Draft

McLAREN PIT RESPONSE ACTION ENGINEERING EVALUATION/COST ANALYSIS NEW WORLD MINING DISTRICT RESPONSE AND RESTORATION PROJECT

Prepared For:

USDA Forest Service
Northern Region
Missoula, Montana

Prepared By:

Maxim Technologies, Inc.
851 Bridger Drive
P.O. Box 1413
Bozeman, Montana 59715

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EXECUTIVE SUMMARY

Maxim Technologies, Inc. (Maxim) prepared this McLaren Pit Response Action Engineering Evaluation/Cost Analysis (EE/CA) for the United States Department of Agriculture Forest Service (USDA-FS). This report presents an engineering evaluation and cost analysis of response alternatives for response and restoration work proposed for the McLaren Pit and mine waste sources in the headwaters of Daisy Creek. The McLaren Pit is located in the New World Mining District (District), which is located in Park County, north of Cooke City, Montana. The primary environmental issues at the pit and headwaters of Daisy Creek are associated with impacts from historic mining and more recent mineral exploration activities. Human health and environmental issues are related to elevated levels of base-metal contaminants present in mine waste piles, open pits, acidic water discharging from mine openings, and transported and contaminated sediments.

The District is located at an elevation that ranges from 2,400 meters (7,900 feet) to over 3,200 meters (10,400 feet) above sea level and is snow-covered for much of the year. The District covers an area of about 100 square kilometers (40 square miles) with historic mining disturbances affecting about 20 hectares (50 acres). The topography of the District is mountainous, with the dominant topographic features created by glacial erosion. The headwaters of Daisy Creek are located at or near tree line.

This EE/CA was developed using the "non-time-critical removal" process that is 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. The USDA-FS has identified the McLaren Pit Response Action to address the immediate threat to human health and the environment posed by open–pit mine workings and associated mine waste used to backfill the pit. Outlying waste rock located near the portal of a mine adit at the northwest end of the McLaren Pit and wastes dozed over the hillside to the west of the pit are also identified for targets for this response action.

Response activities at the McLaren Pit represent the second response action proposed during this multi-year project. The McLaren Pit is the highest ranked mine waste source area in the District and accounts for the majority of the waste located on District Property. Two other nearby sources, the McLaren Pit Spoils and the McLaren Multicolored Dump, are ranked number 9 and number 17, respectively, in the priority listing of mine waste sites (Maxim, 2001). These three waste rock source areas (Table ES-1) account for 154,911 cubic meters (202,616 cubic yards) or about 67% of the District's total waste rock on public lands.

Existing surface water, groundwater, and in-stream sediment data were reviewed and summarized to plan response activities and evaluate risks to human health and the aquatic environment. In addition, material samples collected from numerous waste rock dumps and pit backfill materials in the vicinity of the McLaren Pit were analyzed for heavy metals and acid-base characteristics. Heavy metals associated with these waste rock sources can affect human health through inhalation or ingestion. Metals may also be toxic to plant growth, preventing reestablishment of plant cover on the waste rock. Sediment containing heavy metals can erode from the waste rock, impacting surrounding land, and potentially enter surface water drainages. Water percolating through the waste rock can carry heavy metals into groundwater, which, in some areas, discharges to surface water. Percolation of water through waste rock lowers the pH, which promotes the solubility of most metals.

TABLE ES-1
Mine Dumps and Source Areas Included in McLaren Pit Response Action
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Waste Dump Name And Designation	Area hectares (acres)	Volume cubic meters (cubic yards)
McLaren Pit Waste Rock (DCSI-96-2)	3.35 (8.3)	136,495 (178,529)
McLaren Multicolor Dump (DCSI-96-1)	0.24 (0.6)	2,360 (3,087)
McLaren Spoils (mine wastes below the county road)	1.21 (2.98)	16,056 (21,000)
TOTALS	**4.8 (11.9)**	**154,911 (202,616)**

A comparison of waste rock, water, and in-stream sediment data with background concentrations and regulatory standards indicates seven metals are contaminants of concern at this site: arsenic, aluminum, cadmium, copper, iron, lead, and zinc. A human health risk evaluation based on *Risk-Based Cleanup Guidelines for Abandoned Mine Sites* (Tetra Tech, 1996) found that average arsenic concentrations in the selected waste rock dumps exceed human health guidelines based on a recreational use scenario. A comparison of metals levels to literature guidelines and state aquatic water quality standards indicates that aluminum, copper, iron, and zinc pose risk to organisms in the aquatic environment. In addition, arsenic, cadmium, and copper occur at phytotoxic levels in the McLaren waste dumps and mine backfill material.

The objectives of the McLaren Pit Response Action are:

- Minimize phytotoxicity resulting from high concentrations of copper and low pH in mine wastes present in the McLaren Pit area

- Prevent soluble metal contaminants or metals contaminated solid materials in the wastes from migrating into adjacent surface water courses, to the extent practicable.

- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or metals contamination to adjacent surface water and groundwater, to the extent practicable.

- Prevent potential exposure through the food chain to metal contaminants from acid discharges, waste rock and mineralized bedrock to the extent practicable.

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

- Identify in a preliminary fashion the applicable or relevant and appropriate requirements (ARARs) for response actions and evaluate how each alternative complies with ARARs.

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

Cleanup goals were identified for metals posing risk at the site. Groundwater and surface water goals are the State of Montana water quality standards. Solid media goals are based on in-stream sediment and soil guidelines found in the literature.

After screening a variety of response technologies and process options, several alternatives were developed for detailed analysis. The alternatives were evaluated for effectiveness, implementability, and cost, and are listed in Table ES-2. In general, waste consolidation, surface water diversion, run-on control, erosion control, and revegetation were included as elements in all the alternatives except for No Action.

The alternatives evaluated present a range of effectiveness. The overall effectiveness of the No Action alternative is poor. Under existing conditions, metals will continue to migrate from the waste dumps at the headwaters of Daisy Creek into surface water and groundwater. While slopes are stable in the McLaren Pit as a result of Crown Butte Mines, Inc.'s (CBMI) reclamation, the unvegetated McLaren Spoils and Multicolor Dump will continue to erode unabated into Daisy Creek tributaries. The McLaren Mine adit discharge will continue to flow through the Multicolor Dump, leaching additional metals into surface water. The declining vegetation condition and cover in the McLaren Pit will likely continue to decline over time as acid conditions in the regraded and amended surface soil worsen, causing a reduction in vegetation cover and vigor.

In terms of reducing contaminant seepage and migration from the McLaren Pit, Alternative 3C is the most effective of the alternatives evaluated. This is because all of the wastes are below a geomembrane liner, protected from infiltrating waters. A soil cap placed over the waste promotes vegetation growth in this alternative. Alternatives 3B and 3D are as effective or only somewhat less effective than Alternative 3C, as most of the wastes are protected under the liner, and the remainder of the waste is completely neutralized, amended, and capped. Alternative 3A is much less effective because the soil cap, although providing for vegetation reestablishment, does not decrease either the rate of infiltration nor substantially diminish the risk for contaminant migration out of the waste rock.

