerobic polishing cell downstream from the anaerobic bioreactor.

Anaerobic bioreactors can be constructed with either a solid reactant (solid substrate bioreactors, such as composted cow manure, sawdust or alfalfa hay (Drury, 1999), or a liquid reactant (liquid-reactant bioreactors), such as, methanol, ethanol or ethylene glycol (Tsukamoto, Miller et al., 1999; Greben, Maree et al., 2000). Liquid reactant bioreactors can overcome three deficiencies associated with solid-reactant systems: decreases in permeability with time, decreasing substrate reactivity, and freezing in cold climates (URS, 2003).

Often, an anaerobic bioreactor is coupled with other treatment technologies to maintain the effectiveness of the system and ensure that all the metals are removed. Sulfate reducing bacteria are generally most active in the pH range of 5 to 8, and therefore when influent waters are very acidic (i.e., pH < 4) anoxic limestone drains (see below) can be placed upstream of the bioreactor to add alkalinity and ensure that conditions are optimal for sulfate reduction (Hammack, et al., 1994). The primary mechanism of metals removal is through precipitation as metal sulfide mineral phases. Not all metals are amenable to formation of sulfide minerals (e.g., aluminum and manganese) and therefore are not effectively removed within the bioreactor. However, aluminum and manganese can be removed downstream of the bioreactor in an aerobic polishing pond or by passing the bioreactor effluent through an oxic limestone channel (see below).

Anaerobic bioreactors can be designed to handle a wide range of flows and metals concentrations. These systems alone, or in combination with other technologies, as discussed above, would be appropriate for discharges with acidic to alkaline pH, and that have sulfate concentrations in excess of total metals concentrations, which includes discharges in Groups 1 through 4.

These systems are passive or semi-passive, could be operated with minimal maintenance, and have been successfully used at other mine sites for metal treatment. ***Aerobic and anaerobic bioreactor processes are retained*** for future consideration.

❖ CONSTRUCTED WETLANDS

Constructed treatment wetlands have been used at numerous ARD sites for water treatment to remove heavy metals. Because of long, harsh winters that are characteristic of the District, it is unlikely that constructed wetlands could function for more than a few months out of the year. ***Constructed wetlands are not retained*** for future consideration.

❖ PASSIVE CHEMICAL ADSORPTION/ION EXCHANGE

Passive chemical adsorption and/or ion exchange reactions remove metal contaminants from water by absorbing cations or exchanging inherent cations for other aqueous phase cations on a basis of ion selectivity. Synthetic and natural iron and aluminum oxyhydroxides strongly adsorb numerous metal cations and natural and synthetic zeolites have been shown to be very effective for removing metal ions from waste water through ion exchange reactions (Cornell, et al. 1996; Langmuir 1997).

This treatment approach would be most applicable to low flows and low concentrations of dissolved metals or as a polishing step following other treatments. There is a finite adsorption/exchange capacity with any material, and, because of the passive nature of the systems, when retention capacity is exceeded, the material would need to be replaced and disposed off site. The systems could be sized, however, to last for numerous years before needing replacement. Adit discharges in Group 5 would be most amenable to treatment with this passive technology. ***Passive chemical Adsorption/ion exchange processes are retained*** for future consideration.

❖ LIMESTONE DRAINS AND MANGANESE REMOVAL CELLS

Limestone drains add alkalinity to mine wastewater streams and thereby facilitate the precipitation of metal (hydr)oxide mineral phases, removing precipitating species from the aqueous phase and promoting sorption of other trace metals.

Limestone ($CaCO_3$) is used extensively for treatment of ARD to increase the pH of waste water and promote metal removal by enhancing precipitation reactions (Ziemkiewicz, et al., 1997; Cravotta and Trahan, 1999). Treatment with limestone is generally passive or semi-passive and is used in various system configurations such as open limestone channels, anoxic limestone drains (ALD), and vertical flow reactors or sequential alkalinity producing systems. The adit discharges considered for treatment in the District are oxic with measured DO levels greater than 4 mg/L. While open limestone channels and sequential alkalinity producing systems would be applicable for treatment of some of the discharges, anoxic limestone drains would not be applicable as a stand alone technology.

As discussed previously, anoxic limestone drains coupled to anaerobic bioreactors could help to add alkalinity and maintain the reactors at a pH that supports optimum sulfate reducing biotic activity. Anoxic limestone drains would therefore be appropriate in treatment trains for treating acidic water from Group 1 discharges. Several of the flows contain aluminum and/or manganese that exceed water quality standards; these contaminants may not be removed effectively in an anaerobic bioreactor. For these flows in Groups 1 through 4, positioning an open limestone channel downstream from the bioreactor would enhance aluminum and manganese removal. In addition, manganese is the only COC that exceeds the applicable water quality standard in flows from the Gold Dust adit and Lower Tredennic Dump 1, both of which are oxic and have a pH above 6.5. For these flows, an open limestone channel could effectively remove manganese as a stand-alone treatment technology. A modification of the open limestone channel is the manganese removal bed, which is a lined pond filled with limestone that provides a residence time sufficiently long to allow manganese oxides to precipitate.

Manganese removal beds would also be applicable for those systems that have manganese as the primary COC, such as the Gold Dust Adit and Lower Tredennic Dump 1. ***Limestone drains and manganese removal cells are retained*** for future consideration.

6.1.4.3 Active Treatment Technologies

- *Ion Exchange*

Ion exchange is a reversible reaction wherein an ion (an atom or molecule with an electrical charge) in solution is exchanged for a similarly charged ion attached to an immobile solid particle. The solid ion exchange particles are either naturally occurring inorganic zeolites or synthetically produced organic resins. The synthetic organic resins are most commonly used today because their characteristics can be tailored to specific applications. This alternative can achieve high quality effluent, and is most applicable when used as a polishing step for production of high purity water.

The ion exchange treatment process typically involves emplacement of multiple pressure treatment vessels to ensure continuous treatment. System redundancy is required so that one reaction vessel can be operated while others are on standby or in the regeneration mode. Ion exchange reactions are susceptible to interference by competing ions such as calcium, sodium, chloride, and sulfate, and the systems are easily clogged by suspended solids. Therefore, extensive pretreatment to remove suspended solids and competing ions may be required to achieve effluent goals at some of the discharge sites. In addition, ion exchange resins are susceptible to poisoning through the non-reversible incorporation of certain ions on exchange sites. Resins must be regenerated using acid and/or caustic solutions, which generate waste brine that must then be treated on site or disposed off site. Depending on influent water quality, waste brine might be classified a hazardous waste, which would significantly increase disposal costs. The ability of the treatment process to consistently achieve water quality goals and maintain reactivity without extensive water pretreatment for discharges with high total dissolved solids (TDS) is uncertain. Because many of the discharges being evaluated have relatively clean water with potentially low TDS levels and suspended solids, ion exchange may provide an appropriate polishing step for discharges in Group 5. ***Active treatment using ion exchange processes are retained*** for future consideration.

- *Reverse Osmosis*

Reverse osmosis uses a membrane that is semi-permeable, allowing the fluid being purified to pass through, while rejecting contaminants that remain. Reverse osmosis, also known as hyperfiltration, will remove particles as small as ions from a solution. Reverse osmosis is used to purify water and remove salts and other impurities in order to improve the color, taste, or other properties of the fluid. It is used to produce water that meets the most demanding specifications that are currently in place.

Most reverse osmosis technology uses a process known as crossflow to allow the membrane to continually clean itself. As some of the fluid passes through the membrane, the rest continues downstream, sweeping the rejected species away from the membrane. The reject water (called *retentate* or *waste brine*) requires further treatment and/or disposal. The process of reverse osmosis requires a driving force to push the fluid through the membrane, and the most common force is pressure from a pump. The separation of ions with reverse osmosis is aided by charged particles and is therefore very effective for removing divalent and trivalent metal ions.

Reverse osmosis membranes are susceptible to fouling and therefore must be inspected often and periodically cleaned using specialized cleaning solutions. Often pretreatment of feed water is required for optimized treatment efficiency. Pretreatment can consist of pressure filtration, softening, treatment with antiscalants, and/or water heating.

Reverse osmosis has been used effectively for treatment of various mine wastewater streams. However, reverse osmosis requires a reliable power supply, significant infrastructure including a heated facility to house the equipment, disposal of waste brine, and regularly scheduled routine maintenance. These factors suggest that reverse osmosis may have limited applicability for water treatment at sites in remote locations with limited access. However, this proven technology has a high probability of treating the mine discharges to the aquatic standards required for the discharge sites.

In the New World District, reverse osmosis may be applicable as a polishing step in a treatment train for discharges in Groups 1 through 4 if other technologies are unable to treat discharges to acceptable levels. However, due to the infrastructure, power, and the high maintenance requirements, ***reverse osmosis is not retained*** for future consideration.

- *CHEMICAL ADDITION, PRECIPITATION AND MICRO-FILTRATION*

Water treatment using this technology involves addition of chemical agents to the wastewater stream to change the chemistry (e.g., increase and/or decrease pH) and facilitate precipitation of insoluble mineral phases. Treatment of acidic water that contains elevated concentrations of metals through pH adjustment is a demonstrated technology capable of treating large volumes and can, under some conditions, remove metals to acceptable levels (Skousen, et al., 1998; Smith, 2000). Low pH water can be neutralized or made alkaline by the addition of readily available additives such as sodium hydroxide ($NaOH$), calcium hydroxide (hydrated lime, $Ca(OH)_2$), or calcium oxide (lime, CaO). The mechanism for removal of constituents is primarily through precipitation, co-precipitation, and/or sorption reactions. As acidic waters increase in pH, many metals become supersaturated with respect to various mineral phases and these species are precipitated from solution. Other COCs can co-precipitate and/or sorb to surfaces of the precipitating minerals (Stumm and Morgan, 1981). In addition, kinetic limitations on redox reactions and the formation of certain mineral phases are overcome at more alkaline pH levels (Cornell and Schwertmann, 1996). Following metal precipitation, which removes the bulk of the metals, residual fine suspended particles are removed by micro-filtration, which is used as a polishing step. Depending on the water quality of the waste stream, residual waste solids may be considered a hazardous waste.

Packaged, skid-mounted systems consisting of membrane modules, recirculation pumps, in-place cleaning loop, backpulse mechanism, instrumentation, and controls are commercially available and require a minimal footprint. The systems would require routine monitoring and maintenance and year-round access. This technology would be most applicable for treating Groups 1 through 4 discharges containing elevated iron and aluminum, which would form the bulk of the precipitate and provide adsorption sites for other trace elements and nucleation mass for flocculation formation. ***Chemical addition, Precipitation, and Micro-filtration processes are retained*** for future consideration.

- *COAGULATION/FLOCCULATION*

The process of coagulation involves the addition of metal salts that dissolve, undergo hydrolysis, and form precipitates in the treatment system. The amorphous precipitates that form during coagulation provide adsorption sites for oppositely charged particles and/or molecules. These charged compounds can then be removed from solution by attachment to the precipitates, a mechanism referred to as surface complexation, facilitating physical removal by sedimentation and/or filtration. This technology has been used effectively to remove metals from mine wastewater streams and domestic drinking water supplies.

The process of metal removal with this technology is approximately equivalent to that discussed above for chemical addition/precipitation. The discharge waters of concern in the New World district, in general, contain a molar excess of iron and/or aluminum when compared to other trace metals (e.g., cadmium, copper, lead, manganese, and zinc). It is therefore unlikely that the addition of extra metal salts to remove the trace heavy metals would be required for treatment of discharges from Groups 1 through 4. Such a process is more applicable to discharges in Group 5 but other technologies are available that would require much less infrastructure, maintenance, and would be equally effective for metals removal. ***Coagulation and Flocculation processes are not retained*** for future consideration.

- *THERMAL EVAPORATION*

Thermal evaporation uses energy to evaporate contaminated water and generates solid wastes that contain the contaminants. Solids that are generated can then be disposed off site in an appropriate disposal facility.

Thermal evaporation is generally applicable to low flows and requires significant energy resources. The generated solids can contain relatively high levels of contaminants and therefore require disposal as a hazardous waste, which increases disposal costs. In addition, evaporation would remove water from the watershed. Implementation of this technology would require emplacement of infrastructure to house and protect the units and delivery of power to each location where used. ***Thermal Evaporation processes are not retained*** for future consideration.

6.1.4.4 SUMMARY OF WATER TREATMENT TECHNOLOGIES

In this section, several technologies have been discussed and evaluated for potential applicability in treating metals-contaminated discharges in the District. Results of the initial technology screening are shown in **Table 6-4**. Six of the ten technologies discussed in Section 6.1 will be retained for further evaluation.

The treatment technologies listed in **Table 6-4** are thought to be the most applicable for treating the varied water quality present in the nine District Property discharges. As there is considerable variability in flow rates and water quality associated with the discharges listed in **Table 6.2** and illustrated in **Figures 31** and **32**. However, as discussed in Section 3.4, similarities in water quality between the discharges allow for consolidation based on similar water chemistries and/or other characteristics such as metals concentrations, flow rates, or COC mass loadings. Therefore, rather than evaluate each of the potential treatment technologies against each discharge, the discharges have been grouped and technologies have been evaluated according to the likely effectiveness in relation to discharge characteristics. These groups are the following:

TABLE 6-4
RESULTS OF WATER TREATMENT TECHNOLOGY SCREENING

Treatment Technology	Retained	Rejected
Infiltration/Natural Attenuation	✓	
Anaerobic bioreactors	✓	
Constructed wetlands		✓
Passive chemical adsorption/ion exchange	✓	
Limestone drains	✓	
Ion exchange	✓	
Reverse osmosis		✓
Chemical addition-precipitation-micro filtration	✓	
Coagulation/Flocculation		✓
Thermal evaporation		✓

1. Group 1 discharges can be described as acid rock drainage (ARD). Water quality from this group is of the poorest quality, with acidic pH, relatively high metals concentrations, and elevated sulfate (**Figures 31** and **32**). Total mass loadings of metals from these sources equal about 110,000 kg/yr (242,500 lbs/yr), respectively. Water quality from the McLaren Adit is near neutral (pH = 6.5) and is more similar to that of the Little Daisy Adit, but because this discharge is adjacent to the McLaren Pit subsurface drains, combining these flows into a single source for treatment was deemed appropriate. Therefore sources in this group include:

    a. McLaren Pit subsurface drains (DCSW-101, -102, and -103)
    b. McLaren Adit (D-18)
    c. Glengarry Millsite Adit (F-8B)

2. Water from the Little Daisy Adit (M-1), the only source in Group 2, is of circumneutral pH, and flows with a median rate of 32 Lpm (8.5 gpm). The total mass loading of metals from this discharge is about 700 kg/yr (1550 lbs/yr) (**Figure 32**).
3. The Gold Dust Adit (F-28) discharge is being evaluated as a separate group. This source is circumneutral (pH = 7.3) with a post-borehole plugging flow of 13.6 Lpm (3.6 gpm). Manganese is the only COC for this discharge and exceeds the human health guideline.
4. Henderson Mt Adit (M-25) is the lone member of Group 4. This adit discharge of 34 Lpm (9 gpm), is slightly acidic (pH = 5.8), contains very little iron, and has elevated concentrations of aluminum, copper, and lead.
5. The fifth group is characterized by low water flows (less than 11 Lpm [3 gpm]), near neutral pH, and relatively low concentrations of metals. Sources in this group include:

    a. Henderson Mountain Dump 7 (AE-17)
    b. Lower Tredennic Dump 1 (FCSI-96-5)
    c. Black Warrior Adit (M-8)

6.2 RESPONSE ALTERNATIVE DEVELOPMENT

The most promising technologies and process options identified and retained through the screening process are shown as shaded rows in **Table 6-1**. These options appear to be effective and readily implementable over a range of costs, and will be used as the basis for developing response action alternatives for further consideration in Section 7.0.

One approach to developing alternatives is to combine a variety of process options from different response technologies into alternatives. Each alternative, then, can consist of different options that offer either a distinct benefit over options in other alternatives or that provide a different approach to meeting RAOs and goals. This method of alternative development is best used when the alternatives will be used to respond to multiple and different types of contamination issues on one site. This approach works well for Engineering Source Control response alternatives, where a number of process options could be applied in different combinations to stem the flow from adit discharges.

Combining process options into alternatives does not lend itself as well to Water Treatment Control process options. So, for application in this EE/CA, a number of different process options using water treatment control technologies will be considered to address a single issue: treatment of contaminated water at multiple sites with different characteristics. It is this unique set of attributes that lead us to define the actual process options as the response action alternatives for the Water Treatment Control response alternatives.

The Engineering Source Control and Water Treatment Control response action alternatives that will be evaluated further are presented in **Table 6-5**. To facilitate this analysis, the discharge sites were grouped by physical characteristics for engineering source control technologies and by water quality and flow characteristics for water treatment options (**Table 6-3**). In addition to covering a range of effectiveness and implementability, these alternatives also cover a reasonable range of costs. Each of these attributes, effectiveness, implementability, and cost, are important factors that will be considered in some detail in Section 7.0.

The institutional controls brought forward though the screening process are access restrictions that include fencing and gates, land use controls, and portal closures (**Table 6-6**). These controls are designed principally to provide for public safety with respect to limiting access to the underground workings. Rather than carrying these forward as response action alternatives, each site will need to be evaluated individually for how best to provide for public safety and closure. The sites currently range from completely collapsed and stable adit portals, to open adits with no provisions for limiting access.

TABLE 6-5
RESPONSE ACTION ALTERNATIVES FOR MINING-RELATED DISCHARGES

Alternative		Process Option Description
NA-1	No Action	Water quality monitoring and assessment of site conditions.
EC-1	Plug an Accessible Adit	Applicable for the McLaren and/or Gold Dust Adits. Place high strength, acid-resistant, cement plugs to block and seal workings at a location about 76 meters (250 feet) into the mine and another plug near the portal to reduce or eliminate adit discharge. Cement or conventional backfill placed around the plug for ground support and to further restrict water flow. Portal closure and site reclamation.
EC-2	Reopen and Plug an Inaccessible Adit	Applicable for the Little Daisy, Lower Tredennic and/or Black Warrior Adits. Reopen inaccessible adits by excavation of portals, water discharge through a sediment pond, and mucking workings to 76 meters (250 feet). Place high strength, acid-resistant, cement plugs to block and seal workings at a location about 76 meters (250 feet) into the mine and another plug near the portal to reduce or eliminate adit discharge. Cement or conventional backfill will be placed around the plug for ground support and to further restrict water flow. Portal closure and site reclamation.
WT-1	Infiltration and Natural Attenuation	Discharge directed to subsurface drain field. As discharge infiltrates ground, aeration, dispersion, precipitation, and other chemical and biological attenuation processes act to reduce contaminants of concern (COC) concentrations.
WT-2	Passive Chemical Adsorption/Ion Exchange	Synthetic and/or natural aluminum and iron oxyhydroxides and synthetic zeolites adsorb metal cations from water through ion exchange reactions.
WT-3	Anoxic Limestone Drain, Anaerobic Bioreactor (SSBR or LRBR), and Open Limestone Channel	Designs rely on metabolic activity of microorganisms to attenuate COCs primarily through precipitation as metal sulfide mineral phases in either a solid substrate (SSBR) or liquid substrate (LRBR) anaerobic reactant media. Used in series following an anoxic limestone drain and ahead of an open limestone channel that both add alkalinity to the waste stream, thereby facilitating precipitation of metal hydroxides.
WT-4	Anaerobic Bioreactor (SSBR or LRBR), and Open Limestone Channel	Designs rely on metabolic activity of microorganisms to attenuate COCs primarily through precipitation as metal sulfide mineral phases in either a solid substrate (SSBR) or liquid substrate (LRBR) anaerobic reactant media. Used in series with open limestone channels to add alkalinity to the waste stream and facilitate precipitation of metal hydroxides.
WT-5	Manganese Removal Cell	Manganese removal cells are modifications of limestone drains that allow sufficient residence time for precipitation of manganese oxides.
WT-6	Chemical Addition, Precipitation, Micro-filtration	Chemical agents added to waste water stream to increase or decrease pH; facilitates precipitation of insoluble mineral phases. Residual suspended solids removed by micro-filtration.
WT-7	Ion Exchange	Inorganic zeolites or synthetic organic resins provide a solid immobile substrate to capture charged particles.

TABLE 6-6
INSTITUTIONAL CONTROLS OPTIONS

Alternative	Process Option Description
Fencing/Signage	Install fences around contaminated areas to limit access. Gating of access roads or mine portals
Land Use Controls	Legal restrictions to control current and future land use
Portal Closures	Close mine portals with backfill, plugging, or installation of locking bared gates. Also necessary for public safety.

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7.0 DETAILED ANALYSIS OF RESPONSE ALTERNATIVES

Response alternatives that were developed and that passed the initial screening process in Section 6 (**Table 6-1**) have been carried forward for analysis here in Section 7.0. These alternatives represent a range of potential actions or process options that can meet, to some degree, RAOs for this portion of the project, and achieve distinct levels of protectiveness to the environment for a reasonable range of costs. The detailed evaluation includes a description of each alternative and an evaluation based on effectiveness, implementability, and cost.

7.1 ORGANIZATION

The detailed analysis presented in this section has been organized into two separate discussions: one for Engineering Response Technology Control alternatives and the other for Water Treatment Response Technology Control alternatives. The alternatives are evaluated as stand-alone alternatives; that is, a detailed analysis of a combination of alternatives from the two types of resource technology groups is not done. However, combined alternatives are considered in the comparative analysis discussion presented in Section 8.

Similarities between the adit sites and discharge sources allow for consolidation into groups based on similar engineering/site characteristics or water quality/chemistry characteristics. The eight discharges were subdivided into 3 groups (A, B, and C) based on accessibility and length of the adits (**Table 6-2**) for the Engineering Source Control alternatives. For Water Treatment Control alternatives, 5 groups (1 to 5) were designated based on water chemistry, range of flow, and location of the discharge (**Table 6-3**). An appropriate range of treatment alternatives was then identified for each of the source groups (**Table 6-4**). The grouping allowed a more expedient analysis where, in some cases, the appropriate alternative was evaluated against a group rather than an individual adit or discharge source.

7.2 EVALUATION CRITERIA

Three criteria will be used to evaluate response action alternatives: effectiveness, implementability, and cost. A general description of each criterion is presented below.

7.2.1 Effectiveness

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. For the adit discharge response alternatives, effectiveness was gauged primarily by the ability of an alternative to either reduce or eliminate the discharge (loading) in the case of the Engineering Response Action Alternatives, or in the case of Water Treatment Response Alternatives, to remove COCs such that treatment effluent meets chronic aquatic water quality standards (**Table 3-3**).

As some of the response alternatives evaluated may not achieve the appropriate standards, the effectiveness evaluation also considered an alternative's ability to reduce total outflow from adits or to remove a portion of COCs from the waters to be treated. Also considered was the ability of the alternative to provide long-term effectiveness based on the alternative's reliability.

7.2.2 ***Implementability***

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 contaminant source, availability of the required equipment and expertise to implement the alternative, and overall reliability of the alternative. In particular, alternative evaluation with respect to implementability included:

- Construction considerations including schedule and the availability of manpower, equipment, and materials required for implementation
- Infrastructure requirements (power supply)
- Reliability and simplicity or complexity of operation and the required maintenance
- Remoteness of location, accessibility, and climatic conditions

Implementability also considers the appropriateness of combinations of alternatives based on site-specific conditions. Administrative feasibility evaluates logistical and scheduling constraints.

7.2.3 ***Cost***

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. Where possible, cost data incorporate actual operating costs and unit costs that have been realized during similar reclamation projects. Unit costs are based on assessments of materials handling and procurement, site conditions, administrative and engineering costs, and a contingency.

In addition to the capital costs discussed above, post-removal site control (PRSC) costs are estimated for the water treatment alternatives. These PRSC costs were estimated using reasonable assumptions for likely and potential maintenance and monitoring requirements. PRSC are estimated for a 20-year period. The present worth for PRSC is calculated using a discount rate factor of 4.0% (OSWER, 1993). It is not anticipated that there would be any PRSC costs associated with the engineering response alternatives in that they are designed to be a "walk-away" solution to adit discharge. There would also be no PRSC casts associated with the No Action Alternative (NA-1) because the only likely charge, ongoing monitoring, would be covered by other monitoring programs for the project.

The total estimated project cost for each alternative is the sum of the estimated capital cost, the estimated present worth PRSC cost, and engineering design and construction oversight costs, which are calculated as a percentage of the estimated capital cost. In line with EPA guidance, the total estimated cost is expected to be within plus 50% and minus 30% of actual costs. Summary cost tables are presented in the cost discussion for each alternative with the supporting unit cost spreadsheets presented in **Appendix D**.

7.3 ALTERNATIVE NA-1, NO ACTION

The no action alternative involves leaving the various mine adits in their existing condition. No further underground flow control or water treatment measures would be attempted at the sites. There would be no attempt to control or treat contaminant migration from the mines, or to reduce its toxicity or volume. (It should be noted that previous response actions have been completed at the majority of the discharges included in the detailed evaluation -- waste rock dumps were removed from the McLaren, Lower Tredennic, Black Warrior, Glengarry, Little Daisy, and Gold Dust adits, and the portal was closed at the Henderson Mountain Dump 7 site).

Seepage from the adits/discharges would continue under this alternative. Natural attenuation may reduce COC concentrations and loading over time. However, the degree of natural attenuation, particularly at Group 1 Water Treatment sites (McLaren Pit subsurface drains and Glengarry Millsite), is likely minimal and any noticeable degree of natural attenuation would take place over a very long time. The No Action alternative is most applicable to discharges in Group 5 (Black Warrior, Henderson Mountain Dump 7, and Lower Tredennic), which have low flows and metal concentrations. More permanent closures have been installed at the McLaren Adit and Gold Dust to prevent public access and to provide for public safety, and it is likely that an access closure would be designed for the Glengarry Millsite as well under this alternative. Water quality monitoring would be performed each year in following with the rule for temporary standards and the objectives outlined in the project Overall Project Work Plan (Maxim, 1999). Assessment of site conditions would be performed annually to evaluate whether changes in water quality warrant any additional actions at a site(s).

7.3.1 <u>Effectiveness (NA-1)</u>

Overall effectiveness of no action is poor. Under existing conditions, acidic water, dissolved metals, and/or sediment will continue to flow from adit portals and percolate into nearby soils or migrate to surface water or groundwater. Discharges would not be altered from present conditions and would not meet water quality standards for the contaminants that exceed standards. The No Action Alternative does not address surface water and/or groundwater impacts, nor does it provide any controls on direct contact or ingestion by humans or wildlife. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative, although contaminant sources may be expected to diminish over time as oxidation of sulfides depletes the contaminant source.

For discharges that are a significant distance from a receiving surface water body, natural attenuation reactions, such as infiltration, evaporative precipitation, adsorption, and dilution occurring between the source and the receiving stream could significantly reduce metals loadings and ecological risk. Adits that fall into this category include the Gold Dust, Little Daisy, Lower Tredennic, Henderson Mountain #7, and the Henderson Mountain Adit.

The No Action alternative is currently in compliance with narrative and numeric temporary water quality standards at the principal downstream stations monitored in each of the drainages (Daisy Creek, DC2, DC-5 and SW-7; and Fisher Creek; SW-3, SW4 and CFY-2). However, as these standards expire in 2014, No Action is not expected to move water quality toward compliance with the B-1 standards for these streams.

7.3.2 <u>Implementability (NA-1)</u>

This alternative is both technically and administratively feasible.

7.3.3 <u>Cost (NA-1)</u>

No capital or annual maintenance costs would be incurred under the No Action alternative. As annual monitoring costs associated with this alternative are carried under the long-term water quality monitoring plan for the project (Appendix D, Overall Project Work Plan, Maxim, 1999), there are no costs specifically identified with this alternative for this evaluation.

7.4 ANALYSIS OF ENGINEERING SOURCE CONTROL ALTERNATIVES

This section presents the detailed analysis of underground Engineering Source Control alternatives listed in **Table 6-1**. Because the two Engineering Source Control alternatives are similar, the level of analysis under effectiveness for Alternative EC-2 is abbreviated rather than reiterating the same evaluation presented for Alternative EC-1. A summary of common elements is provided in the analysis for Alternative EC-2, along with specific distinctions between the two source control alternatives.

7.4.1 Alternative EC-1, Plugging an Accessible Adit

This alternative involves closing the Gold Dust and the McLaren adits to reduce or eliminate the discharges. (Both adits were secured in 2005 to prevent physical access to the workings, and these would be removed to implement this alternative). Water quality assessments have been completed at both sites. Two watertight plugs would be utilized for plugging these workings.

The McLaren Adit was driven in the early 1950's to the northeast from the northwest corner of the McLaren Pit near the junction of the main county road with the Lake Abundance road (**Figure 3**). It collars at about 2,938 meters (9,640 feet) in elevation, The length of workings have been estimated from the size of the waste rock dump at 540 meters (1,770 feet), including cross-cuts and drifts and/or stopes developed in the mine.

The McLaren Adit was reopened in 2001 by the USDA-FS. Only the first 129 meters (423 feet) of the total workings are accessible, however. The first 30.5 meters (100 feet) are timbered and lagged in both the back and the ribs, although portions of the lagging are damaged or missing. The entire length of the assessable workings were driven in altered and mineralized sedimentary rocks of the Meagher Limestone (pyrite, chalcopyrite, and abundant iron oxides) that are complexly intruded by the Fisher Mountain porphyry. Water flow at the portal during reopening was about 26.5 Lpm (7.0 gpm). No water sources other than an occasional drip were observed in the first 107 meters (350 feet), but an exploration borehole drilled from the surface that had intersected the adit at about 112 meters (366 feet) was flowing at about 20.8 Lpm (5.5 gpm). The mine was blocked by a cave-in at about 129 meters (423 feet) where water was flowing from the slough that blocked the tunnel at a rate of about 5.7 Lpm (1.5 gpm). Because the mine flows year-round, it was assumed that a significant inflow must occur at some point further into the mine. In a successful effort to reduce flow into the adit, the drill hole that penetrated the adit from the surface was plugged in September 2003, reducing the average flow. The waste rock dump was removed during reclamation of the McLaren Pit and a rock armored drainage ditch and sediment pond were constructed below the mine to settle suspended materials from the adit discharge.

The Gold Dust Adit was driven between 1920 and 1925, and drifts to the southwest for about 701 meters (2,300 feet). A major portion of the waste rock dump, which contained approximately 4,358 cubic meters (5,700 cubic yards), was removed from below the portal of the Gold Dust Adit in 2005. The adit is driven in Precambrian granite for the first 274 meters (900 feet) and then crosses into monzonite porphyry intrusion breccia of the Homestake stock (**Figure 13**). The intrusion breccia contains varying amounts of subangular clasts of sedimentary rocks of predominantly Wolsey shale. There are only a few short segments of timber sets within the mine after the initial portal sets. Crown Butte Mines opened the mine in 1992 and executed an underground drilling program from the Gold Dust Adit, drilling 23 angle holes from four drill stations near the back of the mine. Drill holes that were making water when drilled were closed with mechanical packers. The mine discharged water at an average rate of about 49 Lpm (13 gpm), about 42 Lpm (11 gpm) of which comes from water discharging from underground boreholes. A borehole grouting project was completed at the drill stations in September 2005 and involved reentering the Gold Dust Adit, removing packers from drill holes, and grouting and plugging with cement all drill holes in the adit that were making water. Successful plugging of these drill holes reduced the flow from the portal by 68% in the first month following plugging. Flow measured in September 2006 at the site (13.6 Lpm) indicated that the reduction in flow was maintained through the first year after plugging.

Alternative EC-1 will further stem the flow of water from these two adits using the same general plan for closure. Two high-strength, watertight, cement plugs would be placed in each adit (**Figure 33**). The innermost plug would be constructed about 76 meters (250 feet) in from the portal, outboard of any significant inflows into either of the mines. This plug would be designed as a high pressure plug and placed in competent, relatively unfractured rock. It is envisioned that this plug would stem most of the mine outflow and hold back the largest portion of the hydrostatic head behind the plug. The outermost plug would be designed as a low pressure plug and be placed about 18 meters (60 feet) in from the portal. Both plugs are designed to redirect water that now leaves the adit back into fractures that carried water along pre-mining flow paths. Both plugs would have either a cemented or a conventional backfill placed on either side of the plug to provide ground support for the section of the workings containing the plugs. The watertight plugs are expected to appreciably reduce or eliminate adit discharge. The portals would be closed with conventional backfill methods and disturbances in the portal area would be reclaimed and revegetated. Site drainage would be established that would minimize or eliminate long-term maintenance requirements.

7.4.1.1 TASK DESCRIPTION (EC-1)

The following work is included in the implementation of Alternative EC-1:

- *Engineering:* Prior to commencing work, a general scoping of the portal site would be completed to determine the stability and safety requirements for routine work access and activities. A plan would be devised to dispose of water on-site during the construction phases of work. A suitable sediment retention pond would be designed. Portal plugs would be designed based on the rock mass quality, the potential hydrostatic head, the burden of rock above the plug, and other considerations. A system of two plugs is anticipated. The inner plug would be a high pressure plug situated in competent rock with enough burden overhead to prevent hydraulic jacking of the fractures in the rock mass. The inner plug would contain most of the water flow. The outer plug would be a low pressure plug designed to disperse the water that enters the drift outward of the high pressure plug.

- *Excavation and Plug Site Preparation*: If necessary, topsoil would be stripped from the site and stockpiled. A laydown area would be leveled and prepared for equipment set-up. A muck storage pad would be constructed adjacent to the portal site. A sediment retention pond sufficient to contain surges of sediment-laden water during plug construction would be excavated and bermed using fill material from the excavation. Water from the portal and muck storage pad would be ditched or piped to the sediment retention pond. The portal would be stabilized for safe access and working conditions and portal integrity would be maintained with bolts, mesh, or timbers as necessary. Plugs would be constructed beginning with the high pressure plug and working outward (**Figure 33**). The same procedure would be followed for each plug. Prior to construction, compressed air, drill water, and ventilation utilities would be installed to the plug sites. The sill and ribs at the plug location would be notched, scaled, and cleaned to allow a watertight bond between the cement and rock. The back would be domed to permit a tight seal at the top of the plug. A dam upstream of the plug would be constructed to prevent tunnel water from entering the plug excavation. A bypass pipe would be installed in the dam to pass tunnel water through the plug site and discharge the water downstream of the plug site during construction. Wooden forms approximately four meters apart would be constructed at the front and back of the plug. To facilitate cement pumping, steel pipe either 10 cm or 15 cm in diameter would be installed from the portal to the plug sites. If suitable, rock removed from the drift would be saved on-site for future use as backfill in the closure process.

- *Plug Construction:* The space between the back form and the front form would be pumped full of cement. Air would discharge through a breather pipe at the highest point of the dome in the back. The forms would be abandoned in place. If necessary, during the pouring and curing time, the tunnel water would pass through the bypass pipe.

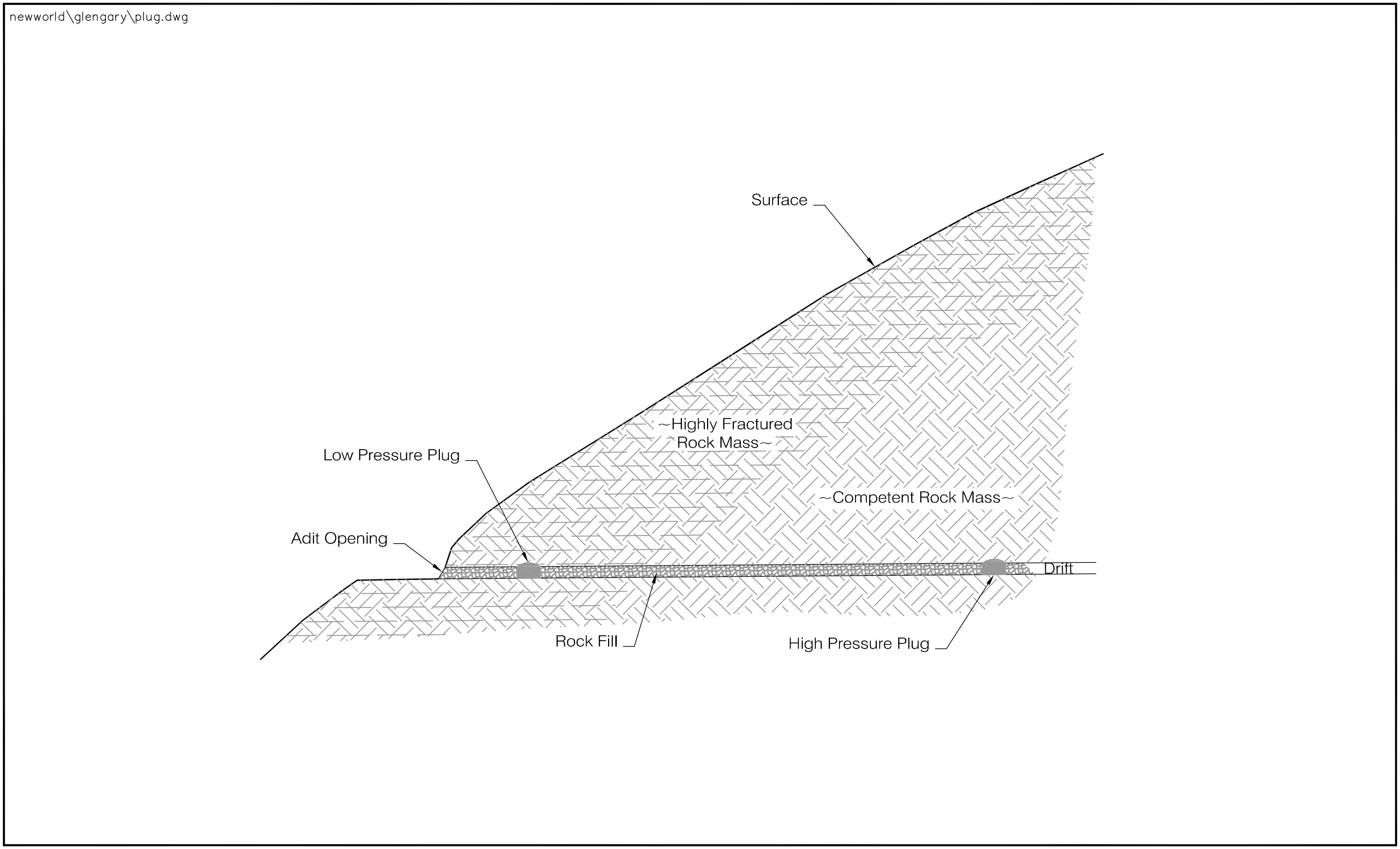
- *Grouting:* Upon completion of the cement pour, the small void left in the dome would be pressure grouted with Portland cement or bentonite based grout. If the bypass pipe was left in place during pouring and grouting, it would be grouted shut once the plug pour is complete.

- *Backfill for Stability:* Rock would be gobbed behind, between, and in front of the plugs to help ensure drift stability adjacent to the plugs (**Figure 33**). The gob would also help prevent potential catastrophic failure of the plugs. Rock from the waste rock dump or rock removed from the portal area or drift would be used as backfill. A small contingency has been added if rock needs to be hauled in for use as backfill material.

- *Site Clean-up and Restoration:* Upon completion of the plug work, the portal would be backfilled. The sediment retention pond may be mucked out and then backfilled. The site would be graded so that surface water drains naturally into nearby channels and reclaimed. Excess waste rock or mine muck may need to be hauled off-site to a designated repository.

7.4.1.2 EFFECTIVENESS (EC-1)

Cement plugs to stop water flow are commonly used in dams and similar water retaining structures as well as in mines. In some mine reclamation applications, plugs have been inadequate because they have been installed too near the portal. Over time, the hydrostatic head behind the plug rose to a level sufficient to force water through fractures, bypassing the plug, and exiting the mine portal or elsewhere. Alternative EC-1 addresses the problem of high head behind the inboard plug in the McLaren Adit by installing a plug 76 meters (250 feet) back in the tunnel in a zone of silicified Meagher Limestone where the surrounding rock is tight and the hydrostatic head will not be large enough to force water to the surface through fractures. In the Gold Dust Adit, the inboard plug at 76 meters (250 feet) will be placed in low permeability Precambrian Granite rock. The Gold Dust Adit has the potential to develop very large hydrostatic heads behind plugs due to the difference in elevation between the innermost plug, estimated at 2,804 meters (9,200 feet) in elevation, and the top of Henderson Mountain at 3,139 meters (10,300 feet). The plugs will have to be high-strength to account for this condition, and it may be desirable to place a third plug in the adit.



April 2005

Schematic of Two Plug System
New World Mining District
Response and Restoration Project
Cooke City, Montana
FIGURE 33

Not To Scale

MAXIM TECHNOLOGIES 4560831.112

Figure 33 – back page

Both mines will have a second plug placed about 18 meters (60 feet) in from the portal as a backup to the first plug. This plug would allow water to be redirected into adjacent fractures at a lower pressure than those generated behind the inboard plug. In both adits, it is anticipated that water will seek pre-mining routes as a preferred flow pattern rather than exiting the portals.

- *REMOVAL ACTION OBJECTIVES*

Implementation of Alternative EC-1 meets one of the RAOs for the project by minimizing or preventing contaminants dissolved in water from entering surface water in either Daisy or Fisher Creek.

- *OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT*

Alternative EC-1 provides considerable control to the migration of contaminated water and reduces risk to human health and the environment. It reduces the flow of metal-laden water directly into either Daisy Creek from the McLaren Adit or to Fisher Creek from the Gold Dust Adit by constructing two barriers to water movement through the adits.

The removal of metal-bearing water-flow exiting the McLaren Adit portal (21 Lpm [5.8 gpm]) and the Gold Dust portal (13.6 Lpm [3.6 gpm]) will lessen exposure of the environment to contaminated water. This alternative has the potential to significantly diminish or eliminate the flow of water from the either of the mine portals. The use of two plugs provides a measure of redundancy should one plug fail in the future. In addition, the use of a cement or conventional backfill on either side of the plug provides long-term ground stability in the vicinity of the plug, thereby protecting the plugs in the event nearby sections of the mine collapse in future years.