The overall effectiveness of Alternative 2C, a totally amended waste rock cover, may be as effective as 3B in controlling contaminant migration out of the McLaren wastes. This is true, not because it eliminates seepage, but rather because the seepage should be near neutrality and will not contain significant metals concentrations. Alternatives 2B and 2A are progressively less effective because smaller volumes of waste material are amended, the seepage rate remains about the same as existing conditions, and non-amended wastes will likely still release contaminants to the environment. From this point of view, with the exception of the benefits of a soil cover, Alternative 3A will probably be little more effective than Alternative 2A.

Alternative 4, removal of 80% of the wastes to the SB-4B repository, is effective from the point of view that the source material in the McLaren area is removed and placed in a proper storage facility. The remaining effectiveness is dependant on Alternatives 2 or 3, which are required to close the remaining wastes in place as a cap over the underlying bedrock deposit.

The greatest risk to human health is exposure to dust and direct contact with wastes that result from recreational uses of the lands underlain by waste rock. Alternatives 3A, 3C, and 3D call for a soil cap on the waste rock, which clearly offers the greatest reduction of risk to human health of all the alternatives evaluated by providing a barrier layer to direct contact with the wastes. The remaining alternatives, except for No Action, include a vegetated surface on the waste rock areas, which reduces the potential for further erosion and migration of contaminants from source areas by stabilizing the

TABLE ES-2
Response Action Alternatives
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Alternative	Response Technology/Process Options
1. No Action	None
2A. In-Situ Treatment of Select Waste with Shallow Amendment	Consolidation of local wastes onto the McLaren Pit, regrading and compaction of waste in-situ, amendment of the upper 30 cm of the regraded surface with lime, addition of nutrients, and revegetation on a waste rock surface.
2B. In-Situ Treatment of Select Waste with Deep Amendment	Consolidation of local wastes onto the McLaren Pit, regrading and compaction of waste in-situ, amendment of consolidated wastes and the upper 0.5 to 1.0 m of the regraded surface, addition of nutrients, and revegetation on a waste rock surface.
2C. In Situ Treatment of All Wastes	Excavation of all unconsolidated waste rock, lime amendment of all waste rock, placing waste back into the pit, compaction, regrading, addition of nutrients, and revegetation on a waste rock surface.
3A. In-Situ Treatment with Soil Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, shallow amendment of waste rock (upper 30 cm), constructing a soil cover or cap, addition of nutrients and revegetation.
3B. In-Situ Treatment with Geomembrane Cover and Amended Waste Rock Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, constructing a geomembrane cover with a drain layer and an amended waste rock cap, addition of nutrients, and revegetation on a waste rock surface.
3C. In-Situ Treatment with Geomembrane Cover and Soil Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, constructing a geomembrane cover with a drain layer and soil cap, addition of nutrients, and revegetation.
3D. In-Situ Treatment with Geomembrane Cover, Composite Waste Rock and Soil Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, constructing a geomembrane cover with a drain layer and a composite amended waste rock and soil cap, addition of nutrients, and revegetation on a soil surface.
4. Disposal of McLaren Waste Rock in On-Site Repository	Partial removal (80%) of waste rock to the SB-4B repository; closure of the removed wastes with a composite cover, a bottom liner, and a leachate collection system; closure of the pit and remaining waste with Alternative 2 or 3.

wastes. All of the alternatives (except No Action) will reduce human health risks by consolidating the wastes in the McLaren Pit and reducing the surface area of the wastes by 30%.

The greatest risk to the environment comes from degraded surface and groundwater quality and its impact to aquatic life. A 30% reduction in the surface area of waste exposed through consolidation of the outlying wastes in the pit will lessen exposure of the environment to contaminated media. However, none of the alternatives will result in a significant improvement of surface or groundwater quality in the Daisy Creek or Stillwater drainages. None of the alternative actions proposed will achieve compliance with surface water standards. The HELP and load modeling studies suggest that the unconsolidated McLaren Pit wastes only contribute 10-20% of the total load to Daisy Creek. Even a reduction of the full 20% will not bring surface water in Daisy Creek into compliance with established surface water standards.

Failure to meet Montana surface and groundwater standards results principally because waste rock is not the only source of contaminants in the headwaters of Daisy Creek. It has been demonstrated that naturally occurring sulfide minerals in bedrock are a major source of metals and acid rock drainage. There are other sources as well, such as groundwater migration and transported sediment. Cleaning up or preventing seepage from wastes at the headwaters of Daisy Creek does not address the larger sources in the Daisy Creek drainage.

None of the alternatives reduce the volume of the contaminants but all the alternatives, except No Action, reduce the mobility of contaminants to some degree. Alternatives 2A, 2B, 2C, 3A, 3B, and 3D rely on treatment of wastes with a neutralizing amendment in varying degrees to reduce mobility. Alternatives 3A, 3C, and 3D also use a cover soil to reduce mobility. Alternatives 3B, 3C, and 3D use a geomembrane liner as a part of a composite cover system to reduce mobility. The greatest reduction in mobility through treatment is achieved by Alternative 2C. Reduction in plant toxicity through treatment or soil placement is achieved by all the alternatives, except for No Action.

All the alternatives are implementable, and technically and administratively feasible. Essential project components such as equipment, materials, and construction expertise, although distant from the site, are available. However, there is the potential for incomplete mixing of neutralizing amendments for those alternatives where mixing is required for the alternative to be effective, especially Alternative 2C. Costs of the various alternatives are summarized in Table ES-3.

None of the alternatives considered in this evaluation will meet Montana's B1 standards for surface water quality in Daisy Creek. However, all the alternatives evaluated provide some measure of mitigation to man-caused mining impacts. Alternative 2A, which involves simple consolidation of outlying wastes, amendment of the upper 30 cm of waste rock on the McLaren site, and revegetation, will do much to reduce the impact of erosion of sediments into Daisy Creek and would reduce the total area of waste rock exposed on the McLaren site.

Given what is known about the source of metals impacts in Daisy Creek, the fact that natural sources contribute a considerable metals load to the creek via groundwater and surface water pathways, and the difficult environmental conditions, eliminating metals impacts from mining related activities will not allow achievement of water quality standards. However, short of water treatment, Alternatives 3B, 3C, and 3D would be the most effective at reducing mining related metals impacts. Each of these sub-alternatives uses a geomembrane liner in different positions in a composite cover system to confine the wastes and reduce the mobility of contaminants.

Of the alternatives considered, Alternative 3C is the preferred alternative because all wastes materials would be protected from contact with surface water below a liner, and would likely achieve the greatest reduction in potential loading to Daisy Creek. Alternative 3C will meet most project ARARs with the exception of surface water and groundwater quality.

TABLE ES-3
Summary Cost Analysis of Response Action Alternatives
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Alternative	Cost (millions)
1. No Action	**$ 0.06**
2A. In-Situ Treatment Shallow Amendment	**$ 0.91**
2B. In-Situ Treatment Select Waste with Deep Amendment	**$ 1.38**
2C. In Situ Treatment of All Wastes	**$ 6.26**
3A. In-Situ Treatment with Soil Cap	**$ 1.84**
3B. In-Situ Treatment with Geomembrane Cover and Amended Waste Rock Cap	**$ 4.75**
3C. In-Situ Treatment with Geomembrane Cover and Soil Cap	**$ 4.68**
3D. In-Situ Treatment with Geomembrane Cover and Composite Waste Rock and Soil Cap	**$ 4.26**
4. Disposal of McLaren Waste Rock in On-Site Repository	**$ 11.2 to $ 15.1**

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
ATSDR	Agency for Toxic Substances and Disease Registry
BMP	best management practice
CBMI	Crown Butte Mines, Inc.
CDM	Camp, Dresser and McKee
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of Concern
CFR	Code of Federal Regulations
cfs	cubic feet per second
cy	cubic yard
District	New World Mining District
DNRC	Montana Department of Natural Resources and Conservation
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Department of the Interior Environmental Protection Agency
EQ	Ecological Impact Quotient
ER-M	Effect Range- Median
GCL	Geosynthetic Clay Liner
gpm	gallons per minute
HDPE	High Density Polyethylene
HEAST	Health Effects Assessment Summary Tables
HELP Model	Hydrologic Evaluation of Landfill Performance Model
HHS	human health hazard
HQ	Hazard Quotient
IRIS	EPA's Integrated Risk Information System
LAI	Leaf area index
LCS	Leachate Collection System
Maxim	Maxim Technologies, Inc.
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
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
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ppm	parts per million
PRSC	Post Removal Site Control
RAOs	Removal Action Objectives
RCRA	Resource Conservation and Recovery Act
SMP	Shoemaker, McLean, and Pratt
TCLP	Toxicity Characteristics Leaching Procedure
UOS	URS Operating Services
USDA-FS	United States Department of Agriculture Forest Service

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1.0 INTRODUCTION

Maxim Technologies, Inc. (Maxim) developed this Engineering Evaluation/Cost Analysis (EE/CA) for the United States Department of Agriculture Forest Service (USDA-FS). The purpose of this report is to present an engineering evaluation and cost analysis of alternatives for response and restoration work proposed for the headwaters of Daisy Creek in the vicinity of the McLaren Pit, which is located in the New World Mining District (District). Response activities will address environmental media affected by historic gold, silver, copper, and lead mining and will be implemented over the life of the project, which is expected to be completed by 2007. The District is located north of Cooke City, Montana, in the Beartooth Mountains (Figure 1). Mining disturbances are primarily situated on lands managed or controlled by the USDA-FS.

The primary environmental issues within the District are associated with impacts from historic mining and more recent mineral exploration activities that occurred since prospecting in the area was initiated in about 1869. Human health and environmental issues are related to elevated levels of heavy metal contaminants present in mine waste piles, open pits, acidic water discharging from mine openings, and sediments.

1.1 PURPOSE

The purpose of this EE/CA is to screen, develop, and evaluate potential response alternatives that would be used for cleanup of mining wastes associated with historic waste rock dumps located at the headwaters of Daisy Creek. 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 cleanup or removal of released hazardous substances from the environment… as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment…” (EPA, 1993. Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA, EPA/540-R-93-057).

Several investigators collected the data used to support this EE/CA, the most recent of which was collected in 2000. Data were used to assess risks posed by acid-mine drainage from an abandoned open-pit, underground mine workings, mine wastes used as backfill in the open pit present at the McLaren Pit site and nearby mine waste rock dumps. These same data were also used to evaluate the potential effectiveness of removal, in situ treatment, capping methods, and reprocessing methods in alleviating the risks present at the site, and to develop estimates of cost for each alternative for comparative purposes. 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 REPORT ORGANIZATION

This EE/CA is organized into 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 pertinent data used to characterize the McLaren Pit open pit mine, underground workings, mine wastes and contaminated surface and groundwater sources present at the site.

Section 4.0 summarizes risks that are associated with recreational use of the sites. Risks evaluated include both human health risk and ecological risks. Section 5.0 outlines the response action scope, removal action objectives (RAOs) and goals for the site and presents applicable clean-up standards. The RAOs were developed by the USDA-FS and goals were identified based on both applicable or relevant and appropriate requirements (ARARs) and the results of the streamlined risk evaluation.

In Section 6.0, reclamation 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 compares the alternatives against the three primary criteria, effectiveness, implementability, and cost.

Figures and tables are incorporated into the text of the report. References cited in the document are listed at the end of the text. Several appendices that contain supporting documentation are included at the end of the document.

Figure 1 - Project Vicinity Map

Figure 2 - Non-Time Critical Removal Process Schematic

2.0 SITE DESCRIPTION AND BACKGROUND

The New World Mining District, which includes both National Forest and private lands, is an historic metal mining area located near Cooke City, Montana in the Beartooth Mountains (Figure 1). This historic mining district contains several mining related and natural features that are pertinent to mine waste cleanup activities. These features include: massive sulfide deposits exposed at the surface; regional geologic units and deposits enriched in pyrite and chalcopyrite; abandoned mines; hard rock mining wastes; acid discharges from both mine wastes and abandoned mine workings; and natural acid rock drainage (ARD). Human health and environmental issues are related to elevated levels of metals present in various mineralized geologic units, mine wastes, open pits, acidic water discharging from mine openings, and stream sediments.

2.1 PROJECT BACKGROUND

On August 12, 1996, the United States signed a Settlement Agreement (Agreement) with Crown Butte Mining, 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 clean up 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, which, as defined in the Decree, includes all property or interests in property that CBMI relinquished to the United States (Figure 1). 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.

Mitigation of impacts from acid-generating historic mining wastes has been an objective of numerous investigators in the District since the 1970s. One of the first to investigate revegetation in the District was the USDA-FS Intermountain Research Station (Brown et al., 1995; 1996). This research has focused on reclaiming high elevation mine disturbances, with emphasis on specific issues associated with species selection, fertilization, planting season, organic amendments, acid soil amendments, and surface soil treatments. Larger scale reclamation efforts have also been conducted by numerous parties involved in reclamation of the McLaren Tailings near Cooke City (Figure 1). In 1969, the Bear Creek Mining Company covered the McLaren Tailings (not a District property) with soil and rerouted Soda Butte Creek. In 1989, the EPA constructed a dam at the lower end of the tailings to stabilize the banks of Soda Butte Creek (UOS, 1998). The downstream dam was also stabilized and a French drain installed along the south and southeast flank of the tailings. The tailings were then regraded and reseeded.

Some reclamation work was completed voluntarily by CBMI on District Property. In 1991, CBMI began surface restoration work to reclaim the historic McLaren open pit mine disturbance and areas disturbed by exploration activity in the Como Basin. Reclamation activities at the McLaren Pit included recontouring, up-gradient diversion ditches, construction of lined run-on and run-off control ditches, treating acid soils with a lime amendment, and fertilizing and seeding with native grasses. In addition, in the McLaren and Como Basin areas, as many exploration drill holes (CBMI and pre-CBMI) as could be located were plugged and abandoned using bentonite chips and cement caps. Similar reclamation work was completed in the Como Basin, although additional work was done in this area to construct run-on controls to prevent water from entering a raise connected to the Glengarry adit. Drill holes in the Miller Creek and Homestake underground deposits were cemented up through the ore zones and backfilled to surface with bentonite and a cement cap.

From 1993 to 1996, CBMI also reclaimed a number of exploration roads and drill pads. Reclamation work completed in these areas is being evaluated by the project long-term monitoring program for revegetation success and through further assessment of the McLaren Pit and Como Basin.