- *COMPLIANCE WITH ARARS*

A list of ARARs is presented in **Appendix C**. Compliance with surface water quality ARARs can be fully achieved under Alternative EC-1 if the discharge is eliminated. Complete removal of the relatively small contaminant loads associated with the two discharges, however, will likely not affect current conditions in Daisy Creek and Fisher Creek where surface water aquatic standards are not being met. Contaminant concentrations in the headwaters of these streams are several orders of magnitude higher than the applicable Circular WQB-7 aquatic life standards, and complete removal of the relatively small contaminant loads associated with these two discharges is not great enough to meet water quality ARARs. However, surface water quality at stations DC-2 (Daisy Creek) and SW-4 (Fisher Creek) may improve as a direct result of setting plugs in the McLaren and Gold Dust Adits. A minor reduction in metal loading (9.1%) may occur in Daisy Creek as a result of plugging the McLaren Adit. With the elimination of the Gold Dust Adit discharge, a reduction in iron (4.9%), lead (1.1%), and manganese (3.9%) loading might be expected, although the geochemical conditions in Fisher Creek and Daisy Creek are complex and this simple analysis of load reduction does not take into account geochemical equilibrium conditions that control metals concentrations in the two streams.

Groundwater quality will not likely improve by implementation of this alternative, although, with the exception of iron and manganese, groundwater in Fisher Creek complies with groundwater standards both in shallow alluvial and bedrock aquifers. Iron and manganese are ubiquitous throughout the district and their concentrations are believed to be partially controlled by natural bedrock sources. Groundwater quality in the vicinity of the McLaren Adit is poor. As the contaminant load released from the McLaren Adit is very small compared to other contaminant sources in the area, no improvement in groundwater quality is expected from implementing Alternative EC-1. Contaminant-specific ARARs for ambient air will be met under this alternative, as air quality would not be affected by construction operations.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by the implementation of this alternative. Threatened and endangered species present in or near the District may be affected by the activities associated with implementing this alternative in the short-term but it is not likely that these species will be adversely affected, as there will be no new disturbances, no permanent facilities, and implementation of the alternatives 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 wastewater to the environment. Requirements for treating surface drainage, sediment control, construction and maintenance of sediment ponds, discharges from sediment ponds, and provisions for groundwater protection will be met by Best Available Technologies (BATs).

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

OSHA requirements will be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as 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 EC-1 should permanently eliminate the McLaren and Gold Dust Mines as conduits for transporting metal-laden groundwater from the adits directly into Daisy Creek and Fisher Creek, respectively. Potential ground instability conditions in the mines that might lead to mechanical failure of the plugs would be mitigated by the placement of cemented or conventional backfill around the plugs. The use of two plugs in each adit provides redundancy and helps to minimize the development of high hydrostatic pressures behind the outboard plug.

- *REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT*

The mobility and volume of metals will be greatly reduced by Alternative EC-1. The McLaren and Gold Dust adits will no longer be conduits for transporting metals-laden water to Daisy Creek and Fisher Creek, respectively. Mobility will exist within isolated segments of the mine, but the plugs will preclude mobility between segments. There will be no reduction in toxicity or volume through treatment, but a large reduction in the discharge volume will be attained under this alternative.

- *SHORT TERM EFFECTIVENESS*

The effect of placing tunnel and portal plugs will be immediate. Upon completion of the first plug and the placement of adjacent cemented backfill, water inflow into the adits will be terminated. After both tunnel plugs are in place in each mine, the flow from the McLaren and Gold Dust portals will be very significantly reduced or eliminated. The number of construction workers, equipment, and supplies needed to construct the alternative is relatively small; construction of the alternative is not expected to have a noticeable effect on local services or roads in the surrounding area.

7.4.1.3 IMPLEMENTABILITY (EC-1)

Numerous portal and drift plugs have been previously installed in abandoned underground mines, including the Glengarry Mine in the New World District. The greatest technical difficulty with Alternative EC-1 is pumping cement to the plug sites. This will be accomplished by pumping cement from the portal site through a pipeline installed in the adit workings. Pumping cement over these distances is not too difficult as long as the piping system is capable of withstanding the pressures generated by pumping the cement. Cement has been pumped over distances of as much as 152 meters (500 feet) in the Glengarry Adit. Bulkheads capable of holding back the cement in the plug stations are routinely constructed of timbers and steel I-beams.

7.4.1.4 COST (EC-1)

Both the McLaren and Gold Dust adits are currently accessible and the adits are long enough to effectively install a two plug closure system. The cost estimate for construction of two plugs, with cement backfill and site reclamation for either adit is provided in **Table 7-1**. A detailed cost breakdown is provided in **Appendix D**. The cost to plug both of the adits would be double the amount shown in **Table 7-1**, or about $737,000.

TABLE 7-1
COST ESTIMATE SUMMARY
PLUGGING AN ACCESSIBLE ADIT (ALTERNATIVE EC-1)

McLaren or Gold Dust Adits	
Mobilization/Demobilization	$ 60,000
Equipment	$ 60,000
Materials, Supplies, Fuel	$ 62,445
Labor	$114,000
Contingency (10%)	$ 29,644
Subtotal	**$326,089**
Engineering Evaluation and Design (5%)	$ 16,304
Construction Oversight (8%)	$ 26,087
TOTAL	**$368,481**

7.4.2 *Alternative EC-2, Reopen and Plug an Inaccessible Adit*

Three historical mines with caved or backfilled adit portals are considered for closure under alternative EC-2. These mines are the Little Daisy, Lower Tredennic, and Black Warrior, and have workings that are 701, 250, and 130 meters (2,300, 821, and 425 feet) in length, respectively. Physical descriptions of the mines are presented in Section 2.0. As shown in **Table 6-2**, the Henderson Mountain Dump #7, Glengarry Millsite Adit, and Henderson Mountain Adit are too short (less than 18 meters [60 feet]) for placing underground flow controls.

Rock quality and the age of the mine are two attributes that can be used to provide some estimate of likely success of reopening. The three mines were operated in the early 1900's, and have varying degrees of estimated rock quality (**Table 6-2**). The Little Daisy adit was driven in a silicified but brecciated zone developed along the contact of the Homestake stock and the Pilgrim Limestone. Only the first 366 meters (1,200 feet) of the adit were assessable in the mid 1920's when Lovering entered the mine (Lovering, 1929). The Little Daisy adit is rated as "fair to poor" with respect to the likelihood of inaccessible workings being easily reopened. The Lower Tredennic adit was driven in Precambrian granite, which can have varying degrees of rock quality. It is rated as "poor", principally because the mine portal occurs in an area of modest slopes, and the likelihood of workings associated with near-surface fracturing and weathering remaining open over time is low, suggesting gaining access to the inner workings of this mine may be difficult. The Black Warrior Mine is rated as "fair" because the mine is driven in massive and dense dolomite, a unit with excellent rock quality properties. In support of this observation, the raise to surface from the Black Warrior Adit was open to depth as late as 1993 when it was backfilled by CBMI.

Alternative EC-2 involves reopening mines with caved or backfilled portals. Reopening an adit would be accomplished by excavating the portal, discharging mine water into a sediment pond, and mucking sediment from the first 76 to 91 meters (250 to 300 feet) of workings. Another option to reopening the adits would be to drill a boring into the underground workings from the surface and then pump cement to the plug sites. With reasonable access, this option could potentially be less expensive than reopening the mine, although locating the subsurface workings by drilling may be difficult. This method of plug placement is not developed further in this evaluation, as the reopening method is more conservative in terms of cost.

Once adits are open and safely accessible, the two plug system, consisting of high-strength, acid-resistant, watertight, cement plugs described for Alternative EC-1, would be installed to seal the workings. The first plug would be placed at a location about 76 meters (250 feet) into the mine and the second plug near the portal, about 18 meters (60 feet) into the mine. Cement or conventional backfill would be placed around the plug for ground support and to further restrict water flow.

For purposes of evaluation and cost analysis, two scenarios for access are considered. One assumes that once a portal is opened, there would be relatively easy access through the first 76 meters (250 feet) of workings to the point where the innermost plug would be set. The second scenario assumes that once a portal was opened, the mine workings will be in poor condition with a considerable amount of sloughed or caved material that needs to be removed in order to gain access to the first 76 meters (250 feet) of workings. Costs have been developed for both the easy and difficult access scenarios. Of the three mines being considered for closure under this alternative, the Black Warrior Adit is likely to have the easiest access, with access to the Little Daisy likely to be more difficult; reopening the Lower Tredennic Adit is likely to be quite difficult.

7.4.2.1 Task Description (EC-2)

Two scenarios for reopening the three mines are presented below, one assuming an easy access to the interior plug station location, and one assuming the access is difficult. Once access to the interior plug site is gained, tasks required for site preparation, plug construction, grouting, backfilling, and site clean-up and reclamation are identical to those described for Alternative EC-1 and are not repeated here.

❖ *Easy Access Scenario*

- *Engineering:* Prior to commencing work, a general scoping of the portal site will be completed to determine the most effective means of reopening the portal, maintaining portal stability, and disposing of water during the reopening and construction phases of work. An assessment of the portal site will be made to establish the original sill and back locations prior to disturbing the site. A suitable sediment retention pond will be designed. After the portal is reopened, the best method of clearing debris from the drift and supporting the drift will be selected.

- *Site preparation:* If necessary, topsoil would be stripped from the site and stockpiled. A laydown area will be leveled and prepared for equipment set-up. A muck storage pad will be constructed adjacent to the portal site. A sediment retention pond sufficient to contain sediment generated by surges of water produced during the portal and drift reopening will be excavated and bermed using fill material from the excavation. Water from the portal and muck storage pad will be ditched or piped to the sediment retention pond. Once cleared of sediment, water from the retention pond would be discharged to natural drainage channels.

- *Portal Reopening:* Using a hydraulic excavator, the portal will be gently excavated to the original sill elevation. The portal integrity will be maintained with bolts, mesh, or timbers as necessary. If water is dammed-up behind the portal, the dam will be excavated in stages to minimize water surges. The excavator is expected to be able to clear the portal and few feet inside the portal.

- *Drift mucking and ground support:* Using a small mucker or a slusher, all debris will be removed from the sill of the drift and placed on the muck storage pile. Steel and wood will be separated from the rock and mud. Ground stability will be maintained by a combination of scaling, bolting, screening, or timbering. Underground utilities will consist of compressed air and water hoses for drilling, and a vent bag for ventilation.

❖ *DIFFICULT ACCESS SCENARIO*

The tasks required under the difficult access scenario for Alternative EC-2 are the same as those described above for the easy access scenario, with the exception of the Drift Mucking and Ground Support Task described below.

- *Drift mucking and ground support:* Using a small mucker or a slusher, all debris will be removed from the sill of the drift and placed on the muck storage pile. Steel and wood will be separated from the rock and mud. Ground stability will be maintained by a combination of scaling, bolting, screening, or timbering. Underground utilities will consist of compressed air and water hoses for drilling and vent bag. This access scenario anticipates more extensive mucking and ground support requirements than the easy access scenario. The drift may have considerable sloughed and caved sections that needs to cleared over substantial distances and the drift may need to be cleared significantly beyond 250 feet to permit the high pressure plug to be located in competent rock.

7.4.2.2 EFFECTIVENESS (EC-2)

The Little Daisy, Lower Tredennic, and Black Warrior mines are currently inaccessible, but the workings are long enough to effectively close the mines with a two plug system if they can be reopened. Cement plugs to stop water flow are commonly used in a variety of water retaining structures including dams and mines. The Glengarry Mine has had cement plugs installed along its workings that have effectively reduced and seasonally eliminated water flow from the portal. Historically, plugs that have been installed too near the portal have failed over time as the hydrostatic head behind the plug has risen to a level sufficient to force water through fractures, bypassing the plug, and forcing water to exit the mine at the portal or elsewhere. The use of two plugs located at distances of 18 and 76 meters (60 and 250 feet) from the portal provides redundancy and sets the plugs far enough back into the mine to overcome these problems. In addition, the use of two plugs allows the inboard plug to hold most of the hydrostatic head behind it, thereby minimizing the hydrostatic head on the near-surface, or outer, plug.

Alternative EC-2 addresses the problem of high head behind the inboard plug in each of the three adits by installing a plug 76 meters (250 feet) back in the tunnel in a zone of relatively higher competency rock than near-surface rock. It is envisioned that plugs would be set in intrusive breccia in the Little Daisy Mine, in Precambrian granite in the Lower Tredennic Mine, and in dolomite in the Black Warrior Mine. Each of these rock types are likely to be fairly competent at this depth in the mines, where the surrounding rock is tight and the hydrostatic head will not be large enough to force water to the surface through fractures. None of the three mines is likely to generate very large hydrostatic heads behind the innermost plug. The difference in elevation between the portal of the Little Daisy Mine and the top of Henderson Mountain is about 122-152 meters (400-500 feet), and differences in elevation for the other two mines range from about 30.5 meters (100 feet) for the Lower Tredennic Mine to 24 meters (80 feet) for the Black Warrior Mine.

All three mines will have a second plug placed about 18 meters (60 feet) in from the portal as a backup to the first plug and would allow water to be redirected into adjacent fractures at a lower pressure than those generated behind the inboard plug. In the adits, water will seek pre-mining routes as a preferred flow pattern rather than having water exiting the portals.

Many of the detailed items concerning effectiveness discussed under Alternative EC-1 apply directly to this Alternative EC-2. Alternative EC-2 meets the RAOs for minimizing or preventing contaminants dissolved in water from the mines from entering surface water in either Miller Creek or Fisher Creek by constructing two barriers to water movement through the adits, which in turn reduces risk to human health and the environment. The use of a cement or conventional backfill on either side of the plug provides long-term ground stability in the vicinity of the plug, thereby protecting the plugs in the event nearby sections of the mines collapse in future years.

One primary difference between the two alternatives is the analysis of compliance with ARARs, as the adits closed under this Alternative EC-2 have different loading characteristics than the two adits addressed by Alternative EC-1. Compliance with surface water quality ARARs can be fully achieved under Alternative EC-2 if the discharge is eliminated. Complete removal of the relatively small contaminant loads associated with the discharges will likely not affect current conditions in Fisher Creek where surface water aquatic standards are not being met. Contaminant concentrations in the headwaters of Fisher Creek are several orders of magnitude higher than the applicable Circular WQB-7 aquatic life standards, and complete removal of the relatively small contaminant loads associated with the Lower Tredennic Adit is not great enough to meet water quality ARARs in Fisher Creek. In Miller Creek, the receiving water for the Little Daisy and Black Warrior discharges, surface water aquatic standards are currently being met at the nearest downstream monitoring station except for copper. Exceedences of the copper standards in Miller Creek are partially associated with the suspended sediment load from sources that include the Daisy Pass road and the west flank of Henderson Mountain in addition to any concentrations associated with the Little Daisy or Black Warrior discharges.

Groundwater quality will not likely be improved by implementation of this alternative, although, with the exception of iron and manganese, groundwater in the Fisher Creek and Miller Creek drainages in the vicinity of the adits complies with groundwater standards.

7.4.2.3 IMPLEMENTABILITY (EC-2)

Reopening inaccessible closed mines may or may not be successful, and is rife with uncertainty. Because underground conditions are unknown, implementability of this alternative may be extremely difficult, and successful reentry of the mines may not be accomplished. Extensive caving behind the collapsed portals may be present, requiring intensive ground support measures before the workings are stabilized.

If the collapsed workings can be made accessible to the plug sites, implementability of the alternative would be similar as that described for Alternative EC-1. Numerous abandoned underground mines have been reopened, and portal and drift plugs have been previously installed to stem the flow of water from adits in underground mines, including the Glengarry Mine. As with Alternative EC-1, the greatest technical difficulty with Alternative EC-2 is pumping cement to the plug sites. This will be accomplished by pumping cement from the portal site through a pipeline installed in the adit workings. Pumping cement over these distances is not too difficult as long as the piping system is capable of withstanding the pressures generated by pumping the cement. Cement has been pumped over distances of as much as 152 meters (500 feet) in the Glengarry Adit. Bulkheads capable of holding back the cement in the plug stations are routinely constructed of timbers and steel I-beams. Alternative EC-2 is both implementable and technically feasible.

7.4.2.4 Cost (EC-2)

A cost estimate for closure with a two plug system as described in Alternative EC-2 with an easy access scenario is summarized in **Table 7-2**; the cost for a difficult access scenario is summarized in **Table 7-3**. A detailed cost breakdown is provided in **Appendix D**. The cost to plug any one of the three adits is a function of the difficulty in opening the adit for access to the plug sites.

TABLE 7-2
COST ESTIMATE SUMMARY
PLUGGING AN INACCESSIBLE ADIT (ALTERNATIVE EC-2) WITH EASY ACCESS

Mobilization/Demobilization	$ 60,000
Equipment	$ 67,600
Materials, Supplies, Fuel	$ 66,195
Labor	$123,000
Contingency (15%)	$ 47,519
Subtotal	**$364,314**
Engineering Evaluation and Design (10%)	$ 36,431
Construction Oversight (10%)	$ 36,431
TOTAL	**$437,177**

TABLE 7-3
COST ESTIMATE SUMMARY
PLUGGING AN INACCESSIBLE ADIT (ALT. EC-2) WITH DIFFICULT ACCESS

Mobilization/Demobilization	$ 60,000
Equipment	$ 79,300
Materials, Supplies, Fuel	$ 69,990
Labor	$153,000
Contingency (15%)	$ 54,344
Subtotal	**$416,634**
Engineering Evaluation and Design (10%)	$ 41,663
Construction Oversight (10%)	$ 41,663
TOTAL	**$499,960**

7.5 ANALYSIS OF WATER TREATMENT CONTROL ALTERNATIVES

This section presents the detailed analysis of water treatment control alternatives listed in **Table 6-1**. The various water sources typically contain several metal species, not all of which are amenable to treatment by the same technology. For example, anaerobic bioreactors can be very effective for removing cadmium, copper, iron, lead, nickel, and zinc from solution via the formation of metal sulfides. In contrast, manganese is not removed as effectively because manganese is mobile under reducing conditions (as Mn^{2+}) and does not readily react with sulfide to form a solid phase species. Therefore, in this section, treatment trains incorporating more than one of the technologies described in Section 6.0 are evaluated as complete systems that are capable of treating the entire suite of metals in a particular discharge. The source groups and the range of alternatives appropriate to each of the discharges are summarized in **Table 7-4**.

As discussed in Section 6.1.4, the treatment technologies evaluated can be divided into two groups based on whether they require ongoing active operation and maintenance or are passive or semi-passive systems. When multiple treatment technologies have been assembled into treatment trains to remove multiple metals, technologies from within one of the broadly defined groups (i.e., active or passive) have been combined. Conventional water treatment technologies could likely be assembled to treat all discharges to the imposed standards, but only at a significant cost, including both capital and long-term operation and maintenance. Passive treatment systems may not be able to meet all the aquatic standards for all metals but would require substantially less capital and long-term operation and maintenance costs.

The water treatment technologies require a brief discussion of cost analysis that clarifies the items considered and not considered in generating the cost analysis. The following cost items were considered:

- Direct Capital Costs - construction costs (materials, labor, profit)
- Indirect Capital Costs – a percentage of the direct capital costs that includes the following: treatment testing (10%); engineering and design (10%); contingency (25%); and mobilization/demobilization (10%).
- Operation and maintenance – The 20-year present worth of operation and maintenance was calculated assuming an annual discount rate of four percent. Operation and maintenance included labor, reagents, heat/power, residual disposal, and road maintenance, and in some cases, replacement of the system.

Several items that may have an effect on the actual implementation cost of the alternatives were not included in the cost estimates. **Typically, omission of these cost items would not affect the comparative analysis of the alternatives but would affect the actual implementation cost**. The assumptions used in defining the alternative for cost estimating purposes are listed below.

- Treatment systems were designed for average or median flows. Flows from most sources are known to vary seasonally, but the amount of flow data available is limited. Actual remedy implementation would require consideration of peak flows through capacity over-design, flow equalization ponds or tanks, or peak flow diversions. Cost estimates did not consider any of these features.

TABLE 7-4
WATER TREATMENT ALTERNATIVES EVALUATED FOR NEW WORLD DISTRICT DISCHARGES

Treatment Process	McLaren Pit cap drains	McLaren Adit	Glengarry Millsite Adit	Little Daisy Adit	Gold Dust Adit [1]	Henderson Mt Adit	Henderson Mountain Dump 7	Lower Tredennic Dump 1	Black Warrior Adit
Group	1			2	3	4	5		
Median Flow (gpm)	23	8	4	8.5	3.6	8.5	1.4	1.8	2.5
pH	2.6	6.5	3.4	6.9	6.8	5.8	6.7	6.6	7.5
Alternative WT-1: Infiltration							✓	✓	✓
Alternative WT-2: Passive Chemical Adsorption/Ion Exchange									✓
Alternative WT-3: Anaerobic Bioreactor (SSBR or LRBR), Anoxic Limestone Drain (ALD), and open limestone channel (OLD)	✓	✓	✓						
Alternative WT-4: Anaerobic Bioreactor (SSBR or LRBR), and open limestone channel				✓		✓	✓		
Alternative WT-5: Manganese Removal Cell					✓			✓	
Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration	✓	✓	✓	✓	✓	✓			
Alternative WT-7: Ion Exchange							✓	✓	✓

Note 1 Gold Dust flow and pH data are the most recent post-borehole plugging data from September 2006

- Specific location and topography were not considered. It is understood that the sources are in remote, mountainous locations, which would make implementation and operation of a selected remedy more expensive. However, these factors would apply to all alternatives evaluated for a particular source, and therefore would not significantly affect the comparative analysis.
- Road construction/access improvements were not included. Some level of access improvement would be required for the implementation and operation of selected remedies regardless of which alternative(s) is selected. Road maintenance and snow plowing was included for alternatives requiring year-round access.
- Duplication of treatment components was not included. Implementation of a selected treatment system may require a "dual-train" system, where two side-by-side systems would be installed. This would allow continued operation during breakdown or maintenance, and adjustments or further testing in the case of some of the technologies that are not fully developed.
- Monitoring was not included. Some level of monitoring would likely be required as a part of the operation and maintenance for the implemented remedies. Assuming that the level of monitoring would be similar between the various alternatives, this omission would not affect the comparative analysis.

7.5.1 Alternative WT-1: Infiltration

Infiltration is only being considered for Group 5 sources (Henderson Mountain Dump 7, Lower Tredennic, and Black Warrior), which have average flows less than 11 Lpm (3 gpm) and low metals concentrations. Flow sources would simply be rerouted from surface to subsurface, enhancing the potential for dilution and natural biogeochemical reactions to attenuate the migration of COCs.

A subsurface drain field would be constructed using gravel-bedded perforated pipe. The drain field would be covered with a 0.6-meter (two-foot) thick soil layer to protect from freezing. It has been assumed that the system would require replacement every 20 years due to plugging with metal precipitates.

7.5.1.1 Effectiveness (WT-1)

Implementation of Alternative WT-1 meets one of the RAOs for the project by minimizing or preventing contaminants dissolved in water from entering surface water in either Miller Creek or Fisher Creek, and protects human health and wildlife from direct contact and ingestion risks. Dilution and natural attenuation processes occurring in the subsurface are likely to be effective at reducing the already low metals concentrations from Group 5 discharges.

- *Long-Term Effectiveness and Permanence, and Short-Term Effectiveness*

Because the inherent buffering capacity of the soils is unknown, long-term effectiveness may be limited and will be dependent to some extent on the distance between the discharge and the receiving surface water body. Given sufficient distance for natural attenuation reactions to occur, and mass of organic and inorganic material to interact with, it is likely that this option could provide long-term treatment for these low flow discharges. Replacement of the gravel infiltration basin may be required in the future if minerals deposit in interstitial spaces and constrict water flow through the gravel.

The number of construction workers, equipment, and supplies needed to construct the alternative is small; construction of the alternative can be completed in a matter of days or weeks and is not expected to have a noticeable effect on local services or roads in the surrounding area.

- *COMPLIANCE WITH ARARS*

A list of ARARs is presented in **Appendix C**. Compliance with surface water quality ARARs may not be achieved under Alternative WT-1. While surface discharges will be eliminated during most of the year, some discharge to surface water may occur before attenuation of contaminants is complete. Complete removal of the relatively small contaminant loads associated with the Group 5 discharges will likely not be measurable in Miller Creek and Fisher Creek. For the Black Warrior discharge, no impact to water quality in Miller Creek could be measured downstream of where the discharge enters the stream. The Little Daisy does not directly discharge to Miller Creek. For the Lower Tredennic, the discharge does not directly enter surface water, and Fisher Creek surface water aquatic standards are not being met currently due to other sources of metals.

Groundwater quality will not likely improve under this alternative, although, with the exception of iron and manganese, groundwater in Fisher Creek complies with groundwater standards both in shallow alluvial and bedrock aquifers. Iron and manganese are ubiquitous throughout the district and their concentrations are believed to be partially controlled by natural bedrock sources. Contaminant-specific ARARs for ambient air will be met under this alternative, as air quality would not be affected by construction operations.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by the implementation of this alternative. Threatened and endangered species present in or near the District may be affected by the activities associated with implementing this alternative in the short-term, but it is not likely that these species will be adversely affected, as there will be no new disturbances, no permanent facilities, and implementation of the alternatives 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 demonstrating compliance with non-degradation requirements will be met. Requirements for groundwater protection will be met by Best Available Technologies (BATs). Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met by using Best Management Practices (BMPs).

- *REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT*

Contaminant mobility will be reduced by Alternative WT-1, and toxicity may be reduced through natural attenuation processes. There will be no reduction in discharge volume through treatment.

7.5.1.2 IMPLEMENTABILITY (WT-1)

This alternative is implementable and feasible given that adequate area with a sufficient depth of soil above the water table or bedrock is available. If soil depths are insufficient, imported soil can be used. Construction is straight-forward using readily available materials and equipment. Operation and maintenance is minimal, excepting periodic replacement. A two-foot burial depth should provide sufficient frost protection given the deep snowpack in the area. Additional testing of infiltration rate and buffering capacity would provide for design optimization.

7.5.1.3 COST (WT-1)

A cost estimate to implement this alternative at a single site is provided in **Table 7-5**; detailed costs are provided in **Appendix D**. If this alternative were implemented at each of the Group 5 sites, the cost would be multiplied by three.

TABLE 7-5
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-1

Infiltration	
Direct Capital Costs	$8,684
Indirect Capital Costs	$6,947
O+M Costs (Present Worth)	$4,000
TOTAL	**$19,631**

7.5.2 Alternative WT-2: Passive Chemical Adsorption/Ion Exchange

Passive chemical adsorption and ion exchange would entail contacting the flow to be treated with a commercially available zeolite that would act as a natural ion exchange medium to selectively remove cadmium, copper, lead, and zinc ions. This alternative is only applicable to one of the Group 5 sources, the Black Warrior Adit, because the Black Warrior has a low flow, low metals concentrations, and manganese concentrations less than standards. This alternative is not applicable to the other Group 5 sites due to higher manganese concentrations.

It has been assumed that the treatment system would consist of zeolite-filled plastic barrels plumbed in series and fed by gravity flow (**Figure 34**). The system could be set up underground in a shelter such as a 6-foot diameter manhole to protect from freezing. Systems could be sized to provide a known adsorption/ion exchange capacity for individual flows such that several years' treatment could be expected. Discharge from each Zeolite-filled barrel could be monitored and barrels could be replaced as needed.

7.5.2.1 EFFECTIVENESS (WT-2)

It is likely that zeolite would be effective at reducing cadmium, copper, lead, and zinc concentrations at the Black Warrior Mine to below standards. Because of this, Alternative WT-2 meets the RAOs for the project and protects human health and the environment.

- LONG-TERM EFFECTIVENESS, PERMANENCE, SHORT-TERM EFFECTIVENESS, AND REDUCTION IN TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

Long-term effectiveness of this treatment process is expected to be good. The effectiveness of the system should be easy to monitor to determine if treatment levels are being met, and barrels could be replaced or added as needed. Long-term effectiveness critically depends on continual monitoring and maintenance of the system and the system will have to be operated in perpetuity. Alternative WT-2 will substantially reduce contaminant volume, mobility, and toxicity through treatment.

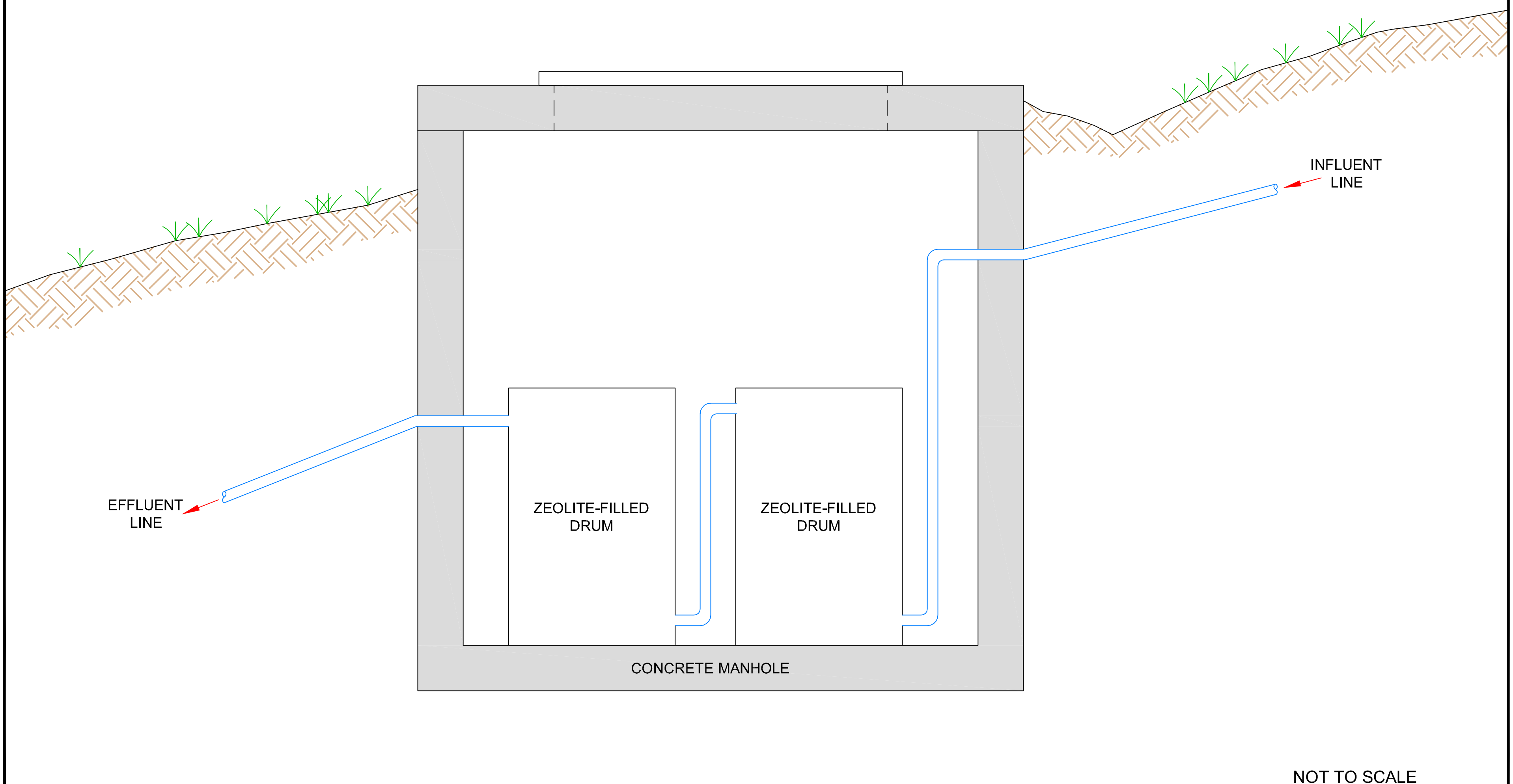


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FIGURE 34
PASSIVE CHEMICAL ADSORPTION
INSTALLATION SCHEMATIC

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Short- and long-term effectiveness could be adversely affected by the very harsh climate in the area, which could potentially lead to system upset due to freezing and/or inundation during the snowmelt period. Short-term impacts resulting from construction will be minimal, as the number of construction workers, equipment, and supplies needed to construct the system are minor. Construction of the alternative can be completed in a matter of days or weeks and is not expected to have a noticeable effect on local services or roads in the surrounding area.

- *COMPLIANCE WITH ARARS*

Compliance with surface water quality ARARs should be achieved under Alternative WT-2. Groundwater quality will improve in the immediate vicinity of the Black Warrior discharge, although groundwater quality in Miller Creek currently meets standards except for copper, which is not directly attributable to the Black Warrior discharge (there have been no exceedances of copper in the two most recent sampling events). Contaminant-specific ARARs for ambient air will be met under this alternative.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by implementation of the alternative. Threatened and endangered species present in or near the District may be affected by the activities associated with implementing this alternative in the short-term. However, it is not likely that these species will be adversely affected, as there is only a small disturbance to install the system, the permanent facility will be buried, and construction 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 treated water will meet surface water aquatic criteria. Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met by using Best Management Practices (BMPs).

7.5.2.2 IMPLEMENTABILITY (WT-2)

This alternative is easily implemented. Subsurface installation will protect the system from freezing and allow year-round operation. The estimated volume of zeolite needed to treat the Black Warrior discharge is relatively small and should allow at least several years' treatment before requiring replacement.

7.5.2.3 COST (WT-2)

The cost estimate for this alternative (**Table 7-6**) assumes the use of a commercially available zeolite. The estimated volume of zeolite needed to treat 5-year's flow from the Black Warrior is about 1.6 cubic meters (57 cubic feet).

TABLE 7-6
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-2

Passive Chemical Adsorption/Ion Exchange	
Direct Capital Costs	$13,110
Indirect Capital Costs	$8,522
O+M Costs (Present Worth)	$27,181
TOTAL	**$48,812**

7.5.3 Alternative WT-3: Anoxic Limestone Drain, Anaerobic Bioreactor, and Open Limestone Channel

Alternative WT-3 primarily relies on metal removal as sulfides in a liquid- or solid-reactant sulfate-reducing bioreactor (LRBR or SSBR followed by an open limestone channel (OLD). An anoxic limestone drain (ALD) is constructed in conjunction with the sulfate reducing bioreactor to generate alkalinity and raise the pH. This alternative is applicable for treatment of Group I discharges (the McLaren Pit Cap subsurface drains, McLaren Adit, and the Glengarry Millsite Adit), which are acidic to circumneutral in pH and contain multiple metals that exceed standards.

Figure 35 illustrates one possible configuration of the three component system using the solid-reactant sulfate reducing bioreactor. A treatment train employing the liquid-reactant sulfate reducing bioreactor would be designed very much the same, although the entire bed would be filled with a mixture of gravel and limestone and the liquid organic substrate would be added to the influent mine water. In the configuration shown in **Figure 35**, the anoxic limestone drain/bioreactor functions similar to a successive alkalinity producing system, which combines the benefits of an anoxic limestone drain and an organic substrate into one system. The treatment system generates alkalinity and raises the pH in the anoxic limestone drain and additional alkalinity is produced within the bioreactor. Metals are removed as metal sulfides. The effluent from the solid-reactant sulfate reducing bioreactor/liquid-reactant sulfate reducing bioreactor would be passed through an open limestone channel/aeration cell for removal of residual manganese, aluminum, soluble organics, nitrogen compounds, and sulfides.

For design parameters, assumptions include a 24-hour flow residence time in the anoxic limestone drain, a porosity of 0.3, and a 5-day flow residence time in the bioreactor with a porosity of 0.2. The open limestone channels were nominally sized – 61 meters (200 feet) in length for the combined flows from the McLaren Pit subsurface drains and the McLaren Adit (McLaren Unit) with a design flow of 133 Lpm (35 gpm). For the Glengarry Millsite Adit, 30 meters (100 feet) in length and a flow of 15 Lpm (4 gpm) was assumed.

The liquid-reactant bioreactor is considered a semi-passive treatment system requiring the addition of alcohol or other nutrient to fuel bacterial respiration; therefore, this system would require some level of maintenance. The alcohol would be stored in a heated shelter and metered directly into the influent line just upstream of the liquid-reactant sulfate reducing bioreactor. In contrast, a solid-reactant sulfate reducing bioreactor would require no ongoing operations and maintenance, but recent literature has suggested that solid-substrate bioreactors have not been effective for ARD treatment for more than about 3 to 5 years and therefore may need to be replaced more often (URS, 2003). For this evaluation, we have assumed a treatment life of 5 years for the SSBR and 10 years for the LRBR.

7.5.3.1 EFFECTIVENESS (WT-3)

Solid-reactant sulfate reducing bioreactors and LRBRs are able to treat metals-contaminated water to low concentrations (Tsukamoto, Miller et al. 1999; URS, 2003). However, full-scale liquid-reactant treatment systems have only been implemented at a few sites (e.g. the Leviathan Mine in California [URS, 2003] and the Hollister Mine in Nevada); therefore, a significant amount of testing would be required before a full-scale design could be completed. If testing proves the system successful, RAOs and overall protectiveness of human health and the environment would be met by this alternative at the three sites.

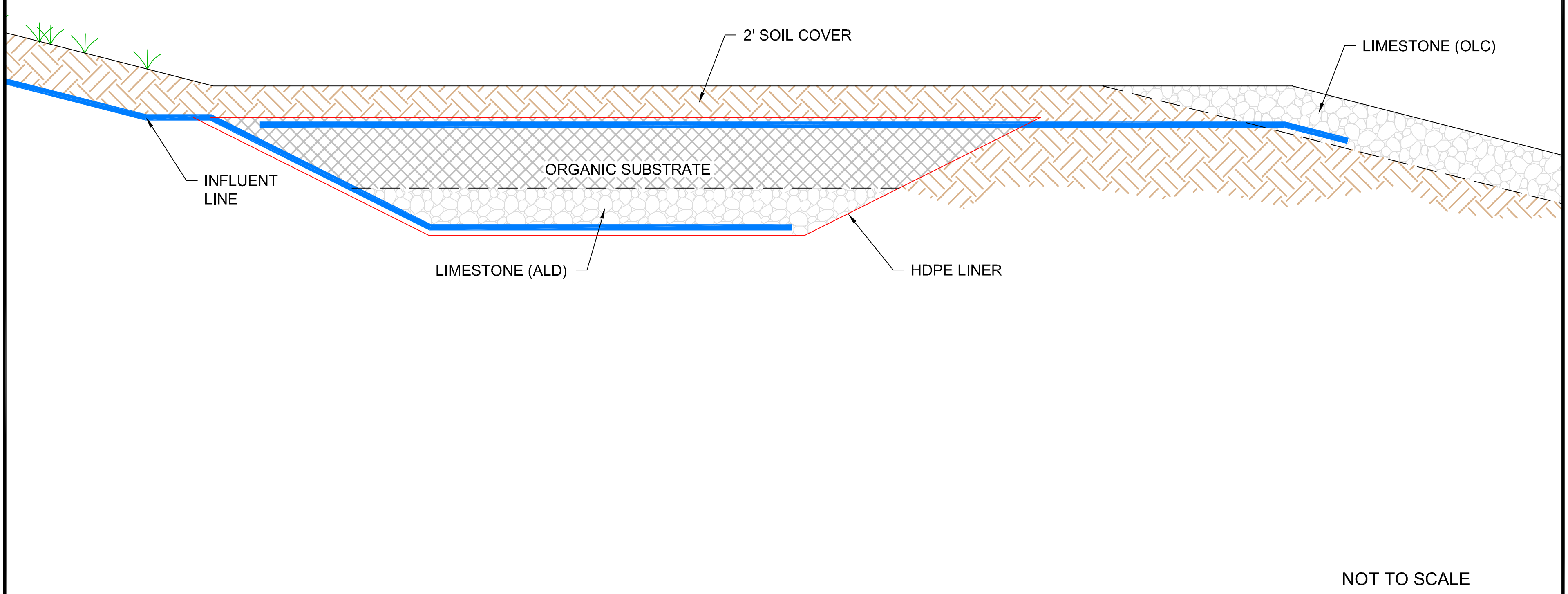

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FIGURE 35
ANAEROBIC BIOREACTOR SCHEMATIC
ANOXIC LIMESTONE DRAIN (ALD) - OPEN LIMESTONE CHANNEL (OLC)

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❖ *LONG-TERM EFFECTIVENESS AND PERMANENCE*

Long-term reliability of this system is unknown. However, given the water chemistries associated with the various discharges, a theoretical ranking for longevity should be possible based on the relative flows and concentrations of aluminum (Al^{3+}), iron ($Fe^{3+/2+}$), and sulfate (SO_4^{-2}). This type of analysis would suggest that the long-term effectiveness of Alternative WT-3 would be much greater for the Glengarry Millsite Adit than for the McLaren Unit.

Longevity of treatment can be a concern for anoxic limestone drains and successive alkalinity producing system, especially in terms of plugging. If appreciable dissolved Fe^{3+} and Al^{3+} are present, clogging of limestone pores with Fe and Al hydroxides has been observed; gypsum ($CaSO_4$) may also be problematic for waters high in sulfate (>1,500 mg/L) (Faulkner and Skousen, 1994; Watzlaf et al., 1994; Nairn et al., 1991).

Open limestone channels can also be subject to decreasing effectiveness due to limestone armoring with iron and/or aluminum oxyhydroxides. However, recent experiments have demonstrated that coated limestone continues to dissolve at a significant rate, and that armored limestone was 50 to 90% as effective as unarmored limestone in neutralizing acid (Ziemkiewicz, Skousen et al., 1997). The length of the channel and the gradient, which affects turbulence and build up of coatings, are design factors that can be varied to optimize performance. Optimum performance appears to be attained with slopes greater than 20% where flow velocities keep precipitates in suspension and clean solids from limestone surfaces. A secondary concern for open limestone channels is the very cold temperatures in the District and presence of a considerable amount of snowpack -- typically in the range of 4.5 to 7.5 meters (15 to 25 feet). It is assumed that the open limestone channel would need to be over designed to allow for some amount of freezing at the surface while providing protection for subsurface flow.