In 1995, the EPA began a site investigation after the initial announcement of the property transfer from CBMI. The EPA investigation 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 (UOS, 1996; 1998) and included a description of the following: a review of all previous surface water and groundwater data collected by the Montana Department of Natural Resources and Conservation, USDA-FS, CBMI, EPA, and UOS; an evaluation of the data collected during the 1996, 1997 and 1998 field season; 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. The Support Document and Implementation Plan were submitted to the State of Montana Board of Environmental Review on January 22, 1999, and a rule 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.

2.2 SITE LOCATION AND DESCRIPTION

The New World Mining District falls within the boundaries of the Gallatin and the Custer National Forests and abuts Yellowstone National Park's northeastern-most corner. 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 public 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 neighboring communities of Mammoth, Wyoming and Gardiner, Montana are located about 80 kilometers (km) (50 miles) to the west. Red Lodge, Montana is about 105 km (65 miles) to the northeast, via the Beartooth Highway, and Cody, Wyoming is located 100 km (60 miles) to the southeast.

As the District is located at an elevation that ranges from 2,400 meters (7,900 feet) to over 3,200 meters (10,400 feet) above 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, Wyoming, and Cooke City. The Sunlight Basin road accesses 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, 0.2% of the district lands) according to recent measurements made by the USDA-FS Interagency Spatial Analysis Center. The McLaren Tailings, located on non-District Property, cover an additional 4.4 hectares (11 acres). The topography of the District is mountainous, with the dominant topographic features created by glacial erosion. The stream valleys are U-shaped and broad while the ridges are steep, rock covered, and narrow. Much of the

District is located at or near tree line, especially in the Fisher Mountain area 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. The Lamar River flows through Yellowstone Park. The major named tributary streams in the District include Daisy, Miller, Fisher, Goose, Sheep, Lady of the Lake, Republic, Woody, and Soda Butte creeks (Figure 1).

2.3 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 built the Republic Smelter in Cooke City for the reduction of silver-lead ore. 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 1920s, 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. 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 (UOS, 1996). The Glengarry Mining Company operated a flotation mill on the south side of Scotch Bonnet Mountain in the 1920s to process copper-gold ores from the Spalding Tunnels ores on Scotch Bonnet Mountain (U.S. Bureau of Mines, 1950). By 1925, the estimated production of the District was $215,000 in gold, silver, copper and lead (Wolle, 1963). 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 the mine was done in Cooke City at the former Cooke City Smelter. The Cooke City Smelter was a gravity/flotation mill that produced a concentrate that was shipped through the park to a railhead in Gardiner, Montana. With the closure of the McLaren Mill in 1953, mining in the District ceased. Extensive exploration of the area by a number of major mining companies continued until 1996, however, with CBMI as the last major company to hold an interest in district. CBMI executed an exploratory drilling program in the District from 1987 to 1993.

2.3.1 THE MCLAREN GOLD MINE

In 1933, The McLaren gold-copper-silver mining operation was developed on the west side of Fisher Mountain (Figures 1 and 3). Initial mining and exploration was conducted from a series of five east-northeast trending adits. 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. As mine development progressed, it was discovered the McLaren deposit continued to the north in the subsurface. The waste rock stored to the north of the pit was removed and placed back into the "mined-out" main pit, with the intention of extending the mine workings to the north. However, at about that time in 1953, the mill burned to the ground, and was never rebuilt.

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.

Total production from McLaren Pit from 1933 to 1953 is estimated at 305,700 metric tons of ore grading 6.31 grams per ton (g/t) [0.2 ounce per ton (opt)] gold, 8.91 g/t (0.28 opt) silver, and 0.59% copper (Elliot 1992). Additional geologic reserves identified by CBMI in the McLaren area include 1,969,530 metric tons grading 3.12 g/t (0.09 opt) gold, 13.06 g/t (0.38 opt) silver, and 0.70% copper. Approximately 312,000 metric tons of mine waste as pit backfill remains in the McLaren Pit.

2.4 GEOLOGY

The ore deposits in the McLaren Mine area were essentially (if not literally) exposed at the surface prior to mining and exploration. The gold-copper-silver-bearing skarn and massive sulfide replacement ores of the McLaren deposit are stratabound and hosted primarily in the Cambrian Meagher Limestone (Figures 4 and 5). The deposit occurs, and is genetically related to hydrothermal alteration within the Fisher Mountain Intrusive Complex, which is in high angle intrusive contact with the adjacent Cambrian-age sediments (Figure 6). The resulting deposits are tabular, stratabound, and occur within the gently southwesterly dipping Meagher Limestone at distances from 0-150 meters (0-500 feet) west from the intrusive contact. The deposit is approximately 910 meters (3,000 feet) long in a northwest-southeast direction and is crescent-shape in plan view as it wraps around the roughly cylindrical Fisher Mountain Intrusive stock (Figure 6). The deposit varies in thickness from 0-30 meters (0 to 100 feet, the total thickness of the Meagher Limestone), is thickest in the sediments near the contact with the intrusive stock, and thins to selective bed replacement as distance from the stock increases.

The northern part of the McLaren deposit is both bounded and down-dropped along the Crown Butte Fault (Figure 4). The Crown Butte fault is a major north-south trending dip-slip fault within the New World District. Sedimentary rocks to the west of the fault, in the vicinity of the McLaren deposit, have been down-dropped as much as 280 feet relative to the same units to the east. Part of the southern portion of the deposit has been removed by glacial and recent post-glacial erosion, and by historical mining.

Fracture controlled stockwork vein-type mineralization occurs in the upper seven meters (20 feet) of the underlying Wolsey Shale (Elliot 1992) and considerable mineralization occurs in intrusion breccias containing numerous Meagher Limestone breccia clasts within, but near the contact of, the Fisher Mountain intrusive complex (Johnson and Meinert, 1994).

2.5 CLIMATE

The New World District has a continental climate modified by the 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.

Figure 3

Figure 4

Figure 5

Figure 6 -

Precipitation and temperature data have been collected periodically at Cooke City from 1967 through 1995 (EarthInfo, 1996). The Cooke City station is located at an elevation of 2273.8 meters (7,460 feet). 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 -16.5ºC (2.4ºF) and an average maximum temperature of –4.8ºC (23.3ºF.) Temperatures are warmest in July with an average minimum temperature of 3.3ºC (37.9ºF) and an average maximum temperature of 22.8ºC (73.1ºF.)

Precipitation and temperature vary with elevation, and freezing conditions can occur any day of the year. Precipitation records from a Soil Conservation Service SNOTEL station (SCS 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 being the highest average precipitation month (14.4 percent) and August having the lowest average monthly precipitation (3.9 percent) (UOS, 1998). Average annual snowfall at higher elevations is about 13 meters (500 inches) (USDA, 1975).

A meteorological station was maintained in upper Fisher Creek near the proposed mill site for various periods during exploration activities by CBMI. 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).

2.6 HYDROLOGY

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 flow and water quality characteristics of the Daisy Creek drainage is directed affected by the McLaren Pit and other smaller waste dumps at the Daisy Creek headwaters.

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, and from the historic McLaren open pit mine. 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. Measured flows in Daisy Creek range from 0.0022 cubic meters per second (m^3/s) (0.078 cubic feet per second (cfs)) on November 19, 1974 to 1.6 m^3/s (57 cfs) on June 27, 1990. Daisy Creek is impacted by a combination of natural acid rock drainage and acid mine drainage from the McLaren Mine workings (UOS, 1998).