The liquid-reactant sulfate reducing bioreactors have several advantages over the solid-reactant sulfate reducing bioreactors, with better control of the reaction rate and constant permeability. A disadvantage of the solid/liquid sulfate reducing bioreactor system is that it is semi-passive and requires critically applied operation and maintenance activities. This includes a building that would be heated year-round using a generator fueled by diesel or gasoline, and delivery of reagents year-round to the site which would require plowing the Daisy Pass and Lulu Pass roads or making deliveries of fuels and reagents in the winter with a snowcat or other large, over-the-snow equipment.

❖ *SHORT-TERM EFFECTIVENESS AND REDUCTION IN MOBILITY, TOXICITY, AND VOLUME THROUGH TREATMENT*

Short-term impacts resulting from construction are not expected to impact local services or roads in the surrounding area, as the number of construction workers, equipment, and supplies needed to construct the system would only be a minor addition to the current level of use. Construction of the alternative could be completed in one construction season, although weather conditions may require more than one season to complete all work for the system. Shipments of reagents will occur several times per year, and every few years increased activity will be required to fully replace reactants in the bioreactor. Periodic maintenance will also be required.

Alternative WT-3 will substantially reduce contaminant volume, mobility, and toxicity through treatment.

❖ *COMPLIANCE WITH ARARS*

Compliance with surface water quality ARARs (**Appendix C**) can be fully achieved under Alternative WT-3. Treatment of the discharges will result in effluent that meets aquatic standards. Complete removal of the McLaren Unit contaminant load should result in a substantial change in water quality at station DC-2 in Daisy Creek, as the McLaren Pit subsurface drains contribute as much as 150% of the iron load and substantial (5.5% to 31.1%) of the remaining contaminants during low flow conditions. An improvement in water quality in Fisher Creek could also be expected with the treatment of the Glengarry Millsite adit discharge, especially with regard to iron and manganese. However, surface water quality in these streams will not likely meet B-1 standards, as other sources are present in these headwater drainages that would cause water quality exceedances to persist.

Groundwater quality may improve substantially in Daisy Creek with the treatment of the McLaren Unit flows. In conjunction with a reduction in loading as a result of the McLaren Pit cap, contaminant loads to groundwater would be much lower than under current conditions. In Fisher Creek, reducing the load from the Glengarry Millsite Adit may have a positive impact on iron and manganese concentrations in groundwater, although these two contaminants may still exceed human health guidelines. Iron and manganese are ubiquitous throughout the district and their concentrations are believed to be partially controlled by natural bedrock sources. Contaminant-specific ARARs for ambient air will be met under this alternative, as air quality would not be affected by construction operations.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by implementation of the alternative. Threatened and endangered species present in or near the District may be affected by the activities associated with implementing this alternative. The alternative requires a facility at each site and year-round operations that could disturb threatened and endangered species movements and distribution, particularly during the winter months. Regular operations and maintenance through the winter will also substantially change winter access on the Daisy Pass and Lulu Pass roads because the roads may require plowing unless large, over-the-snow equipment is used. While the level of traffic involved with operation and maintenance activities is expected to be within the level of traffic currently associated with recreational use of the area, plowing these roads may change migration patterns for area wildlife, with potential impacts to the grey wolf. 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 treated water will meet surface water aquatic criteria. Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met by using Best Management Practices (BMPs).

7.5.3.2 IMPLEMENTABILITY (WT-3)

Construction of the anoxic limestone drain, SSBR/LRBR, and open limestone channel components are implementable and the treatment process is feasible. Construction is straight-forward using readily available materials and equipment. However, the construction season is short, and this may cause difficulties in completing the system in one season. The systems require a fairly large area to construct (about 0.41 hectares or one acre) for the combined flows of McLaren Unit. Access to the site for delivery of reagents would be difficult during the winter due to deep snow.

7.5.3.3 COST (WT-3)

The cost estimate presented in **Appendix D** presents the estimated construction cost for an Alternative WT-3 treatment system. Line item costs include an anaerobic cell/ALD, reagent storage and delivery system (liquid-reactant sulfate reducing bioreactor only), and an open limestone channel. Operations and maintenance costs include operating labor, reagents, snow plowing, road maintenance, and complete replacement of the solid-reactant sulfate reducing bioreactor every five years and replacement of the liquid-reactant sulfate reducing bioreactor every 10 years (**Table 7-7**). Year-round access and labor have been included in the liquid-reactant sulfate reducing bioreactor cost estimate, only.

TABLE 7-7
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-3

Anoxic Limestone Drain/Sulfate Reducing Bioreactor/ Open Limestone Channel - McLaren Unit		
	Solid Reactant	**Liquid Reactant**
Direct Capital Costs	$573,046	$856,525
Indirect Capital Costs	$315,175	$471,089
O+M Costs (Present Worth)	$2,350,000	$3,535,485
TOTAL	**$3,238,221**	**$4,863,099**

As shown in **Table 7-7**, estimated costs for the liquid-reactant sulfate reducing bioreactor at the McLaren Unit are significantly more expensive than for the solid-reactant sulfate reducing bioreactor, primarily due to labor and access requirements associated with the liquid-reactant sulfate reducing bioreactor. **Table 7-8** summarizes the estimated costs for the Group 1 sources. Estimated cost for the solid-reactant sulfate reducing bioreactor at the Glengarry site is significantly less expensive, reflecting the site's better water quality and lower flows.

TABLE 7-8
COSTS FOR ALTERNATIVE WT-3 GROUP 1 SITES
MCLAREN PIT DRAINS AND GLENGARRY MILLSITE ADIT

McLaren Pit Cap Drains - Solid-Reactant Sulfate Reducing Bioreactor	$3,238,221
McLaren Pit Cap Drains – Liquid-Reactant Sulfate Reducing Bioreactor	$4,863,099
Glengarry Millsite Adit – Solid-Reactant Sulfate Reducing Bioreactor	$564,827

7.5.4 ***Alternative WT-4: Anaerobic Bioreactor (solid-reactant sulfate reducing bioreactor or liquid-reactant sulfate reducing bioreactor)-open limestone channel***

Alternative WT-4 is equivalent to that described for Alternative WT-3 with the exception that the upstream anoxic limestone drain has been eliminated. This configuration is applicable for treating water in discharges from the Little Daisy Adit, Henderson Mt Adit, and the Henderson Mountain Dump 7 in Group 5. These flows have a pH that is near-neutral, metals amenable to sulfide precipitation, and contain aluminum and/or manganese above the aquatic standards or human health guidelines.

7.5.4.1 Effectiveness (WT-4)

Solid-reactant sulfate reducing bioreactors and liquid-reactant sulfate reducing bioreactors are able to treat metals-contaminated water to low concentrations (URS, 2003; Tsukamoto and Miller, undated; MFG, Inc, undocumented project experience). Because Alternative WT-3 and WT-4 are very similar, the discussion of short and long-term effectiveness contained in the previous section for Alternative WT-3 is applicable to Alternative WT-4.

7.5.4.2 Implementability (WT-4)

The solid-reactant sulfate reducing bioreactor/liquid-reactant sulfate reducing bioreactor-open limestone channel system components are implementable and the treatment process is feasible. Construction is straight-forward using readily available materials and equipment. However, the construction season is short. Access, including delivery of reagents, would be difficult during winter weather due to the deep snow. The liquid-reactant sulfate reducing bioreactors have several advantages over the solid-reactant sulfate reducing bioreactors, including control of the reaction rate and constant permeability. A disadvantage of the liquid reactant is that it requires more operation and maintenance costs.

7.5.4.3 Cost (WT-4)

Cost estimates were prepared assuming a SSBR with a 32 Lpm (8.5 gpm) capacity is needed for the Little Daisy and Henderson Mountain adits, and a solid-reactant sulfate reducing bioreactor with a 5 Lpm (1.4 gpm) capacity is needed for the Henderson Mountain Dump #7 Adit. The cost estimate includes construction cost of the treatment systems with line items for the solid-reactant sulfate reducing bioreactor and open limestone channel. Operations and maintenance costs include complete solid-reactant sulfate reducing bioreactor replacement every five years except at the Henderson Mtn. Dump 7 site where replacement every 10 years has been assumed to be sufficient. **Table 7-9** summarizes costs associated with this alternative; a detailed breakdown of cost is provided in **Appendix D**.

TABLE 7-9
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-4

Anaerobic Bioreactor (Solid-Reactant Sulfate Reducing Bioreactor) and Open Limestone Channel		
	Little Daisy and Henderson Mtn. Adits (8.5 gallons per minute)	**Henderson Mountain Dump #7 Adit (1.4 gallons per minute)**
Direct Capital Costs	$112,049	$31,685
Indirect Capital Costs	$61,627	$14,258
O+M Costs (Present Worth)	$480,000	$52,000
TOTAL	**$653,676**	**$97,943**

7.5.5 Alternative WT-5: Manganese Removal Cell

Manganese removal cells can add alkalinity and provide suitable residence time and substrate contact to allow manganese to precipitate prior to discharging to a receiving stream. This technology is appropriate for the Gold Dust and Lower Tredennic adits. These two discharges are circumneutral in pH with only manganese concentrations that exceed a water quality standard, the human health guideline of .050 mg/L.

7.5.5.1 Effectiveness (WT-5)

Manganese removal cells have been shown to be effective for manganese removal, especially for low flows and where iron and aluminum concentrations are relatively low and limestone armoring is minimal (URS, 2003). Typically, manganese removal cells are configured as a limestone-filled pond, which presents limitations in an area with a harsh winter climate such as that in the New World District. Thus, the manganese removal cell envisioned for this site would be constructed similar to the solid-reactant sulfate reducing bioreactor (**Figure 35**) except it would be filled with limestone only.

- *Long-Term Effectiveness, Permanence, Short-Term Effectiveness, and Reduction in Toxicity, Mobility, and Volume Through Treatment*

Because the manganese loads contained in the Gold Dust Adit and the Lower Tredennic are very low as compared to many ARD streams, there is a reasonable expectation that the system would remain effective over the long-term. A trench would be sized to allow for sufficient residence time for manganese removal via precipitation as manganese oxide (MnO_2). The trench would be constructed below grade and covered with sufficient soil to protect from freezing, thus allowing the system to operate year round.

Alternative WT-5 will substantially reduce contaminant volume, mobility, and toxicity through treatment.

Short-term impacts resulting from construction will be minimal, as the number of construction workers, equipment, and supplies needed to construct the system are minor. Construction of the alternative can be completed in a matter of days or weeks and is not expected to have a noticeable effect on local services or roads in the surrounding area.

- *Compliance with ARARs*

Compliance with surface water quality ARARs should be achieved at the two sites where this alternative could be applied. Groundwater quality will improve in the immediate vicinity of the adits, as iron and manganese are the only contaminants that exceed groundwater guidelines in Fisher Creek. Contaminant-specific ARARs for ambient air will be met under this alternative.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by implementation of the alternative. Threatened and endangered species present in or near the District will not be affected by this alternative, as there will be only a small disturbance to install the system, the permanent facility will be buried, and construction 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 treated water will meet surface water aquatic criteria. Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met by using Best Management Practices (BMPs).

7.5.5.2 IMPLEMENTABILITY (WT-5)

Manganese removal cells are easily implemented and would require little to no maintenance.

7.5.5.3 COST (WT-5)

Costs for manganese removal cells, shown in **Table 7-10**, were estimated for a flow of about 49 Lpm (13 gpm) at the Gold Dust Adit (to account for higher flows associated with the snowmelt period) and a flow at the Lower Tredennic of about 7 Lpm (1.8 gpm).

TABLE 7-10
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-5

Manganese Removal Cell		
	Gold Dust Adit (13 gallons per minute)	**Lower Tredennic Adit (1.8 gallons per minute)**
Direct Capital Costs	$50,919	$11,749
Indirect Capital Costs	$22,913	$5,287
O+M Costs (Present Worth)	$86,500	$17,250
TOTAL	**$160,332**	**$34,286**

7.5.6 Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration

Active treatment for sources in Groups 1 through 4 would utilize a packaged, skid-mounted treatment system with a capacity of between 19 to 95 Lpm (5 to 25 gpm) or 95 to 188 Lpm (25 to 50 gpm), dependent on source requirements. The system would consist of pretreatment, filtration, and neutralization (**Figure 36**). Pretreatment consists of pH adjustment to 8.5 to 9.5 s.u. that causes metal hydroxides to precipitate to a filterable size. Filtration would utilize a proprietary advanced membrane filtration system that discharges very low metal concentration filtrates. The pH would be adjusted to neutral prior to discharge. Additional studies would be required to test pretreatment and filtration scenarios to optimize operation and effluent water quality.

The system would include reagent storage and feed equipment, and sludge handling including filter press and sludge storage. The system would be powered by a diesel generator located on site. The complete treatment system would be housed in heated buildings with adequate space for reagent, fuel, sludge, and equipment storage, offices, and break and changing rooms. Assumptions for operation of the system include storage capacity for at least a one-month supply of reagents, fuel, and any consumables as well as adequate space to store one month's sludge production. The road to the site would require improvement and snow removal year-round. This would mean both the Daisy Pass and Lulu Pass roads would require plowing.

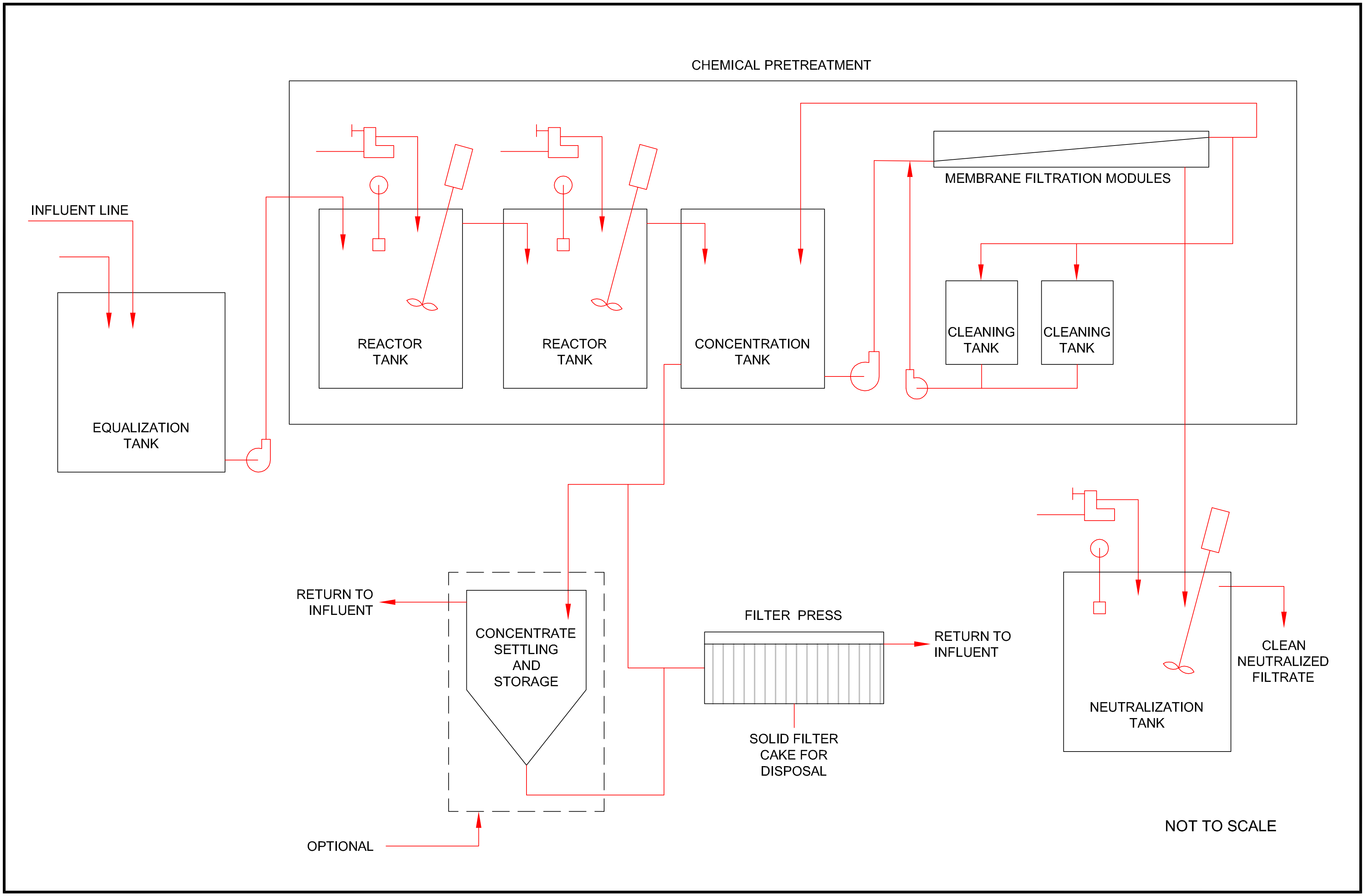

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FIGURE 36
CHEMICAL ADDITION,
PRECIPITATION, AND MICRO-FILTRATION SCHEMATIC

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7.5.6.1 EFFECTIVENESS (WT-6)

Treatment systems using pH adjustment and filtration are able to treat metals-contaminated water to very low concentrations at similar sites (McKenzie, 1980; Skousen, Rose et al., 1998). Further testing will be required to determine actual achievable effluent quality. Further processing by reverse osmosis may be required to meet standards for all metals, although this contingency has not been included in the cost estimate for the system. Implementing this alternative would meet RAOs and overall protectiveness of human health and the environment.

❖ LONG-TERM EFFECTIVENESS AND PERMANENCE

There will be considerable demand for short and long-term operation and maintenance to keep these systems running efficiently. Fiber optic cable, which would allow for remote system monitoring, could be installed to reduce operation and maintenance costs. This would involve installing cable from a station located in Cooke City to the site. The cost to install such a system has not been included in this analysis. Excluding this type of infrastructure investment, it is probable that routine site visits (possibly daily) will be required to ensure effective system operation. It is also assumed that monthly deliveries of fuel (diesel for the electrical generator and propane for the heating system) will be required along with monthly trips to deliver chemicals and remove sludge. It would be possible to extend the time between deliveries, but this would involve increasing storage capacity and the size of associated infrastructure.

The very cold temperatures and deep snowpack characteristic of the District may impact overall system effectiveness and assumptions for long-term operations and maintenance. Any disruption of power and/or heat generation could cause significant damage to the system and require additional expenditures for system maintenance beyond what has been assumed for this analysis. Long-term effectiveness critically depends on continual monitoring and maintenance of the system and the system will have to be operated in perpetuity.

❖ SHORT-TERM EFFECTIVENESS AND REDUCTION IN MOBILITY, TOXICITY, AND VOLUME THROUGH TREATMENT

Short-term impacts resulting from construction are not expected to have a major impact on local services or roads in the surrounding area, as the number of construction workers, equipment, and supplies needed to construct the system would be a nominal addition to the current level of use. Construction of the alternative could be completed in one construction season, although weather conditions may require more than one season to complete all work for the systems. Shipments of fuel and reagents will occur monthly, and this requirement will severely affect the recreational snowmobile use of the Daisy Pass and Lulu Pass roads.

Alternative WT-6 will substantially reduce contaminant volume, mobility, and toxicity through treatment.

❖ COMPLIANCE WITH ARARS

Compliance with surface water quality ARARs (**Appendix C**) can be fully achieved under Alternative WT-6 for the applicable adit discharges. Treatment of the discharges will result in effluent that meets aquatic standards. Complete removal of the McLaren Unit contaminant load should result in a substantial change in water quality at station DC-2 in Daisy Creek, as the McLaren Pit subsurface drains contribute a substantial portion of the metals load during both low and high flow conditions. An improvement in water quality in Fisher Creek could also be expected with the treatment of the Glengarry Millsite and Gold Dust discharges, especially with regard to iron and manganese. However, surface water quality in Daisy Creek and Fisher Creek will likely not meet B-1 standards, as other sources are present in these headwater drainages that would allow water quality exceedances to persist.

Groundwater quality may improve substantially in Daisy Creek with the treatment of the McLaren Unit flows. In conjunction with reduction in loading as a result of the McLaren Pit cap, contaminant loads to groundwater would be much lower than under current conditions. In Fisher Creek, reducing the load from the Glengarry Millsite and the Gold Dust discharges may have a positive impact on iron and manganese concentrations in groundwater, although these two contaminants may still exceed human health guidelines for these metals. Iron and manganese are ubiquitous throughout the district and their concentrations are believed to be partially controlled by natural bedrock sources. Contaminant-specific ARARs for ambient air will be met under this alternative, as air quality would not be affected by construction operations, although exhaust from diesel generators may locally affect air quality.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by implementation of the alternative. Threatened and endangered species present in or near the District may be affected by the activities associated with implementing this alternative. The alternative requires a facility at each site and year-round operations that could disturb threatened and endangered species movements and distribution, particularly during the winter months. Regular operations and maintenance will be required through the winter, which will substantially change winter access on the Daisy Pass and Lulu Pass roads because the roads will require plowing. While the level of traffic involved with operation and maintenance activities is expected to be within the level of traffic currently associated with recreational use of the area, plowing these roads may change migration patterns for area wildlife, with potential impacts to the grey wolf. 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 treated water will meet surface water aquatic criteria. Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met by using Best Management Practices (BMPs).

7.5.6.2 Implementability (WT-6)

The active treatment system alternative is implementable and feasible. The treatment processes are well understood and commonly used. Packaged treatment systems are readily available. Construction is straight-forward using readily available materials and equipment. However, the construction season is short and this may require a two-season period to complete installation of the system. Access including delivery of reagents and sludge disposal would be difficult during winter weather due to the deep snow.

7.5.6.3 Cost (WT-6)

The cost estimate summarized in **Table 7-11** includes construction cost of the treatment system, shelter, and support equipment. Operations and maintenance costs include operating labor, electrical power, reagents, sludge disposal, snow plowing, and road maintenance. Cost estimates are provided for a 95-189 Lpm (25-50 gpm) system and a 19-95 Lpm (5-25 gpm) system. A detailed cost breakdown is provided in **Appendix D**.

TABLE 7-11
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-6

Chemical Addition, Precipitation, and Micro-filtration		
	McLaren Pit Cap Drains and McLaren Adit (25 to 50 gallons per minute)	**Glengarry Millsite Adit and Group 2, 3, and 4 Discharges (5 to 25 gallons per minute)**
Direct Capital Costs	$594,382	$477,191
Indirect Capital Costs	$326,910	$310,484
O+M Costs (Present Worth)	$3,961,634	$2,392,849
TOTAL	**$4,882,927**	**$3,180,999**

7.5.7 *Alternative WT-7: Ion Exchange*

The ion exchange process as evaluated for the sources in Group 5 would be a semi-active system. Such a system would typically be housed in a permanent heated structure and require nearly continuous maintenance. The system as proposed here would be placed in underground vaults for freeze protection and be gravity fed (**Figure 37**). Because the source water is of reasonably good water quality, the system would consist of pre-filtration (0.2 to 0.3 μm diameter pore size) and a single ion exchange vessel sized to provide at least one-year capacity.

7.5.7.1 EFFECTIVENESS (WT-7)

This alternative is capable of achieving high quality effluent meeting Circular WQB-7 standards in the effluent stream. Bench-scale testing would be needed to determine which commercial ion exchange resins would provide the best results and to allow estimation of system capacity.

- *LONG-TERM EFFECTIVENESS, PERMANENCE, SHORT-TERM EFFECTIVENESS, AND REDUCTION IN TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT*

Long-term effectiveness of this treatment process is expected to be good. The effectiveness of the system should be easy to monitor to determine if treatment levels are being met, and barrels could be replaced or added as needed. Long-term effectiveness critically depends on continual monitoring and maintenance of the system and the system will have to be operated in perpetuity.

As with passive ion exchange using natural zeolites (Section 7.5.2), short and long-term effectiveness could be adversely affected by the very harsh climate in the area, which could potentially lead to system upset due to freezing and/or inundation during the snowmelt period. Short-term impacts resulting from construction will be minimal, as the number of construction workers, equipment, and supplies needed to construct the system are minor. Construction of the alternative can be completed in a matter of days or weeks and is not expected to have a noticeable effect on local services or roads in the surrounding area.

❖ *COMPLIANCE WITH ARARS*

Compliance with surface water quality ARARs should be achieved under Alternative WT-7. Groundwater quality will improve in the immediate vicinity of the discharges. Contaminant-specific ARARs for ambient air will be met under this alternative.

Location-specific ARARs, particularly those associated with cultural and historic resources will be met, as no cultural or historic resources will be impacted by implementation of the alternative. Threatened and endangered species present in or near the District may be affected by the activities associated with implementing this alternative in the short-term. However, it is not likely that these species will be adversely affected, as there will be only a small disturbance to install the system, the permanent facility will be buried, and construction will be completed in one season. Regular operations and maintenance will be required, but the level of traffic involved with these activities is expected to be within the level of traffic currently associated with recreational use of the area. 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 treated water will meet surface water aquatic criteria. Action-specific State of Montana air quality regulations related to dust suppression and control during construction activities will be met by using Best Management Practices (BMPs).

7.5.7.2 IMPLEMENTABILITY (WT-7)

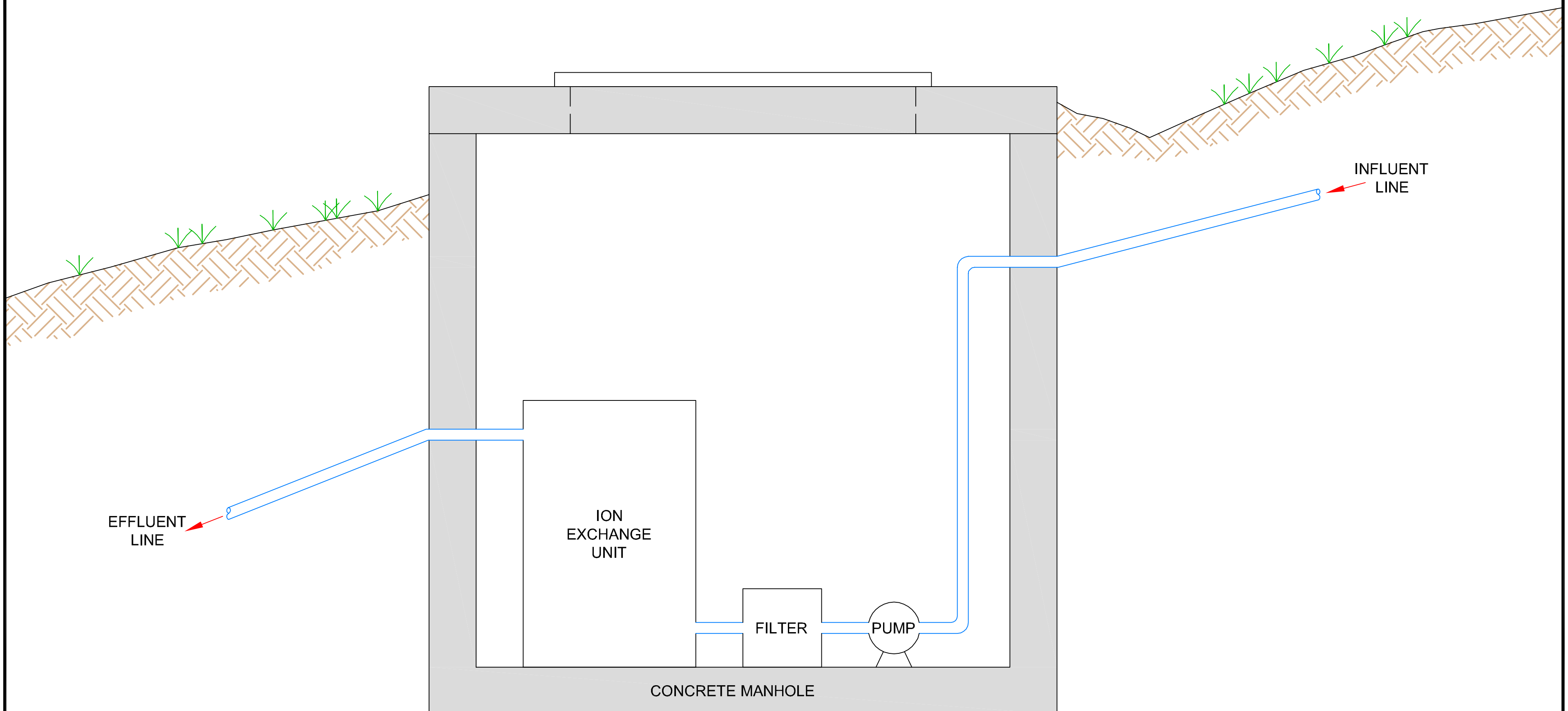
The ion exchange treatment system alternative is implementable and feasible. Packaged treatment systems are readily available and a simple system as described here could easily be constructed on site. Construction is straight-forward using readily available materials and equipment. Access would be difficult during winter weather due to the deep snow. However, if properly sized, the resin would only need to be replaced annually and could be done when weather permitted.

7.5.7.3 COST (WT-7)

The cost estimate includes flow collection system, manhole installation, and ion exchange system installation. Operations and maintenance costs include annual system replacement. Cost estimates are provided for a 9.5 Lpm (2.5 gpm) system appropriate for Group 5 sources (**Table 7-12**). A cost breakdown is provided in **Appendix D**.

TABLE 7-12
CAPITAL AND OPERATIONAL COST ESTIMATE SUMMARY FOR ALTERNATIVE WT-7

Ion Exchange	
Direct Capital Costs	$16,605
Indirect Capital Costs	$10,793
O+M Costs (Present Worth)	$27,181
TOTAL	**$54,579**



NOT TO SCALE

MFG, Inc.
consulting scientists and engineers

FIGURE 37
ION EXCHANGE
INSTALLATION SCHEMATIC

Date:	APRIL 2005
Project:	181159X
File:	SCHEM-01.dwg

Figure 37 – back page

8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the alternatives developed in Section 6.2 (**Table 6-5**) and evaluated in detail in Section 7.0. Response alternatives were developed to reduce, minimize, or eliminate environmental impacts associated with contaminated discharges to receiving surface water and groundwater resources. There is no human health risk associated with the discharges.

Two very different types of response technologies were used to develop the response alternatives: Engineering Source Control and Water Treatment Control technologies. Alternatives for both of these technologies were developed along parallel paths by dividing the mines into groups for engineering and water treatment alternative analysis (**Tables 6-2 and 6-3**, respectively). The comparative analysis developed in this section is performed for each of the three primary criteria -- effectiveness, implementability, and cost. As described in Section 7.1, costs are estimated for comparative purposes only, as many design details that would affect costs are preliminary. Actual costs are expected to range from 50% higher to 30% lower than comparative costs estimated for this EE/CA. For the water treatment alternatives, operations and maintenance costs are included at present worth value for a 20-year period and include replacement of reactive media on either a one, five, or ten-year schedule, depending on the treatment technology requirements. The engineering control alternatives do not have any associated operation and maintenance costs.

The following sections first summarize the evaluation of alternatives as applied to the three types of response actions (No Action, Engineering Closure, and Water Treatment) and then compares the alternatives. The comparison is based on the groups of mines developed for each type of response action, and each of the relevant alternatives is compared on a group-by-group basis. A preferred alternative is identified at the end of the section.

8.1 SUMMARY OF THE NO ACTION ALTERNATIVE (NA-1)

No Action does not alter the existing condition of mining related discharges. Underground flow controls or water treatment measures would not be attempted at the sites. There would be no attempt to control or treat contaminant migration from the mines to nearby surface water, or to reduce its toxicity or volume.

Water captured in drains below the McLaren Pit cap would continue to discharge via the subsurface drains into Daisy Creek tributaries. The McLaren, Glengarry Millsite, Black Warrior, and Henderson Mountain adit discharges would continue to discharge contaminated water into or within short distances of active streams. The Lower Tredennic, Henderson Mountain Dump 7, and Little Daisy adit discharges would continue to infiltrates into nearby soils.

As a result of no action, natural attenuation would reduce contaminant concentrations and loading over time. However, the degree of natural attenuation, particularly at Group 1 water treatment sites, is likely minimal and any noticeable degree of natural attenuation would take place over a very long period of time. The No Action alternative is most applicable to discharges in Water Treatment Group 5 (**Table 6-3**), which have low flows and relatively low metal concentrations. From an engineering point of view, the No Action alternative is also most applicable to Engineering Group C (**Table 6-2**) because the adits are too short to construct an effective physical closure.

No Action appears to be more applicable to those discharges that have relatively small contributions to the total metals loads measured at the nearest downstream surface water monitoring site (**Table 8-1**). For example, the Lower Tredennic and Black Warrior adit discharges each contribute less than 1.0 % of the total load of individual COCs at the nearest downstream surface water sampling site.

TABLE 8-1
SUMMARY OF ADIT AND SUBSURFACE DRAINS LOADING ANALYSIS

Source Name	Al	Cd	Cu	Fe	Pb	Mn	Zn
Percent of Load as Measured at DC-2 Daisy Creek							
McLaren Subsurface Drains	**18.7**	**17.6**	**31.1**	**150.2**	5.5	**15.4**	25.3
McLaren Adit	**0.04**	**0.07**	**0.04**	**9.1**	0.6	**2.6**	0.25
Unaccounted or Non-specific Load Source at DC-2	81.3	82.3	69.9	--	93.9	82	74.5
Percent of Load as Measured at SW-3 Fisher Creek							
Glengarry Millsite	**0.51**	1.0	**0.45**	**11.4**	**1.36**	**2.9**	**1.03**
Lower Tredennic Dump #1	0.02	0.28	0.01	0.17	0.69	**0.29**	0.31
Percent of Load as Measured at SW-4 Fisher Creek							
Gold Dust Adit	0.44	0.14	0.006	4.91	1.1	**3.88**	0.48
Henderson Mtn. Dump #7	**0.73**	**0.57**	**0.57**	**22.3**	**1.1**	**4.8**	0.66
Percent of Load as Measured at SW-2 Miller Creek							
Black Warrior Adit	0.01	**0.9**	**0.01**	0.02	**0.2**	0.03	**1.0**
Little Daisy Adit	**0.01**	**0.3**	**0.01**	**0.7**	**0.2**	**3.1**	**0.4**
Henderson Mtn. Adit	**0.2**	1.0	**2.2**	0.01	**0.5**	0.1	0.5

Notes: Shading indicates loads that are greater than 1% of total load at the next downstream surface water station; McLaren Pit subsurface drain loads at DC-2 are September 2006 low flow data.
Bold numbers highlight constituents that exceed the applicable surface water standard.

8.2 SUMMARY OF ENGINEERING SOURCE FLOW CONTROL ALTERNATIVES

Engineering source controls were only considered for adit discharges that are amenable to this type of closure. These include the currently accessible McLaren and Gold Dust adits, and the currently inaccessible Little Daisy, Lower Tredennic, and Black Warrior adits. Other adits evaluated in this EE/CA are considered to have underground workings that are too short to be considered for engineering source control measures. This is because adit water sources are too near the surface, and diverted water from a physical closure would likely easily bypass the closure and discharge to the surface through another nearby fracture.

The two engineering source control alternatives evaluated (EC-1 and EC-2) use a high strength, acid-resistant, watertight cement plug placed approximately 76 meters (250 feet) into the mine workings with a second plug placed near the portal. Plugs block the flow of water and greatly reduce or eliminate a discharge. Backfill is used for ground support for plugs as well as increasing the restriction to flow.

Watertight plugs have been shown at a number of sites, including the Glengarry Adit, to greatly reduce or eliminate mine discharges. The effect of placing tunnel and portal plugs will be immediate and permanent, and the mobility of metals will be permanently reduced or eliminated. The two alternatives differ in that one addresses mines that are currently accessible (EC-1) and the other addresses mines that are not accessible and need to be reopened prior to plugging (EC-2). These is more uncertainty associated with the effectiveness, implementability, and cost of Alternative EC-2 because little is known of the conditions of the underground workings that would make this alternative successful.

8.3 SUMMARY OF WATER TREATMENT ALTERNATIVES

While all of the COCs identified at the discharge sites are heavy metals, differences in metal characteristics and reactivity complicates water treatment response action alternative selection. For discharges with several metals above the applicable aquatic standards, scenarios were developed that combine water treatment response alternatives to successfully remove the entire set of target COCs from the discharge stream.

Passive, semi-passive, and conventional active treatment response alternatives were evaluated for each source under review. **With many of the innovative or passive treatment approaches, it is unclear given available current literature if the technology can meet the stringent aquatic standards applied to the New World sites.** This is due in part because, in many of the studies reported in the literature, the recorded detection limits are above the aquatic criteria set for Montana B-1 standards. It is therefore difficult to predict removal efficiencies by biological and/or other passive treatment technologies, and treatability testing with actual adit discharge waters will be necessary to define achievable removal efficiencies for each discharge.

In contrast, conventional, active treatment technologies such as chemical addition-precipitation followed by micro- or nano-filtration, or reverse osmosis typically have the best chance of consistently meeting effluent discharge standards from a proven technology standpoint. However, the remoteness of the location, limited access, and the severe winter climate in the District would make operation and maintenance of the active technologies very difficult and expensive, and may render these more proven technologies less efficient than would be expected with close monitoring in a very controlled environment. Typically, implementation of an active treatment technology could only be accomplished at a significant increase in cost over a passive treatment system.

8.4 COMPARISON OF ALTERNATIVES BY MINE GROUP

8.4.1 Group 1 Alternatives

Comparison of the Group 1 alternatives is summarized in **Tables 8-2 and 8-3**. Group 1 discharges include the combined McLaren Adit (D-18) and McLaren subsurface drain discharges (DCSW-101, -102, and -103), and the Glengarry Millsite Adit (F-8B). The flow from the McLaren Adit was combined with the McLaren subsurface drains because of its proximity to the subsurface drain outflows. However, as can be seen from **Table 8-1**, the McLaren Adit contributes only 9.1 % of the total iron and 2.6% of the total manganese loads measured at DC-2, and less then 0.6% of the total load for aluminum, cadmium, copper, lead, and zinc. Load contributions from the subsurface drains are much greater, with notable contributions of 150% of the iron, 31% of the copper, and 25% of the zinc, among others (**Table 8-1**). This leaves an unaccounted, or non-specific (non-point) source, load in Daisy Creek at station DC-2 ranging from 94% of the lead to 70% of the copper (**Table 8-1**).

Engineering Source Flow Controls are not suitable for closing the McLaren subsurface drains or the very short Glengarry Millsite Adit, but are appropriate for closure of the McLaren Adit (**Table 8-2**). Alternative EC-1, plugging an accessible adit, is considered to be a highly effective method of closure for the McLaren Adit, as it would likely greatly reduce or eliminate flow from the adit. It is also technically and administratively feasible and implementable. The cost of closure is about $368,000.

Alternative WT-3 (Anoxic Limestone Drain, Anaerobic Bioreactor & Open Limestone Channel) and Alternative WT-6 (Chemical Addition, Precipitation & Micro-filtration) were evaluated for treatment of water from the McLaren Unit (**Table 8-2**). The combined chemical mass loading from the McLaren Pit subsurface drains and the McLaren Adit (~105,000 kg/yr or 116 tons) and associated high flow rates creates a difficult treatment situation. Alternative WT-6 has a high probability of meeting water quality standards and could be supplemented with a reverse osmosis unit, if necessary. Alternative WT-3, although it would be effective in reducing COCs, may have a difficult time meeting water quality standards. In addition, Alternative WT-6 would likely be very effective over the long term, whereas the long-term effectiveness of Alternative WT-3 is unknown and the organic substrate in the passive anaerobic bioreactor would need to be replaced frequently to account for the high metal loads treated.

Both alternatives are implementable using conventional equipment and materials, although Alternative WT-3 would likely require a very large area to install the passive system and the innovative technologies would require on-site testing to complete a design for the site. The passive technology of Alternative WT-3 simplifies operations and requires no infrastructure or routine operations. The problems associated with trying to operate an active water treatment system for Alternative WT-6, considering access required for the materials that routinely need to be delivered or stored at the site, the waste that needs to be routinely removed, and the daily access required for operation would seem to be truly formidable. This is particularly true given the severe weather, remoteness of the site, difficult site access, lack of power, and high level of winter recreational use at the site.

Both systems are quite expensive; the passive Alternative WT-3 ranges in price from $3,238,000 for a solid substrate bioreactor to $4,864,000 for a liquid substrate bioreactor. A liquid substrate bioreactor is the most likely choice between these two types of bioreactors because of the requirement that the system operate year-round with temperatures below freezing for at least six months of the year. The cost for the active WT-6 system is $4,883,000 (**Table 8-2**).

In contrast, due to the much lower flows and lower metals concentration associated with the Glengarry Millsite Adit, the passive anaerobic bioreactor system, Alternative WT-3, would be a much more reasonable alternative for water treatment at this site (**Table 8-3**). Its price at $565,000 is much less expensive than Alternative WT-6 for the millsite, $3,181,000. In addition, Alternative WT-6 would have the same problems described above for infrastructure requirements and difficulty in access and year-round operation.

8.4.2 Group 2 - Little Daisy Adit Alternatives

The comparative evaluation of alternatives for the Group 2 site, the Little Daisy Adit, is summarized in **Table 8-4**. The Little Daisy Adit is amenable to closure using engineering source controls for an inaccessible adit, Alternative EC-2. As with the McLaren Adit, use of a plugging system for closure is considered to be a highly effective method for the Little Daisy Adit. Implementation of this alternative would greatly reduce or eliminate flow from the adit. It is also technically and administratively feasible and implementable. The cost of implementing Alternative EC-2 is about $500,000.

Table 8-2
Comparison of Selected Water Treatment Alternatives for the McLaren Pit Subsurface Drains and McLaren Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Alternative	Description of Technology	Effectiveness	Implementability	Infrastructure & Operational Needs	Total Estimated Cost [1]
No Action Alternative **Alternative NA-1**	No technology involved.	Overall effectiveness is poor. Leaves the McLaren Adit and subsurface drain discharges in existing condition. Acidic water, dissolved metals, and sediment will continue to flow to Daisy Creek. No reduction in toxicity or volume. Not effective in reducing concentrations of metals at the source. Natural attenuation reactions may effectively reduce some metal loading and ecological risk in McLaren Adit discharge through time; not expected for subsurface drains. Does not meet ARARs.	Technically and administratively feasible. Implementable as no action is required.	None	No Cost
Engineering Alternative **Alternative EC-1** **Plug an Accessible Adit** (McLaren Adit Only)	Underground engineering flow control treatment using high strength, acid-resistant, water-tight cement plugs installed about 76 meters (250 feet) into mine and plug near the portal to block flow. Backfill would be used for ground support for plugs and increased restriction of flow.	Water-tight plugs will greatly reduce or eliminate water flow from the McLaren Adit to Daisy Creek. The mobility of metals will be permanently reduced. The effect of placing tunnel and portal plugs will be immediate and permanent. However, the load of metals from McLaren Adit to Daisy Creek is less than 13% of total load at DC-2; therefore this closure method will not significantly affect instream water quality in Daisy Creek. Meets ARARs.	Implementable using readily available equipment and technologies. Numerous portal and drift plugs have been previously installed in abandoned in underground mines, including the Glengarry Mine in the New World District.	No permanent infrastructure required. Requires conventional construction and underground mining equipment and materials. Requires trained personnel that are readily available in the Western US. No operation or maintenance required once project is completed.	$ 368,481
Water Treatment Alternative **Alternative WT-3: Anoxic Limestone Drain, Anaerobic Bioreactor (SSBR or LRBR), and Open Limestone Channel**	Passive treatment technology that relies on water neutralization with limestone, biological sulfate reduction to precipitate metal sulfides, and an aeration/neutralization cell for removal of residual aluminum and manganese.	Effective at reducing COC concentrations but may have difficulty in meeting standards. Difficult to predict final effluent water quality due to site-specific conditions. Long-term effectiveness is unknown. High likelihood that effectiveness could decrease rapidly due to high metals loading.	Implementable using conventional equipment and materials although a fairly large area is required. Innovative technologies would require testing to complete design. Passive technology simplifies operation.	Passive system with no infrastructure or routine operational needs. Requires replacement of organic substrate every 5 to 10 years.	SSBR: $3,238,000 LRBR: $4,863,000
Water Treatment Alternative **Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration.**	Active treatment system utilizing the addition of chemicals (NaOH or other base to raise pH and possibly ferric iron salt to add sorptive capacity), precipitation tank to remove large flocs, and a membrane filtration unit to remove suspended solids.	High probability of achieving target aquatic standards. RO unit could be added to further reduce COC concentrations. Good long-term effectiveness. Meets ARARs. Does not meet project objectives for minimizing changes to historic character of the District.	Packaged systems make installation of this technology feasible. Remote location and harsh weather would make operation difficult. Common technologies would require some testing for optimization. Would severely impact recreational winter use on Daisy Pass Road.	Requires significant infrastructure to hold equipment, bulk chemicals, and solid filter cake. Continuous supply of electrical power and heat source for buildings is required. Monthly deliveries of reagents and fuel are assumed along with monthly trips for waste disposal. Daily access for system operation and maintenance may be required.	$4,883,000

Notes: 1 Capital and 20-years O+M (includes scheduled reactant replacement costs for water treatment alternatives)

Table 8-3
Comparison of Selected Water Treatment Alternatives for the Glengarry Millsite Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Alternative	Description of Technology	Effectiveness	Implementability	Infrastructure & Operational Needs	Total Estimated Cost [1]
No Action Alternative **Alternative NA-1**	No technology involved.	Overall effectiveness is poor. Leaves the Glengarry Millsite Adit in its existing condition. Acidic water, dissolved metals, and sediment will continue to flow from the adit portal through colluvial materials into Fisher Creek. No attempt to reduce discharge toxicity or volume. Not effective for reducing concentrations of metals at the source. Natural attenuation reactions may effectively reduce some metal loading and ecological risk through time. Does not meet ARARs.	Technically and administratively feasible. Implementable as no action is required	None	No Cost
Water Treatment Alternative **Alternative WT-3: Anoxic Limestone Drain, Anaerobic Bioreactor (SSBR or LRBR), and Open Limestone Channel**	Passive treatment technology that relies on water neutralization with limestone, biological sulfate reduction to precipitate metal sulfides, and an aeration/ neutralization cell for removal of residual aluminum and manganese.	Effective at reducing COC concentrations. Difficult to predict final effluent water quality. Long-term effectiveness is unknown. Effectiveness could decrease due to high metals loading to system from discharge, particularly from iron.	Implementable using conventional equipment and materials although ferricrete at the site may prove difficult to excavate and would require blasting. Innovative technologies would require testing to complete design. Passive technology simplifies operation.	Passive system with no infrastructure or routine operational needs. Requires replacement of organic substrate every 5 to 10 years.	$554,000
Water Treatment Alternative **Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration.**	Active treatment system utilizing the addition of chemicals (NaOH or other base to raise pH and possibly ferric iron salt to add sorptive capacity), precipitation tank to remove large flocs, and a membrane filtration unit to remove suspended solids.	High probability of achieving target aquatic standards. RO unit could be added to further reduce COC concentrations. Good long-term effectiveness. Meets ARARs. Does not meet project objectives for minimizing changes to historic character of the District.	Packaged systems make installation of this technology feasible. Remote location and harsh weather would make operation difficult. Common technologies would require some testing for optimization. Would severely impact recreational winter use on Lulu Pass Road.	Requires significant infrastructure to hold equipment, bulk chemicals, and solid filter cake. Continuous supply of electrical power and heat source for buildings is required. Monthly deliveries of reagents and fuel are assumed along with monthly trips for waste disposal. Daily access for system operation and maintenance may be required.	$3,181,000

Notes: 1 Capital and 20-years O+M (includes scheduled reactant replacement costs for water treatment alternatives)

Table 8-4
Comparison of Selected Water Treatment Alternatives for the Little Daisy Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Alternative	Description of Technology	Effectiveness	Implementability	Infrastructure & Operational Needs	Total Estimated Cost [1]
No Action Alternative **Alternative NA-1**	No technology involved.	Not effective for reducing concentrations of metals at the source. Natural attenuation reactions may effectively reduce metals loading and ecological risk. Does not meet ARARs.	Implementable as no action is required.	None	No Cost
Engineering Alternative **Alternative EC-2** **Reopen and Plug Inaccessible Adit**	Reopen inaccessible Little Daisy adit involves excavation of the portal, water discharge through a sediment pond, and mucking workings to 76 meters. High strength, acid-resistant, water-tight cement plugs would be placed at 76 meters (250 feet) from portal and near the portal to block flow. Backfill would be used for ground support for plugs and increased restriction of flow.	Water-tight plugs will greatly reduce or eliminate water flow from the Little Daisy Adit to upper Miller Creek drainage Basin. There is no direct discharge to Daisy Creek. The mobility of metals will be permanently reduced. Effective as a barrier or seal to water flow along workings or isolating select areas of underground workings in order to prevent groundwater mixing. The effect of placing tunnel and portal plugs will be immediate and permanent. Meets ARARs	Implementable using available equipment and technologies. Installing portal and drift plugs has been shown to be successful. However, regaining access to the Little Daisy workings to set plugs is unpredictable, and may be somewhat difficult. Because underground conditions are unknown, implementability of this alternative may be extremely difficult, and reentry of the mine may not be successful.	No permanent infrastructure required. Requires conventional construction and underground mining equipment and materials. Requires trained personnel that are readily available in the Western US. No operation or maintenance required once project is completed.	$500,000
Water Treatment Alternative **Alternative WT-4: Anaerobic Bioreactor (SSBR or LRBR) and OLC**	Passive treatment technology that relies on biological sulfate reduction to precipitate metal sulfides and an aeration/ neutralization cell for removal of residual aluminum and manganese.	Effective at reducing concentration of all COCs. Difficult to predict final effluent water quality. Long term effectiveness may be affected if system becomes plugged with precipitates.	Implementable using conventional equipment and materials. Testing required to complete design. Passive technology simplifies operation.	Passive system with no infrastructure or routine operational needs. Requires replacement of organic substrate every 10 to 20 years.	$654,000
Water Treatment Alternative **Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration.**	Active treatment system utilizing the addition of chemicals (NaOH or other base to raise pH and possibly ferric iron salt to add sorptive capacity), precipitation tank to remove large flocs, and a membrane filtration unit to remove suspended solids.	High probability of achieving target aquatic standards. RO unit could be added to further reduce COC concentrations. Good long-term effectiveness. Meets ARARs. Does not meet project objectives for minimizing changes to historic character of the District.	Packaged systems make installation of this technology feasible. Remote location and harsh weather would make O+M difficult. Common technologies would require some testing for optimization. Would severely impact recreational winter use on Daisy Pass Road.	Requires significant infrastructure to hold equipment, bulk chemicals, and solid filter cake. Continuous supply of electrical power and heat source for buildings is required. Monthly deliveries of reagents and fuel are assumed along with monthly trips for waste disposal. Daily access for system operation and maintenance would be required.	$3,181,000

Notes: 1 Capital and 20-years O+M (includes scheduled reactant replacement costs for water treatment alternatives)

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The water treatment alternatives deemed most applicable for the Little Daisy Adit are Alternative WT-4 (Anaerobic Bioreactor and OLC) and Alternative WT-6 (Chemical Addition, Precipitation & Micro-filtration). The Little Daisy discharge has several metals above aquatic standards and a near-neutral pH; however, total metals loading is relatively low (less than 1% except for manganese). These factors, combined with a moderate flow of about 30 Lpm (8 gpm), suggests that an Anaerobic Bioreactor system could function for an extended time period, possibly 10 to 20 years depending on the type of bioreactor installed (i.e., SSBR or LRBR). In this case, the anaerobic bioreactor would benefit from the addition of an Open Limestone Channel downgradient of the bioreactor to add alkalinity to the water and enhance the precipitation of metals. Alternative WT-6, active treatment, is plagued by the same difficulties with respect to year-round operations, site access, power, and supply requirements as those described for the Group 1 sites. In addition, the projected cost differential of almost $2.5 million dollars between the passive bioreactor ($654,000) and the active treatment system ($3,181,000) makes the passive system more attractive, particularity considering the potentially long-term effectiveness.

8.4.3 Group 3 - Gold Dust Adit Alternatives

The comparative evaluation of alternatives for the Gold Dust Adit is summarized in **Table 8-5**. The Gold Dust Adit is suitable for closure using Alternative EC-1, Plugging an Accessible Adit. Use of a plugging system for closure is considered to be a highly effective method for flow reduction from the Gold Dust Adit. Implementation of this alternative would reduce or eliminate flow from the adit that, following grouting of boreholes in the drill stations in October 2005, has been reduced to 13.6 Lpm (3.6 gpm). This alternative is technically and administratively feasible and implementable, with an estimated cost of about $370.000.

The water treatment alternatives selected for treating the Gold Dust Adit discharge are Alternative WT-5 (Manganese Removal Cell) and Alternative WT-6 (Chemical Addition, Precipitation & Micro-filtration). Currently, the only contaminant in the Gold Dust discharge is manganese, which exceeds the human health guideline of 0.05 mg/L. Alternative WT-5 is a passive treatment technology, which consists of a large subsurface limestone filled chamber to add alkalinity and provide adequate residence time for manganese precipitation. This technology has been shown to be effective at removing manganese at other mining sites. However, it is difficult to predict final effluent water quality because of the uniqueness of site conditions. Active water treatment, Alternative WT-6, although effective at removing low levels of metals, is very expensive and plagued by the same difficulties discussed above related to surface infrastructure requirements, power requirements, sludge disposal, and the ability to operate on a year-round basis under the extreme climate and access conditions present at the site. The cost of a passive manganese removal cell is estimated to be about $160,000, and the cost of active water treatment is about $3,181,000.

It is probable that No Action could achieve the level of manganese reduction required given sufficient distance between the discharge source and Fisher Creek. Manganese is oxidized by numerous bacteria found in nature, and it is likely that in the oxidizing, organic-rich uppermost soil horizon, manganese would be sequestered and removed from solution. This situation exists downstream of the Gold Dust Adit under current conditions where there is a long, open, low gradient stretch of stream that flows through grassland and willow covered wetlands before entering Fisher Creek. In the synoptic study completed on Fisher Creek by Amacher et. al. (1998), manganese concentrations measured at the mouth of the Gold Dust tributary were well below the manganese guideline.

8.4.4 Group 4 - Henderson Mountain Adit Alternatives

The Henderson Mountain Adit (M-25) is the only adit discharge included in Group 4. **Table 8-6** summarizes the comparative analysis of alternatives appropriate for this adit. This adit is situated on the southwest flank of Henderson Mountain in an area of known metal anomalies in both soils and bedrock (e.g., copper concentrations in soils in excess of 500 parts per million). The adit is inaccessible except by foot up a steep hillside above the Daisy Pass road; the adit is too short and too close to the surface to close using engineering source control Alternative EC-2.

Water treatment alternatives deemed most applicable to the treatment of this discharge include Alternative WT-4 (Anaerobic Bioreactor and OLC) and Alternative WT-6 (Chemical Addition, Precipitation & Micro-filtration). The moderate flow rates averaging 32 Lpm (8.5 gpm) and low total metals loading (~215 kg/yr or 0.24 tons) suggest that Alternative WT-4 would provide effective treatment. Alternative WT-4 is a passive treatment technology that relies on biological sulfate reduction to precipitate metal sulfides and an aeration/neutralization cell for removal of residual aluminum and manganese. Alternative WT-4 should be effective in reducing metals for a number of years before its effectiveness begins to be reduced; however, final water quality is not predictable. The alternative is implementable using conventional equipment and materials, although access to the site will be difficult and the limited area at the site coupled with its location on a steeply sloping hillside may preclude optimizing a design for this passive system. The cost to implement Alternative WT-4 is about $654,000, although this cost does not include the cost for building a road to the site, which would be considerable.

Active chemical treatment has been discussed in association with several mine groups listed above. In this application, although it is very effective at removal of COCs, the cost to implement Alternative WT-6 ($3,181,000) coupled with the limited space and difficult topography of the site make implementing this alternative prohibitive.

The presence of multiple metals above the aquatic standards and the slightly acidic pH of this discharge make it difficult to predict the effectiveness of the No Action Alternative (NA-1). Only copper is measured at station SW-2 in Miller Creek above the aquatic standard and the Henderson Mountain Adit is not the only source of copper above SW-2 (samples collected by Cleasby and Nimick (2002) in three nearby tributaries that flow off the southwest flank of Henderson Mountain contained elevated copper levels).

8.4.5 Group 5 Alternatives

Group 5 includes Henderson Mountain Dump 7, Lower Tredennic Dump 1, and the Black Warrior adits. These adits are characterized by low flow volumes and relatively low metal concentrations. A summary of the comparative analysis is presented in **Table 8-7**.

Although the Henderson Mountain Dump #7 is too short and too shallow for an Engineering Source Control closure, both of the other mines, the Black Warrior and Lower Tredennic, are suitable for such a closure using Alternative EC-2, Reopen and Plug an Inaccessible Adit. Use of a plugging system for closure is considered to be a highly effective method for flow reduction from both adits. However, reopening inaccessible adits may or may not be successful and is rife with uncertainty. Because underground conditions are unknown, implementability of this alternative may be extremely difficult and successful reentry of the mines may not be accomplished.

Table 8-5
Comparison of Selected Water Treatment Alternatives for the Gold Dust Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Alternative	Description of Technology	Effectiveness	Implementability	Infrastructure & Operational Needs	Total Estimated Cost [1]
No Action Alternative **Alternative NA-1**	No technology involved.	Not effective for reducing concentrations of metals at the source. Natural attenuation reactions may achieve the level of manganese reduction required given sufficient distance between the discharge source and the receptor stream. Does not meet ARARs.	Implementable as no action is required.	None	No Cost
Engineering Alternative **Alternative EC-1** **Plug an Accessible Adit** (Gold Dust Adit)	Underground engineering flow control treatment using high strength, acid-resistant, water-tight cement plugs installed about 76 meters (250 feet) into mine and plug near the portal to block flow. Backfill would be used for ground support for plugs and increased restriction of flow.	Water-tight plugs will greatly reduce or eliminate water flow from the Gold Dust Adit to Fisher Creek. Mobility of metals will be permanently reduced. Effective as a barrier or seal to water flow along workings or isolating select areas of underground workings in order to prevent mixing of groundwater. The effect of placing tunnel and portal plugs will be immediate and permanent. Meets ARARs.	Implementable using readily available equipment and technologies. Numerous portal and drift plugs have been previously installed in abandoned underground mines, including the Glengarry Mine in the New World District.	No permanent infrastructure required. Requires conventional construction and underground mining equipment and materials. Requires trained personnel that are readily available in the Western US. No operations or maintenance required once project is completed.	$ 368,481
Water Treatment Alternative **Alternative WT-5: Manganese Removal Cell**	Passive treatment technology, which would consist of a large subsurface limestone filled chamber to add alkalinity and provide residence time to allow manganese precipitation.	This technology has been shown to be effective at removing manganese at other mining sites. Difficult to predict final effluent water quality due to site-specific conditions.	Implementable using conventional equipment and materials. Testing required for design. Passive technology simplifies operation.	Requires construction of a subsurface impoundment. No above ground infrastructure required and no routine operational requirements.	$160,000
Water Treatment Alternative **Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration**	Active treatment system utilizing the addition of chemicals (NaOH or other base to raise pH and possibly ferric iron salt to add sorptive capacity), precipitation tank to remove large flocs, and a membrane filtration unit to remove suspended solids.	High probability of achieving target aquatic standards. RO unit could be added to further reduce COC concentrations. Good long-term effectiveness. Meets ARARs. Does not meet project objectives for minimizing changes to historic character of the District.	Packaged systems make installation of this technology feasible. Remote location and harsh weather would make operation difficult. Common technologies would require some testing for optimization. Would severely impact recreational winter use on Lulu Pass Road.	Requires significant infrastructure to hold equipment, bulk chemicals, and solid filter cake. Continuous supply of electrical power and heat source for buildings is required. Monthly deliveries of reagents and fuel are assumed along with monthly trips for waste disposal. Access for system operation and maintenance will be required.	$3,181,000

Notes: 1 Capital and 20-years O+M (includes scheduled reactant replacement costs for water treatment alternatives)

Table 8-6
Comparison of Selected Water Treatment Alternatives for the Henderson Mt Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Alternative	Description of Technology	Effectiveness	Implementability	Infrastructure & Operational Needs	Total Estimated Cost (1)
No Action Alternative **Alternative NA-1**	No technology involved.	Not effective in reducing concentrations of metals at the source. Natural attenuation reactions may effectively reduce metals loading and ecological risk. Only copper exceeds aquatic standards at station SW-2 in Miller Creek, and this adit is not the only source of copper. Does not meet ARARs.	Implementable as no action is required.	None	No Cost
Water Treatment Alternative **Alternative WT-4: Anaerobic Bioreactor (SSBR or LRBR), and OLC**	Passive treatment technology that relies on biological sulfate reduction to precipitate metal sulfides and an aeration/ neutralization cell for removal of residual aluminum and manganese.	Effective at reducing COC concentrations. Difficult to predict final effluent water quality. Long-term effectiveness is unknown. Effectiveness could decrease due to high metals loading to the system from discharge water.	Implementable using conventional equipment and materials. Innovative technologies would require testing to complete design. Requires new road construction to access site along difficult terrain. Limited area at the site coupled with location on a steeply sloping hillside may preclude optimizing a design for this passive system.	Passive system with no infrastructure or routine operational needs. Organic substrate will require replacement as often as every 5 years	$654,000
Water Treatment Alternative **Alternative WT-6: Chemical Addition, Precipitation & Micro-filtration**	Active treatment system utilizing the addition of chemicals (NaOH or other base to raise pH and possibly ferric iron salt to add sorptive capacity), precipitation tank to remove large flocs, and a membrane filtration unit to remove suspended solids.	High probability of achieving target aquatic standards. RO unit could be added to further reduce COC concentrations. Good long-term effectiveness. Meets ARARs. Does not meet project objectives for minimizing changes to historic character of the District.	Packaged systems make installation of this technology feasible. Requires new road construction to access site along difficult terrain. Remote location and harsh weather would make operation difficult. Common technologies would require some testing for optimization. Would severely impact recreational winter use on Daisy Pass Road.	Requires significant infrastructure to hold equipment, bulk chemicals, and solid filter cake. Continuous supply of electrical power and heat source for buildings is required. Monthly deliveries of reagents and fuel are assumed along with monthly trips for waste disposal. Access for system operation and maintenance would be required.	$3,181,000

Notes: 1 Capital and 20-years O+M (includes scheduled reactant replacement costs for water treatment alternatives)

Table 8-7
Comparison of Selected Water Treatment Alternatives for Group 5 Discharges
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Alternative (applicable sources)	Description of Technology	Effectiveness	Implementability	Infrastructure & Operational Needs	Total Estimated Cost [1]
No Action Alternative **Alternative NA-1**	No technology involved.	Not effective for reducing concentrations of metals at the source. Natural attenuation reactions may effectively reduce metals loading and ecological risk. Does not meet ARARs for all Group 5 sites.	Implementable as no action is required.	None	No Cost
Engineering Alternative **Alternative EC-2 Reopen and Plug Inaccessible Adits** (Lower Tredennic and Black Warrior adits)	Reopening inaccessible Lower Tredennic and Black Warrior adits involves excavation of the portal, water discharge through a sediment pond, and mucking workings to 76 meters. High strength, acid-resistant, water-tight cement plugs would be placed at 76 meters (250 feet) from portal and near the portal to block flow. Backfill would be used for ground support for plugs and increased restriction of flow.	Water-tight plugs will greatly reduce or eliminate water flow from the Lower Tredennic and Black Warrior Adits to Fisher Creek and Miller Creek, respectively. The mobility of metals will be permanently reduced. Effective as a barrier or seal to water flow along workings. The effect of placing tunnel and portal plugs will be immediate and permanent. Meets ARARs.	Implementable using available equipment and technologies. Installing portal and drift plugs has been shown to be successful. Regaining access to the Black Warrior should be relatively easy, although accessing deeper workings in the Lower Tredennic may be very difficult. Because underground conditions are unknown, implementability of this alternative may be extremely difficult, and reentry of the mines may not be successful.	No permanent infrastructure required. Requires conventional construction and underground mining equipment and materials. Requires trained personnel that are readily available in the Western US. No operation or maintenance required once project is completed.	$437,000 Black Warrior Adit $500,000 Lower Tredennic Adit
Water Treatment Alternative **Alternative WT-1: Infiltration** (Henderson Mtn Dump, Lower Tredennic, and Black Warrior adits)	Surface water discharges are converted to subsurface flows via infiltration through a drainfield. Allows for greater contact with unconsolidated materials to enhance natural attenuation and reduce contaminant loads.	Dilution and natural attenuation processes would be effective at reducing COCs. Long term effectiveness may be limited. May meet ARARs.	Easily constructed and implemented if suitable location exists. Additional testing would determine long-term effectiveness	Requires installation of subsurface piping grid. No above ground infrastructure required and no routine operation is needed.	$20,000
Water Treatment Alternative **Alternative WT-2: Passive Chemical Adsorption/Ion Exchange** (Black Warrior Adit)	Passive system that removes metal contaminants via ion exchange onto natural zeolite material.	Effective at reducing COCs to below standards. Long-term effectiveness would be good as the system is easily monitored and maintained. Meets ARARs.	Easily constructed and implemented if suitable location exists. Minimal O and M as small zeolite volume required to treat flows for several years. Some testing likely required to optimize design.	Requires installation of subsurface vault and emplacement of zeolite reaction vessels. Minor routine maintenance required and periodic replacement of zeolite, depending on system size.	$49,000
Alternative WT-4: Anaerobic Bioreactor& OLC (Henderson Mtn Dump, Lower Tredennic)	Passive treatment technology that relies on biological sulfate reduction to precipitate metal sulfides and an aeration/neutralization cell for removal of residual aluminum and manganese.	Effective at reducing COC concentrations. Difficult to predict final effluent water quality due to site conditions. Long-term effectiveness is unknown.	Easily constructed and implemented. Innovative technologies would require testing to optimize design.	Passive system with no infrastructure or routine operational needs. Requires replacement of organic substrate every 5 years.	$98,000
Alternative WT-5: Manganese Removal Cell (Lower Tredennic)	Passive treatment technology consisting of a large subsurface limestone filled chamber to add alkalinity and provide residence time to allow Mn precipitation.	Effective at removing manganese. Difficult to predict final effluent water quality and long term effectiveness due to site conditions.	Easily constructed and implemented. Testing required to optimize design	Requires construction of a subsurface impoundment. No above ground infrastructure required and no routine operational requirements.	$34,000
Alternative WT-7: Ion Exchange (Henderson Mtn Dump, Lower Tredennic, and Black Warrior adits)	Semi-passive system consisting of a pump, filtration unit, and ion exchange vessels. Relies on ion exchange reactions onto natural and/or synthetic resins for contaminant removal.	Capable of achieving high quality effluent meeting stringent standards. Good long term effectiveness. Meets ARARs.	Easily constructed and implemented. Testing required to optimize design. Higher inflow pressures (approximately 10 feet of head) required to drive system may not be achievable at some sites.	Requires construction of a subsurface impoundment to hold reaction vessels. Pump(s) will require a reliable source of electricity. Operational requirements consist of inspection of pumps, filters, and replacement of ion exchange resin on an annual basis.	$54,000

Notes: 1 Capital and 20-years O+M (includes scheduled reactant replacement costs for water treatment alternatives)

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The cost to implement Alternative EC-2 is a function of ease of access. The Black Warrior adit is thought to present relatively easy access for reopening and is estimated to cost about $437,000; the Lower Tredennic is thought to be difficult to reopen, raising the cost to access and plug the site to about $500,000.

Several Water Treatment Alternatives are suitable for treatment of water in Group 5. These alternatives are compared in **Table 8-7** and discussed briefly below. Costs associated with water treatment alternatives for Group 5 adit discharges are also shown in **Table 8-7**.

- Alternative NA-1 – No Action: This alternative is potentially applicable to all three flows in Group 5 because of the low flow and relatively low metals concentrations.
- Alternative WT-1 – Infiltration: This alternative is potentially applicable to all flows in Group 5 because of the relatively low flows and low metals concentrations. Discharges from all three adits currently flow into mine water control systems that were constructed in front of the collapsed adit. These systems may be suitable for infiltration but would have to be evaluated for capacity, function, and effectiveness if this alternative is implemented.
- Alternative WT-2 – Passive Chemical Adsorption/Ion Exchange: This alternative uses natural zeolite material and would be effective at removing cadmium, copper, lead, and zinc but much less efficient for aluminum and manganese. Therefore, it is only appropriate for the Black Warrior discharge.
- Alternative WT-4 – Anaerobic Bioreactor and OLC: This alternative would be applicable to Henderson Mountain Dump 7 that exceeds standards for aluminum, copper, iron, and manganese.
- Alternative WT-7 – Ion Exchange: This alternative is applicable to all the discharges in Group 5, as commercially available resins can be designed to remove all COCs. However, relatively high inflow pressures (approximately 10 feet of head) are required to drive this system and this may not be achievable at some sites.

The No Action alternative (NA-1) is the most cost-effective response action presented for this group. Whether No Action can meet RAOs will likely be site-specific and depend on site geology, topography, and distance from the receiving surface water stream.

8.5 PREFERRED ALTERNATIVE

This section presents the preferred alternative for each of the discharge sites. This discussion is summarized in **Table 8-8**.

8.5.1 McLaren Pit Subsurface Drains

Table 8-1 shows that the McLaren Pit subsurface drain discharges exceed standards for all COCs and are a major source of loading at station DC-2. However, the majority of the load at DC-2 remains to be from non-specific, unidentified (non-point) sources other than the McLaren Adit or McLaren subsurface drains (**Table 8-1**) except for possibly iron during low flow periods.

TABLE 8-8
PREFERRED ALTERNATIVE FOR MINING-RELATED DISCHARGES

Site Name	Preferred Alternative
Group 1	
McLaren Pit Subsurface Drains	No Action (NA-1)
McLaren Adit	No Action (NA-1)
Glengarry Millsite Adit	No Action (NA-1)
Group 2	
Little Daisy Adit	No Action (NA-1)
Group 3	
Gold Dust Adit	No Action (NA-1)
Group 4	
Henderson Mountain Adit	No Action (NA-1)
Group 5	
Henderson Mountain Dump 7	No Action (NA-1)
Lower Tredennic Dump 1	No Action (NA-1)
Black Warrior Adit	No Action (NA-1)

Only water treatment alternatives are applicable to the subsurface drains (relevant source containment options were screened out in Section 6.0 due to high cost and difficult implementability). Alternative WT-3 (Anoxic Limestone Drain, Anaerobic Bioreactor & Open Limestone Channel) and Alternative WT-6 (Chemical Addition, Precipitation, and Micro-filtration) were both determined to be effective in treating water discharging from the drains but are expensive (about $4,800,000) and have serious construction and operation problems associated with them. The problems associated with trying to operate an active water treatment system (Alternative WT-6), considering the access required, are many and difficult, and such a treatment system would seriously impact recreational use of the Daisy Pass Road by winter recreationists.

The chances of successful installation and effective operation of a water treatment system when weighed against the total cost leaves the No Action Alternative as the most desirable, particularly while the results of longer term monitoring of the effectiveness of the McLaren Pit Cap are evaluated over the next few years. No Action is also preferred because the large loading contribution from non-specific and unidentified (non-point) sources other than the McLaren Adit or subsurface drains will prevent water quality standards at station DC-2 from being met even if a water treatment technology was employed for the subsurface discharges.

8.5.2 McLaren Adit

Both water treatment options and Engineering Source Control Alternative EC-1 could be employed to stem the flow from the McLaren Adit. These methods would undoubtedly reduce or eliminate flow and contaminants, and subsequently reduce loading to Daisy Creek. However, it does not appear to be cost effective to remove 13% of the total metals load to Daisy Creek at station DC-2 (of which most of this total is iron), particularly when there is little chance of achieving water quality standards at station DC-2 due to other sources of contaminants. Therefore, No Action is selected as the preferred alternative for the McLaren Adit discharge, particularly while the results of longer term monitoring of the effectiveness of the McLaren Pit Cap are evaluated over the next few years.

8.5.3 Glengarry Millsite

The Glengarry Millsite Adit is not amenable to closure using Engineering Source Controls because the workings are too short and too close to the surface. Due to the much lower flows and lower metals concentrations associated with the Glengarry Millsite Adit discharge, a passive anaerobic bioreactor system (Alternative WT-3) is a much more reasonable alternative for water treatment at this site. Its price at $565,000 is about a sixth of the cost of active water treatment (Alternative WT-6) and would be far easier to implement.

While treatment of the millsite adit discharge would be effective, hydrogeologic conditions at the site are in flux with the hydrologic changes that are occurring as a result of the Glengarry Adit closure. The hydrologic system is in the midst of reestablishment of a higher regional groundwater table, and the diversion of water from the Glengarry Adit into pre-mining fracture systems may alter both groundwater flows and change discharges to surface water in the area (i.e. in the form of new or altered seeps and springs). The presence of an extensive ferricrete bench at the Glengarry site suggests that deposition of ferricrete could be reinitiated with changes in the hydrologic regime. Water quality of these discharges and the locations of discharges that result from this altered hydrologic regime are unknown. Therefore, it is premature to construct an expensive passive water treatment system in an area where the volume of water is likely to change over current conditions and whose source area and water quality cannot now be predicted. For these reasons, No Action is the preferred response action for the Glengarry Millsite Adit discharge, particularly because continued monitoring of this site under the longer term monitoring of the Glengarry Adit closure will allow the USDA-FS to regularly evaluate whether taking no action is appropriate.

8.5.4 Little Daisy Adit

The Little Daisy discharge, which exceeds aquatic standards for a number of COCs, does not discharge to surface water; it instead percolates into colluvial material below the collapsed portal, and does not surface again downgradient of the mine. Therefore, if this discharge ultimately reaches Miller Creek, it does so as a dilute and dissipated source some 1,067 meters (3,500 feet) downgradient of the mine site in Miller Creek. Load from the Little Daisy discharge could not be detected in Miller Creek during a synoptic study of metals loading to the Creek by the USGS.

The Little Daisy Adit is amenable to closure by Engineering Source Control Alternative EC-2, Plugging an Inaccessible Adit. This method may be an effective closure, depending on underground conditions in the workings, with water flow from the adit reduced or eliminated. However, because underground conditions are unknown, implementability of this alternative may be extremely difficult, and successful reentry of the Little Daisy may not be possible.

As the Little Daisy discharge exceeds aquatic standards, the moderate flow of about 30 Lpm (8 gpm) suggests that an anaerobic bioreactor system could function for an extended time, although the cost of passive treatment is about twice that of the Engineering Source Control alternative. Active treatment (Alternative WT-6) is plagued by many difficulties with respect to year-round operations, site access, and power and supply requirements. The projected cost of over $3 million makes the passive system more attractive, particularity considering its potential long-term effectiveness.

Loading data presented in **Table 8-1** indicate the only metal in the Little Daisy discharge that exceeds 1% of the load in Miller Creek at station SW-2 is manganese (3.1% of the total in-stream load of manganese in Miller Creek). There is no direct traceable connection from this discharge to Miller Creek, and groundwater data from monitoring wells in Miller Creek below the Little Daisy (MW-5P and MW-5A) do not appear to be impacted from the signature of the Little Daisy discharge. In addition, recent water quality results (2006) for Miller Creek stations SW-2 and SW-5, showed that only copper exceeds applicable standards, with suspended sediment the cause of a portion of these exceedances in the total recoverable fraction. The area of elevated soil copper levels on the west flank of Henderson Mountain is one source of copper in the suspended fraction.

Based on the flow path for the Little Daisy Adit discharge and the lack of measurable impact to receiving groundwater, it appears that infiltration into surrounding soils and colluvial materials provide conditions where natural attenuation and/or dilution of contaminants is occurring under existing conditions. Because there does not appear to be any measurable impact from the Little Daisy discharge and because the costs associated with treating or eliminating the discharge are several hundred thousand dollars, the preferred alternative for this site is No Action. Long-term monitoring of water quality in Miller Creek that will be done as part of the overall project plan will allow the USDA-FS to regularly evaluate whether this alternative continues to be appropriate for the site.

8.5.5 Gold Dust Adit

After completing work involved with grouting boreholes in the Gold Dust Adit, discharge from the adit has been reduced to about 14 Lpm (3.6 gpm). Water flowing from the portal flows through about 305 meters (1,000 feet) of open grassy meadows and willow covered wetlands prior to entering Fisher Creek. At the portal, the Gold Dust discharge meets all chronic aquatic life standards, and only exceeds the human health guideline for manganese (0.05 mg/L). Manganese loading from the Gold Dust Adit discharge contributes about 3.9% of the total manganese load at station SW-4 in Fisher Creek.

The Gold Dust Adit is suitable for closure using Engineering Source Control Alternative EC-1, Plugging an Accessible Adit. Use of a plugging system for closure is considered to be a highly effective method to reduce or eliminate flows from the Gold Dust Adit. Implementing this alternative is technically and administratively feasible. The cost of closure is estimated to be about $370.000.

Constructing a manganese removal cell under Alternative WT-5 would be a passive treatment technology that has been shown to be effective at removing manganese at other mining sites, although it is difficult to predict final effluent water quality at this time because site-specific performance data is needed before this assessment can be made. While the cost of passive treatment is one-twentieth that of active water treatment, final effluent water quality from an active treatment system would assure the manganese standard is met. However, while it is effective, active treatment (Alternative WT-6) is plagued by difficulties related to surface infrastructure requirements, power requirements, and the ability to operate on a year-round basis under the extreme climate and access conditions present at the site. Due to these supply requirements, winter recreation along the Lulu Pass Road would be significantly impacted under active treatment.

It is probable that Alternative NA-1, No Action, could achieve the level of manganese reduction required given sufficient distance between the discharge source and the receptor stream. Manganese is oxidized by numerous bacteria found in nature, and, therefore, it is likely that in the oxidizing, organic-rich, uppermost soil horizon, manganese would be sequestered and removed from solution. This is in fact what happens downstream of the Gold Dust Adit under existing conditions; that is, a long, open, low gradient stretch of stream that flows through grassland and willow covered wetlands before entering Fisher Creek.

Based on the reduction in flow achieved by grouting boreholes in 2005, and on the relatively high cost to either plug or treat the existing discharge, and the fact that there is no aquatic risk associated with manganese, the preferred alternative for the Gold Dust Adit is No Action.

8.5.6 Henderson Mountain Adit

This adit is inaccessible except by foot up a steep hillside above the Daisy Pass Road. Because the small dump at the site indicates that the underground workings are very short (probably less than three to five meters [10 to 15 feet] based on the size of the waste rock dump), this discharge is likely a natural spring. As the bedrock source in the area is known to contain elevated metals, water from the Henderson Mountain Adit exceeds standards for aluminum, copper, and lead, with only copper exceeding aquatic standards at station SW-2 in Miller Creek.

The Henderson Mountain Adit is not amenable to Engineering Source Control alternatives as it is too short and too close to the surface. Due to difficult access and the small physical size of the site, implementation of either passive or active water treatment would be difficult if not impossible, and would likely not allow optimizing these technologies to assure final effluent water quality. Therefore, No Action is the preferred alternative for this discharge.

8.5.7 Group 5

The Group 5 discharges, Henderson Mountain Dump 7, Lower Tredennic, and Black Warrior, are characterized by relatively low flows and relatively low metal concentrations. Of these three adits, the Lower Tredennic discharge does not currently exceed any aquatic surface water quality standards.

The Black Warrior discharge exceeds standards for several COCs at the collapsed adit portal. It then flows for about 30 meters (100 feet) in a small tributary before joining the main stem of Miller Creek. In a synoptic sampling run conducted by Cleasby and Nimick (2002), there was no measurable impact to surface water in Miller Creek in a sample collected immediately downstream of the confluence of the Black Warrior tributary with Miller Creek.

Henderson Mountain Dump #7 discharges at an average rate of 3.8 Lpm (1.0 gpm) onto a topographic swale on the southeast flank of Henderson Mountain. The discharge is located approximately 760 meters (2,500 feet) from Fisher Creek. Historically, the water has infiltrated into surrounding soils and could not be traced as either a seep or spring downgradient of the site.

Although Henderson Mountain Dump #7 is too short and too shallow for an engineering flow control closure, both of the other mines, the Black Warrior and Lower Tredennic, are suitable for such a closure using Alternative EC-2, which would be effective and could be expected to reduce or eliminate flow from the adits. The cost of implementing this alternative is a function of estimated ease of access. The Black Warrior adit is thought to present a relatively easy access for reopening and is estimated to cost about $437,000 to implement, while the Lower Tredennic is expected to present a difficult reopening, increasing the estimated cost to access and plug the adit to about $500,000. However, because underground conditions are unknown, implementability of this alternative may prove to be difficult, and successful reentry of the mines may not be accomplished.

The No Action Alternative is most applicable to discharges in Group 5. The lack of impact to receiving waters for the Lower Tredennic and the Black Warrior adits, and the fact that the Henderson Mountain Dump 7 discharges to colluvial materials some 760 meters (2,500 feet) distant from Fisher Creek, support the preferred alternative selection of No Action.