Surface water discharge in the area is quite variable and seasonally dependent. All three watersheds show rapid flow response to snowmelt and summer precipitation events. Rain on snow events typically produce major spring and early summer peak run-off events. Significant diurnal variations also occur particularly during the peak snowmelt periods. Although a substantial number of summer and fall flow measurements have been made in the Daisy Creek drainage, winter and spring flow measurements have largely been restricted to those made at selected locations during the 1974-75 hydrograph year and a few late spring measurements made in 1995 (UOS, 1998).

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3.0 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

Numerous environmental samples have been collected at the McLaren Mine to identify the source, nature and extent of contamination. The data used to support this EE/CA include geochemical analyses of solid samples collected from waste rock dumps; relevant water quality data from surface water, adit discharges, and groundwater sources; and stream sediment data. In accordance with the 2000 Work Plan (Maxim 2000), historic data collected in the McLaren Mine area was augmented with pore water, waste rock, and meteorological data collected during the period of May through October 2000. Maxim personnel measured infiltration and collected pore water chemistry in backfilled wastes using lysimeters at several locations in the McLaren Pit. Maxim conducted water-balance modeling studies to evaluate surface water infiltration into the McLaren Pit backfill materials. The U. S. Geological Survey and Maxim conducted mass loading studies on Daisy Creek to quantify loading from the McLaren Pit.

3.1 CONTAMINANT SOURCES IN THE MCLAREN MINE AREA

The source areas included in the McLaren Pit Response Action were chosen from the list of prioritized sites created using the Abandoned and Inactive Mines Scoring System (AIMSS). This modified hazard ranking system (HRS) was developed for the Montana Department of Environmental Quality (MDEQ) Mine Waste Cleanup Bureau (Pioneer, 1995) to prioritize abandoned mine sites in Montana. AIMSS scoring was completed on 132 source areas using data collected in 1996 and 1999. Table 3-1 lists the top 20 sites in the District, including the three that are being considered for this Response Action. Complete and detailed AIMSS scoring results were included as Appendix A in the Selective Source Response Action EE/CA (Maxim, 2001).

AIMSS ranks waste sources relative to each other using site-specific data and the HRS scoring algorithm. In preparing these AIMSS rankings, four distinct exposure pathways were 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, large contaminant concentrations, large contaminant quantities, and/or large areas of disturbance.

The three source areas are situated at the headwaters of Daisy Creek in the vicinity of the McLaren Pit. The source areas include the McLaren Pit (No. 1), McLaren Pit spoils (No. 9), and the McLaren Multicolored Dump (No. 17) (Table 3-2). These three waste rock source areas account for 154,911 cubic meters (202,616 cubic yards) or about 67% of the District's total waste rock on public lands. These sites meet several of the criteria for selecting a response action including: the sites are located on District Property, the sites are large with respect to both aerial extent and volume of waste rock materials, and the source areas pose a clear threat to surface and groundwater quality.

Table 3-1
Source Area Ranking
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Site Name	AIMSS Rank*	Area (hectares)	Volume (cu. meters)**	Adit Discharge†
McLaren Open Pit Mine‡	1	4.60	136,495	Yes
Miller Creek Headwaters Dump One	2	0.07	610	Yes
Soda Butte Dump Two	3	0.15	630	No
Soda Butte Dump Six-B	4	0.18	590	No
Soda Butte Dump One	5	0.11	270	Yes
Soda Butte Dump Four	6	0.09	670	No
Soda Butte Dump Five	7	0.06	510	No
Soda Butte Dump Six	8	0.06	570	No
McLaren Pit Spoils‡	9	1.21	16,420	Yes
West Miller Creek Dump Two	10	0.05	400	No
Rommel Tailings	11	0.90	13,730	No
Alice E Mill Site	12	0.53	2,550	Yes
Soda Butte Dump Eight	13	0.10	30	Yes
Soda Butte Dump Seven	14	1.25	6,080	No
Glengarry Dump	15	0.43	9,880	Yes
West Miller Creek Dump Four	16	0.10	140	No
McLaren Multicolor Dump‡	17	0.24	2,360	Yes
Soda Butte Dump Three	18	0.07	60	No
Soda Butte Dump Six-A	19	0.04	30	No
Little Daisy Adit and Dump	20	0.20	680	Yes

Notes:
- * AIMSS - Abandoned and Inactive Mines Scoring System
- ** cu. meters - cubic meters
- † Adit discharge associated with waste dump from adit, collapsed adit, or seep
- ‡ Shading indicates source areas included in this response action

TABLE 3-2
Mine Dumps and Source Areas Included in McLaren Pit Response Action
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Waste Dump Name And Designation	Area hectares (acres)	Volume cubic meters (cubic yards)
McLaren Pit Waste Rock (DCSI-96-2)	3.35 (8.3)	136,495 (178,529)
McLaren Multicolor Dump (DCSI-96-1)	0.24 (0.6)	2,360 (3,087)
McLaren Spoils (mine wastes below the county road)	1.21 (2.98)	16,056 (21,000)
TOTALS	**4.8 (11.9)**	**154,911 (202,616)**

3.2 MINE WASTE INVESTIGATION RESULTS

Waste rock samples were collected from many of the dumps in the District, both in 1999 by Maxim and in 1996 by George Furniss on behalf of CBMI. Dump volumes and areas are listed in Table 3-2 and the dump locations are show on Figure 7. Volumes were calculated from a field reconnaissance conducted in August 1999 for the Multicolored Dump and the McLaren Spoils. Area estimates were interpreted from aerial photography by the Gallatin National Forest Interagency Spatial Analysis Center in Bozeman, Montana. The volume of the unconsolidated waste rock used as mine backfill in the McLaren Pit was recalculated for this report (136,495 cubic meters) from CBMI data reports in which the tonnage of unconsolidated wastes were calculated based on a planar polygon reserve calculations from drill hole data on approximately 7.6-meter (25-foot) centers (Noranda Minerals, Inc., 1989). Approximately 140 drill holes were used for this calculation. The tonnage calculated for these materials was 344,305 tons; the density of this material was measured at 14 cubic feet/ton.

From calculations based on pilot scale metallurgical testing of composite samples from 9 large diameter drill holes of McLaren Pit backfill and bedrock, it was determined that processed material totaling 1,110,885 tons would produce a pyrite/chalcopyrite concentrate weighing approximately 32,215 tons (Brenda Mines, Ltd., 1992). This indicates that the total sulfide content of the unconsolidated waste rock is about 3% by weight.

Mine waste samples were collected from the McLaren Pit, the Multicolored Dump, and two small waste rock dumps south of the pit following standard operating procedures referenced in the Site-Wide Sampling and Analysis Plan (Maxim, 1999b). Samples were collected from hand dug test pits using a shovel. Subsample test pits were dug to a depth of about 18 inches. Field quality control (QC) samples were collected at a frequency of 5% of natural samples. Laboratory quality control samples included duplicates and matrix spikes. Quality assurance was completed according to the quality assurance project plan presented in the Site-Wide SAP. Precision and accuracy were within acceptable limits for all samples collected.