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APPENDIX A

SELECTED SURFACE AND ADIT WATER QUALITY AND FLOW DATA

Adit Discharge Response Action EE/CA

New World Mining District Response and Restoration Project

TABLE A-1
ADIT DISCHARGE SAMPLING SUMMARY
New World Mining District Adit Discharge Engineering Evaluation/Cost Analysis

Adit Station #	Site Name	Other Station Identifier	Location	Last pH (su)	Flow (gpm)		No. of Samples		Last Sampled
					Range	Last	Field	Lab	
FISHER CREEK DRAINAGE									
F-28	Gold Dust Adit	FCSI-96-1 FCSI-96-1A	Middle Fisher Creek Valley; portal	6.8	1.3-250	3.6	2	17	9/26/2006
F-28-367	Gold Dust underground sample	F-28-367 FCSI-96-1A-367	367 feet from portal	7.9	1.5	1.5	--	1	8/14/2003
F-28-111	Gold Dust underground sample	GDPT 111	730 feet from portal	7.7	--	--	--	1	3/29/1992
F-28-112	Gold Dust underground sample	GDPT 112	730 feet from portal	7.7	--	--	--	1	3/29/1992
F-28-800	Gold Dust underground sample	RR-GD-800	800 feet from portal	6.9	38.6	38.6	--	1	9/16/2004
F-28-D1	Gold Dust underground sample	FCSI-96-1A-D1	Drill station D1; 1850 feet from portal	7.7	0.5	0.5	--	1	8/14/2003
F-28-D2	Gold Dust underground sample	GDDS 2	Drill station D2; about 2000 feet from portal	8.2	--	--	--	2	3/28/1992
F-28-D3	Gold Dust underground sample	FCSI-96-1A-D3	Drill station D3; about 2150 feet from portal	7.7	7	7	--	1	8/14/2003
F-8A	Glengarry Adit	FCSI-96-2A	Glengarry Mine at base of Lulu Pass switchbacks in Fisher Creek	7.1	1.6-143	1.6	42	87	9/26/2006
F-8B	Glengarry Millsite Adit	FCSI-96-4	Glengarry Millsite adit	3.3	3-26.9	5	2	4	7/29/2004
F-8	Glengarry Middle Adit	--	Middle adit between main adit and millsite	3.5	0-1.4	Dry	4	3	8/26/2004
FCSI-99-1	Sheep Mountain #1 (NDP)[3]	--	Upper Tredennic basin, flank of Sheep Mountain	6.1	0.4-10	4	2	3	7/28/2004
FCSI-96-15-1	Upper Tredennic Dump 1	FCSI-96-15	Upper Tredennic basin	3.3	0-1.0	Dry	3	1	7/28/2004
FCSI-96-15-2	Upper Tredennic Dump 2	--	Upper Tredennic basin	2.9	0-0.5	Dry	2	1	7/16/2003
FCSI-96-6	Middle Tredennic Dump 1	--	Lower Tredennic basin	4.8	0-10	Dry	4	2	7/28/2004
FCSI-96-5	Lower Tredennic Dump 1	--	Lower Tredennic Basin	6.1	0.6-5	1.4	2	3	9/22/2004
F-2	Lower Spaulding Dump	FCSI-96-8 Lulu-1	South side of Lulu Pass	2.6	0-0.9	Dry	3	3	7/13/2001

TABLE A-1
ADIT DISCHARGE SAMPLING SUMMARY
New World Mining District Adit Discharge Engineering Evaluation/Cost Analysis

Adit Station #	Site Name	Other Station Identifier	Location	Last pH (su)	Flow (gpm)		No. of Samples		Last Sampled
					Range	Last	Field	Lab	
FCSI-96-7	Middle Spaulding	--	South side of Lulu Pass	--	--	Dry	2	1	8/27/2004
FCSI-99-71	Henderson Mountain Dump 10	--	Above upper road to Homestake Mine	7.5	0-12	Dry	3	--	7/27/2004
FCSI-99-73	Henderson Mountain Dump 13	--	SE Henderson Mt, off Henderson Mt Rd	6.6	5-15	15	1	2	7/27/2004
AE-17	Henderson Mountain Dump 7	FCSI-99-68	SE Henderson Mt, off Henderson Mt Rd.	6.2	0-5	2.0	3	4	7/27/2004
DAISY CREEK DRAINAGE									
D-18	McLaren Adit	DCSI-96-1	W flank of Fisher Mountain; portal	5.8	1.8-29.6	6.3	3	23	9/23/2004
D-18-366	McLaren Mine underground	--	Borehole 366 feet in from portal	7.1	0-5.5	Dry	1	1	9/23/2003
D-18-423	McLaren Mine underground	--	Caved area 423 feet in from portal	7.1	1.5-4.7	4.7	--	2	8/7/2003
DCSI-99-102	Near McLaren Pit	--	Headwall below county road east of McLaren Pit	--	0	Dry	2	--	7/29/2004
DCSI-96-3-1	Daisy Pass Dump 1	--	Below Daisy Pass	6.8	<0.1-2	1.0	2	1	7/29/2004
DCSI-96-6	West of Como Dump 1	--	West side of Lulu pass, Goose Creek	--	0	Dry	2	--	7/29/2004
MILLER CREEK DRAINAGE									
M-8	Black Warrior Adit	MCSI-96-2; M-4; PA# 34-079	SE Bull of the Woods Pass	7	0.1-10	8.1	13	4	9/23/2004
MCSI-96-3	Upper Miller Creek Dump	--	Near Black Warrior, private land	6.5	0.5-2	2	3	2	7/21/2004
M-1	Little Daisy Adit	MCSI-96-6	SE Daisy Pass	6.8	0.5-220	2.9	5	16	9/23/2004
M-10	Upper Little Daisy Adit	--	Shaft above Little Daisy Adit	7.84	0-5.8	--	--	5	9/26/1991
M-25	Henderson Mt Adit	--	SW side Henderson Mountain; above Daisy Pass road	5.9	1.8-25	5	5	3	7/21/2004

TABLE A-1
ADIT DISCHARGE SAMPLING SUMMARY
New World Mining District Adit Discharge Engineering Evaluation/Cost Analysis

Adit Station #	Site Name	Other Station Identifier	Location	Last pH (su)	Flow (gpm)		No. of Samples		Last Sampled
					Range	Last	Field	Lab	
SODA BUTTE CREEK DRAINAGE									
SBSI-99-74	Woody Ck. Mine Dump 1 (NDP)	--	Woody Creek, Mohawk claim	6.9	3.1-10	4.0	2	1	7/29/2004
AE-12	Reeb #1	--	SE flank of Henderson Mountain	3.3	0	Dry	1	1	7/7/2001
SBSI-99-85	Alice E. Millsite seep (NDP)	AE-6	S Henderson Mountain	5.4	0-10.0	4.0	3	1	7/29/2004
SBSI-99-87	Soda Butte Dump 8 (NDP)	--	Off Miller Mt Road, near Cooke City	6.9	3-100	3	3	1	7/29/2004
SBSI-99-95	Soda Butte Dump 1 (NDP)	--	Off Miller Mt Road, near Cooke City	7.4	0-0.1	Dry	2	1	7/29/2004

Notes: NDP = Non-District Property
(1) Monitored in July, August, and September 2003
(2) monitored in July and October 2003

TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
CFY-2	9-Aug-90	Hydrometrics	0.69		6.78	0.1		0.0050	<	0.00100	<	0.0200	<	0.05		0.12		0.01	<	0.04		0.02	<
CFY-2	5-Jun-91	Hydrometrics	91.6		7.05	0.5		0.0010	<	0.00010	<	0.0200	<	0.06	<	0.83		0.002		0.03		0.01	<
CFY-2	9-Jul-91	Hydrometrics	4.7		8.62	0.1	<	0.0050	<	0.00020		0.0200	<	0.06		0.25			J	0.03		0.03	
CFY-2	13-Aug-91	Hydrometrics	2.4		8.6	0.1		0.0050	<	0.00020		0.0200	<	0.052		0.06		0.002	<	0.04		0.04	
CFY-2	24-Sep-91	Hydrometrics	1.4		9.22	0.1	<	0.0050	<	0.00010	<	0.0200	<	0.017		0.03	<	0.002	<	0.02	<	0.01	
CFY-2	23-Jul-93	Hydrometrics	17.03		7.44	0.3		0.0010	<	0.00010		0.0010	<	0.11		0.42		0.002	<	0.05		0.03	<
CFY-2	21-Sep-93	Hydrometrics	2.46		7.3	0.1		0.0010	<	0.00020		0.0010	<	0.06		0.17		0.002	<	0.09		0.028	
CFY-2	15-Jun-94	Hydrometrics	39.63		6.23	0.2		0.0010	<	0.00010	<	0.0010	<	0.05	J	0.2		0.002	<	0.03		0.012	J
CFY-2	6-May-99	Maxim	0.091		7.35	0.1	<			0.00010	<			0.004		0.01	<	0.001	<	0.005	<	0.01	<
CFY-2	9-Jul-99	Maxim	21.46		7.24	0.2				0.00010				0.09		0.23		0.001	<	0.019		0.04	
CFY-2	29-Sep-99	Maxim	2.071		7.33	0.1	<			0.00020				0.022		0.04		0.001	<	0.017		0.04	J
CFY-2	13-Apr-00	Maxim	0.658		8.02	0.05	<			0.00010	<			0.008		0.05	<	0.001	<	0.005	<	0.02	<
CFY-2	8-Jul-00	Maxim	20.55		6.19	0.2	J			0.00010	<			0.068	J	0.24	J	0.001	<	0.035	J	0.02	J
CFY-2	22-Sep-00	Maxim			7.09	0.1	<			0.00010	<			0.004		0.01		0.001	<	0.003	<	0.01	<
CFY-2	28-Sep-00	Maxim			7.1	0.1	<			0.00010	<			0.01		0.03		0.001	<	0.004		0.01	<
CFY-2	10-Oct-00	Maxim				0.1	<			0.00010	<			0.01		0.05	<	0.003	<	0.005	<	0.02	<
CFY-2	19-Oct-00	Maxim			6.19	0.1	<			0.00010	<			0.008		0.05	<	0.001	<	0.004		0.01	
CFY-2	21-Apr-01	Maxim	0.48		7.47	0.1	<			0.00010	<			0.005		0.01	<	0.001	<	0.003	<	0.01	
CFY-2	26-Jun-01	Maxim	30.66		6.95	0.1	<			0.00010				0.054		0.24		0.002	J	0.024		0.01	<
CFY-2	11-Oct-01	Maxim	0.49		6.42	0.1	<	0.0030	<	0.00010	<			0.007		0.05	<	0.001	<	0.003	<	0.03	J
CFY-2	26-Apr-02	Maxim	0.28		6.5	0.1	<			0.0001	<			0.007		0.02		0.001	<	0.005		0.03	
CFY-2	1-Jul-02	Maxim	13		7.51	0.3	J			0.0001	<			0.062		0.34		0.001		0.03		0.04	J
CFY-2	8-Oct-02	Maxim	0.027		7.92	0.1	<			0.0002				0.008		0.03		0.001	<	0.003	<	0.03	J
CFY-2	22-Apr-03	Maxim	0.002		6.47	0.05	<			0.0001	<			0.004		0.09		0.001	<	0.003	<	0.01	<
CFY-2	1-Jul-03	Maxim	4		6.35	0.17				0.0001	<			0.04		0.19		0.001	<	0.024		0.01	<
CFY-2	30-Sep-03	Maxim	0.014		5.67	0.05	<			0.0001	<			0.008		0.01		0.001	<	0.003	<	0.01	
CFY-2	6-Apr-04	Maxim	0.045		7.38	0.05	<			0.0001	<			0.004		0.01	<	0.001	<	0.005	<	0.02	JF%
CFY-2	28-Jun-04	Maxim	2.48		7.8	0.09				0.0001	<			0.035		0.13		0.001	<	0.013		0.01	<
CFY-2	5-Oct-04	Maxim	4.33		7.25	0.08				0.0001				0.02		0.04		0.001	<	0.01		0.03	
CFY-2	5-Apr-05	Maxim	0.54		7.57	0.05	<			0.0001	<			0.004		0.01		0.001	<	0.003	<	0.01	<
CFY-2	6/28/2005	Maxim	58.17		6.3	0.2			--	0.0001	<		--	0.045		0.2		0.001		0.021		0.02	
CFY-2	10/11/2005	Maxim	0.77		6.86	0.05	<		--	0.0001	<		--	0.009		0.01	<	0.001	<	0.003	<	0.01	
CFY-2	26-Apr-06	Maxim	0.92		6.9	0.05	<			0.0001	<			0.008		0.01	<	0.001	<	0.003	<	0.01	<
CFY-2	28-Jun-06	Maxim	34.94		7.3	0.16				0.0001	<			0.045		0.17		0.001	<	0.025		0.01	<
CFY-2	26-Sep-06	Maxim	0.87		7.2	0.05	<			0.0001	<			0.007		0.01	<	0.001	<	0.003	<	0.09	
Station CFY-2: Pre-1999 Samples (n)			8		8	8		8		8		8		8		8		7		8		8	
Minimum			0.690		6.230	0.050		0.001		0.0001		0.001		0.017		0.015		0.001		0.010		0.005	
Maximum			91.600		9.220	0.500		0.003		0.0005		0.010		0.110		0.830		0.005		0.090		0.040	
Mean			19.989		7.655	0.175		0.002		0.0002		0.006		0.054		0.258		0.002		0.040		0.019	
Standard Deviation (SD)			31.828		1.043	0.156		0.001		0.0002		0.005		0.027		0.262		0.001		0.023		0.012	
Mean + (2 x SD); for pH: Mean - (2 x SD)			83.644		5.570	0.487		0.0036		0.0005		0.0163		0.108		0.783		0.005		0.087		0.043	
Station CFY-2: 1989-2006 Samples (n)			31		34	35		9		35		8		35		35		34		35		35	
Minimum			0.002		5.670	0.025		0.001		0.0001		0.001		0.004		0.005		0.001		0.002		0.005	
Maximum			91.600		9.220	0.500		0.003		0.0005		0.010		0.110		0.830		0.005		0.090		0.090	
Mean			11.508		7.164	0.101		0.002		0.0001		0.006		0.029		0.120		0.001		0.016		0.019	
Standard Deviation (SD)			20.678		0.759	0.104		0.001		0.0001		0.005		0.028		0.165		0.001		0.019		0.017	
Mean + (2 x SD); for pH: Mean - (2 x SD)			52.863		5.646	0.309		0.004		0.0003		0.016		0.085		0.451		0.003		0.055		0.053	
Station CFY-2: 10/04-10/06 Low Flow (n)			5		5	5		0		5		0		5		5		5		5		5	
Minimum			0.540		6.860	0.025				0.0001				0.004		0.005		0.001		0.002		0.005	
Maximum			4.330		7.570	0.080				0.0001				0.020		0.040		0.001		0.010		0.090	
Mean			1.486		7.156	0.036				0.0001				0.010		0.013		0.001		0.003		0.028	
Standard Deviation (SD)			1.597		0.290	0.025				0.0000				0.006		0.015		0.000		0.004		0.036	
Mean + (2 x SD); for pH: Mean - (2 x SD)			4.679		6.577	0.085				0.0001				0.022		0.043		0.001		0.011		0.100	
Temporary Standard - CFY-2					5.7	0.47		NA		NA		NA		0.11		0.75		0.002		0.082		0.044	

Notes: mg/l = milligrams/liter; su = standard units
n = number of samples

< = less than detection
J = estimated value

NA - not applicable

TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-3	2-Aug-89	Hydrometrics				0.1	<	0.0050	<	0.00100	<			0.03		0.03	<	0.01	<	0.11		0.01	
SW-3	15-Sep-89	Hydrometrics	0.36			3.7		0.0050	<	0.00100	<			1.04		5.58		0.01	<	1.24		0.18	
SW-3	20-Oct-89	Hydrometrics	0.26		3.43	3.7		0.0050	<	0.00100	<			0.85		5.59		0.01	<	1.23		0.17	
SW-3	17-Mar-90	Hydrometrics	0.25		3.44	2.2		0.0050	<	0.00100	<			0.61		3.27		0.01	<	1		0.15	
SW-3	28-May-90	Hydrometrics	0.9		3.35	3		0.0050	<	0.00040		0.0200	<	0.593		3.3		0.003		0.49		0.11	
SW-3	5-Jun-90	Hydrometrics	5.75		5.49	2.1								0.51		2.9						0.06	
SW-3	13-Jun-90	Hydrometrics	4.54		3.33	1.8								0.43		0.04						0.04	
SW-3	20-Jun-90	Hydrometrics	6.15		6.56	1.8				0.00200		0.0200	<	0.49		2.26		0.01	<	0.23		0.05	
SW-3	27-Jun-90	Hydrometrics	17.89		4.76	1.7		0.0050	<	0.00010		0.0200	<	0.419		5.89		0.004		0.16		0.04	
SW-3	3-Jul-90	Hydrometrics	14.9		4.66	1.6				0.00100	<	0.0200	<	0.486		4.3		0.01	<	0.19		0.04	
SW-3	10-Jul-90	Hydrometrics	3.9			1.7				0.00100	<	0.0200	<	0.59		3.18		0.01	<	0.27		0.08	
SW-3	17-Jul-90	Hydrometrics	2.3		3.67	2								0.8		3.79						0.07	
SW-3	26-Jul-90	Hydrometrics	1.6		3.6	2.6		0.0050	<	0.00040		0.0200	<	0.99		5.66		0.003		0.56		0.22	
SW-3	25-Sep-90	Hydrometrics	0.4		4.5	3.3		0.0050	<	0.00090		0.0200	<	0.96		6.98		0.007		1.29		0.16	
SW-3	15-Mar-91	Hydrometrics	0.2		2.79	2.7		0.0050	<	0.00100	<	0.0200	<	0.72		2.79		0.01	<	0.89		0.15	
SW-3	5-Jun-91	Hydrometrics	7		3.46	1.1		0.0010	<	0.00010		0.0200	<	0.39		3.78		0.002		0.16		0.03	
SW-3	9-Jul-91	Hydrometrics	3		2.91	1.46		0.0050	<	0.00180	J	0.0200	<	0.65		4.32		0.002	J	0.29		0.05	
SW-3	14-Aug-91	Hydrometrics	0.5		3.24	2.9		0.0050	<	0.00070		0.0200		0.95		5.93		0.004		0.93		0.14	
SW-3	24-Sep-91	Hydrometrics	0.2		3.29	4.3		0.0050	<	0.00220		0.0200	<	0.95		5.51		0.006		1.26		0.16	
SW-3	23-Jul-93	Hydrometrics	2.36		3.37	3.3		0.0010		0.00040		0.0030		1.1		6.62		0.002	<	0.56		0.13	
SW-3	21-Sep-93	Hydrometrics	0.38		3.46	3.8		0.0010	<	0.00100		0.0010	<	1.1		11.6		0.009		1.67		0.17	
SW-3	14-Jun-94	Hydrometrics	5.42		3.79	2.6		0.0010	<	0.00030		0.0010	<	0.54	J	5		0.007		0.29		0.058	J
SW-3	14-Jul-95	Hydrometrics	7.29		3.29	2.5		0.0020		0.00040		0.0010		0.766	J	3.32	J	0.008		0.41		0.076	
SW-3	27-Sep-95	Hydrometrics	0.31		3.6	4.8		0.0010	<	0.00090		0.0010		1.53		11		0.008		1.66		0.231	
SW-3	21-May-96	Hydrometrics			3.22	4.3				0.00100				0.92		4.8		0.006		0.891		0.22	
SW-3	12-Jun-96	Hydrometrics	9.04		3.1									0.417		2.73	J					0.08	J
SW-3	20-Jun-96	Hydrometrics	7.795		3.4	1.6				0.00020				0.395		1.72		0.003	<	0.167		0.03	
SW-3	26-Jun-96	Hydrometrics	12.65		4.16									0.381		3.25						0.04	
SW-3	2-Jul-96	Hydrometrics	15.9		3.67									0.374		6.88						0.08	J
SW-3	11-Jul-96	Hydrometrics	9.18		4.09	1.3	J			0.00010				0.448		1.93		0.003	<	0.163		0.04	
SW-3	18-Jul-96	Hydrometrics	5.644		3.76									0.646		2.84						0.08	<
SW-3	25-Jul-96	Hydrometrics	6.767		3.59									0.803		3.83						0.09	
SW-3	21-Aug-96	Hydrometrics	2.552		3.94									0.98		6.46						0.15	
SW-3	11-Sep-96	Hydrometrics	0.38		3.58	3.5				0.00090	J			1.04		6.91		0.008		1.32		0.18	
SW-3	8-Jul-97	UOS Data	10.843			1.81		0.0100	<	0.00500	<	0.0100	<	0.411		2.6				0.165		0.0368	
SW-3	27-Mar-98	UOS Data	0.17		2.5	3.15								0.691		7.35				1.31		0.177	
SW-3	23-Apr-98	UOS Data	0.112		3.5	3.08								0.745		6.92				1.26		0.177	
SW-3	5-May-98	UOS Data	0.217		5.44	2.51								0.535		3.03				0.502		0.0965	
SW-3	13-May-98	UOS Data	4.783		6.3	2.26								0.443		2.82				0.348		0.0689	
SW-3	29-May-98	UOS Data	2.172		3.63	1.77								0.361		2.71				0.231		0.0547	
SW-3	6-May-99	Maxim	0.2244		3.45	3.9				0.00110				0.9		7.49		0.007		1.35		0.29	
SW-3	9-Jul-99	Maxim	7.53		4.12	1.5				0.00020				0.41		1.85		0.002		0.162		0.06	
SW-3	30-Sep-99	Maxim	0.306		3.43	3.1				0.00050				1		7.03		0.002		1.3		0.18	J
SW-3	13-Apr-00	Maxim	0.055		3.25	3.2				0.00140				0.86		6.2		0.008		1.32		0.02	<
SW-3	18-May-00	Maxim	0.935		4.1									0.58								0.11	
SW-3	18-May-00	Maxim	0.797		4									0.62								0.12	
SW-3	18-May-00	Maxim	1.04		4.1	2.5				0.00040				0.6		3.19		0.003		0.56		0.12	
SW-3	18-May-00	Maxim	0.809		4									0.63								0.12	
SW-3	18-Jun-00	Maxim	7.18		3.91	1.8				0.00020				0.43		2.67		0.003		0.18		0.04	
SW-3	18-Jun-00	Maxim	6.37		3.79									0.46								0.05	
SW-3	18-Jun-00	Maxim	6.24		3.81									0.44								0.05	
SW-3	18-Jun-00	Maxim	5.52		3.78									0.44								0.06	
SW-3	8-Jul-00	Maxim	3.02		3.54									0.82	J							0.07	J
SW-3	8-Jul-00	Maxim	3.03		3.44	2	J			0.00010	<			0.67	J	3.11	J	0.002		0.37	J	0.06	J
SW-3	8-Jul-00	Maxim	3.16		3.5									0.77	J							0.07	J
SW-3	8-Jul-00	Maxim	3.3		3.71									0.74	J							0.07	J
SW-3	16-Aug-00	Maxim	0.49		2.6	2.8				0.00110				0.95		5.21		0.007		1.06		0.15	

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TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-3	1-Sep-00	Maxim	0.381		3.6	2.8				0.00060				0.82		7.38		0.005		1.11		0.16	
SW-3	17-Sep-00	Maxim	0.218		3.4	3.1								0.76		22		0.003		1.5		0.15	
SW-3	19-Oct-00	Maxim			3	2.9				0.00010	<			0.67		7.84	J	0.007		1.29		0.39	
SW-3	6-Dec-00	Maxim			3.28	3				0.00100				0.72		6.44		0.007		1.25		0.18	
SW-3	21-Apr-01	Maxim	0.103		3.74	2.6				0.00100				0.74		6.21		0.006		1.12		0.12	
SW-3	11-Jun-01	Maxim			3.05	1.7		0.0030	<	0.00010	<			0.48		1.92		0.003	<	0.2		0.05	J
SW-3	26-Jun-01	Maxim	4.208		3.79	2.5				0.00030				0.53		6.53		0.007	J	0.31		0.06	
SW-3	31-Aug-01	Maxim	0.29		3.57	2.7				0.00560				0.84		10.1		0.012		1.17		0.15	
SW-3	11-Oct-01	Maxim	0.27		3.29	2.4		0.0030	<	0.00110				0.67		5.79		0.004		0.87		0.15	
SW-3	26-Apr-02	Maxim	0.37		2.76	3.1				0.001				0.83		7.1		0.006		1.28		0.18	
SW-3	1-Jul-02	Maxim	7.6		3.92	1.7	J			0.0003				0.54		4.31		0.003		0.3		0.08	J
SW-3	8-Oct-02	Maxim	0.29		3.55	3.6				0.001				0.85		10.6		0.009		1.48		0.71	J
SW-3	23-Apr-03	Maxim	0.05		3.31	2.51				0.0012				0.83		6.92		0.008		1.3		0.26	
SW-3	1-Jul-03	Maxim	6.57		3.41	1.62				0.0002				0.45		2.32		0.002		0.29		0.02	
SW-3	31-Jul-03	Maxim			4.1	2.83		0.001	<	0.0005				1.04		5.38		0.005		0.78		0.14	JF%
SW-3	14-Aug-03	Maxim			3.6	3.1		0.001	<	0.0005				1.15		6.13		0.01		1.31		0.13	
SW-3	21-Aug-03	Maxim				3				0.0009				1.06		10.9		0.009		1.5		0.14	
SW-3	22-Aug-03	Maxim				3.1				0.0009				0.94		8.58		0.013		1.48		0.19	
SW-3	30-Sep-03	Maxim	0.258		3.3	2.86				0.0008				0.8		10.5		0.009		1.74		0.21	
SW-3	5-Apr-04	Maxim	0.136		3.4	2.2				0.0008				0.7		2.34		0.004		0.9		0.18	JF%
SW-3	28-Jun-04	Maxim	9.32		4.5	2.27				0.0002				0.37		3.84		0.005		0.18		0.05	
SW-3	5-Oct-04	Maxim	0.35		3.85	1.52				0.0005				0.6		0.87		0.002		0.29		0.08	
SW-3	5-Apr-05	Maxim	0.08		3.84	1.75				0.0009				0.8		0.9		0.002		0.49		0.18	
SW-3	28-Jun-05	Maxim	8.13		4	1.49			--	0.0001			--	0.36		1.14		0.002		0.14		0.04	
SW-3	29-Aug-05	Maxim	0.38		3.8	1.36			--	0.0006			--	0.59		1.36		0.002		0.42		0.13	(1)
SW-3	11-Oct-05	Maxim	0.31		4.53	2.31			--	0.0007			--	0.73		0.9		0.002		0.52		0.12	
SW-3	26-Apr-06	Maxim	0.07		3.8	2.61				0.0009				0.87		1.1		0.001		0.54		0.15	
SW-3	28-Jun-06	Maxim	5.46		5	1.74				0.0001				0.39		1.52		0.002		0.18		0.02	
SW-3	26-Sep-06	Maxim	0.16		3.62	2.81				0.0008				0.79		1.89		0.002		0.59		0.14	
Station SW-3: Pre-1999 Samples (n)			38		36	34		19		26		18		40		40		25		31		40	
Minimum			0.112		2.500	0.050		0.0005		0.00010		0.0005		0.030		0.015		0.001		0.110		0.010	
Maximum			17.890		6.560	4.800		0.0050		0.00250		0.0200		1.530		11.600		0.009		1.670		0.231	
Mean			4.581		3.830	2.529		0.0021		0.00076		0.0078		0.677		4.485		0.005		0.685		0.103	
Standard Deviation (SD)			4.867		0.903	1.041		0.0011		0.00065		0.0050		0.291		2.446		0.002		0.507		0.063	
Mean + (2 x SD); for pH: Mean - (2 x SD)			14.314		2.024	4.611		0.0043		0.00207		0.0179		1.258		9.377		0.009		1.700		0.229	
Station SW-3: 1989-2006 Samples (n)			77		80	71		23		62		18		86		77		62		68		86	
Minimum			0.050		2.500	0.050		0.001		0.000		0.001		0.030		0.015		0.001		0.110		0.010	
Maximum			17.890		6.560	4.800		0.005		0.006		0.020		1.530		22.000		0.013		1.740		0.710	
Mean			3.494		3.743	2.507		0.002		0.001		0.008		0.690		4.922		0.005		0.766		0.120	
Standard Deviation (SD)			4.131		0.690	0.853		0.001		0.001		0.005		0.245		3.389		0.003		0.508		0.095	
Mean + (2 x SD); for pH: Mean - (2 x SD)			11.756		2.363	4.212		0.004		0.002		0.018		1.180		11.700		0.011		1.782		0.310	
Station SW-3: 10/04-10/06 Low Flow (n)			6		6	6		0		6		0		6		6		6		6		6	
Minimum			0.070		3.620	1.360				0.001				0.590		0.870		0.001		0.290		0.080	
Maximum			0.380		4.530	2.810				0.001				0.870		1.890		0.002		0.590		0.180	
Mean			0.225		3.907	2.060				0.001				0.730		1.170		0.002		0.475		0.133	
Standard Deviation (SD)			0.139		0.317	0.601				0.000				0.114		0.399		0.000		0.107		0.033	
Mean + (2 x SD); for pH: Mean - (2 x SD)			0.502		3.273	3.262				0.001				0.957		1.968		0.003		0.688		0.200	
Narrative Standard - SW-3					2.1	4.54		NA		0.002		NA		1.256		9.259		0.01		1.718		0.225	

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New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-4	2-Aug-89	Hydrometrics				0.1	<	0.005	<	0.001	<			0.03		0.03	<	0.01	<	0.11		0.01	
SW-4	15-Sep-89	Hydrometrics	1.35			0.2		0.005	<	0.001	<			0.09		0.09		0.01	<	0.07		0.07	
SW-4	20-Oct-89	Hydrometrics	1.19		5.75	0.1		0.005	<	0.001	<			0.07		0.04		0.01	<	0.06		0.05	
SW-4	17-Mar-90	Hydrometrics	1		5.55	0.1	<	0.005	<	0.001	<			0.04		0.03	<	0.01	<	0.02	<	0.07	
SW-4	29-May-90	Hydrometrics	15.4		7.22	0.8		0.005	<	0.0001	<	0.02	<	0.116		0.71		0.002	<	0.05		0.03	
SW-4	5-Jun-90	Hydrometrics	27.84		6.7	0.3								0.08		0.42						0.02	
SW-4	13-Jun-90	Hydrometrics	30.73		5.52	0.2								0.06		0.21						0.02	
SW-4	15-Jun-90	Hydrometrics	21.9																				
SW-4	20-Jun-90	Hydrometrics	47.46		6.45	0.3				0.001	<	0.02	<	0.08		0.39		0.01	<	0.04		0.41	
SW-4	22-Jun-90	Hydrometrics	88.8																				
SW-4	26-Jun-90	Hydrometrics	112.4		7.11	0.5		0.005	<	0.0002		0.02	<	0.087		1.02		0.002	<	0.05		0.02	
SW-4	28-Jun-90	Hydrometrics	100.37																				
SW-4	3-Jul-90	Hydrometrics	83.9		9.07	0.4				0.002		0.02	<	0.08		0.65		0.01		0.04		0.02	
SW-4	5-Jul-90	Hydrometrics	49.4																				
SW-4	6-Jul-90	Hydrometrics																					
SW-4	7-Jul-90	Hydrometrics																					
SW-4	8-Jul-90	Hydrometrics																					
SW-4	10-Jul-90	Hydrometrics	30.6			0.3				0.001	<	0.02	<	0.09		0.43		0.01	<	0.05		0.03	
SW-4	11-Jul-90	Hydrometrics																					
SW-4	12-Jul-90	Hydrometrics	25																				
SW-4	13-Jul-90	Hydrometrics																					
SW-4	14-Jul-90	Hydrometrics																					
SW-4	15-Jul-90	Hydrometrics																					
SW-4	16-Jul-90	Hydrometrics																					
SW-4	17-Jul-90	Hydrometrics	14.4		6.6	0.4								0.14		0.49						0.03	
SW-4	18-Jul-90	Hydrometrics																					
SW-4	19-Jul-90	Hydrometrics	11.7																				
SW-4	20-Jul-90	Hydrometrics																					
SW-4	21-Jul-90	Hydrometrics																					
SW-4	22-Jul-90	Hydrometrics																					
SW-4	23-Jul-90	Hydrometrics																					
SW-4	24-Jul-90	Hydrometrics																					
SW-4	25-Jul-90	Hydrometrics																					
SW-4	26-Jul-90	Hydrometrics																					
SW-4	27-Jul-90	Hydrometrics	7.1		6.87	0.3		0.005	<	0.0004		0.02	<	0.16		0.44		0.002	<	0.1		1.95	J
SW-4	23-Aug-90	Hydrometrics	3.2		7.05																		
SW-4	25-Sep-90	Hydrometrics	1.5		5	0.3		0.005	<	0.0003		0.02	<	0.11		0.21		0.002	<	0.13		0.05	
SW-4	15-Mar-91	Hydrometrics	0.8		6.79	0.1	<	0.005	<	0.001		0.02	<	0.06		0.03	<	0.01	<	0.02	<	0.07	
SW-4	5-Jun-91	Hydrometrics	55.3		7.07	0.2	<	0.001	<	0.0001	<	0.02	<	0.05	<	0.67	<	0.002	<	0.03	<	0.01	<
SW-4	9-Jul-91	Hydrometrics	21		6.72	0.1	<	0.005	<	0.0002		0.02		0.1		0.38		0	J	0.05		0.03	
SW-4	14-Aug-91	Hydrometrics	1.7		6.25	0.4		0.005	<	0.0002		0.02	<	0.15		0.21		0.002	<	0.12		0.07	
SW-4	24-Sep-91	Hydrometrics	1.1		6.66	0.3		0.005	<	0.0006		0.02	<	0.11		0.24		0.002	<	0.08		0.04	
SW-4	27-May-92	Hydrometrics	77.78		7.72	0.2		0.005	<	0.0001	<	0.01	<	0.051		0.31		0.002	<	0.03		0.02	
SW-4	19-Jul-92	Hydrometrics	15		6.87	3.4	<	0.005	<	0.0002		0.01	<	0.29		7.1	<	0.002	<	0.16		0.15	<
SW-4	23-Sep-92	Hydrometrics	1.95		7.04	0.3		0.005	<	0.0004		0.01	<	0.117		0.17		0.002	<	0.13		0.05	
SW-4	21-Jul-93	Hydrometrics	19.92		7.47	0.3		0.001	<	0.0001		0.001	<	0.146		0.65		0.002	<	0.09		0.04	J
SW-4	21-Sep-93	Hydrometrics	1.98		6.95	0.2		0.001	<	0.0002		0.001	<	0.1		0.32		0.002	<	0.16		0.038	
SW-4	2-Mar-94	Hydrometrics	0.4		7.7	0.1	<	0.001	<	0.0005		0.001	<	0.06		0.03	<	0.002	<	0.01	<	0.07	
SW-4	26-May-94	Hydrometrics	75.23		8.45	0.8		0.001		0.0001		0.001	<	0.11		2.25		0.003		0.06		0.018	
SW-4	15-Jun-94	Hydrometrics	33.79		7.01	0.5		0.001	<	0.0001		0.001	<	0.07	J	0.55		0.002	<	0.05		0.021	J
SW-4	14-Jul-95	Hydrometrics	43.74		6.64	0.5		0.001	<	0.0001		0.002		0.118	J	0.8	J	0.002	<	0.07		0.026	<
SW-4	27-Sep-95	Hydrometrics	1.34		6.7	0.2		0.001	<	0.0003		0.001	<	0.173		0.09		0.002	<	0.12		0.08	<
SW-4	21-May-96	Hydrometrics			6.15	0.2				0.0001				0.063		0.18		0.003	<	0.03		0.05	<
SW-4	29-May-96	Hydrometrics			7.84	0.4				0.0001	<			0.086		0.44		0.003	<	0.05		0.05	<
SW-4	5-Jun-96	Hydrometrics			6.27	1.1				0.0001				0.139		3.17		0.005		0.067		0.03	<
SW-4	12-Jun-96	Hydrometrics	33.7		6.23									0.055		0.62	J					0.05	J
SW-4	19-Jun-96	Hydrometrics	72.157		7.82	0.2				0.0001				0.066		0.35		0.003	<	0.031		0.01	<

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TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-4	26-Jun-96	Hydrometrics			6.41									0.066		1.14						0.02	
SW-4	2-Jul-96	Hydrometrics			6.58									0.11		2.17						0.08	J
SW-4	11-Jul-96	Hydrometrics	54.84		5.96	0.2	J			0.0001	<			0.07		0.49	<	0.003	<	0.033		0.02	
SW-4	18-Jul-96	Hydrometrics	26.42		6.81									0.105		0.34						0.03	<
SW-4	25-Jul-96	Hydrometrics	19.92		6.64									0.129		0.4						0.03	
SW-4	21-Aug-96	Hydrometrics	4.315		6.91									0.17		0.31						0.05	
SW-4	11-Sep-96	Hydrometrics	1.46		6.4	0.4				0.0003	J			0.154		0.17		0.003	<	0.15		0.06	
SW-4	27-Mar-98	UOS Data	0.69		6.95																		
SW-4	22-Apr-98	UOS Data	0.578		7.08																		
SW-4	5-May-98	UOS Data			6.41																		
SW-4	13-May-98	UOS Data	4.783		6.05																		
SW-4	6-May-99	Maxim	0.42		7.38	0.1	<			0.0004				0.06		0.03		0.001	<	0.021		0.05	
SW-4	9-Jul-99	Maxim	45.706		7.21	0.3				0.0001				0.08		0.29		0.001	<	0.027		0.03	
SW-4	30-Sep-99	Maxim	1.46		5.28	0.1	<			0.0003				0.07		0.03		0.001	<	0.072		0.06	J
SW-4	13-Apr-00	Maxim	0.837		8.21	0.05	<			0.0004				0.064		0.05	<	0.001	<	0.014		0.02	<
SW-4	8-Jul-00	Maxim	15.48		6	0.3	J			0.0001	<			0.12	J	0.38	J	0.001	<	0.064	J	0.03	J
SW-4	19-Oct-00	Maxim	1.39		5.25	0.1	<			0.0001	<			0.057		0.07	J	0.001	<	0.058		0.04	
SW-4	21-Apr-01	Maxim	0.62		7.17	0.1	<			0.0003				0.038		0.03		0.001	<	0.008		0.08	
SW-4	26-Jun-01	Maxim	23.84		7.01	0.3				0.0002				0.089		0.43		0.001	J	0.048		0.02	
SW-4	11-Oct-01	Maxim	0.61		6.79	0.2		0.003	<	0.0003				0.058		0.11		0.001	<	0.009		0.09	
SW-4	26-Apr-02	Maxim			6.28	0.1	<			0.0003				0.03		0.01	<	0.001	<	0.006		0.04	
SW-4	1-Jul-02	Maxim	47		7.5	0.3	J			0.0001	<			0.1		0.5		0.001	<	0.051		0.02	J
SW-4	8-Oct-02	Maxim	1.91		7.58	0.1				0.0004				0.085		0.13		0.001	<	0.088		0.07	J
SW-4	23-Apr-03	Maxim			6.25	0.05	<			0.0003				0.049		0.1		0.001	<	0.013		0.08	
SW-4	1-Jul-03	Maxim	40.8		6.21	0.25				0.0001	<			0.07		0.29		0.001	<	0.044		0.01	<
SW-4	30-Sep-03	Maxim	0.903		5.72	0.05	<			0.0002				0.079		0.02		0.001	<	0.055		0.13	
SW-4	5-Apr-04	Maxim	0.784		5.57	0.05	<			0.0002				0.04		0.02		0.001	<	0.005		0.1	JF%
SW-4	28-Jun-04	Maxim	70.91		7.9	0.8				0.0001	<			0.11		1.48		0.003		0.045		0.05	
SW-4	5-Oct-04	Maxim	3.21		6.2	0.12				0.0002				0.05		0.06		0.001	<	0.029		0.02	
SW-4	4/5/2005	Maxim	0.7		7.19	0.05	<		--	0.0002			--	0.033		0.01		0.001	<	0.008		0.08	1)
SW-4	6/28/2005	Maxim	50.84		6.6	0.25			--	0.0001	<		--	0.063		0.2		0.001	<	0.028		0.02	
SW-4	10/11/2005	Maxim	1.62		6.3	0.05	<		--	0.0002			--	0.05		0.16		0.001	<	0.005		0.03	
SW-4	26-Apr-06	Maxim	0.62		7.18	0.05	<			0.0002				0.043		0.02		0.001	<	0.005		0.04	
SW-4	28-Jun-06	Maxim	33.1		6.26	0.19				0.0001	<			0.064		0.21		0.001	<	0.034		0.01	<
SW-4	26-Sep-06	Maxim	0.66		5.56	0.08				0.0002				0.034		0.01		0.001	<	0.026		0.18	
Station SW-4: Pre-1999 Samples (n)			45		43	35		23		32		22		41		41		32		32		41	
Minimum			0.400		5.000	0.050		0.001		0.000		0.001		0.025		0.015		0.000		0.005		0.005	
Maximum			112.400		9.070	1.700		0.003		0.002		0.020		0.290		3.550		0.010		0.160		1.950	
Mean			27.670		6.778	0.353		0.002		0.000		0.007		0.101		0.599		0.002		0.069		0.092	
Standard Deviation (SD)			30.774		0.750	0.327		0.001		0.000		0.005		0.049		0.794		0.002		0.045		0.304	
Mean + (2 x SD); for pH: Mean - (2 x SD)			89.218		5.277	1.008		0.0037		0.00109		0.0171		0.198		2.186		0.007		0.159		0.700	
Station SW-4: 1989-2006 Samples (n)			67		67	59		24		56		22		65		65		56		56		65	
Minimum			0.400		5.000	0.025		0.001		0.000		0.001		0.025		0.005		0.000		0.005		0.005	
Maximum			112.400		9.070	1.700		0.003		0.002		0.020		0.290		3.550		0.010		0.160		1.950	
Mean			23.710		6.717	0.271		0.002		0.000		0.007		0.087		0.449		0.002		0.053		0.078	
Standard Deviation (SD)			28.594		0.778	0.292		0.001		0.000		0.005		0.045		0.684		0.002		0.042		0.242	
Mean + (2 x SD); for pH: Mean - (2 x SD)			80.898		5.162	0.854		0.004		0.001		0.017		0.177		1.816		0.005		0.137		0.562	
Station SW-4: 10/04-10/06 Low Flow (n)			5		5	5		0		5		0		5		5		5		5		5	
Minimum			0.620		5.560	0.025				0.000				0.033		0.010		0.001		0.005		0.020	
Maximum			3.210		7.190	0.120				0.000				0.050		0.160		0.001		0.029		0.180	
Mean			1.362		6.486	0.055				0.000				0.042		0.052		0.001		0.015		0.070	
Standard Deviation (SD)			1.114		0.698	0.043				0.000				0.008		0.064		0.000		0.012		0.066	
Mean + (2 x SD); for pH: Mean - (2 x SD)			3.590		5.089	0.142				0.000				0.059		0.180		0.001		0.038		0.201	
Narrative Standard - SW-4					5.24	0.74		NA		0.001		NA		0.172		1.726		0.005		0.79		0.66	

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New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-6	2-Oct-89	Hydrometrics	4		4.82			0.0050	<	0.00100	<			0.01	<	0.03	<			0.02	<	0.01	
SW-6	20-Oct-89	Hydrometrics	4.52		6.02	0.1	<	0.0050	<	0.00100	<			0.01	<	0.03	<	0.01	<	0.02	<	0.01	
SW-6	29-May-90	Hydrometrics	102.1		7.34	0.2		0.0050	<	0.00010	<	0.0200	<	0.035		0.23		0.002	<	0.02		0.02	
SW-6	6-Jun-90	Hydrometrics	123.2		7.25	0.1				0.00200		0.0200	<	0.02		0.13		0.01		0.02	<	0.01	
SW-6	7-Jun-90	Hydrometrics	138.6																				
SW-6	13-Jun-90	Hydrometrics	116.97		7.25	0.1	<			0.08000		0.0200	<	0.01	<	0.06		0.01	<	0.02	<	0.01	
SW-6	14-Jun-90	Hydrometrics	86																				
SW-6	20-Jun-90	Hydrometrics	167.97		8.75	0.2				0.00100		0.0200	<	0.03		0.26		0.01	<	0.02		0.15	
SW-6	22-Jun-90	Hydrometrics	273.3																				
SW-6	26-Jun-90	Hydrometrics	251.5		8.52	0.2		0.0050	<	0.00010	<	0.0200	<	0.037		0.4		0.002	<	0.02		0.02	
SW-6	29-Jun-90	Hydrometrics	218.48																				
SW-6	2-Jul-90	Hydrometrics	210.6		9.39	0.2				0.00100	<	0.0200	<	0.039		0.35		0.01	<	0.02		0.04	
SW-6	4-Jul-90	Hydrometrics	165.4																				
SW-6	9-Jul-90	Hydrometrics	89.9		9.2	0.1				0.00100	<	0.0200	<	0.03		0.14		0.01	<	0.02	<	0.02	
SW-6	11-Jul-90	Hydrometrics	72																				
SW-6	17-Jul-90	Hydrometrics	35.4		8.86	0.2								0.07		0.3						0.03	<
SW-6	19-Jul-90	Hydrometrics	26.4																				
SW-6	27-Jul-90	Hydrometrics	18.9		6.81	0.1	<	0.0050	<	0.00010	<	0.0200	<	0.03		0.1		0.002	<	0.02	<	0.03	<
SW-6	23-Aug-90	Hydrometrics	10.1		6.7																		
SW-6	25-Sep-90	Hydrometrics	3.3		5.5	0.1	<	0.0050	<	0.00010	<	0.0200	<	0.007		0.03	<	0.002	<	0.02	<	0.04	
SW-6	15-Mar-91	Hydrometrics	1		8.01	0.1	<	0.0050	<	0.00100	<	0.0200	<	0.01	<	0.06		0.01	<	0.02	<	0.02	
SW-6	5-Jun-91	Hydrometrics	201.7		6.67	0.2		0.0010	<	0.00010	<	0.0200	<	0.017	<	0.18		0.002	<	0.02	<	0.01	<
SW-6	9-Jul-91	Hydrometrics	51.2		6.72	0.1		0.0050	<	0.00010		0.0200	<	0.033		0.14		0	J	0.02	<	0.03	
SW-6	14-Aug-91	Hydrometrics	3.9		7.31	0.1	<	0.0050	<	0.00010	<	0.0200	<	0.011		0.06		0.002	<	0.02	<	0.02	
SW-6	24-Sep-91	Hydrometrics	2.5		6.71	0.1	<	0.0050	<	0.00010	<	0.0200	<	0.013	<	0.03	<	0.002	<	0.02	<	0.01	<
SW-6	19-Jul-92	Hydrometrics	30.67		7.52	1.6		0.0050	<	0.00010	<	0.0100	<	0.11		2.88		0.002	<	0.05		0.13	
SW-6	23-Sep-92	Hydrometrics	3.54		6.43	0.1	<	0.0050	<	0.00010		0.0100	<	0.016		0.2		0.002	<	0.02		0.05	
SW-6	21-Jul-93	Hydrometrics	38.11		7.46	0.2		0.0010	<	0.00010		0.0010	<	0.062		0.24		0.002	<	0.03		0.01	J
SW-6	22-Sep-93	Hydrometrics	4.2		7.25	0.1	<	0.0010	<	0.00010		0.0010	<	0.019		0.03		0.002	<	0.03		0.018	<
SW-6	14-Apr-94	Hydrometrics	19.2					0.0010	<	0.00010	<			0.001	<								
SW-6	15-Jun-94	Hydrometrics	87.64		8.3	0.1		0.0010	<	0.00010	<	0.0010	<	0.016	J	0.11		0.002	<	0.01		0.005	J
SW-6	21-May-96	Hydrometrics	45.62		4.86	0.1				0.00010	<			0.021		0.15		0.003	<	0.012		0.04	<
SW-6	10-Jul-96	Hydrometrics	149.2		5.41	0.1	<			0.00010				0.024		0.01		0.003	<	0.013		0.01	<
SW-6	11-Sep-96	Hydrometrics	2.91		6.63	0.1	<			0.00010	<			0.011		0.02		0.003	<	0.007		0.01	<
SW-6	6-May-99	Maxim	13.65		7.57	0.1				0.00010	<			0.01		0.13		0.001	<	0.008		0.01	<
SW-6	7-Jul-99	Maxim	148.39		7.64	0.2				0.00010	<			0.034		0.27		0.001	<	0.014		0.02	
SW-6	29-Sep-99	Maxim	3.727		7.43	0.1	<			0.00010	<			0.016		0.06		0.001	<	0.007		0.02	J
SW-6	13-Apr-00	Maxim	2.55		6.86	0.05	<			0.00010	<			0.004		0.05	<	0.001	<	0.005	<	0.02	<
SW-6	8-Jul-00	Maxim	36.08		6.05	0.1	J			0.00010	<			0.032	J	0.14	J	0.001	<	0.018	J	0.01	J
SW-6	19-Oct-00	Maxim	3.34		6.5	0.1	<			0.00010	<			0.005		0.05	<	0.001	<	0.003	<	0.01	<
SW-6	21-Apr-01	Maxim	2.67		8.02	0.1	<			0.00010	<			0.004		0.02		0.001	<	0.003	<	0.01	<
SW-6	26-Jun-01	Maxim	60.42		6.95	0.1	<			0.00010	<			0.027		0.12		0.001	<	0.008		0.01	<
SW-6	11-Oct-01	Maxim	1.17		6.62	0.1	<	0.0030	<	0.00010	<			0.004		0.1		0.001	<	0.008		0.03	J
SW-6	23-Apr-02	Maxim	0.64		6.56	0.1	<			0.0001	<			0.004		0.06		0.001	<	0.003		0.01	<
SW-6	1-Jul-02	Maxim	110		7.06	0.1	J			0.0002				0.032		0.14		0.001		0.008		0.01	J
SW-6	8-Oct-02	Maxim	3.36		7.87	0.1	<			0.0001				0.014		0.01		0.001	<	0.006		0.05	J
SW-6	22-Apr-03	Maxim	4.13		6.49	0.05	<			0.0001	<			0.005		0.12		0.001	<	0.007		0.01	<
SW-6	1-Jul-03	Maxim	120.5		6.13	0.12				0.0001	<			0.021		0.12		0.001		0.014		0.01	<
SW-6	30-Sep-03	Maxim	1.21		6.32	0.05	<			0.0001	<			0.003		0.01	<	0.001	<	0.02		0.03	
SW-6	6-Apr-04	Maxim	7.119		7.32	0.05	<			0.0001	<			0.014		0.04		0.001	<	0.005	<	0.05	JF%
SW-6	28-Jun-04	Maxim	107.21		7.5	0.06				0.0001	<			0.025		0.18		0.001	<	0.008		0.03	
SW-6	5-Oct-04	Maxim	24.85		6.2	0.09				0.0001	<			0.007	B	0.02		0.001	<	0.003	<	0.01	
SW-6	4/5/2005	Maxim	2.3		7.67	0.05	<		--	0.0001	<		--	0.001	<	0.01		0.001	<	0.003	<	0.01	JF%(
SW-6	6/28/2005	Maxim	120.34		6.6	0.1			--	0.0001	<		--	0.019		0.08		0.001	<	0.01		0.01	
SW-6	10/11/2005	Maxim	2.37		7.27	0.05	<		--	0.0001	<		--	0.005		0.01	<	0.001	<	0.003	<	0.01	<
SW-6	26-Apr-06	Maxim	5.58		7.3	0.05	<			0.0001	<			0.003		0.01		0.001	<	0.003	<	0.01	<
SW-6	28-Jun-06	Maxim	72.63		6.04	0.07				0.0001	<			0.024		0.12		0.001	<	0.015		0.01	<

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NA - not applicable

TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-6	26-Sep-06	Maxim	2.13		7.15	0.05	<			0.0001	<			0.004		0.01	<	0.001	<	0.003	<	0.01	
Station SW-6: Pre-1999 Samples (n)			34		26	24		17		25		19		26		25		23		24		25	
Minimum			1.000		4.820	0.050		0.0005		0.00005		0.0005		0.001		0.010		0.000		0.007		0.005	
Maximum			273.300		9.390	1.600		0.0025		0.08000		0.0100		0.110		2.880		0.010		0.050		0.150	
Mean			81.177		7.142	0.169		0.0019		0.00346		0.0080		0.025		0.244		0.002		0.016		0.027	
Standard Deviation (SD)			81.893		1.239	0.312		0.0009		0.01595		0.0037		0.024		0.560		0.002		0.010		0.036	
Mean + (2 x SD); for pH: Mean - (2 x SD)			244.963		4.664	0.792		0.0038		0.03537		0.0153		0.074		1.365		0.007		0.035		0.099	
Station SW-6: 1989-2006 Samples (n)			58		50	48		18		49		19		50		49		47		48		49	
Minimum			0.640		4.820	0.025		0.001		0.000		0.001		0.001		0.005		0.000		0.002		0.005	
Maximum			273.300		9.390	1.600		0.003		0.080		0.010		0.110		2.880		0.010		0.050		0.150	
Mean			62.352		7.056	0.115		0.002		0.002		0.008		0.019		0.162		0.001		0.011		0.021	
Standard Deviation (SD)			73.233		0.981	0.227		0.001		0.011		0.004		0.020		0.408		0.002		0.009		0.028	
Mean + (2 x SD); for pH: Mean - (2 x SD)			208.817		5.094	0.568		0.0037		0.0246		0.0153		0.059		0.978		0.005		0.029		0.077	
Station SW-6: 10/04-10/06 Low Flow (n)			5		5	5		0		5		0		5		5		5		5		5	
Minimum			2.130		6.200	0.025				0.000				0.001		0.005		0.001		0.002		0.005	
Maximum			24.850		7.670	0.090				0.000				0.007		0.020		0.001		0.002		0.010	
Mean			7.446		7.118	0.038				0.000				0.004		0.010		0.001		0.002		0.008	
Standard Deviation (SD)			9.835		0.549	0.029				0.000				0.002		0.006		0.000		0.000		0.003	
Mean + (2 x SD); for pH: Mean - (2 x SD)			27.115		6.020	0.096				0.00005				0.009		0.022		0.001		0.002		0.013	
Narrative Standard - SW-6					5.7	0.763		NA		0.03472		NA		0.076		1.132		NA		0.034		0.110	
DC-2	3-Oct-89	Hydrometrics	0.2		3.48			0.0050	<	0.00100	<			7.89		28.26				3.37		1.03	
DC-2	12-Jul-90	Hydrometrics	4.39		3.97	7.2		0.0050	<	0.00500				2.74		17.9				0.71		0.31	
DC-2	15-Jun-94	Hydrometrics	2.86		3.18	9		0.0010	<	0.00210		0.0040		2.64	J	10.4		0.003		1.08		0.332	J
DC-2	26-Jul-94	Hydrometrics			3.96	16.4		0.0010	<	0.00540		0.0050		5.32		15.8		0.009		2.57		0.667	
DC-2	22-Aug-94	Hydrometrics			3.5	28.6		0.0020		0.00760		0.0100		8.26		41.8		0.024		3.65		0.904	
DC-2	23-Aug-94	Hydrometrics			3.46	23.9		0.0010	<	0.00740		0.0060		7.27		20.4		0.006		3.43		0.886	
DC-2	20-Sep-94	Hydrometrics			4.21	25		0.0010	<	0.00760		0.0070		7.44		23.6		0.004		3.59		1.2	J
DC-2	13-Oct-94	Hydrometrics			5.29																		
DC-2	26-Sep-95	Hydrometrics	0.194		3.5	22		0.0010	<	0.00520		0.0060		6.33		16.2		0.005		2.99		0.894	
DC-2	21-May-96	Hydrometrics	0.467		4.69	8.3				0.00270				1.91		5.55		0.004		1.12		0.43	
DC-2	30-May-96	Hydrometrics	1.116		4.45	6.9				0.00190				1.62		5.52		0.004		0.785		0.31	
DC-2	5-Jun-96	Hydrometrics	2.79		3.38	7				0.00140				1.83		19.3		0.008		0.629		0.24	
DC-2	12-Jun-96	Hydrometrics	10.8		3.35									1.25		10.7	J					0.21	J
DC-2	18-Jun-96	Hydrometrics	14.33		5.06	5				0.00120				1.44		9.69		0.003	<	0.481		0.19	
DC-2	26-Jun-96	Hydrometrics	11.3		5.03									1.52		8.54						0.19	
DC-2	2-Jul-96	Hydrometrics	13.79		4.5									1.38		6.76						0.24	J
DC-2	9-Jul-96	Hydrometrics	15.48		4	4.2	J			0.00080				1.11		8.05		0.01		0.379		0.15	
DC-2	18-Jul-96	Hydrometrics	4.937		4.64									2.23		8						0.33	
DC-2	25-Jul-96	Hydrometrics	1.175		6.83									2.7		9.84						0.39	
DC-2	21-Aug-96	Hydrometrics	0.138		3.89									4.74		15.4						0.64	
DC-2	10-Sep-96	Hydrometrics	0.18		3.32	20.2				0.00580				6.22		15.6		0.006		2.72		0.89	
DC-2	9-Jul-97	UOS Data				3.27		0.0100	<	0.00500	<	0.0100	<	0.876		5.32				0.304		0.129	
DC-2	30-Mar-98	UOS Data	0.13			12.3								2.69		12.8				2.14		0.688	
DC-2	22-Apr-98	UOS Data	0.072		4.54	12.1								2.66		11.2				1.95		0.589	
DC-2	4-May-98	UOS Data	0.699		4.3	5.4								1.23		6.43				0.574		0.162	
DC-2	29-May-98	UOS Data	2.67		3.88	5.34								1.47		10				0.592		0.22	
DC-2	6-May-99	Maxim	0.028		4.49	9.2				0.00380				1.94		16		0.006		1.61		0.51	
DC-2	8-Jul-99	Maxim	9.46		4.78	3.7				0.00120				1.07		4.83		0.002		0.37		0.15	
DC-2	29-Sep-99	Maxim	0.464		4.48	12.4				0.00440				3.98		13.6		0.002		1.93		0.6	J
DC-2	12-Apr-00	Maxim	0.012		4.88	10.7				0.00560				2.51		13.5		0.004		2.02		0.02	<
DC-2	20-May-00	Maxim	1.57		4.26									1.42								0.19	
DC-2	20-May-00	Maxim	1.57		4.22									1.44								0.19	
DC-2	20-May-00	Maxim	1.61		4.24									1.89								0.26	
DC-2	20-May-00	Maxim	2.61		4.12	5.5				0.00110				1.34		14.4		0.007		0.6		0.17	
DC-2	14-Jun-00	Maxim	5.16		4.5									1.59								0.24	
DC-2	14-Jun-00	Maxim	6.07		4.58									1.64								0.24	

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New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
DC-2	14-Jun-00	Maxim	6.44		4.42									1.61								0.22	
DC-2	14-Jun-00	Maxim	7.66			4.7				0.00140				1.43		8.26		0.002		0.5		0.2	
DC-2	9-Jul-00	Maxim	3.5		4.61									1.59	J							0.23	J
DC-2	9-Jul-00	Maxim	2.4		4.5	6.1	J			0.00190				2.01	J	8.55	J	0.003		0.72	J	0.26	J
DC-2	9-Jul-00	Maxim	2.83		4.47									2.04	J							0.28	J
DC-2	9-Jul-00	Maxim	3.35		4.69									1.75	J							0.26	J
DC-2	9-Oct-00	Maxim	0.2		3.28	14				0.00450				3.77		6.54	J	0.007		2.23		0.54	
DC-2	20-Apr-01	Maxim	0.15		5.05	11.1				0.00370				2.2		10.8		0.004		1.66		0.37	
DC-2	29-Jun-01	Maxim	3.217		4.95	5.5				0.00170				1.34		10.3		0.022	J	0.63		0.29	
DC-2	10-Oct-01	Maxim	0.17		3.97	17.1		0.0030	<	0.00540				4.15		14.5		0.007		2.62		0.79	
DC-2	25-Apr-02	Maxim	0.31		3.98	10.8				0.0038				2.2		12.1		0.003		1.91		0.6	
DC-2	2-Jul-02	Maxim	5		4.88	6.2	J			0.0016				1.59		8.1		0.002		0.57		0.25	J
DC-2	18-Sep-02	Maxim			3.58	17.6				0.0047				4.13		15.5		0.006		2.31		0.64	
DC-2	26-Sep-02	Maxim				14.3				0.0053				4.65		10.1		0.005		2.21		0.64	
DC-2	9-Oct-02	Maxim	0.381		3.99	13.7				0.0038				2.92		11.8		0.01		1.91		0.54	J
DC-2	22-Apr-03	Maxim	0.19		4.63	7.85				0.0038				2.14		8.79		0.005		1.62		0.45	
DC-2	11-Jul-03	Maxim	2.36		4.8	6.17				0.0019				1.92		4.86		0.003		0.88		0.25	
DC-2	31-Jul-03	Maxim			4.6	13.1		0.001	<	0.0032				3.57		12.2		0.005		1.83		0.57	JF%
DC-2	14-Aug-03	Maxim			4.1	15.9		0.001	<	0.0044				4.46		14.4		0.007		2.25		0.63	
DC-2	21-Aug-03	Maxim				15.3				0.0048				4.37		13.3		0.007		2.29		0.65	
DC-2	22-Aug-03	Maxim				19.2				0.0051				4.35		21.4		0.008		2.81		0.87	
DC-2	8-Sep-03	Maxim			3.6	18.5				0.0046				5.03		19.4		0.013		2.8		0.81	
DC-2	29-Sep-03	Maxim	0.066		4.52	12.5				0.0043				3.63		8.69		0.005		2.5		0.76	
DC-2	6-Apr-04	Maxim	0.181		5.82	10.1				0.0036				2.15		5.94		0.005		1.67		0.5	JF%
DC-2	29-Jun-04	Maxim	9.56		6.8	2.97				0.0007				0.58		4.16		0.003		0.31		0.1	
DC-2	11-Aug-04	Maxim	0.36		4.24	9.38				0.0032				2.79		11.1		0.004		1.44		0.45	
DC-2	6-Oct-04	Maxim	0.53		4.8	6.58				0.0024				1.9		7.36		0.002		1.25		0.35	
DC-2	6-Apr-05	Maxim	0.05		4.47	11.6				0.0046				2.49		15.5		0.003		2.25		0.84	
DC-2	29-Jun-05	Maxim	6.8		5.8	2.37			--	0.0008			--	0.31		3.42		0.002		0.31		0.14	
DC-2	27-Sep-05	Maxim	0.19		3.7	13.2			--	0.0035			--	2.57		12.1		0.006		1.82		0.51	
DC-2	25-Apr-06	Maxim	0.08		4.74	9.15				0.003				1.54		10.2		0.002		1.95		0.5	
DC-2	27-Jun-06	Maxim	5.19		6.25	3.12				0.0005				0.69		3.38		0.002		0.34		0.1	
DC-2	27-Sep-06	Maxim	0.14		3.76	12.4				0.0043				3.17		7.78		0.004		2.14		0.55	
Station DC-2: Pre-1999 Samples (n)			20		24	18		9		15		7		25		25		12		19		25	
Minimum			0.072		3.180	3.270		0.001		0.00050		0.0040		0.876		5.320		0.002		0.304		0.129	
Maximum			15.480		6.830	28.600		0.005		0.00760		0.0100		8.260		41.800		0.024		3.650		1.200	
Mean			4.386		4.184	12.339		0.002		0.00381		0.0061		3.391		13.722		0.007		1.740		0.489	
Standard Deviation (SD)			5.453		0.830	8.194		0.002		0.00259		0.0020		2.458		8.361		0.006		1.252		0.322	
Mean + (2 x SD); for pH: Mean - (2 x SD)			15.292		2.524	28.728		0.0047		0.00898		0.0100		8.307		30.445		0.019		4.244		1.133	
Station DC-2: 1989-2006 Samples (n)			56		63	52		12		49		7		68		59		46		53		68	
Minimum			0.012		3.180	2.370		0.001		0.001		0.004		0.310		3.380		0.002		0.304		0.010	
Maximum			15.480		6.830	28.600		0.005		0.008		0.010		8.260		41.800		0.024		3.650		1.200	
Mean			3.171		4.412	11.040		0.001		0.003		0.006		2.774		11.965		0.006		1.648		0.440	
Standard Deviation (SD)			4.040		0.767	6.149		0.001		0.002		0.002		1.818		6.502		0.005		0.970		0.267	
Mean + (2 x SD); for pH: Mean - (2 x SD)			11.252		2.878	23.337		0.004		0.007		0.010		6.411		24.969		0.015		3.587		0.974	
Station DC-2: 10/03-10/06 Low Flow (n)			7		7	7		0		7		0		7		7		7		7		7	
Minimum			0.050		3.700	6.580				0.002				1.540		5.940		0.002		1.250		0.350	
Maximum			0.530		5.820	13.200				0.005				3.170		15.500		0.006		2.250		0.840	
Mean			0.219		4.504	10.344				0.004				2.373		9.997		0.004		1.789		0.529	
Standard Deviation (SD)			0.170		0.724	2.256				0.001				0.552		3.273		0.001		0.363		0.151	
Mean + (2 x SD); for pH: Mean - (2 x SD)			0.558		3.056	14.857				0.005				3.477		16.544		0.007		2.514		0.831	
Narrative Standard - DC-2					**2.7**	**28.4**		**NA**		**0.009**		**NA**		**8.064**		**29.649**		**0.018**		**4.088**		**1.104**	

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TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
DC-5	3-Oct-89	Hydrometrics	0.370		5.69			0.0050	<	0.00300				2.54		6.88				1.16		0.4	
DC-5	12-Jul-90	Hydrometrics	8.910		7.43	2.7		0.0050	<	0.00100	<			0.97		4.3				0.28		0.12	
DC-5	28-Jul-93	Hydrometrics			7.2	3.2		0.0020	<	0.00100	<	0.0020		1.09		4.19		0.002		0.35		0.12	
DC-5	23-Sep-93	Hydrometrics	0.540		6.61	5.3		0.0010	<	0.00230		0.0020		2.17		4.68		0.002		1.2		0.36	
DC-5	25-Aug-94	Hydrometrics	0.240		6.4	8.1	J	0.0010	<	0.00270		0.0020		2.85	J	5.7	J	0.002		1.23		0.42	
DC-5	13-Jul-95	Hydrometrics	30.430		7.1	2		0.0010	<	0.00050		0.0020		0.485	J	3.8	J	0.003		0.18		0.062	
DC-5	27-Sep-95	Hydrometrics	0.420		5.3	7.7		0.0010	<	0.00230		0.0020		2.45		2.38		0.003		1.18		0.391	
DC-5	18-Jun-96	Hydrometrics	30.740		7.63	1.4				0.00040				0.346		3.12		0.003	<	0.143		0.06	
DC-5	9-Jul-96	Hydrometrics	28.140		6.34	1.7	J			0.00040				0.46		2.48		0.003	<	0.166		0.07	
DC-5	10-Sep-96	Hydrometrics	0.312		6.13	7.2				0.00230				2.62		4.42		0.003	<	1.08		0.37	
DC-5	6-May-99	Maxim	1.180		6.29	1.4				0.00060				0.33		0.65		0.001		0.25		0.08	
DC-5	8-Jul-99	Maxim	23.830		7.46	1.2				0.00040				0.31		1.54		0.001		0.124		0.07	
DC-5	29-Sep-99	Maxim	1.484		2.64	4				0.00120				1.26		2.67		0.002		0.5		0.17	J
DC-5	12-Apr-00	Maxim	0.429		6.59	2.9				0.00140				1.04		1.38		0.004		0.041		0.02	<
DC-5	9-Jul-00	Maxim	8.900		7.65	1.6	J			0.00050				0.54	J	2.11	J	0.001	<	0.19	J	0.07	J
DC-5	9-Oct-00	Maxim	1.200		7.17	2.7				0.00460				0.61		1.3	J	0.003	<	0.23		0.08	
DC-5	29-Jun-01	Maxim	5.107		6.95	1.8				0.00060				0.55		3.02		0.002	J	0.21		0.09	
DC-5	10-Oct-01	Maxim	0.340		7.73	3.5		0.0030	<	0.00100				0.71		1.19		0.003		0.41		0.15	
DC-5	25-Apr-02	Maxim		ice	5.6	0.1	<			0.0004				0.024		0.01	<	0.001	<	0.16		0.04	
DC-5	2-Jul-02	Maxim	12.600		6.5	1.6	J			0.0005				0.54		2.48		0.002		0.19		0.08	J
DC-5	18-Sep-02	Maxim			5.86	5.9				0.0021				1.61		3.66		0.003		0.93		0.21	
DC-5	26-Sep-02	Maxim				0.3				0.0004				0.079		0.25		0.001	<	0.086		0.02	
DC-5	9-Oct-02	Maxim	0.740		7.1	3.7				0.001				0.76		2.07		0.003		0.45		0.15	J
DC-5	21-Apr-03	Maxim	0.570		6.26	2.07				0.0009				0.56		1.3		0.002		0.35		0.13	
DC-5	11-Jul-03	Maxim	5.460		6.37	2.1				0.0006				0.48		1.55		0.001		0.29		0.07	
DC-5	8-Sep-03	Maxim			5.7	7.84				0.0017				2.01		15.7		0.018		1.05		0.38	
DC-5	29-Sep-03	Maxim	0.185		7.01	5.34				0.0012				1.44		3		0.003		0.62		0.3	
DC-5	7-Apr-04	Maxim	1.197		6.44	2.18				0.0007				0.52		1.1		0.001		0.34		0.13	JF%
DC-5	29-Jun-04	Maxim	19.210		7.7	0.73				0.0002				0.16		1.23		0.001		0.1		0.04	
DC-5	11-Aug-04	Maxim	0.820		7.35	3.03				0.0011				0.87		3.69		0.001		0.46		0.15	
DC-5	6-Oct-04	Maxim	1.800		6.62	1.93				0.0007				0.51		2.13		0.001	<	0.33		0.11	
DC-5	4/6/2005	Maxim	0.24		7.23	2.43			--	0.001			--	0.54		1.74		0.001		0.51		0.35	JF%
DC-5	6/29/2005	Maxim	19.26		6.9	0.7			--	0.0002			--	0.17		0.98		0.001		0.095		0.1	
DC-5	9/27/2005	Maxim	0.43		6.3	3.88			--	0.0015			--	0.97		2.61		0.004		0.73		0.22	
DC-5	25-Apr-06	Maxim	0.46		6.94	0.96				0.0005				0.23		0.64		0.001	<	0.29		0.06	
DC-5	27-Jun-06	Maxim	15.78		6.62	1.13				0.0001	<			0.21		1.13		0.001	<	0.11		0.04	
DC-5	27-Sep-06	Maxim	0.28		6.73	2.83				0.0014				0.79		0.91		0.001		0.66		0.17	
Station DC-5: Pre-1999 Samples (n)			9		10	9		7		10		5		10		10		8		10		10	
Minimum			0.240		5.300	1.400		0.0005		0.00040		0.0020		0.346		2.380		0.002		0.143		0.060	
Maximum			30.740		7.630	8.100		0.0025		0.00300		0.0020		2.850		6.880		0.003		1.230		0.420	
Mean			11.122		6.583	4.367		0.0011		0.00149		0.0020		1.598		4.195		0.002		0.697		0.237	
Standard Deviation (SD)			14.272		0.760	2.729		0.0009		0.00111		0.0000		1.017		1.387		0.001		0.504		0.161	
Mean + (2 x SD); for pH: Mean - (2 x SD)			39.667		5.062	9.826		0.0030		0.00370		0.0020		3.632		6.969		0.003		1.704		0.560	
Station DC-5: 1989-2006 Samples (n)			32		36	36		8		37		5		37		37		35		37		37	
Minimum			0.185		2.640	0.050		0.001		0.000		0.002		0.024		0.005		0.001		0.041		0.010	
Maximum			30.740		7.730	8.100		0.003		0.005		0.002		2.850		15.700		0.018		1.230		0.420	
Mean			6.925		6.598	2.975		0.001		0.001		0.002		0.914		2.756		0.002		0.451		0.158	
Standard Deviation (SD)			9.953		0.926	2.174		0.001		0.001		0.000		0.777		2.679		0.003		0.368		0.124	
Mean + (2 x SD); for pH: Mean - (2 x SD)			26.832		4.746	7.323		0.003		0.003		0.002		2.467		8.114		0.008		1.186		0.406	
Station DC-5: 10/03-10/06 Low Flow (n)			7		7	7		0		7		0		7		7		7		7		7	
Minimum			0.240		6.300	0.960				0.001				0.230		0.640		0.001		0.290		0.060	
Maximum			1.800		7.350	3.880				0.002				0.970		3.690		0.004		0.730		0.350	
Mean			0.747		6.801	2.463				0.001				0.633		1.831		0.001		0.474		0.170	
Standard Deviation (SD)			0.574		0.392	0.921				0.000				0.256		1.077		0.001		0.170		0.094	
Mean + (2 x SD); for pH: Mean - (2 x SD)			1.894		6.017	4.305				0.00174				1.145		3.986		0.004		0.815		0.357	
Temporary Standard - DC-5					4.6	9.51		NA		0.004		NA		3.53		6.83		NA		1.71		0.54	

Notes: mg/l = milligrams/liter; su = standard units
n = number of samples
< = less than detection
J = estimated value
NA - not applicable

TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-7	28-May-90	Hydrometrics	40.30		7.02	0.1		0.0050	<	0.00010	<	0.0200	<	0.03		0.2		0.002	<	0.02	<	0.02	
SW-7	5-Jun-90	Hydrometrics	81.11		7.23	0.4								0.11		0.99						0.02	
SW-7	6-Jun-90	Hydrometrics	115.10																				
SW-7	13-Jun-90	Hydrometrics	69.81		7.15	0.26								0.07		0.61						0.02	
SW-7	15-Jun-90	Hydrometrics	56.30																				
SW-7	20-Jun-90	Hydrometrics	97.51		7.28	0.5								0.14		0.99						0.02	
SW-7	22-Jun-90	Hydrometrics	129.15																				
SW-7	27-Jun-90	Hydrometrics	138.80		8.76	0.6		0.0050	<	0.00020		0.0200	<	0.147		1.02		0.002	<	0.05		0.03	
SW-7	28-Jun-90	Hydrometrics	140.13																				
SW-7	3-Jul-90	Hydrometrics	122.90		9.58	0.4								0.11		0.78				0.05		0.03	
SW-7	10-Jul-90	Hydrometrics	50.20			0.3				0.00100	<	0.0200	<	0.11		0.67		0.01	<	0.04		0.04	
SW-7	12-Jul-90	Hydrometrics	41.70																				
SW-7	17-Jul-90	Hydrometrics	24.70		9.09	0.5								0.17		0.93						0.03	<
SW-7	19-Jul-90	Hydrometrics	20.90																				
SW-7	26-Jul-90	Hydrometrics	10.40		6.65	0.5		0.0050	<	0.00020		0.0200	<	0.21		1.05		0.003		0.07		0.04	
SW-7	22-Aug-90	Hydrometrics	5.60		7.41																		
SW-7	25-Sep-90	Hydrometrics	2.20		6.63	0.1	<	0.0050	<	0.00010	<	0.0200	<	0.02		0.14		0.002	<	0.05		0.02	
SW-7	15-Mar-91	Hydrometrics	1.50		6.54	0.1	<	0.0050	<	0.00100	<	0.0200	<	0.01	<	0.24		0.01	<	0.04		0.01	
SW-7	6-Jun-91	Hydrometrics	157.60		7.75	0.3		0.0050	<	0.00010	<	0.0200	<	0.06	<	0.74		0.002	J	0.03		0.04	
SW-7	10-Jul-91	Hydrometrics	37.70		7.84	0.4		0.0050	<	0.00010		0.0200	<	0.18		1.2		0.024	J	0.05		0.04	
SW-7	13-Aug-91	Hydrometrics	4.10		7.81	0.1		0.0050	<	0.00020		0.0200		0.034		0.15		0.002	<	0.07		0.06	
SW-7	24-Sep-91	Hydrometrics	3.50		8.23	0.1	<	0.0050	<	0.00010		0.0200	<	0.017		0.21		0.002	<	0.06		0.01	
SW-7	19-Jul-92	Hydrometrics	20.00		8.02	0.5		0.0050	<	0.00010	<	0.0100	<	0.17		0.07		0.002	<	0.07		0.03	
SW-7	22-Sep-92	Hydrometrics	3.23		7.58	0.1		0.0050	<	0.00020		0.0100	<	0.087	<	0.2	<	0.002	<	0.08		0.04	
SW-7	23-Sep-93	Hydrometrics	3.71		8.11	0.2		0.0010	<	0.00010		0.0010	<	0.06		0.29		0.002	<	0.07		0.016	
SW-7	25-Aug-94	Hydrometrics	1.69		8.18	0.02	J	0.0010	<	0.00010	<	0.0010	<	0.007	J	0.16	J	0.002	<	0.027		0.008	<
SW-7	13-Jul-95	Hydrometrics	113.48		6.93	0.6		0.0010	<	0.00010		0.0030		0.098	J	0.97	J	0.002	<	0.05		0.02	
SW-7	27-Sep-95	Hydrometrics	2.80		5.4	0.1	<	0.0010	<	0.00010	<	0.0010	<	0.021		0.17		0.002	<	0.03		0.027	<
SW-7	18-Jun-96	Hydrometrics	223.08		8.04	0.5				0.00020				0.087		1.05		0.003	<	0.046		0.02	
SW-7	9-Jul-96	Hydrometrics	97.63		6.84	0.3	J			0.00010				0.096		0.53		0.003	<	0.038		0.02	
SW-7	10-Sep-96	Hydrometrics	2.12		7.36	0.1	<			0.00010	<			0.019		0.13		0.003	<	0.025		0.01	
SW-7	6-May-99	Maxim	6.48		6.32	0.4				0.00010	<			0.008		0.62		0.001	<	0.036		0.01	<
SW-7	8-Jul-99	Maxim	111.83		7.58	0.4				0.00010				0.064		0.53		0.001	<	0.027		0.02	
SW-7	29-Sep-99	Maxim	2.49		6.47	0.1	<			0.00010	<			0.001	<	0.42		0.001	<	0.023		0.03	J
SW-7	12-Apr-00	Maxim	0.41		7.01	0.05	<			0.00010	<			0.004		0.43		0.001	<	0.066		0.05	
SW-7	9-Jul-00	Maxim	32.25		7.67	0.3	J			0.00010	<			0.072	J	0.36	J	0.001	<	0.029	J	0.02	J
SW-7	9-Oct-00	Maxim	1.81		8.1	0.01	<			0.00010	<			0.001	<	0.22	J	0.003	<	0.02	<	0.01	<
SW-7	29-Jun-01	Maxim	36.63		7.29	0.2				0.00080				0.12		0.53		0.004	J	0.035		0.01	<
SW-7	10-Oct-01	Maxim	1.53		7.63	0.1	<	0.0030	<	0.00010	<			0.005		0.12		0.001		0.015		0.02	J
SW-7	25-Apr-02	Maxim			6.14	0.1	<			0.0001	<			0.003		0.26		0.001	<	0.028		0.01	<
SW-7	2-Jul-02	Maxim	74.60		7.06	0.3	J			0.0001	<			0.089		0.49		0.001	<	0.024		0.02	J
SW-7	9-Oct-02	Maxim	2.42		7.1	0.1				0.0001				0.019		0.23		0.001	<	0.038		0.06	J
SW-7	21-Apr-03	Maxim			6.43	0.05	<			0.0001				0.007		0.31		0.001	<	0.018		0.01	
SW-7	11-Jul-03	Maxim	39.60		6.58	0.31				0.0001				0.067		0.27		0.001	<	0.02	<	0.01	<
SW-7	29-Sep-03	Maxim	1.42		7.11	0.05	<			0.0001	<			0.005		0.29		0.001		0.023		0.01	
SW-7	6-Apr-04	Maxim			7	0.05	<			0.0001	<			0.003		0.46		0.001	<	0.046		0.02	JF%
SW-7	29-Jun-04	Maxim	88.54		7.9	0.2				0.0001	<			0.037		0.34		0.001	<	0.02		0.01	<
SW-7	6-Oct-04	Maxim	7.83		7.13	0.08				0.0001	<			0.02		0.17		0.001	<	0.038		0.01	<
SW-7	4/6/2005	Maxim	1.22		7.26	0.05	<		--	0.0001	<		--	0.001		0.47		0.001	<	0.037		0.01	1)
SW-7	6/29/2005	Maxim	81.8		6.5	0.15			--	0.0001	<		--	0.026		0.2		0.001	<	0.016		0.01	<
SW-7	9/27/2005	Maxim	3.18		6.8	0.05	<		--	0.0001	<		--	0.015		0.18		0.001	<	0.037		0.04	
SW-7	25-Apr-06	Maxim	2.04		6.69	0.11				0.0001	<			0.003		0.49		0.001	<	0.051		0.01	<
SW-7	27-Jun-06	Maxim	68.62		6.28	0.14				0.0001	<			0.028		0.26		0.001	<	0.02		0.01	<
SW-7	27-Sep-06	Maxim	1.95		7.55	0.05	<			0.0001	<			0.003		0.13		0.001	<	0.008		0.01	<

Notes: mg/l = milligrams/liter; su = standard units
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< = less than detection
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NA - not applicable

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Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
Station SW-7: Pre-1999 Samples (n)			31		24	24		15		19		16		24		24		19		20		24	
Minimum			1.500		5.400	0.020		0.0005		0.00005		0.0005		0.005		0.070		0.001		0.010		0.004	
Maximum			223.080		9.580	0.600		0.0025		0.00050		0.0200		0.210		1.200		0.024		0.080		0.060	
Mean			58.676		7.560	0.285		0.0020		0.00015		0.0078		0.083		0.558		0.003		0.048		0.025	
Standard Deviation (SD)			59.809		0.900	0.201		0.0009		0.00014		0.0051		0.062		0.395		0.005		0.018		0.013	
Mean + (2 x SD); for pH: Mean - (2 x SD)			178.294		5.759	0.686		0.0038		0.00042		0.0180		0.207		1.348		0.013		0.085		0.051	
Station SW-7: 1989-2006 Samples (n)			51		47	47		16		42		16		47		47		42		43		47	
Minimum			0.405		5.400	0.005		0.001		0.000		0.001		0.001		0.070		0.001		0.008		0.004	
Maximum			223.080		9.580	0.600		0.003		0.001		0.020		0.210		1.200		0.024		0.080		0.060	
Mean			46.777		7.299	0.210		0.002		0.000		0.008		0.055		0.450		0.002		0.037		0.020	
Standard Deviation (SD)			53.639		0.788	0.184		0.001		0.000		0.005		0.057		0.317		0.004		0.019		0.015	
Mean + (2 x SD); for pH: Mean - (2 x SD)			154.054		5.723	0.578		0.0037		0.0004		0.0180		0.1696		1.084		0.009		0.075		0.050	
Station SW-7: 10/03-10/06 Low Flow (n)			6		7	7		0		7		0		7		7		7		7		7	
Minimum			1.220		6.690	0.025				0.000				0.001		0.130		0.001		0.008		0.005	
Maximum			7.830		7.550	0.110				0.000				0.020		0.490		0.001		0.051		0.040	
Mean			2.940		7.077	0.045				0.000				0.007		0.313		0.001		0.034		0.014	
Standard Deviation (SD)			2.491		0.287	0.064				0.000				0.013		0.147		0.000		0.014		0.012	
Mean + (2 x SD); for pH: Mean - (2 x SD)			7.922		6.504	0.173				0.00005				0.032		0.606		0.001		0.063		0.038	
Temporary Standard - SW-7					5.5	0.67		NA		NA		NA		0.2		1.32		0.013		0.086		0.049	
SW-2	2-Aug-89	Hydrometrics				0.1	<			0.001	<			0.01	<	0.03	<	0.01	<	0.02	<	0.01	<
SW-2	16-Sep-89	Hydrometrics	0.53			0.1	<			0.001	<			0.01		0.08		0.01	<	0.02	<	0.04	
SW-2	19-Oct-89	Hydrometrics	0.71		6.98	0.1	<			0.001	<			0.01	<	0.03	<	0.01	<	0.02	<	0.01	<
SW-2	6-Jun-90	Hydrometrics	10.9		7.32	0.1	<			0.0001	<			0.026		0.18		0.002	<	0.02	<	0.02	
SW-2	7-Jun-90	Hydrometrics	14.7																				
SW-2	13-Jun-90	Hydrometrics	19.52		7.38	0.1	<							0.02		0.13						0.01	<
SW-2	14-Jun-90	Hydrometrics	13.5																				
SW-2	20-Jun-90	Hydrometrics	30.65		8.52	1.6								0.25		4.5						0.04	
SW-2	22-Jun-90	Hydrometrics	33.3																				
SW-2	26-Jun-90	Hydrometrics	48.7		9.13	0.9				0.0004				0.132		1.9		0.014		0.09		0.03	
SW-2	28-Jun-90	Hydrometrics	43.3																				
SW-2	3-Jul-90	Hydrometrics	44		8.55	0.2								0.02		0.49						0.01	<
SW-2	5-Jul-90	Hydrometrics	27.3																				
SW-2	10-Jul-90	Hydrometrics	17.7			0.1	<							0.02	<	0.05						0.01	<
SW-2	11-Jul-90	Hydrometrics	12																				
SW-2	17-Jul-90	Hydrometrics	7.4		8.51	0.1	<							0.01		0.06						0.01	<
SW-2	19-Jul-90	Hydrometrics	4.4																				
SW-2	27-Jul-90	Hydrometrics	2.5		6.39	0.1	<			0.0001	<			0.007		0.03	<	0.002	<	0.02	<	0.02	<
SW-2	23-Aug-90	Hydrometrics	1.6		7.48																		
SW-2	25-Sep-90	Hydrometrics	0.6		6	0.1	<			0.0001	<			0.006		0.15		0.002	<	0.02	<	0.02	
SW-2	5-Jun-91	Hydrometrics	38.7		7.3	1.9				0.0001				0.07	<	3.35		0.042		0.15		0.05	
SW-2	9-Jul-91	Hydrometrics	9.1		8.55	0.1	<			0.0001	<			0.027		0.06		0	J2	0.02	<	0.02	
SW-2	13-Aug-91	Hydrometrics	0.7		7.96	0.1	<			0.0001				0.009		0.05		0.001	<	0.02	<	0.02	
SW-2	24-Sep-91	Hydrometrics	0.7		8.26	0.1	<			0.0002				0.007	<	0.04		0.002	<	0.02	<	0.01	<
SW-2	27-May-92	Hydrometrics	30.81		8.02	0.1				0.0001	<			0.029		0.42		0.002	<	0.02		0.03	
SW-2	18-Jul-92	Hydrometrics	3.5		8.02	0.1	<			0.0001	<			0.012		0.05		0.002	<	0.02	<	0.19	
SW-2	22-Sep-92	Hydrometrics	0.77		7.73	0.1	<			0.0001	<			0.009		0.04		0.002	<	0.02	<	0.01	
SW-2	21-Jul-93	Hydrometrics	7.24		8.23	0.1	<			0.0001				0.029		0.04		0.002	<	0.01	<	0	J4
SW-2	23-Sep-93	Hydrometrics	0.43		7.65	0.1	<			0.0001	<			0.006		0.04		0.002	<	0.01	<	0.008	
SW-2	16-Jun-94	Hydrometrics	10.03		7.84	0.1	<			0.0001	<			0.017	J4	0.05		0.002	<	0.01	<	0.01	J4
SW-2	15-Sep-95	Hydrometrics	0.863		7.5																		
SW-2	26-Sep-95	Hydrometrics	0.71		7.9																		
SW-2	30-Sep-99	Maxim	0.841		7.4	0.1	<			0.0001	<			0.003		0.05		0.001	<	0.005	<	0.03	JF%
SW-2	14-Apr-00	Maxim	0.288		10.14	0.05	<			0.0001	<			0.01		0.05	<	0.001	<	0.005	<	0.02	<
SW-2	7-Jul-00	Maxim	9.2		7.95	0.1	<			0.0001	<			0.014	JF%	0.09	JF%	0.001	<	0.005	<	0.01	<
SW-2	10-Oct-00	Maxim	0.62		8.04	0.1	<			0.0001	<			0.001		0.13	JF%	0.003	<	0.02	<	0.01	<
SW-2	19-Apr-01	Maxim	0.62		6.14	0.1	<			0.0001	<			0.008		0.04		0.001	<	0.003	<	0.01	<