Waste rock and soil samples were placed in one gallon, heavy-duty, polyethylene bags and labeled with date, sampler, and sample number according to sample designation and labeling procedures. Composite samples were analyzed for saturated paste pH and electrical conductivity, total metals (arsenic, cadmium, copper, lead, mercury, and zinc), sulfur fractionation, and lime requirement. All samples were analyzed according to methods presented in the Site-Wide SAP. Analytical results for samples collected from the mine waste dumps included in Table 3-2 are summarized in Tables 3-3 and 3-4.

TABLE 3-3
Waste Rock Sample Analytical Results - pH and Total Metals
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Waste Dump Name	pH+ (s.u.)	Total Metals (milligrams per kilogram)						
		As	Cd	Cr	Cu	Pb	Hg	Zn
McLaren Multicolor Dump	2.4	3	15	<5	808	73	0.68	7
	3.5	60	24	<5	1260	41	<0.5	8
McLaren Pit Waste Rock	3.2	60	16	<5	256	188	<0.5	89
	3	100	31	<5	454	264	<0.5	93
	3.3	100	44	<5	1500	299	<0.5	94
Dumps near McLaren Pit	6.9	88	13	<5	177	266	3.76	673
	2.1	326	25	<5	2510	295	9.45	87
Average	**--**	**105**	**24**	**<5**	**995**	**204**	**2.27**	**150**
Average background concentration*	**--**	**2**	**5**	**13**	**63**	**51**	**--**	**31**

Notes:
-- Not available or not applicable
< less than the indicated value
* Based on mean concentrations from five natural samples collected by Furniss
+ pH measured in standards units (s.u.)

Data in Table 3-3 show that the total concentrations of the elements arsenic, cadmium, copper, lead, mercury, and zinc exceed average background concentrations by more than three times. Data summarized in Table 3-4 for specific samples indicate that a considerable amount of lime (115 tons per 1000 tons), on average, would be needed to adjust the pH of the waste rock materials to a pH of 7.0 standard units (s.u). Some of the total sulfur present in the dumps was measured in the residual fraction, which indicates that the minerals present in the waste did not react to a great extent with the strong acids used to digest the pyritic and sulfate sulfur fractions. Pyritic sulfur forms were more prevalent than either sulfate (hydrochloric soluble) or jarosite (water soluble) sulfur forms.

The McLaren Spoils, which are located below the road, were not sampled. These are assumed to be pit backfill wastes that were dozed over the edge of the road over time, and are therefore likely to be similar in composition to the pit waste rock backfill. More precise sampling and analysis will be required prior to calculating actual lime amendment rates should a treatment option involving lime addition be selected. For the purposes of relative cost analysis presented in this report, the assumption that the spoils are comparable to in-pit backfilled wastes is adequate. Waste rock sample locations are shown on Figure 3

Using 3% for the pyrite content of waste rock, the calculated lime amendment required for the McLaren Pit backfill is 93.8 metric tons of lime/kiloton of waste. For the Multicolored Dump, a lime amendment rate of 140.6 metric tons of lime/kiloton of waste was calculated. Both of these values are in reasonable agreement with the average lime requirement shown in Table 3.4.

Figure 7

Figure 7 - Back page.

TABLE 3-4
Waste Rock Sample Analytical Results - Sulfur Fractions and Lime Requirement
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Waste Dump Name	Rock Type	Non-Sulfate Sulfur (%)	AP[1] (t/1000t)	NP[1] (t/1000)t	Lime requirement[2] (t/1000t)
McLaren Multicolor Dump	Grab Sample	4.35	136	3	150
	Grab Sample	4.86	152	10	167
McLaren Pit Backfill	Grab Sample	0.45	14	4	15
	Grab Sample	0.48	15	3	17
	Grab Sample	1.44	45	4	50
Small Dumps Near McLaren Pit	Grab Sample	3.14	98	0	108
	Grab Sample	5.63	176	1	194
McLaren Pit Waste Rock by Lithology	Wolsey Sh. (floor)	4.11	128	12	141
	Wolsey Sh. (floor)	8.1	253	2	278
	Wolsey Sh. (floor)	5.8	181	6	199
	Wolsey Sh. (floor)	4.73	148	3	163
	Wolsey Sh. (floor)	4.44	139	35	153
	Intrusive (Floor)	2.13	67	78	73
	Intrusive (mod Sulfur)	2.86	91	19	98
	Intrusive (low Sulfur)	3.15	98.5	37	108
	Meagher Ls. (low sulfur)	0.13	4	783	4
	Park Sh. (hi sulfur)	6.85	214	74	235
	Park Sh. (mod sulfur)	3.17	99	97	109
	Park Sh. (low sulfur)	1.25	39	30	43
Average		**3.35**	**105**	**60**	**115**

Notes: (1) NP = neutralization potential in tons per 1000 tons; AP = acid potential in tons/1000 tons
(2) Lime requirement in tons per 1000 tons calculated according to the formula {(non-sulfate sulfur) * 31.25 * 1.1; to convert to metric tons/kiloton, multiply by 0.91.

For the purposes of this EE/CA, a lime requirement of 93.8 metric tons lime/kiloton waste will be used for the McLaren Spoils (wastes below the road) and McLaren Pit backfill. The average value of 140.6 metric tons lime/kiloton waste will be used for the lime requirement of the Multicolor Dump wastes.

3.3 SURFACE WATER QUALITY

Surface water in the Daisy Creek is impacted by runoff from mine waste dumps and other disturbances, as well as discharges from adits, seeps, and natural groundwater that carry high metal loads. Mean concentrations of selected parameters for the 1989-2000 period for sample sites located on Daisy Creek are summarized in Table 3-5. Sampling stations are shown on Figure 3.

It is clear from the summary data presented in Table 3-5 that mine wastes and other contaminant sources at the headwaters of Daisy Creek significantly impact surface water quality. Several parameters, including total recoverable aluminum, copper, iron, lead (at DC-1 only), manganese, and zinc exceed Montana's water quality standards (MDEQ, 1998). The McLaren Mine adit discharge exceeds water quality standards for aluminum, copper, iron, and lead, although the mean flow from this adit based on eight measurements was only 14 gallons per minute (gpm) (Hydrometrics, 1992). Temporary standards shown in Table 3-5 were approved by Montana Board of Environmental Review for particular stream reaches. These standards are twice the standard deviation of the mean shown in the table, added to the mean, at a particular sampling station.

TABLE 3-5
Mean Surface Water Concentrations Of Selected Parameters
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Location	Total Recoverable Metals (milligrams/liter)								pH[(1)] (su)
	Al	Cd	Cr	Cu	Fe	Pb	Mn	Zn	
McLaren Mine Adit (D-18) [(2)]	0.233	0.0008	<0.02	0.013	14.975	0.004	0.892	0.046	3.7
Daisy Creek @ DC-1[(3)]	17.3	0.0048	0.014	5.646	27.782	0.019	2.37	0.732	3.2
Daisy Creek @ DC-2[(3)]	12.93	0.0037	0.006	3.61	14.22	0.006	1.81	0.503	3.6
Daisy Creek @ DC-5 [(3)] (Temp. Stds. Compliance Pt.)	3.83	0.001	0.002	1.375	3.6	<0.002	0.60	0.207	6.6
Temporary Standard @ DC-5	9.51	0.004	--	3.530	6.830	--	1.71	0.540	4.6
Chronic Aquatic Life Standard	0.087	0.0014	0.089	0.009	1.0	0.003	--	0.120	--

Notes:
(1) pH in standard units
(2) Data from Hydrometrics (1992); average for samples collected during 1989-1991 time period
(3) Mean concentrations calculated from available data in project database - 1989 - 2000
-- Not applicable

Additional data on surface water quality in Daisy Creek has been collected at other intermediary surface water sites at various times of the year over a number of years by a number of sources. These data are available on the Internet from the New World project database at http://www.fs.fed.us/rl/gallatin.