Notes: mg/l = milligrams/liter; su = standard units
n = number of samples
< = less than detection
J = estimated value
NA - not applicable

TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-2	26-Jun-01	Maxim	10.04		7.1	0.1	<			0.0001	<			0.015		0.07		0.001	<	0.003	<	0.01	<
SW-2	12-Oct-01	Maxim	0.29		8.18	0.1	<	0.003	<	0.001	<			0.004		0.05	<	0.001	<	0.003		0.08	
SW-2	24-Apr-02	Maxim	0.27		6.78	0.1	<			0.0001	<			0.006		0.02		0.001	<	0.003	<	0.01	<
SW-2	2-Jul-02	Maxim	14.8		6.95	0.1	<			0.0001	<			0.017		0.15		0.001		0.003	<	0.05	JF%
SW-2	24-Jul-02	Maxim	2.237		5.53	0.1				0.0001	<			0.011		0.08		0.002		0.003	<	0.03	
SW-2	7-Oct-02	Maxim	0.63		7.5	0.1	<			0.0001				0.006		0.04		0.001		0.004		0.04	JF%
SW-2	22-Apr-03	Maxim	0.32		6.26	0.05	<			0.0001	<			0.012		0.2		0.001	<	0.008		0.02	
SW-2	30-Jun-03	Maxim	31.4		7.28	0.28				0.0001	<			0.017		0.38		0.004		0.015		0.01	<
SW-2	29-Sep-03	Maxim	0.247		6.03	0.05	<			0.0001	<			0.015		0.03		0.004		0.003	<	0.01	<
SW-2	6-Apr-04	Maxim	0.885		6.64	0.05	<			0.0001	<			0.02		0.06		0.001	<	0.005	<	0.08	JF%
SW-2	29-Jun-04	Maxim	27.93		7.8	0.26				0.0001	<			0.019		0.29		0.002		0.09		0.01	
SW-2	5-Oct-04	Maxim	1.38		7.2	0.05	<			0.0001	<			0.005	B	0.04		0.001	<	0.003	<	0.01	<
SW-2	6-Apr-05	Maxim	0.15		7.6	0.05	<			0.0001	<			0.005		0.05		0.001	<	0.006		0.25	JF%
SW-2	27-Jun-05	Maxim	31.6		7.3	0.13				0.0001	<			0.02		0.16		0.002		0.009		0.01	
SW-2	28-Sep-05	Maxim	0.5		7.57	0.05	<			0.0001	<			0.007		0.02		0.001	<	0.005		0.01	<
SW-2	25-Apr-06	Maxim	0.22		6.96	0.05	<			0.0001	<			0.01		0.03		0.001	<	0.003	<	0.01	<
SW-2	26-Jun-06	Maxim	15.54		7.32	0.06				0.0001	<			0.014		0.13		0.001	<	0.014		0.01	<
SW-2	25-Sep-06	Maxim	0.73		7.45	0.05	<			0.0001	<			0.006		0.05		0.001	<	0.003	<	0.01	<
Station SW-2: Pre-1999 Samples (n)			31		22	22		0		17		0		22		22		17		17		22	
Minimum			0.430		6.000	0.050		0.000		0.0001		0.000		0.004		0.015		0.000		0.005		0.000	
Maximum			48.700		9.130	1.900		0.000		0.0005		0.000		0.250		4.500		0.042		0.150		0.190	
Mean			14.092		7.783	0.252				0.0002				0.031		0.533		0.005		0.023		0.024	
Standard Deviation (SD)			15.229		0.731	0.520				0.0002				0.056		1.182		0.010		0.038		0.040	
Mean + (2 x SD); for pH: Mean - (2 x SD)			44.550		6.321	1.292				0.00053				0.142		2.897		0.025		0.099		0.103	
Station SW-2: 1989-2006 Samples (n)			54		45	45		1		40		0		45		45		40		40		45	
Minimum			0.150		5.530	0.025		0.002		0.0001				0.001		0.015		0.000		0.002		0.000	
Maximum			48.700		10.140	1.900		0.002		0.0005				0.250		4.500		0.042		0.150		0.250	
Mean			10.882		7.519	0.157				0.0001				0.021		0.309		0.003		0.014		0.027	
Standard Deviation (SD)			13.833		0.861	0.375				0.0001				0.040		0.849		0.007		0.029		0.047	
Mean + (2 x SD); for pH: Mean - (2 x SD)			38.547		5.796	0.906				0.0004				0.1006		2.006		0.016		0.072		0.120	
Station SW-2: 2006 Low Flow (n)			2		2	2		0		2		0		2		2		2		2		2	
Minimum			0.220		6.960	0.025				0.0001				0.006		0.030		0.001		0.002		0.005	
Maximum			0.730		7.450	0.025				0.0001				0.010		0.050		0.001		0.002		0.005	
Mean			0.475		7.205	0.025				0.0001				0.008		0.040		0.001		0.002		0.005	
Standard Deviation (SD)			0.361		0.346	0.000				0.0000				0.003		0.014		0.000		0.000		0.000	
Chronic Aquatic Standard - SW-2 (hardness 100)						**0.087**		**0.15**		**0.00027**		**0.086**		**0.009**		**1**		**0.0032**		**NA**		**0.12**	
SW-5	15-Sep-89	Hydrometrics	0.44			0.1	<			0.001	<			0.01	<	0.03	<	0.01	<	0.02	<	0.03	
SW-5	20-Oct-89	Hydrometrics	0.47		6.29	0.1	<			0.001	<			0.01	<	0.03	<	0.01	<	0.02	<	0.01	<
SW-5	29-May-90	Hydrometrics	14.34		7.04	0.2				0.0001	<			0.019		0.34		0.003		0.02	<	0.02	
SW-5	6-Jun-90	Hydrometrics	19.93		7.16	0.1	<							0.01		0.16						0.01	
SW-5	12-Jun-90	Hydrometrics	29.84		7.65	0.1								0.01		0.3						0.09	
SW-5	14-Jun-90	Hydrometrics	23.6																				
SW-5	20-Jun-90	Hydrometrics	41.26		8.33	1.3								0.2		3						0.03	
SW-5	26-Jun-90	Hydrometrics	90		8.75	1.4				0.0004				0.153		3.22		0.022		0.13		0.04	
SW-5	29-Jun-90	Hydrometrics	80																				
SW-5	2-Jul-90	Hydrometrics	55.5		9.24	0.1	<							0.01	<	0.07						0.01	<
SW-5	4-Jul-90	Hydrometrics	34.4																				
SW-5	9-Jul-90	Hydrometrics	18.2			0.1	<							0.01	<	0.09						0.02	
SW-5	11-Jul-90	Hydrometrics	14																				
SW-5	17-Jul-90	Hydrometrics	6.7		7.97	0.1	<							0.01	<	0.05						0.02	
SW-5	19-Jul-90	Hydrometrics	5.1																				
SW-5	27-Jul-90	Hydrometrics	2.9		6.36	0.1	<			0.0001	<			0.004		0.08		0.002	<	0.02	<	0.04	<
SW-5	23-Aug-90	Hydrometrics	2.2		7.81																		
SW-5	25-Sep-90	Hydrometrics	0.7		6	0.1	<			0.0001	<			0.003		0.03	<	0.002	<	0.02	<	0.46	
SW-5	5-Jun-91	Hydrometrics	50.6		7.64	1.8				0.0004				0.09	<	3.12		0.003		0.11		0.01	
SW-5	9-Jul-91	Hydrometrics	11.1		8.37	0.1	<			0.0001	<			0.021		0.06		0	J2	0.02	<	0.02	

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TABLE A-2 - STATISTICAL SUMMARY OF WATER QUALITY DATA 1989-2006

New World Mining District Response and Restoration Project

Sample Station	Sample Date	Data Source	Flow (cfs)	Flow Flag	Field pH (su)	Aluminum Total Rec. (mg/l)	Al Flag	Arsenic Total Rec. (mg/l)	As Flag	Cadmium Total Rec. (mg/l)	Cd Flag	Chromium Total Rec. (mg/l)	Cr Flag	Copper Total Rec. (mg/l)	Cu Flag	Iron Total Rec. (mg/l)	Fe Flag	Lead Total Rec. (mg/l)	Pb Flag	Manganese Total Rec. (mg/l)	Mn Flag	Zinc Total Rec. (mg/l)	Zn Flag
Chronic Standard (for Hardness = 50 mg/l)						0.087		0.15		0.00142		0.117		0.0052		1		0.0005		NA		0.067	
Acute Standard (for Hardness = 50 mg/l)						0.75		0.34		0.00206		0.984		0.0073		NA		0.014		NA		0.067	
SW-5	13-Aug-91	Hydrometrics	0.7		8.27	0.1	<			0.0001	<			0.001	J4	0.05		0.002	<	0.02	<	0.06	
SW-5	24-Sep-91	Hydrometrics	0.5		8.41	0.1				0.0001	<			0.006	<	0.05		0.002		0.02	<	0.01	
SW-5	27-May-92	Hydrometrics	38.13		8.1	0.2				0.0001	<			0.029		0.54		0.002	<	0.02		0.02	
SW-5	18-Jul-92	Hydrometrics	5.5		7.55	0.1	<			0.0001	<			0.006		0.07		0.002	<	0.02	<	0.13	
SW-5	23-Sep-92	Hydrometrics	0.63		8.14	0.1	<			0.0001	<			0.004		0.06		0.002	<	0.02	<	0.01	<
SW-5	21-Jul-93	Hydrometrics	7.62		7.43	0.1	<			0.0001	<			0.009		0.03	<	0.002	<	0.01	<	0.006	J4
SW-5	23-Sep-93	Hydrometrics	0.53		8.24	0.1	<			0.0001	<			0.005		0.03	<	0.002	<	0.01	<	0.008	
SW-5	16-Jun-94	Hydrometrics	9.4		7.37	0.1	<			0.0001	<			0.002	J4	0.04		0.002	<	0.01	<	0.008	J4
SW-5	15-Sep-95	Hydrometrics	0.546		7.3																		
SW-5	26-Sep-95	Hydrometrics	0.34		8.1																		
SW-5	7-Jul-99	Maxim	22.33		7.95	0.1				0.0001	<			0.014		0.13		0.001		0.005	<	0.01	
SW-5	24-Jul-02	Maxim	1.403		5.45	0.1	<			0.0009				0.006		0.06		0.001		0.003	<	0.04	
SW-5	22-Apr-03	Maxim	0.14		6.44	0.05	<			0.0001	<			0.004		0.16		0.001	<	0.008		0.01	<
SW-5	30-Jun-03	Maxim	21		7.27	0.21				0.0001	<			0.014		0.32		0.003		0.01		0.01	<
SW-5	6-Apr-04	Maxim	0.327		7.32	0.05	<			0.0001	<			0.006		0.02		0.001	<	0.005	<	0.07	JF%
SW-5	29-Jun-04	Maxim	20.68		8.1	0.18				0.0001	<			0.013		0.21		0.001		0.004		0.02	
SW-5	5-Oct-04	Maxim	0.37		7.2	0.05	<			0.0001	<			0.001	<	0.01	<	0.001	<	0.003	<	0.01	<
SW-5	27-Jun-05	Maxim	17.83		6.9	0.12				0.0001	<			0.016		0.21		0.001		0.006		0.01	<
SW-5	28-Sep-05	Maxim	0.08		7.6	0.05	<			0.0001	<			0.004		0.01	<	0.001	<	0.004		0.01	
SW-5	26-Jun-06	Maxim	8.56		6.81	0.05	<			0.0001	<			0.01		0.1	B	0.001	<	0.005		0.01	<
Station SW-5: Pre-1999 Samples (n)			30		23	22		0		16		0		22		22		16		16		22	
Minimum			0.340		6.000	0.050		0.000		0.000		0.000		0.001		0.015		0.000		0.005		0.005	
Maximum			90.000		9.240	1.800		0.000		0.001		0.000		0.200		3.220		0.022		0.130		0.460	
Mean			18.839		7.718	0.266				0.000				0.025		0.517		0.003		0.023		0.047	
Standard Deviation (SD)			24.067		0.792	0.510				0.000				0.051		1.064		0.005		0.038		0.097	
Mean + (2 x SD); for pH: Mean - (2 x SD)			66.973		6.134	1.287				0.00051				0.126		2.646		0.014		0.099		0.241	
Station SW-5: 1989-2006 Samples (n)			40		33	32		0		26		0		32		32		26		26		32	
Minimum			0.080		5.450	0.025				0.000				0.001		0.005		0.000		0.002		0.005	
Maximum			90.000		9.240	1.800				0.001				0.200		3.220		0.022		0.130		0.460	
Mean			16.447		7.532	0.207				0.000				0.020		0.394		0.002		0.016		0.038	
Standard Deviation (SD)			21.712		0.825	0.431				0.000				0.042		0.897		0.004		0.031		0.082	
Mean + (2 x SD); for pH: Mean - (2 x SD)			59.871		5.882	1.069				0.0006				0.1049		2.188		0.011		0.078		0.202	
Chronic Aquatic Standard - SW-5 (hardness 100)						0.087		0.15		0.00027		0.086		0.009		1		0.0032		NA		0.12	

Notes: mg/l = milligrams/liter; su = standard units
n = number of samples
< = less than detection
J = estimated value
NA - not applicable

Table A-3
Water Quality and Flow at Daisy Creek Adit Discharge Monitoring Stations
New World Mining District Response and Restoration Project
Adit Discharge EECA

Station Name	Sample Date	Flow (gpm)	Field pH (su)	Hardness (mg/L CaCO3)	Sulfate (mg/l)	Concentration (Total Recoverable in Milligrams Per Liter)						
						Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
D-18	9/13/1989	1.8	3.41		268							
D-18	7/13/1990	25.1	6.82		246	0.2	0.001	0.01	13.8		0.91	0.09
D-18	7/25/1990	20.2		353	280							
D-18	8/1/1990	22.4	6.49	370	311	*0.1*	*0.001*	*0.01*	17.5	*0.01*	0.86	0.03
D-18	8/22/1990	18.0		393	324	*0.1*	*0.001*	*0.01*	17.3	*0.01*	0.88	0.03
D-18	9/6/1990	9.0		386	324	0.4	*0.001*	*0.01*	22.3	*0.01*	0.9	0.05
D-18	9/25/1990	6.7	5.5	423	350	*0.1*	*0.0001*	0.002	19.2	*0.002*	0.93	0.06
D-18	7/10/1991	18.0	7.1	276	214	0.9	0.0049	0.08	14.7		0.86	0.05
D-18	9/25/1991	6.7	7.02	414	336	0.2	0.0017	0.018	14.6	*0.002*	0.94	0.03
D-18	7/20/1995	20.2	5.9	230	180	1.3	0.0005	0.078	14.4	0.006	0.62	0.028
D-18	9/26/1995	5.6	5.4		349	0.2	0.0008	*0.011*	24	*0.002*	1.07	*0.028*
D-18	7/10/1996	18.0	5.43	252	158	0.3	0.0004	0.045	9.8	*0.003*	0.534	0.02
D-18	8/15/1996	15.0										
D-18	9/10/1996	6.7	6.36	358	333	0.2	0.0009	0.005	38	*0.003*	1.14	0.04
D-18	10/5/1996				333	*0.234*	*0.002*	*0.007*	27.6	0.002	1.06	0.0313
D-18	10/5/1996	3.1	5.7		339	0.1	0.0006	0.003	27	*0.003*	1.1	0.02
D-18	7/6/2001	8.1	6.59	314	264	0.2	0.0017	0.026	20.8	*0.001*	1.04	0.01
D-18	7/2/2002	29.6	6.48	249	149	0.1	0.0001	0.017	6.69	0.001	0.49	0.02
D-18	9/26/2002	6.9	6.6	385	299	*0.1*	0.0003	*0.001*	7.39	*0.001*	1	0.02
D-18	10/7/2002	5.4	7.08	354	288	0.2	0.0004	0.033	14.7	0.002	0.096	0.08
D-18	7/28/2003	10.0	5.4	338	332	4.95	0.0005	0.14	8.35	*0.001*	0.92	0.09
D-18	8/7/2003	7.0	6.8	348	302	0.2	*0.0001*	0.03	3.64	0.002	0.6	*0.01*
D-18	10/1/2003	3.6	6.77	449	379	0.1	*0.0001*	0.025	19.1	*0.001*	0.96	0.05
D-18	7/29/2004	7.3	6.7									
D-18	8/10/2004	7.6	6.65									
D-18	9/23/2004	4.7	6.5	404	363	0.08	*0.0001*	0.018	20	*0.001*	0.97	0.01
D-18	9/23/2005	4.9	6.2									
D-18	8/28/2006	6.3	5.8									
Total number of samples	28	27	23	18	23	21	21	21	21	19	21	21
Number of high flow samples	9	9	8	7	8	7	7	7	7	5	7	7
Total number of samples after plugging inflow to McLaren Adit (September, 2003)	6	6	6	2	2	2	2	2	2	2	2	2

gpm = gallons per minute
s.u. = standard units
mg/l CaCO3 = milligrams per liter as calcium carbonate
mg/l = milligrams per liter
Italices indicate analyte was below detection limit or flow rates that were estimated as equal to or less than the displayed value.

Table A-4
Water Quality and Flow at Fisher Creek Adit Discharge Monitoring Stations
New World Mining District Response and Restoration Project
Adit Discharge EECA

Station Name	Sample Date	Flow (gpm)	Field pH (su)	Hardness (mg/L CaCO3)	Sulfate (mg/l)	Concentration (Total Recoverable in Milligrams Per Liter)						
						Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
F-8A	11/22/2004	13.1	4.06			0.94		0.23	5.07		2.02	0.19
Total number of samples	1	1	1	0	0	1	0	1	1	0	1	1
Number of high flow samples	0	0	0	0	0	0	0	0	0	0	0	0
F-8B	9/18/1989	26.9	3.4		103							
F-8B	8/7/1990	0.8	3.52		98		*0.001*	0.11	7.45		1	0.12
F-8B	8/9/1993	1.0	3.85	38.8	77		*0.00257*	0.121	14.2	0.00245	1.02	0.127
F-8B	8/18/1996	5.0										
F-8B	7/1/2003	3.0	3.1	23	54	0.32	0.0001	0.24	6.46	0.001	0.66	0.05
F-8B	7/29/2004	5.0	3.3									
Total number of samples	6	6	5	2	4	1	3	3	3	2	3	3
Number of high flow samples	2	2	2	1	1	1	1	1	1	1	1	1
FCSI-96-5	8/18/1996	5.0										
FCSI-96-5	7/5/2001	1.8	6.8	99	49	*0.1*	0.0002	0.004	0.12	0.001	0.074	0.04
FCSI-96-5	7/16/2003	0.6	7.1	102	58	*0.05*	0.0001	0.003	0.15	*0.003*	0.12	0.02
FCSI-96-5	7/28/2004	4.0	6.3									
FCSI-96-5	9/22/2004	1.4	6.1	95	51	*0.05*	0.0001	0.003	0.21	0.001	0.13	0.02
Total number of samples	5	5	4	3	3	3	3	3	3	3	3	3
Number of high flow samples	3	3	3	2	2	2	2	2	2	2	2	2
FCSI-99-1	8/5/1999	10.0	7.5									
FCSI-99-1	7/5/2001	0.4	6.92	31	17	0.4	0.0002	0.035	1.01	0.015	0.069	0.05
FCSI-99-1	7/23/2002	0.5	5.46	45	21	*0.1*	0.0009	0.01	0.06	0.004	*0.003*	0.07
FCSI-99-1	7/15/2003	2.0	6.17	24	16	*0.05*	*0.0001*	0.005	0.19	0.007	*0.02*	*0.01*
FCSI-99-1	7/28/2004	4.0	6.1									
Total number of samples	5	5	5	3	3	3	3	3	3	3	3	3
Number of high flow samples	4	4	4	3	3	3	3	3	3	3	3	3
AE-17	8/8/1990	0.0	6.87	79	32	*0.1*	*0.001*	0.01	0.67	*0.01*	0.12	0.04
AE-17	8/9/1993	0.0	6.81	75.8	72		*0.00257*	0.0234	1.61	0.00568	0.102	0.0366
AE-17	8/6/1999		7.3									
AE-17	7/7/2001	0.0										
AE-17	7/23/2002	0.1	6.41	94	35	*0.1*	0.001	0.013	0.87	*0.001*	0.08	0.11
AE-17	7/15/2003	5.0	6.65	68	29	0.11	0.0001	0.022	1.54	*0.003*	0.08	0.05
AE-17	7/27/2004	2.0	6.2									
Total number of samples	7	6	6	4	4	3	4	4	4	4	4	4
Number of high flow samples	4	4	3	2	2	2	2	2	2	2	2	2

Table A-4 (continued)
Water Quality and Flow at Fisher Creek Adit Discharge Monitoring Stations
New World Mining District Response and Restoration Project
Adit Discharge EECA

Station Name	Sample Date	Flow (gpm)	Field pH (su)	Hardness (mg/L CaCO3)	Sulfate (mg/l)	Concentration (Total Recoverable in Milligrams Per Liter)						
						Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
F-28	6/16/1994	26.9	7.24									
F-28	7/14/1995	18.0	6.88		163	*0.1*	0.0001	*0.003*	0.78	0.015	0.04	*0.021*
F-28	9/26/1995	13.5	6.7		376	*0.1*	*0.0001*	*0.003*	0.78	*0.002*	0.07	*0.007*
F-28	8/17/1996	15.0										
F-28	9/12/1996	9.4	6.23	477	351	*0.1*	*0.0001*	*0.001*	0.09	*0.003*	0.04	*0.02*
F-28	7/8/1997	29.2			270	0.206	*0.005*	*0.01*	2.23	*0.003*	0.152	*0.02*
F-28	8/10/1999	15.0										
F-28	7/11/2001	31.4	7.54	595	451	*0.1*	*0.0001*	0.004	0.35	*0.001*	0.073	0.01
F-28	6/30/2002	26.0	7.12	378	233	*0.1*	*0.0001*	0.002	0.18	*0.001*	0.029	0.01
F-28	7/23/2002	9.0	6.3	683	405	*0.1*	0.0009	0.002	0.21	0.001	0.054	0.01
F-28	10/8/2002	4.9	7.38	759	591	*0.1*	0.0003	*0.001*	0.19	*0.001*	0.004	0.03
F-28	7/1/2003	246.9	6.75	376	275	0.06	*0.0001*	0.002	0.26	*0.001*	0.047	*0.01*
F-28	8/14/2003	12.0	7.5	640	469	*0.05*	*0.0001*	0.002	0.38	*0.001*	0.08	*0.01*
F-28	9/30/2003	14.8	7.49	660	484	*0.05*	*0.0001*	0.012	0.23	*0.001*	0.085	*0.01*
F-28	7/29/2004	20.5	7.62	507	371	*0.05*	*0.0001*	0.005	0.2	0.001	0.065	0.05
F-28	9/16/2004	19.7	7.47	668	497	*0.05*	*0.0001*	0.003	0.13	*0.001*	0.082	0.05
F-28	8/15/2005	32.8	7.5	634	460	0.06	*0.0001*	0.002	0.64	0.002	0.18	0.05
F-28	9/22/2005	3.4	7.7	334	282	0.06	*0.0001*	*0.001*	*0.01*	*0.001*		*0.01*
F-28	6/28/2006	18.9	6.12	181	142	0.35	*0.0001*	0.01	2.64	0.005	0.25	0.03
F-28	8/28/2006	3.7	7.47									
F-28	9/26/2006	3.6	6.77	416	323	0.06	*0.0001*	*0.001*	0.62	0.001	0.13	0.04
Total number of samples	21	21	18	14	17	17	17	17	17	17	16	17
Number of high flow samples	9	9	8	6	8	8	8	8	8	8	8	8

gpm = gallons per minute
s.u. = standard units
mg/l CaCO3 = milligrams per liter as calcium carbonate
mg/l = milligrams per liter
Italices indicate analyte was below detection limit or flow rates that were estimated as equal to or less than the displayed value.

Table A-5
Water Quality and Flow at Miller Creek Adit Discharge Monitoring Stations
New World Mining District Response and Restoration Project
Adit Discharge EECA

Station Name	Sample Date	Flow (gpm)	Field pH (su)	Hardness (mg/L CaCO3)	Sulfate (mg/l)	Concentration (Total Recoverable in Milligrams Per Liter)						
						Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
M-1	8/31/1989	5.4	6.1	630	541	*0.1*	*0.001*	0.02	33.7	0.08	3.05	0.33
M-1	9/14/1989	179.5	5.85									
M-1	7/17/1990	12.1			291	*0.1*		*0.01*	1.11			0.03
M-1	7/25/1990	14.8		522	297							
M-1	8/8/1990	9.0	6.41	584	382	*0.1*	*0.001*	*0.01*	7.24	*0.01*	1.5	0.11
M-1	8/22/1990	16.2		562	368							
M-1	9/6/1990	7.2		573	390	*0.1*	*0.001*	*0.01*	6.68	*0.01*	1.57	0.11
M-1	7/11/1991		7.19	215	156	0.2	0.0009	*0.016*	2.1		1.02	0.26
M-1	9/26/1991	0.5	7.27	461	264	0.2	0.0005	0.033	4.13	0.039	0.54	0.06
M-1	7/22/1993		6.84	452	254	*0.1*	0.0003	0.035	1.13	0.02	0.9	0.08
M-1	9/24/1993	3.5										
M-1	6/16/1994	1.6	6.99									
M-1	8/15/1996	10.0										
M-1	8/20/1996	10.0	6.6									
M-1	9/14/1996	5.0	6.99									
M-1	10/12/1996		6.99									
M-1	7/6/2001	1.8	6.97	417	201	0.1	*0.0001*	0.013	1.05	0.047	0.18	*0.01*
M-1	7/16/2003	7.9	7.18	424	246	0.06	0.0001	0.008	0.58	0.015	0.42	0.01
M-1	7/21/2004	20.0										
M-1	9/23/2004	2.9	6.8	618	464	*0.05*	0.0004	0.002	4	0.001	2.53	0.14
Total number of samples	20	17	13	11	12	10	9	10	10	8	9	10
Number of high flow samples	8	6	5	5	6	5	4	5	5	3	4	5
M-25	9/1/1989	1.8	7.01									
M-25	8/9/1990	4.5	5.6	12	20	0.2	*0.001*	0.56	*0.03*	*0.01*	*0.02*	0.1
M-25	7/31/1997	25.0										
M-25	8/20/1997	25.0										
M-25	9/14/1997	15.0										
M-25	10/7/1997	12.0										
M-25	7/10/2003	2.0	4.51	8	18	0.59	0.0001	0.29	*0.05*	0.011	*0.02*	*0.01*
M-25	7/21/2004	5.0	5.9									
Total number of samples	8	8	4	2	2	2	2	2	2	2	2	2
Number of high flow samples	3	3	2	1	1	1	1	1	1	1	1	1

Table A-5 (continued)
Water Quality and Flow at Miller Creek Adit Discharge Monitoring Stations
New World Mining District Response and Restoration Project
Adit Discharge EECA

Station Name	Sample Date	Flow (gpm)	Field pH (su)	Hardness (mg/L CaCO3)	Sulfate (mg/l)	Concentration (Total Recoverable in Milligrams Per Liter)						
						Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
M-8	8/9/1993	2.0	7.22	127	25		*0.00257*	0.0234	1.32	0.0898	0.065	0.43
M-8	7/31/1996	2.5	7.67									
M-8	8/14/1996	10.0										
M-8	8/20/1996	0.5	8.22									
M-8	9/14/1996	0.1	8.01									
M-8	10/12/1996	0.7	7.81									
M-8	11/9/1996	0.5										
M-8	7/17/1997	2.1										
M-8	7/31/1997	5.9										
M-8	8/20/1997	2.9										
M-8	9/14/1997	2.9										
M-8	10/7/1997	0.4										
M-8	8/4/1999	10.0										
M-8	7/11/2001	0.1	7.49	142	43	*0.1*	0.002	0.015	0.55	0.066	0.023	0.42
M-8	7/16/2003	7.9	7.42	106	23	*0.05*	0.001	0.002	0.04	0.006	*0.02*	0.24
M-8	7/21/2004	10.0	7.2									
M-8	9/23/2004	8.1	7.0	147	27	*0.05*	0.0005	*0.001*	0.02	0.001	*0.003*	0.1
Total number of samples	17	17	9	4	4	3	4	4	4	4	4	4
Number of high flow samples	6	6	4	2	2	2	2	2	2	2	2	2
MCSI-96-3	8/9/1993	*1.0*										
MCSI-96-3	8/14/1996	0.5										
MCSI-96-3	8/4/1999	*1.0*										
MCSI-96-3	7/16/2003	2.0	7.57	61	12	*0.05*	0.0004	*0.001*	0.02	*0.003*	*0.02*	0.11
MCSI-96-3	7/21/2004	2.0	6.5									
Total number of samples	5	5	2	1	1	1	1	1	1	1	1	1
Number of high flow samples	2	2	2	1	1	1	1	1	1	1	1	1

gpm = gallons per minute
s.u. = standard units
mg/l CaCO3 = milligrams per liter as calcium carbonate
mg/l = milligrams per liter
Italices indicate analyte was below detection limit or flow rates that were estimated as equal to or less than the displayed value.

Table A-6
Water Quality and Flow From McLaren Pit Cap Sub-Grade Drains
New World Mining District Response and Restoration Project
Adit Discharge EECA

Station Name	Sample Date	Flow (gpm)	Field pH (su)	Hardness (mg/L CaCO3)	Sulfate (mg/l)	Concentration (Total Recoverable in Milligrams Per Liter)						
						Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc
DCSW-101	7/13/2004	19.5	2.6	125	628	29.3	0.01	15.8	117	0.012	3.08	1.7
DCSW-101	8/10/2004	15.8	2.28	125	560	26	0.0094	13.5	106	0.009	2.91	1.59
DCSW-101	10/6/2004	5.6	2.92	176	686	34.3	0.016	20.7	173	0.007	5.1	2.82
DCSW-101	6/29/2005	24.6	2.7	142	736	33.7	0.011	15.8	147	0.014	2.81	1.85
DCSW-101	9/27/2005	3.3	2.73	185	748	31.5	0.012	14.2	199	0.01	3.64	2.09
DCSW-101	6/27/2006	20.6	4.36	114	515	26.1	0.0082	13.5	105	0.012	2.74	1.50
DCSW-101	9/27/2006	2.2	2.93	175	797	29	0.01	13.2	178	0.005	3.41	1.87
DCSW-102	7/13/2004	10.5	2.4	186	862	33.5	0.017	19	142	0.002	4.62	2.69
DCSW-102	8/10/2004	5.8	2.39	155	641	23.2	0.011	13.8	90	0.001	3.47	1.95
DCSW-102	10/6/2004	0.3	2.54	275	1160	39.1	0.017	27.7	265	0.002	6.31	3.18
DCSW-102	6/29/2005	18.8	2.5	240	1030	42.2	0.029	19.6	187	0.005	6.22	4.29
DCSW-102	9/27/2005	0.0	2.55	234	791	24.8	0.016	15.9	146	0.009	4.69	2.33
DCSW-102	6/27/2006	14.8	4.17	192	771	32.500	0.015	19	135.000	0.00	4.76	2.66
DCSW-102	9/27/2006	0.4	2.69	220	876	24.200	0.012	14	116.000	0.00	4.04	1.97
DCSW-103	7/13/2004	2.4	2.3	723	2920	108	0.026	44.6	632	0.002	13.3	4.24
DCSW-103	8/10/2004	1.7	2.53	591	2220	88.1	0.026	34.8	363	0.002	12.5	4.29
DCSW-103	10/6/2004	0.8	2.52	745	2550	110	0.023	46.1	505	0.002	16.7	4.84
DCSW-103	6/29/2005	1.8	2.4	750	3050	122	0	47.3	678	0.004	14.2	5.25
DCSW-103	9/27/2005	0.3	2.42	642	1910	76.6	0	31	352	0.003	11.8	4.33
DCSW-103	6/27/2006	1.8	4.13	619	2210	81.100	0.024	36	434.000	0.00	13.10	4.44
DCSW-103	9/27/2006	0.9	2.62	688	1980	77.300	0.022	29	315.000	0.00	12.50	4.07

gpm = gallons per minute
s.u. = standard units
mg/l CaCO3 = milligrams per liter as calcium carbonate
mg/l = milligrams per liter

APPENDIX B

HUMAN HEALTH RISK EVALUATION CALCULATIONS

Adit Discharge Response Action EE/CA

New World Mining District Response and Restoration Project

Hazard Index Calculations for Adit Discharges

Adit Name	Flow (gpm)	Field ph (su)	Cadmium			Copper			Lead	
			Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose
D-18 -- McLaren Mine	11.5	6.2	0.0008	1.56556E-06	2.34834E-08	0.026	5.08806E-05	1.14481E-06	0.002	3.91389E-06
McLaren Pit Drains	21.7	2.6	0.014	2.73973E-05	4.10959E-07	17.7	0.034637965	0.000779354	0.007	1.36986E-05
F-8B --Glengarry Millsite Adit	7	3.4	0.0006	1.17417E-06	1.76125E-08	0.16	0.000313112	7.04501E-06	0.002	3.91389E-06
Lower Tredennic	2.6	6.6	0.0001	1.95695E-07	2.93542E-09	0.003	5.87084E-06	1.32094E-07	0.002	3.91389E-06
Sheep Mt. # 1	3.4	6.4	0.0004	7.82779E-07	1.17417E-08	0.017	3.32681E-05	7.48532E-07	0.009	1.76125E-05
AE-17 -- Henderson Mt. Dump # 7	1.2	6.7	0.0007	1.36986E-06	2.05479E-08	0.017	3.32681E-05	7.48532E-07	0.003	5.87084E-06
F-28 --Gold Dust Adit	3.63	6.8	0.00005	9.78474E-08	1.46771E-09	0.0005	9.78474E-07	2.20157E-08	0.001	1.95695E-06
M-1 --Little Daisy Adit	18.1	6.8	0.0004	7.82779E-07	1.17417E-08	0.013	2.54403E-05	5.72407E-07	0.026	5.08806E-05
M-25 -- Henderson Mountain	11.3	5.8	0.0003	5.87084E-07	8.80626E-09	0.43	0.000841487	1.89335E-05	0.008	1.56556E-05
M-8 -- Black Warrior Adit	3.9	7.6	0.0012	2.34834E-06	3.5225E-08	0.01	1.95695E-05	4.40313E-07	0.041	8.02348E-05
MCSI-96-3 Upper Miller Ck Dump	1.3	7	0.0004	7.82779E-07	1.17417E-08	0.0005 <	9.78474E-07	2.20157E-08	0.0015 <	2.93542E-06

Notes: Concentrations are total recoverable mean concentrations (milligrams per liter);
< indicates the mean value was less than detection for all samples; mean concentration is listed as half the detection limit)

	Value	***Variable***		
		Cw =	concentration in micrograms per liter	
(ingestion)	0.001	CF =	conversion factor	0.000001 (dermal)
	1	IR =	ingestion rate in liters/day	
	50	EF =	exposure frequency (days/year)	
	30	ED =	exposure duration (years)	
	70	BW =	body weight (kg)	
	10950	AT =	Average time for pathway-specific exposure period (days)	
	2500	SA =	surface area of skin (square centimeters)	
	6	ET =	exposure time (hours/day)	
		PC=	chemical specific dermal permeability constant	

Ingestion Formula: (Cw*CF*IR*EF*ED)/(BW*AT)
Dermal Formula: (Cw*SA*PC*CF*ET*EF*ED)/(BW*AT)
HQ Formula: Dose/Reference Dose
HI Formula: Sum of Ingestion and Dermal HQ

	PC Values	***Reference Dose (mg/kg/day)***
Cadmium	0.001	0.0005
Copper	0.0015	0.037
Lead	0.000004	0.00043
Manganese	0.0015	0.005
Zinc	0.000004	0.3

Recalculated Hazard Index

Adit Name	Flow (gpm)	Field ph (su)	Cadmium			Copper			Lead	
			Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose
McLaren Pit Drains	21.7	2.6	0.014	1.36986E-06	4.10959E-07	17.7	0.001731898	0.000779354	0.007	6.84932E-07

Notes: Assumptions for the following variables changed:

0.25	IR =	ingestion rate in liters/day
10	EF =	exposure frequency (days/year)

Hazard Index Calculations for

Adit Name	Lead	Manganese			Zinc			Hazard Quotient (Ingestion)		
	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Cadmium	Copper	Lead
D-18 -- McLaren Mine	2.34834E-10	0.85	0.001663405	3.74266E-05	0.04	7.82779E-05	4.69667E-09	3.13E-03	1.38E-03	9.10E-03
McLaren Pit Drains	8.21918E-10	4.5	0.008806262	0.000198141	2.3	0.004500978	2.70059E-07	5.48E-02	9.36E-01	3.19E-02
F-8B --Glengarry Millsite Adit	2.34834E-10	0.89	0.001741683	3.91879E-05	0.1	0.000195695	1.17417E-08	2.35E-03	8.46E-03	9.10E-03
Lower Tredennic	2.34834E-10	0.11	0.000215264	4.84344E-06	0.03	5.87084E-05	3.5225E-09	3.91E-04	1.59E-04	9.10E-03
Sheep Mt. # 1	1.05675E-09	0.03	5.87084E-05	1.32094E-06	0.04	7.82779E-05	4.69667E-09	1.57E-03	8.99E-04	4.10E-02
AE-17 -- Henderson Mt. Dump # 7	3.5225E-10	0.1	0.000195695	4.40313E-06	0.06	0.000117417	7.04501E-09	2.74E-03	8.99E-04	1.37E-02
F-28 --Gold Dust Adit	1.17417E-10	0.13	0.000254403	5.72407E-06	0.04	7.82779E-05	4.69667E-09	1.96E-04	2.64E-05	4.55E-03
M-1 --Little Daisy Adit	3.05284E-09	1.3	0.002544031	5.72407E-05	0.11	0.000215264	1.29159E-08	1.57E-03	6.88E-04	1.18E-01
M-25 -- Henderson Mountain	9.39335E-10	0.01 <	1.95695E-05	4.40313E-07	0.06	0.000117417	7.04501E-09	1.17E-03	2.27E-02	3.64E-02
M-8 -- Black Warrior Adit	4.81409E-09	0.03	5.87084E-05	1.32094E-06	0.3	0.000587084	3.5225E-08	4.70E-03	5.29E-04	1.87E-01
MCSI-96-3 Upper Miller Ck Dump	1.76125E-10	0.01 <	1.95695E-05	4.40313E-07	0.11	0.000215264	1.29159E-08	1.57E-03	2.64E-05	6.83E-03

Notes: Concentrations are total recoverable mean concentrations (milligrams per liter);
< indicates the mean value was less than detection for all samples; mean concentration is listed as half the detection limit)

	Value	***Variable***	
		Cw =	concentration in micrograms per liter
(ingestion)	0.001	CF =	conversion factor 0.000001 (dermal)
	1	IR =	ingestion rate in liters/day
	50	EF =	exposure frequency (days/year)
	30	ED =	exposure duration (years)
	70	BW =	body weight (kg)
	10950	AT =	Average time for pathway-specific exposure period (days)
	2500	SA =	surface area of skin (square centimeters)
	6	ET =	exposure time (hours/day)
		PC=	chemical specific dermal permeability constant

Ingestion Formula: (Cw*CF*IR*EF*ED)/(BW*AT)
Dermal Formula: (Cw*SA*PC*CF*ET*EF*ED)/(BW*AT)
HQ Formula: Dose/Reference Dose
HI Formula: Sum of Ingestion and Dermal HQ

	PC Values	***Reference Dose (mg/kg/day)***
Cadmium	0.001	0.0005
Copper	0.0015	0.037
Lead	0.000004	0.00043
Manganese	0.0015	0.005
Zinc	0.000004	0.3

Recalculated Hazard Index

Adit Name	Lead	Manganese			Zinc			Hazard Quotient (Ingestion)		
	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Concen-tration (mg/l)	Ingestion Dose	Dermal Dose	Cadmium	Copper	Lead
McLaren Pit Drains	8.21918E-10	4.5	0.000440313	0.000198141	2.3	0.000225049	2.70059E-07	2.74E-03	4.68E-02	1.59E-03

Notes: Assumptions for the following variables changed:
0.25 IR =
10 EF =

Hazard Index Calculations for										
Adit Name	Hazard Quotient (Ingestion)			Hazard Quotient (Dermal)						Hazard Index
	Manganese	Zinc	Sum	Cadmium	Copper	Lead	Manganese	Zinc	Sum	
D-18 -- McLaren Mine	3.33E-01	2.61E-04	0.3466	4.70E-05	3.09E-05	5.46E-07	7.49E-03	1.57E-08	0.00756	0.35411
McLaren Pit Drains	1.76E+00	1.50E-02	2.7991	8.22E-04	2.11E-02	1.91E-06	3.96E-02	9.00E-07	0.06152	2.86059
F-8B --Glengarry Millsite Adit	3.48E-01	6.52E-04	0.3689	3.52E-05	1.90E-04	5.46E-07	7.84E-03	3.91E-08	0.00806	0.37697
Lower Tredennic	4.31E-02	1.96E-04	0.0529	5.87E-06	3.57E-06	5.46E-07	9.69E-04	1.17E-08	0.00098	0.05388
Sheep Mt. # 1	1.17E-02	2.61E-04	0.0554	2.35E-05	2.02E-05	2.46E-06	2.64E-04	1.57E-08	0.00031	0.05574
AE-17 -- Henderson Mt. Dump # 7	3.91E-02	3.91E-04	0.0568	4.11E-05	2.02E-05	8.19E-07	8.81E-04	2.35E-08	0.00094	0.05777
F-28 --Gold Dust Adit	5.09E-02	2.61E-04	0.0559	2.94E-06	5.95E-07	2.73E-07	1.14E-03	1.57E-08	0.00115	0.05706
M-1 --Little Daisy Adit	5.09E-01	7.18E-04	0.6301	2.35E-05	1.55E-05	7.10E-06	1.14E-02	4.31E-08	0.01149	0.64160
M-25 -- Henderson Mountain	3.91E-03	3.91E-04	0.0646	1.76E-05	5.12E-04	2.18E-06	8.81E-05	2.35E-08	0.00062	0.06525
M-8 -- Black Warrior Adit	1.17E-02	1.96E-03	0.2055	7.05E-05	1.19E-05	1.12E-05	2.64E-04	1.17E-07	0.00036	0.20587
MCSI-96-3 Upper Miller Ck Dump	3.91E-03	7.18E-04	0.0131	2.35E-05	5.95E-07	4.10E-07	8.81E-05	4.31E-08	0.00011	0.01316

Notes: Concentrations are total recoverable mean concentrations (milligrams per liter);
< indicates the mean value was less than detection for all samples; mean concentration is listed as half the detection limit)

	Value	***Variable***		
		Cw =	concentration in micrograms per liter	
(ingestion)	0.001	CF =	conversion factor	0.000001 (dermal)
	1	IR =	ingestion rate in liters/day	
	50	EF =	exposure frequency (days/year)	
	30	ED =	exposure duration (years)	
	70	BW =	body weight (kg)	
	10950	AT =	Average time for pathway-specific exposure period (days)	
	2500	SA =	surface area of skin (square centimeters)	
	6	ET =	exposure time (hours/day)	
		PC=	chemical specific dermal permeability constant	

Ingestion Formula: (Cw*CF*IR*EF*ED)/(BW*AT)
Dermal Formula: (Cw*SA*PC*CF*ET*EF*ED)/(BW*AT)
HQ Formula: Dose/Reference Dose
HI Formula: Sum of Ingestion and Dermal HQ

	PC Values	***Reference Dose (mg/kg/day)***
Cadmium	0.001	0.0005
Copper	0.0015	0.037
Lead	0.000004	0.00043
Manganese	0.0015	0.005
Zinc	0.000004	0.3

Recalculated Hazard Index										
Adit Name	Hazard Quotient (Ingestion)			Hazard Quotient (Dermal)						Hazard Index
	Manganese	Zinc	Sum	Cadmium	Copper	Lead	Manganese	Zinc	Sum	
McLaren Pit Drains	8.81E-02	7.50E-04	1.40E-01	8.22E-04	2.11E-02	1.91E-06	3.96E-02	9.00E-07	6.15E-02	0.20147

Notes: Assumptions for the following variables changed:
0.25 IR =
10 EF =

APPENDIX C

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Adit Discharge Response Action EE/CA
New World Mining District Response and Restoration Project

Identification of Applicable or Relevant and Appropriate Requirements Adit Discharge Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
FEDERAL CONTAMINANT-SPECIFIC			
Safe Drinking Water Act National Primary Drinking Water Regulation	40 USC § 300 40 CFR Part 141	Establishes health-based standards (MCLs) for public water systems.	Relevant and Appropriate
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes welfare-based standards (secondary MCLs) for public water systems.	Relevant and Appropriate
Clean Water Act Water Quality Standards	33 USC. §§ 1251-1387 40 CFR Part 131 Quality Criteria for Water 1976, 1980, 1986	Ch. 26- Water Pollution Prevention & Control Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate
FEDERAL LOCATION-SPECIFIC			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR Part 6.310(b)	Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking.	Applicable
Archaeological and Historic Preservation Act	16 USC § 469; 40 CFR § 6.301(c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Historic Sites, Buildings and Antiquities Act	36 CFR § 62.6(d)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable
Protection of Wetlands Order	40 CFR Part 6	Avoid adverse impacts to wetlands.	Applicable
Migratory Bird Treaty Act	16 USC §§ 703 et seq.	Establishes a federal responsibility for the protection of international migratory bird resource.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Adit Discharge Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
FEDERAL LOCATION-SPECIFIC (continued)			
Fish and Wildlife Coordination Act	16 USC § 661 et seq.; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable
Floodplain Management Order	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain, to the extent possible.	Relevant and Appropriate
Bald Eagle Protection Act	16 USC §§ 668 et seq.	Establishes a federal responsibility for protection of bald and golden eagles. Requires consultation with the USFWS.	Applicable
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR Part 6.302(h); 50 CFR Part 402	Requires action to conserve endangered species within critical habitat upon which species depend. Includes consultation with Dept. of Interior.	Applicable
FEDERAL ACTION-SPECIFIC			
Clean Water Act National Pollutant Discharge Elimination System	33 USC §§ 1251-1387 40 CFR Parts 121, 122, 125	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate
Clean Air Act National Primary and Secondary Ambient Air Quality Standards	42 USC § 7409;40 CFR Part 50.12	Air quality levels that protect public health.	Applicable
Occupational Safety And Health Act Hazardous Waste Operations And Emergency Response	29 USC § 655 29 CFR 1910.120	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, materials handling activities, training & ER.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements
Adit Discharge Response Action

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE CONTAMINANT-SPECIFIC			
Montana Water Quality Act	75-5-101 et seq., MCA	Establishes Montana's laws to prevent, abate and control the pollution of state waters.	Applicable
Regulations Establishing Ambient Surface Water Quality Standard	ARM 17.30.601 et seq.	Provides the water use classification for various streams and imposes specific water quality standards per classification.	Applicable
	ARM 17.30.637	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 globules of grease or other floating materials; (c) produce odors, colors, or other conditions which create a nuisance or render undesirable tastes to fish or make fish in edible; (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.	Applicable
Montana Groundwater Pollution Control System Regulations	ARM 17.30.1006	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater is to be classified to actual quality of actual use, whichever places the groundwater in a higher class.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Adit Discharge Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE CONTAMINANT-SPECIFIC (continued)			
Clean Air Act Of Montana	75-2-101, MCA	Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	Applicacble
Air Quality Regulations	ARM 17.8.206	Establishes sampling, data collection, and analytical requirements to ensure compliance with ambient air quality standards.	Applicable
	ARM 17.8.222	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 17.8.220	No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter.	Applicable
	ARM 17.8.223	No person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standards: 1) 24-hr. avg. : 150 micrograms per cubic meter of air, with no more than one expected exceedance per year; 2) Annual avg.: 50 micrograms per cubic meter of air.	Applicable
Occupational Health Act of Montana	50-70-101, et. seq., MCA	The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety	Applicable
Occupational Air Contaminants Regulations	ARM 17.42.102	Establishes maximum threshold limit values for air contaminants believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.	Applicable
Occupational Noise Regulations	ARM 17.42.101	Addresses occupational noise levels and provides that no worker should be exposed to noise levels in excess of the	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Adit Discharge Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
		specified levels.	
STATE LOCATION-SPECIFIC			
Endangered Species	87-5-106, 107,111, MCA ARM 12.5.201	Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat.	Applicable
STATE ACTION SPECIFIC			
Montana Water Quality Act	75-5-605, MCA	Pursuant to this section, it is unlawful among other things, to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharge into any state waters without a permit or discharge waste into any state waters.	Applicable
MPDES Permit Requirements	ARM17.30.1342-1344	Sets forth the substantive requirements applicable to all MPDES and NPDES permits. Include the requirement to properly operate and maintain all facilities and systems of treatment and control.	Relevant and Appropriate
	ARM 17.30.1203 and 1344	Technology-based treatment for MPDES permits.	Relevant and Appropriate
Clean Air Act Of Montana	75-2-102, MCA	Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	Applicable
Air Quality Requirements	ARM 17.8.1401-1404	Sets forth emission standards for hazardous air pollutants	Applicable

Applicable or Relevant and Appropriate Requirements (ARARs)

Section 300.415(i) of the National Contingency Plan (NCP) and guidance issued by the EPA require that removal actions attain Applicable or Relevant and Appropriate Requirements (ARARs) under federal or state environmental laws or facility siting laws, to the extent practicable considering the urgency of the situation and the scope of the removal (EPA, 1993). In addition to ARARs, the lead Agency may identify other federal or state advisories, criteria, or guidance to be considered for a particular release. ARARs were identified in the Como Basin/Glengarry Adit/Fisher Creek Response Action EE/CA.

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 found at a site and would apply in the absence of a CERCLA cleanup. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting 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 is proceeding 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 that the standards are of general applicability and are legally enforceable. State of Montana ARARs set forth below have been identified in cooperation with, and with assistance from, the State of Montana Department of Environmental Quality.

APPENDIX D

DETAILED COST SPREADSHEETS

Adit Discharge Response Action EE/CA

New World Mining District Response and Restoration Project

Alternative EC-1 Cost Estimate
Two Plug System - Open Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

TASK	UNIT COST	UNITS	QUANTITY	COST
MOBILIZATION/DEMOBILIZATION				
Mobilization	$40,000	/ls	1	$40,000
Site clean-up, restoration	$10,000	/ls	1	$10,000
Demobilization	$10,000	/ls	1	$10,000
Subtotal				**$60,000.00**
EQUIPMENT				
Excavator	$700	/day	2	$1,400
Mucker	$250	/day	36	$9,000
Front-end loader	$250	/day	36	$9,000
Generator	$125	/day	36	$4,500
Compressor	$75	/day	36	$2,700
Water truck	$200	/day	36	$7,200
Ready-mix plant	$500	/day	10	$5,000
Concrete pump	$1,000	/day	10	$10,000
Grout plant	$400	/day	10	$4,000
Pick-up trucks	$100	/day	36	$3,600
Misc. plant (fan, pumps, drills etc.)	$100	/day	36	$3,600
Subtotal				**$60,000.00**
MATERIALS, SUPPLIES, and FUEL				
Fuel	$150	/day	36	$5,400
15 cm Schd. 40 pipe, fittings, and hangers	$66	/m	250	$16,404
Vent bag	$9.84	/m	100	$984
Form materials	$5,000	/ls	1	$5,000
Pre-mix	$196	/m^3	90	$17,656
Cement	$165	/tonne	18	$3,000
Bentonite based grout	$220	/tonne	18	$4,000
Miscellaneous	$10,000	/ls	1	$10,000
Subtotal				**$62,444.74**
LABOR				
5 man crew	$3,000	/day	38	$114,000
Subtotal				**$114,000.00**
SUBTOTAL				**$296,444.74**
Contingency (10%)				$29,644
TOTAL CONSTRUCTION ESTIMATE				**$326,089.22**
Engineering Evaluation and Design (5%)				$16,304
Construction Oversight (8%)				$26,087
TOTAL ESTIMATED COST				**$368,480.81**

Assumptions:

Mine is accessible.

Underground work: 36 days total (mining contractor)
- site/utilities set-up: 7 days
- excavate, support, and clean plug site: 7 days/plug
- forms: 3 days/plug
- place concrete and grout: 4 days/plug
- remove utilities: 1 day

Volume of plug = 4.88 x 3.05 x 3.05 = 45 m^3

Number of plugs: 2

Alternative EC-2 Cost Estimate
Easy Access - Collapsed Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

TASK	UNIT COST	UNITS	QUANTITY	COST
MOBILIZATION/DEMOBILIZATION				
Mobilization	$40,000	/ls	1	$40,000
Site clean-up, restoration	$10,000	/ls	1	$10,000
Demobilization	$10,000	/ls	1	$10,000
TOTAL				**$60,000.00**
EQUIPMENT				
Excavator	$700	/day	5	$3,500
Mucker	$250	/day	41	$10,250
Front-end loader	$250	/day	41	$10,250
Generator	$125	/day	41	$5,125
Compressor	$75	/day	41	$3,075
Water truck	$200	/day	41	$8,200
Ready-mix plant	$500	/day	10	$5,000
Concrete pump	$1,000	/day	10	$10,000
Grout plant	$400	/day	10	$4,000
Pick-up trucks	$100	/day	41	$4,100
Misc. plant (fan, pumps, drills etc.)	$100	/day	41	$4,100
TOTAL				**$67,600.00**
MATERIALS, SUPPLIES, and FUEL				
Fuel	$150	/day	41	$6,150
15 cm Schd. 40 pipe, fittings, and hangers	$66	/m	250	$16,404
Vent bag	$9.84	/m	100	$984
Ground Support	$1,000	/ls	1	$1,000
Form materials	$5,000	/ls	1	$5,000
Pre-mix	$196	/m^3	90	$17,656
Cement	$165	/tonne	18	$3,000
Bentonite based grout	$220	/tonne	18	$4,000
Miscellaneous	$12,000	/ls	1	$12,000
TOTAL				**$66,194.74**
LABOR				
5 man crew	$3,000	/day	41	$123,000
TOTAL				**$123,000.00**
SUBTOTAL				**$316,794.74**
Contingency (15%)				$47,519
TOTAL CONSTRUCTION ESTIMATE				**$364,313.95**
Engineering Evaluation and Design (10%)				$36,431
Construction Oversight (10%)				$36,431
TOTAL ESTIMATED COST				**$437,176.74**

Assumptions:
- Mine is not accessible.
- Contractor can dig an infiltration pond and divert mine water to it for disposal.
- A 1cyd mucker will fit in portal; if it does not, then a slusher can be substituted with the same pricing.
- Ground conditions will require minimal new support.
- Drift will be mucked out from the portal to 250 feet in from portal.
- Muck will be disposed of on-site or will be hauled off-site under a separate contract.
- U/G work: 41 days total (mining contractor)
  - site/utilities set-up: 7 days
  - reopen portal and drift: 5 days
  - excavate, support, and clean plug site: 7 days/plug
  - forms: 3 days/plug
  - place concrete and grout: 4 days/plug
  - remove utilities: 1 day
- Volume of plug = 4.88 x 3.05 x 3.05 = 45 m^3
- Number of plugs: 2

Alternative EC-2 Cost Estimate
Difficult Access - Collapsed Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

TASK	UNIT COST	UNITS	QUANTITY	COST
MOBILIZATION/DEMOBILIZATION				
Mobilization	$40,000	/ls	1	$40,000
Site clean-up, restoration	$10,000	/ls	1	$10,000
Demobilization	$10,000	/ls	1	$10,000
Subtotal				**$60,000.00**
EQUIPMENT				
Excavator	$700	/day	6	$4,200
Mucker	$250	/day	51	$12,750
Front-end loader	$250	/day	51	$12,750
Generator	$125	/day	51	$6,375
Compressor	$75	/day	51	$3,825
Water truck	$200	/day	51	$10,200
Ready-mix plant	$500	/day	10	$5,000
Concrete pump	$1,000	/day	10	$10,000
Grout plant	$400	/day	10	$4,000
Pick-up trucks	$100	/day	51	$5,100
Misc. plant (fan, pumps, drills etc.)	$100	/day	51	$5,100
Subtotal				**$79,300.00**
MATERIALS, SUPPLIES, and FUEL				
Fuel	$150	/day	51	$7,650
15 cm Schd. 40 pipe, fittings, and hangers	$66	/m	250	$16,404
Vent bag	$9.84	/m	130	$1,280
Ground Support	$3,000	/ls	1	$3,000
Form materials	$5,000	/ls	1	$5,000
Pre-mix	$196	/m^3	90	$17,656
Cement	$165	/tonne	18	$3,000
Bentonite based grout	$220	/tonne	18	$4,000
Miscellaneous	$12,000	/ls	1	$12,000
Subtotal				**$69,990.02**
LABOR				
5 man crew	$3,000	/day	51	$153,000
Subtotal				**$153,000.00**
SUBTOTAL				**$362,290.02**
Contingency (15%)				$54,344
TOTAL CONSTRUCTION ESTIMATE				**$416,633.52**
Engineering Evaluation and Design (10%)				$41,663
Construction Oversight (10%)				$41,663
TOTAL ESTIMATED COST				**$499,960.22**

Assumptions:

- Mine is not accessible.
- Contractor can dig an infiltration pond and divert mine water to it for disposal.
- A 1cyd mucker will fit in portal; if it does not, then a slusher can be substituted with the same pricing.
- Ground conditions will require extensive new support.
- Drift will be mucked out from the portal to significantly beyond 250 feet in from portal.
- Muck will be disposed of on-site or will be hauled off-site under a separate contract.
- U/G work: 51 days total (mining contractor)
  - site/utilities set-up: 7 days
  - reopen portal and drift: 15 days
  - excavate, support, and clean plug site: 7 days/plug
  - forms: 3 days/plug
  - place concrete and grout: 4 days/plug
  - remove utilities: 1 day
- Volume of plug = 4.88 x 3.05 x 3.05 = 45 m^3
- Number of plugs: 2

Alternative WT-1 Cost Estimate
Infiltration - Group 5 Discharges (3 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source		
Capital Costs							
Clear site	ls	$ 1,000	1	$ 1,000			
Grading	ls	$ 500	1	$ 500			
Adit Flow Collection System	ls	$ 2,500	1	$ 2,500			
influent piping	lf	$ 9.40	200	$ 1,880	02620 660 0040		
perforated piping	lf	$ 9.40	60	$ 564	02620 660 0030		
Drain gravel	cy	$ 64	10	$ 640	Local vendor estimate		
Geotextile	ls	$ 100	1	$ 100	023400 300 1550		
Backfill	ls	$ 500	1	$ 500			
Revegetation	ac	$ 2,000	0.5	$ 1,000			
TOTAL DIRECT CAPITAL COSTS						**$ 8,684**	
INDIRECT CAPITAL COSTS							
Testing and analysis (30% of direct)				$ 2,605			
Engineering and design (10% of direct)				$ 868			
Contingency (25% of direct)				$ 2,171			
Mobilization and Demobilization (15%)				$ 1,303			
TOTAL INDIRECT CAPITAL COSTS						**$ 6,947**	
TOTAL CAPITAL COSTS						**$ 15,631**	

POST REMOVAL SITE CONTROL COST

Discount: 4.00% for present worth analysis

Component	Unit	Unit Cost	Quantity	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS							
Replace System after 20 years	ls	$ 8,684	1			20	$ 4,000
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)							**$ 4,000**
					GRAND TOTAL		**$ 19,631**

Assumptions

Discharges would be collected and infiltrated in a sub-surface drain field. Assuming a discharge of 3 gpm and an infiltration rate of 1 inch/hr, an infiltration area of 290 sf would be required. Perforated pipe laterals would be installed every 10 feet, bedded in gravel, covered with a geotextile, and buried to a depth of 2 ft. Cost estimate sources are from; R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgement if blank

Alternative WT-2 Cost Estimate
Passive Chemical Adsorption/Ion Exchange - Black Warrior Adit
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source - R.S. Means unless noted
Capital Costs					
Clear site	ls	$1,000	1.5	$1,500	
Grading	ls	$500	1.5	$750	
Adit Flow Collection System	ls	$2,500	1.5	$3,750	
influent piping	lf	$9.40	200	$1,880	02620 660 0040
6 ft dia manhole, 6' deep	ls	$1,725	1	$1,725	02630 400 1160
55 gallon drums	ea	$125	3	$375	
Zeolite	cf	$30	21	$630	Vendor estimate
Plumb system	ls	$2,500	1	$2,500	

TOTAL DIRECT CAPITAL COSTS **$13,110**

INDIRECT CAPITAL COSTS

Treatment Testing (20% of direct)	$2,622
Engineering and design (10% of direct)	$1,311
Contingency (25% of direct)	$3,278
Mobilization and Demobilization (10%)	$ 1,311

TOTAL INDIRECT CAPITAL COSTS **$8,522**

TOTAL CAPITAL COSTS **$21,632**

POST REMOVAL SITE CONTROL COST

Discount: 4.00% for present worth analysis

Component	Unit	Unit Cost	Quantity	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS							
Annual zeolite replacement	ls	$2,000	1	1	$2,000	20	$27,181
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)							**$27,181**
						GRAND TOTAL	**$48,812**

Assumptions:

Flows would be collected and passed through 3 zeolite-filled drums, containing a total of 21 ft3 of zeolite, and plumbed in series. The system would be installed underground in a 6-ft diameter manhole to protect from freezing. The vendor estimated that 57 ft3 of zeolite (CABSORB®ZS500RW) would be adequate to treat 5-years flow from the Black Warrior adit. It has been assumed that 14 ft3 of zeolite (2 drums volume) would be replaced annually. Other evaluated sources would require less zeolite. Cost estimate sources are from Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-3 Cost Estimate
Solid Reactant Sulfate Reducing Bioreactor w/OLC - McLaren Unit (35 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source	
DIRECT CAPITAL COSTS						
Capital Costs						
SSBR Cell	ls	$342,345	1	$432,573	AMD Treat	
Geotextile	sy	$1.34	6,161	$8,256	023400 300 1550	
Soil Backfill	cy	$30	4,107	$123,210		
OLC	ls	$6,404	1.0	$6,407	AMD Treat	
Revegetation	ac	$2,000	1.3	$2,600		
TOTAL DIRECT CAPITAL COSTS					**$573,046**	
INDIRECT CAPITAL COSTS						
Treatment Testing (10% of direct)				$57,305		
Engineering and design (10% of direct)				$57,305		
Contingency (25% of direct)				$143,261		
Mobilization and Demobilization (10%)				$57,305		
TOTAL INDIRECT CAPITAL COSTS					**$315,175**	
TOTAL CAPITAL COSTS					**$888,221**	
POST REMOVAL SITE CONTROL COST						
Discount:	4.0%	for present worth analysis				
Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 5 years	ls	$573,046			20	$1,450,000
Residual disposal every 5 years	ls	$351,885			20	$900,000
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$2,350,000**
				GRAND TOTAL		**$3,238,221**

Assumptions:

A Solid Reactant Sulfate Reducing Bioreactor (SSBR) would be constructed to treat the combined flow (assumed to be 35 gpm) from the three McLaren Pit cap drains plus the McLaren Adit. The discharge from the SSBR would flow to an Open Limestone Channel (OLC). The SSBR was designed using AMD Treat software (see attachments). The SSBR cell was designed to have a water residence time in the organic matter of 5 days and includes a limestone layer with a 24 hr residence time to buffer the inflow. The cell would be covered with 2-feet of soil for frost protection. It is assumed that the SSBR would need to be replaced every 5 years due to plugging with metal precipitates and loss of permeability in the solid reactant. Replacement would include disposal of the organic material and limestone at a cost of $50/ton. Access would not be required during winter-weather months. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining, 2002); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-3 Cost Estimate
Liquid Reactant Sulfate Reducing Bioreactor w/OLC - McLaren Unit (35 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS					
Component	Unit	Unit Cost	Total Quantity	Total Cost	Source
Capital Costs					
Site clearing	ls	$2,136	1	$2,136	AMD Treat SSRB
Collection System	ls	$50,000	1	$50,000	
Influent piping	lf	$9.40	400	$3,760	02620 660 0040
Fittings, overflow	ls	$2,000	1	$2,000	
Reagent Storage/distgribution					
Shelter	ls	$10,000	1	$10,000	
Reagent Storage/distgribution	ls	$10,000	1	$10,000	
Propane Heat System	ls	$10,000	1	$10,000	
LSBR Cell					
Excavation	ls	$36,406	1	$36,406	AMD Treat SSRB
Liner	ls	$78,734	1	$78,734	AMD Treat SSRB
Limestone	ls	$54,845	1	$54,845	AMD Treat
Gravel	cy	$64	6,677	$427,328	AMD Treat
Gravel Spread	cy	$4.50	6,677	$30,047	02315 520 0800
Geotextile	sy	$1.34	6,161	$8,256	023400 300 1550
Soil Backfill	cy	$30	4,107	$123,210	
OLC	ls	$6,404	1.0	$6,404	AMD Treat
Revegetation	ac	$2,000	1.7	$3,400	
TOTAL DIRECT CAPITAL COSTS					**$856,525**
INDIRECT CAPITAL COSTS					
Treatment Testing (10% of direct)				$85,653	
Engineering and design (10% of direct)				$85,653	
Contingency (25% of direct)				$214,131	
Mobilization and Demobilization (10%)				$85,653	
TOTAL INDIRECT CAPITAL COSTS					**$471,089**
TOTAL CAPITAL COSTS					**$1,327,614**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 10 years	ls	$856,525			20	$1,000,000
Residual disposal every 10 years	ls	$671,650			20	$800,000
Reagents	ls	$15,500	1	$15,500	20	$210,650
Propane	ls	$100	12	$1,200	20	$16,308
Labor - 1 full time employee	ls	$75,000	1	$75,000	20	$1,019,274
Road Maintenance/Plowing	ls	$3,000	12	$36,000	20	$489,252
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$3,535,485**
					GRAND TOTAL	**$4,863,099**

Assumptions

A Liquid Reactant Sulfate Reducing Bioreactor (LSBR) would be constructed to treat the combined flows (assumed to be 35 gpm). of the 3 McLaren Drains and the McLaren Adit. The discharge from the LSBR would flow to an Open Limestone Channel (OLC). The LSBR cell would be covered with 2-feet of soil for frost protection. The LSBR cell dimensions are identical to the Solid Reactant SBR, which was designed using AMD Treat software. LSBR uses a mixture of methanol and corn sugar as a reactant, requiring a heated storage and distribution shelter. The LSBR uses gravel in place of the solid organic matter used in the SSBR. Flow residence time in the gravel would be greater than the five days assumed for the SSBR due to the higher porosity of the gravel over the organic substrate. This would increase the life of the system. The cell includes a limestone layer with a 24 hr residence time to buffer the inflow. It is assumed that the LSBR would need to be replaced every 10 years due to plugging with metal precipitates. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining, 2002); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-4 Cost Estimate
Solid Reactant Sulfate Reducing Bioreactor w/OLC - 8.5 gpm Design Flow
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source
Capital Costs					
SSBR Cell	ls	$112,101	1	$112,101	AMD Treat
Geotextile	sy	$1.34	1,525	$2,044	023400 300 1550
Soil Backfill	cy	$30	1,010	$30,300	
OLC	ls	$2,599	1	$2,599	AMD Treat
Revegetation	ac	$2,000	0.6	$1,200	
TOTAL DIRECT CAPITAL COSTS					**$112,049**
INDIRECT CAPITAL COSTS					
Treatment Testing (10% of direct)				$11,205	
Engineering and design (10% of direct)				$11,205	
Contingency (25% of direct)				$28,012	
Mobilization and Demobilization (10%)				$11,205	
TOTAL INDIRECT CAPITAL COSTS					**$61,627**
TOTAL CAPITAL COSTS					**$173,676**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 5 years	ls	$112,049			20	$285,000
Residual disposal every 5 years	ls	$76,661			20	$195,000
TOTAL						**$480,000**
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$480,000**
				GRAND TOTAL		**$653,676**

Assumptions:

A Solid Reactant Sulfate Reducing Bioreactor (SSBR) would be constructed to treat a flow of 8.5 gpm. The discharge from the SSBR would flow to an Open Limestone Channel (OLC). The SSBR was designed using AMD Treat software (see attachments). The cell was designed to have a water residence time in the organic matter of 5 days and includes a limestone layer with a 24 hr residence time to buffer the inflow. The cell would be covered with 2-feet of soil for frost protection. It is assumed that the SSBR would need to be replaced every 5 years due to plugging with metal precipitates and loss of permeability in the solid reactant. Access would not be required during winter-weather months. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-3 Cost Estimate
Solid Reactant Sulfate Reducing Bioreactor w/OLC - Glengarry Adit (4 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source
Capital Costs					
SRSRB Cell	ls	$59,586	1.5	$89,379	AMD Treat
Geotextile	sy	$1.34	850	$1,139	023400 300 1550
Soil Backfill	cy	$30	560	$16,800	
OLC	ls	$4,074	1.0	$4,074	AMD Treat
Revegetation	ac	$2,000	0.5	$1,000	
TOTAL DIRECT CAPITAL COSTS					**$112,392**
INDIRECT CAPITAL COSTS					
Treatment Testing (15% of direct)				$16,859	
Engineering and design (10% of direct)				$11,239	
Contingency (25% of direct)				$28,098	
Mobilization and Demobilization (10%)				$11,239	
TOTAL INDIRECT CAPITAL COSTS					**$67,435**
TOTAL CAPITAL COSTS					**$179,827**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 5 years	ls	$112,392			20	$210,000
Residual disposal every 5 years	ls	$40,800			20	$175,000
TOTAL						**$385,000**
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$385,000**
				GRAND TOTAL		**$564,827**

Assumptions

A Solid Reactant Sulfate Reducing Bioreactor (SSRB) would be constructed to treat Glengarry adit flow of 4 gpm. The discharge from the SSRB would flow to an Open Limestone Channel (OLC). The SSRB was designed using AMD Treat software (see attachments). The cell was designed to have a water residence time in the organic matter of 5 days and includes a limestone layer with a 24-hr residence time to buffer the inflow. The cell would be covered with 2-feet of soil for frost protection. It is assumed that the SSRB would need to be replaced every 5 years due to plugging with metal predipitates and loss of permeability in the solid reactant. Access would not be required during winter-weather months. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining, 2002); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgement if blank.

Alternative WT-4 Cost Estimate
Solid Reactant Sulfate Reducing Bioreactor w/OLC - 1.4 gpm Design Flow
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source	
Capital Costs						
SSBR cell	ls	$20,555	1	$20,555	AMD Treat	
Geotextile	sy	$1.34	335	$449	023400 300 1550	
Soil Backfill	cy	$30	225	$6,750		
OLC	ls	$2,731	1	$2,731	AMD Treat	
Revegetation	ac	$2,000	0.6	$1,200		
TOTAL DIRECT CAPITAL COSTS					**$31,685**	
INDIRECT CAPITAL COSTS						
Treatment Testing (10% of direct)				$3,168		
Engineering and design (10% of direct)				$3,168		
Contingency (25% of direct)				$7,921		
Mobilization and Demobilization (10%)				$3,168		
TOTAL INDIRECT CAPITAL COSTS					**$14,258**	
TOTAL CAPITAL COSTS					**$45,943**	

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 10 years	ls	$31,685			20	$36,000
Residual disposal every 10 years	ls	$14,025			20	$16,000
TOTAL						**$52,000**
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$52,000**
				GRAND TOTAL		**$97,943**

Assumptions:

A Solid Reactant Sulfate Reducing Bioreactor (SSBR) would be constructed to treat a flow of 1.4 gpm. The discharge from the SSBR would flow to an Open Limestone Channel (OLC). The SSBR was designed using AMD Treat software (see attachments). The cell was designed to have a water residence time in the organic matter of 5 days and includes a limestone layer with a 24 hr residence time to buffer the inflow. The cell would be covered with 2-feet of soil for frost protection. It is assumed that the SSBR would need to be replaced every 10 years due to plugging with metal precipitates and loss of permeability in the solid reactant. Access would not be required during winter-weather months. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-5 Cost Estimate
Manganese Removal Cell - Lower Tredennic Dump (1.8 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source
Capital Costs					
MRC cell	ls	$6,877	1	$6,877	AMD Treat
Piping	ls	$2,000	1	$2,000	
Geotextile	sy	$1.34	91	$122	023400 300 1550
Soil Backfill	cy	$30	65	$1,950	
Revegetation	ac	$2,000	0.4	$800	
TOTAL DIRECT CAPITAL COSTS					**$11,749**
INDIRECT CAPITAL COSTS					
Treatment Testing (10% of direct)				$1,175	
Engineering and design (10% of direct)				$1,175	
Contingency (25% of direct)				$2,937	
Mobilization and Demobilization (10%)				$1,175	
TOTAL INDIRECT CAPITAL COSTS					**$5,287**
TOTAL CAPITAL COSTS					**$17,036**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 10 years	ls	$11,749			20	$ 13,500
Residual disposal every 10 years	ls	$3,300			20	$3,750
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$ 17,250**
				GRAND TOTAL		**$34,286**

Assumptions:

A Manganese Removal Cell (MRC) would be constructed to treat a 1.8 gpm flow. The MRC was designed using AMD Treat software (see attachments). The cell was designed to have a water residence time in crushed limestone of 1 day. The cell would be covered with 2-feet of soil for frost protection. O+M would be minimal and has been neglected. It is assumed that the MRC would need to be replaced every 10 years due to plugging with metal precipitates or coating of the limestone. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining, 2002); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-5 Cost Estimate
Manganese Removal Cell - Gold Dust Adit (13 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source
Capital Costs					
MRC Cell	ls	$35,882	1	$35,882	AMD Treat
Piping	ls	$4,000	1	$4,000	
Geotextile	sy	$1.34	475	$637	023400 300 1550
Soil Backfill	cy	$30	320	$9,600	
Revegetation	ac	$2,000	0.4	$800	
TOTAL DIRECT CAPITAL COSTS					**$50,919**

INDIRECT CAPITAL COSTS

Component	Total Cost	Total
Treatment Testing (10% of direct)	$5,092	
Engineering and design (10% of direct)	$5,092	
Contingency (25% of direct)	$12,730	
Mobilization and Demobilization (10%)	$5,092	
TOTAL INDIRECT CAPITAL COSTS		**$22,913**
TOTAL CAPITAL COSTS		**$73,832**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS						
Replace system every 10 years	ls	$50,919			20	$ 58,000
Residual disposal every 10 years	ls	$25,050			20	$28,500
TOTAL						**$86,500**
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)						**$86,500**
				GRAND TOTAL		**$160,332**

Assumptions:

A Manganese Removal Cell (MRC) would be constructed to treat a 13 gpm flow. The MRB was designed using AMD Treat software (see attachments). The cell was designed to have a water residence time in crushed limestone of 1 day. The cell would be covered with 2-feet of soil for frost protection. O+M would be minimal and has been neglected. It is assumed that the MRC would need to be replaced every 10 years due to plugging with metal precipitates or coating of the limestone. Cost estimate sources are from AMD Treat 3.2 software (Office of Surface Mining, 2002); R.S. Means Heavy Construction Cost Data, 2005 where reference numbers are provided or professional judgment if blank.

Alternative WT-6 Cost Estimate
Active Treatment - Glengarry Millsite Adit (5-25 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Quantity	Total Cost	Source
Capital Costs					
Water Collection System	ls	$ 10,000	1	$ 10,000	
Trenching	cy	$ 9.52	100	$ 952	02315 610 0062
Influent piping	lf	$ 3.43	500	$ 1,715	02620 520 1000
Packaged Treatment System	ls	$ 300,000	1	$ 300,000	
Reagent Storage/distribution	ls	$ 10,000	1	$ 10,000	
Sludge Storage	ls	$ 5,000	1	$ 5,000	
Diesel Generator 50kW	ls	$ 25,000	1	$ 25,000	16230 450 2100
Propane Heat System	ls	$ 25,000	1	$ 25,000	Unifield
Shelter/Site Improvements	ls	$ 100,000	1	$ 100,000	2000 sf @ $50/sf

TOTAL DIRECT CAPITAL COSTS **$ 477,667**

INDIRECT CAPITAL COSTS

Testing (20% of direct)	$ 95,533
Engineering and design (10% of direct)	$ 47,767
Contingency (25% of direct)	$ 119,417
Mobilization and Demobilization (10%)	$ 47,767

TOTAL INDIRECT CAPITAL COSTS **$ 310,484**

TOTAL CAPITAL COSTS **$ 788,151**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Quantity	Each/yr	$/year	Years	Present Worth, 4%	
DIRECT OPERATION AND MAINTENANCE COSTS								
Reagents	ls	$ 10	1	12	$ 120	20	$ 1,631	$0.06/1000 gal
Sludge Disposal	ls	$ 13	1	12	$ 150	20	$ 2,039	3 tons per year
Filter Replacement	ls	$ 100	1	12	$ 1,200	20	$ 16,308	
Generator Fuel	ls	$ 1,500	1	12	$ 18,000	20	$ 244,626	1 gal/hr @$2/gal
Propane	ls	$ 300	1	12	$ 3,600	20	$ 48,925	
Labor	ls	$ 75,000	1	1	$ 75,000	20	$ 1,019,274	1 full-time employee
Road Maintenance/Plowing	ls	$ 6,500	1	12	$ 78,000	20	$ 1,060,045	
TOTAL							**$ 2,392,849**	

OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS) **$ 2,392,849**

GRAND TOTAL **$ 3,180,999**

Assumptions:

- One (1) Equalization tank
- Two (2) forwarding pump skid
- Two (2) two stage reaction tank system
- One (1) Microfiltration skid
- Two (2) sludge pump skid
- One (1) sludge storage tank
- One (1) 100 % duty filter press
- One (1) filtered storage tank

Glengarry Millsite adit with a flow of 4 gpm would be treated using a packaged treatment system from U.S.Filter. The system would neutralize/precipitate the flow with sodium hydroxide and filter the precipitate. Reagent costs and sludge disposal assume average flows and water quality. Sodium hydroxide costs of $0.20 per lb of 50% NaOH and 90% mixing efficiency.

Alternative WT-6 Cost Estimate
Active Treatment - McLaren Pit Subsurface Drains (25-50 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Quantity	Total Cost	Source	
Capital Costs						
Water Collection System	ls	$20,000	1	$20,000		
Trenching	cy	$4.76	100	$476	02315 610 0062	
Influent piping	lf	$3.43	500	$1,715	02620 520 1000	
Packaged Treatment System	ls	$375,000	1	$375,000	US Filter	
Reagent Storage/distribution	ls	$25,000	1	$25,000		
Sludge Storage	ls	$10,000	1	$10,000		
Diesel Generator 50kW	ls	$25,000	1	$25,000	16230 450 2100	
Propane Heat System	ls	$25,000	1	$25,000	Unifield	
Shelter/Site Improvements	ls	$100,000	1	$100,000	2000 sf @ $50/sf	
TOTAL DIRECT CAPITAL COSTS						**$582,191**
INDIRECT CAPITAL COSTS						
Testing (10% of direct)				$58,219		
Engineering and design (10% of direct)				$58,219		
Contingency (25% of direct)				$145,548		
Mobilization and Demobilization (10%)				$ 58,219		
TOTAL INDIRECT CAPITAL COSTS						**$320,205**
TOTAL CAPITAL COSTS						**$902,396**

POST REMOVAL SITE CONTROL COST

Discount: 4.0% for present worth analysis

Component	Unit	Unit Cost	Quantity	Each/yr	$/year	Years	Present Worth, 4%	
DIRECT OPERATION AND MAINTENANCE COSTS								
Reagents	ls	$1,410	1	12	$16,920	20	$229,948	$1.19/1000 gal
Sludge Disposal	ls	$1,000	1	12	$12,000	20	$163,084	10 tons/mo@$50/ton
Filter Replacement	ls	$1,000	1	12	$12,000	20	$163,084	
Generator Fuel	ls	$1,500	1	12	$18,000	20	$244,626	1 gal/hr @$2/gal
Propane	ls	$300	1	12	$3,600	20	$48,925	
Labor	ls	$75,000	2	1	$150,000	20	$2,038,549	2 full-time employees
Road Maintenance/Plowing	ls	$6,500	1	12	$78,000	20	$1,060,045	
TOTAL							**$3,948,262**	
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)							**$3,948,262**	
				GRAND TOTAL			**$4,850,658**	

Assumptions

Packaged system from U.S. Filter 25-50 gpm - $350-375 K

- One (1) Equalization tank
- Two (2) forwarding pump skid
- Two (2) two stage reaction tank system
- One (1) Microfiltration skid
- Two (2) sludge pump skid
- One (1) sludge storage tank
- One (1) 100 % duty filter press
- One (1) filtered storage tank

McLaren Pit cap drains with a flow of 27 gpm would be treated using a packaged treatment system from U.S. filter. The system would neutralize/precipitate the flow with sodium hydroxide and filter the precipitate. Reagent costs and sludge disposal assume average flows and water quality. Sodium hydroxide costs of $0.20 per lb of 50% NaOH and 90% mixing efficiency. Sludge disposal costs assumed $50/ton.

Alternative WT-7 Cost Estimate
Ion Exchange - Group 5 Discharges (1.4-2.5 gpm Design Flow)
New World Mining District Response and Restoration Project
Adit Discharge EE/CA

DIRECT CAPITAL COSTS

Component	Unit	Unit Cost	Total Quantity	Total Cost	Source - R.S. Means unless noted
Capital Costs					
Clear site	ls	$1,000	1	$1,000	
Grading	ls	$500	1	$500	
Adit Flow Collection System	ls	$2,500	1	$2,500	
influent piping	lf	$9.40	200	$1,880	02620 660 0040
6 ft dia manhole, 6' deep	ls	$1,725	1	$1,725	02630 400 1160
Ion exchange system	ea	$5,000	1	$5,000	
Plumb system	ls	$2,500	1	$2,500	
TOTAL DIRECT CAPITAL COSTS					**$15,105**

INDIRECT CAPITAL COSTS

Treatment Testing (10% of direct)	$1,511	
Engineering and design (10% of direct)	$1,511	
Contingency (25% of direct)	$3,776	
Mobilization and Demobilization (10%)	$ 1,511	
TOTAL INDIRECT CAPITAL COSTS		**$8,308**
TOTAL CAPITAL COSTS		**$23,413**

POST REMOVAL SITE CONTROL COST

Discount: 4.00% for present worth analysis

Component	Unit	Unit Cost	Quantity	Each/yr	$/year	Years	Present Worth, 4%
DIRECT OPERATION AND MAINTENANCE COSTS							
Annual system replacement	ls	$2,000	1	1	$2,000	20	$27,181
OPERATION AND MAINTENANCE PRESENT WORTH (20 YEARS)							**$27,181**
						GRAND TOTAL	**$50,593**

Assumptions:

Flows would be collected and passed through a packaged ion exchange (IX) system that includes prefiltration. The system would be installed underground in a manhole to protect from freezing. It has been assumed that the IX system would be replaced annually.