3.4 STREAM SEDIMENT DATA

Stream sediment data (Table 3-6) were collected from Daisy Creek and the upper Stillwater River in 1996 by Camp, Dresser, and McKee (1997). At most sites, samples were collected during high and low flow conditions. Sixteen elements were analyzed using X-ray fluorescence.

Stream sediment data indicate that arsenic, copper, and lead concentrations are considerably higher in sediment than in waste rock. These data also indicate that arsenic, chromium, copper, iron, manganese, lead and zinc in stream sediments are significantly above background levels for these elements in soil.

TABLE 3-6
Mean Concentrations Of Selected Elements In Stream Sediment(1)
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Location	Ag	As	Ba	Cd	Cr	Cu
DC-2 (Daisy Creek)	8	72	1,640	2	96	957
SW-8 (Daisy Creek)	5	6	1,717	4	36	5,245
DC-5 (Daisy Creek)	4	50	1,962	0.5	90	1,878
STW-2 (Stillwater River)	4	22	1,286	2	54	2,437
SW-7 (Stillwater River)	0.9	4	1,882	0.6	126	1,166
Average	**4.3**	**25.7**	**1,414**	**1.5**	**67**	**1,947**
Background Concentration*	**--**	**2**	**72**	**5**	**13**	**63**
Location	**Fe**	**Mn**	**Ni**	**Pb**	**Sb**	**Zn**
DC-2 (Daisy Creek)	167,072	922	ND	138	2.4	202
SW-8 (Daisy Creek)	105,645	1,371	23	113	1.6	360
DC-5 (Daisy Creek)	106,505	1,255	23	138	11	382
STW-2 (Stillwater River)	69,040	2,630	43	108	1.7	292
SW-7 (Stillwater River)	36,436	718	8.2	42	3.5	1,244
Average	**80,783**	**1,149**	**19.4**	**90**	**3.4**	**413**
Background Concentration*	**17,100**	**461**	**24**	**51**	**5**	**31**

Notes: (1) Analysis by X-ray fluorescence; all values are rounded in mg/kg; data source: CDM (1997)
-- Not detected or not available
* From soil sample collected near Glengarry Mine by Pioneer (1995) or mean concentrations from five natural samples collected by Furniss

3.5 GROUNDWATER DATA

Table 3-7 presents average groundwater chemistry data from monitoring wells in the vicinity of the McLaren Mine. Well locations are shown on Figure 3. These water quality data indicate there are significant impacts to groundwater from acidic and metal laden sources, presumably the McLaren ore deposit and backfilled waste rock material.

TABLE 3-7
Mean Groundwater Concentrations of Selected Parameters
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Monitoring Well Name	pH	Average Total Metals (milligrams per liter)					
		As	Cd	Cr	Cu	Pb	Zn
EPA-01	4.5	0.0147	0.0164	0.005	1.12	0.0977	2.38
EPA-02	2.9	0.0078	0.0105	0.0105	6.23	0.044	1.685
EPA-03	--	0.0061	0.0094	0.014	11.7	0.089	1.13
EPA-04	2.4	0.0075	0.0245	0.0814	37.35	0.0207	3.83
EPA-05	--	0.01	0.004	0.05	7.49	0.01	0.17
EPA-06	3.9	0.0075	0.0035	0.0142	3.02	0.0052	0.1855
EPA-07	--	0.01	0.005	0.01	1.17	0.0055	0.076
EPA-08	4.2	0.01	0.02	0.03	35.45	0.02	3.22
EPA-09	6.3	0.0089	0.0035	0.007	0.086	0.005	0.159
EPA-10	3.6	0.0088	0.023	0.0415	28.2	0.036	3.375
MW-2	3.8	0.0109	0.005	0.01	0.0342	0.0092	0.238
MCL	--	0.050	0.005	0.100	1.0	0.015	5.0

Notes: -- Indicates not measured or not applicable; MCL = maximum contaminant level

3.6 SOURCES AND EVIDENCE FOR PRE-MINING ACID ROCK DRAINAGE

A number of pre-mining sources, some of which are introduced and described above, have been identified as probable natural occurrences of acid rock drainage (ARD). Considerable evidence provides convincing support for the conclusion that some of these sources existed prior to mining. Absolute quantification of the amount of contamination attributable to these pre-mining sources is difficult, however, and has been the subject of considerable investigation (Runnells, 1992; Furniss and Hinman, 1998; Lovering, 1929). Probable natural background sources of ARD at New World include: metal-enriched, massive sulfide deposits; mineralized zones in bedrock; disseminated sulfides contained within very large masses of intrusive rocks; fracture and fault controlled mineralization; anomalous metal concentrations in native soils; groundwater migration through sulfide and metal-bearing bedrock units; transported and deposited metal-bearing sulfide sediments; chemical precipitates along tributary drainages and in over-bank sediments; ferricrete deposits; and, metal–enriched bogs.

3.6.1 BEDROCK SOURCES

In the New World Mining District, there are five known deposits that consist of gold-copper-silver mineralization hosted in massive sulfide-rich (pyrite and chalcopyrite-bearing) sedimentary replacement deposits. The total amount of this material identified by past exploratory drilling in the vicinity of Fisher Mountain and at the northern end of Henderson Mountain is quite large (CBMI, unpublished data). Approximately 12,000,000 tons were identified as geologic reserves, or zones of contiguous ore grade or near-ore grade mineralization. These massive sulfide deposits average about 35% total sulfides by weight and range between 10% and 60% total sulfides. Oxidation of sulfides in the presence of oxygen and water produces sulfuric acid and releases the metals trapped in the sulfide structures, as shown in the following set of chemical equations.

$2FeS_2 + 2H_2O + O_2 = 2\ Fe^{++} + 4H^+ + SO_4^{2-}$
pyrite + water + oxygen = iron (in solution) + acid + sulfate (in solution)
pyrite + water + air = metal + acid + salt + heat

Most metals are very soluble in acidic waters, and therefore, when sulfide-bearing rocks weather or oxidize, they have the potential to release acid and metals to the environment unless other minerals are available to neutralize the acidic water (such as limestone). Unconsolidated materials weather and oxidize more rapidly, and typically generate a higher load of acidity, metals, and sulfate, but it has long been recognized that as long as adequate oxygen and water are present, sulfide oxidation occurs in undisturbed materials as well. Indeed, in-situ oxidation has provided an important prospecting tool that has led to the discovery of many ore bodies.

Two of the five deposits at New World are exposed at the surface, and have probably been exposed to surface weathering and leaching by infiltrating meteoric waters for the last 10,000 years since glaciers last eroded the topography (Lovering, 1929). These deposits are the McLaren deposit (discussed in this report) located at the headwaters of Daisy Creek on the southwest flank of Fisher Mountain, and the Como deposit located in the Como Basin immediately east of Lulu Pass at the north end of Fisher Mountain. The McLaren deposit consists of about 300,000 tons of unconsolidated waste rock that overlies 1,800,000 tons of bedrock (in-place) ore. The bedrock ore occurs as replacement mineralization in the Meagher Limestone, which is 30 meters (100 feet) thick. The ore ranges in thickness from 0 to 24 meters –(80 feet) thick. There is volumetrically about six times more bedrock ore than waste rock in the McLaren deposit. The bedrock is intensely fractured and faulted based on detailed drilling investigations conducted by CBMI. In addition, the deposit is cut by the major Crown Butte fault zone, which runs essentially north to south throughout the entire New World District over a zone about 15 meters (50 feet) wide

Ample material has been exposed to weathering at the surface since post-glacial times that has undoubtedly produced a considerable amount of historic ARD. This is evidenced by large aprons and terraces of ferricrete that have been deposited downgradient and downstream of exposed surface deposits. In addition, large fluctuations in groundwater have been measured in bedrock wells developed within the McLaren deposit that clearly demonstrate that most of the mineralized Meagher Limestone is subjected to periodic (at least annual) oxidation and flushing events that remove stored acidity and metals that accumulate during the oxidation period.

The intrusive (igneous) rock that comprises Fisher Mountain (Fisher Mountain Intrusive Complex) and the northern end of Henderson Mountain (the Homestake Stock and Intrusive Complex) was extensively altered by hydrothermal activity some 40 million years ago. The alteration is so classic and widespread that these two intrusive bodies were explored as potential molybdenum and copper-porphyry deposits (large tonnage, low-grade deposits) in the 1970s and 1980s. The type of alteration present within these stocks is named for the assemblage of minerals that make up the alteration, *quartz-sericite-pyrite*. In the New World District, there are very large volumes of rock that contain disseminated sulfides, predominantly pyrite, chalcopyrite, and molybdenite (iron, copper, and molybdenum sulfides, respectively). These very large volumes (conservatively 200,000,000 tons) of altered intrusive rocks contain between 2 and 4 percent disseminated sulfides (with larger amounts on fractures and faults. Rocks containing as little as 0.3% pyrite are potentially acid generating depending on the neutralization potential of the host rock. Altered granitic intrusive rocks like those found in the New World District contain very little neutralization potential. These intrusive rocks have been exposed to weathering since the retreat of the last glaciers some 10,000 years ago, and are unquestionably a source of acid and metal loading to ground and surface waters.

Fractures and faults throughout the district have been mined and thoroughly prospected in the past for metals. These fractures systems contain abundant sulfide mineralization and metals (gold, copper, silver, lead, and zinc, as well as other metals) as vein and fracture-fillings that extend out from the altered intrusive centers. Fracture systems within the intrusives themselves have been identified by geophysical techniques (conductivity, resistivity, and induced polarization) and drilled to examine the style, type and grade of mineralization present. These fracture systems were observed to contain as much as 30-40 % sulfides. These fracture systems also represent the major conduits for water movement in the district where the rock is most permeable in the plane of the fractures and most groundwater is stored in secondary porosity zones created by fractures. The Crown Butte Fault zone in the subsurface beneath Fisher Mountain contains an ore deposit called the "Fisher Mountain Zone" where the fault and the adjacent Pilgrim Limestone are completely replaced by massive sulfide ore (generally in excess of 80% sulfide). This deposit was shown to be over 365 meters (1,200 feet) long (north-south along the fault), is as much as 15 meters (50 feet) wide, and 60 meters (200 feet) high in the plane of the fault in mineral exploration studies, and lies only about 60 meters below the crest of the mountain in the plane of the fault. This fault zone has been shown to have very high permeability by pump-testing in the Miller Creek drainage (CBMI, unpublished data) along the fault zone, and by dye tracer studies conducted by the EPA, where dyes introduced near the fault on Fisher Mountain showed up in the Miller and Fisher Creek drainages (UOS, 1998).

3.6.2 Soil Anomalies

One of the most common techniques used by mining companies to explore for deposits hidden beneath soil covers is to sample soils for anomalous naturally occurring concentrations of metals. During the porphyry copper exploration period (1970-1986), a number of mining companies explored the New World District for a large tonnage, low-grade copper and molybdenum deposit. These companies included Kennecott, Rancher Exploration, Gulf Mineral Resources and Amoco Mineral Resources. These companies identified many areas within the district where the soils were anomalously enriched in copper, lead, and zinc, and a number of these areas were subsequently drilled for their porphyry potential. Crown Butte Mines, Inc. duplicated some of the better soil anomalies on Henderson Mountain and obtained copper values in soils as large as 200 parts per million (ppm). Lead and zinc anomalies were also identified.

3.6.3 Groundwater Migration from Mineralized Ground

There is abundant evidence of acidic, metal-laden water exiting from mineralized ground and depositing secondary mineralization throughout the District. Some of these deposits include actively forming chemical precipitates such as aluminum-iron hydroxides (with associated trace metals) that are present as rusty or white coatings on streambeds and boulder/sediment substrates of the Fisher Creek and Daisy Creek drainages (Amacher, 1998). These deposits are evidence of active ferricrete formation (iron-oxide precipitation and cementation of sediments) as the result of active weathering of sulfide rich deposits with transport by surface and ground waters with subsequent dilution and neutralization to a point of mineral precipitation from metal laden waters. Ferricrete deposits are discussed in detail below.

In addition, a number of seeps and springs from the New World District are acidic and contain large metal loads. These are described in detail in CBMI's environmental baseline studies (Crown Butte Mines, Inc., 1990). Several of these seeps and springs originate in areas that are not obviously mineralized and lie outside of areas affected by historic mining or prospecting activities. In a paper by Runnels and others (1992), two such seeps are described. The results of the chemical analysis of these seeps and springs show very low pH and anomalous metal concentrations present in undisturbed areas (Table 3-8).

Table 3-8
Ranges of Compositions of Spring Waters from Undisturbed Sites in the New World Mining District

Location/ Type of Water Sampled	Rock Type	pH	Concentration, mg/L			
			Cu	Zn	Pb	Cd
Park County, Montana (two springs)	Igneous/ sedimentary contact	2.73 - 3.93	0.30 - 7.9	0.07 - 1.1	<0.01	<0.0002 - 0.003

Note: Data from Runnels (1992)

Groundwater migration out of sulfide and metal-bearing bedrock units into surface water and groundwater supplying base flow to Daisy Creek is an additional significant source of metal and acid contamination (Nimick, 2001). Nimick postulates that groundwater table intersection with topography in the Daisy Creek valley is responsible for the base flow in Daisy Creek. Nimick's study shows that the upper 60 meters of Daisy Creek is relatively unaffected by historic mining activity and resulting water quality impacts. However, once the tributaries draining the McLaren Pit and related groundwater inflows are encountered, significant impacts of acidity and elevated metals are encountered in Daisy Creek. The principal observable impacts from the McLaren Pit proper occur from about 60 meters (200 feet) to a point about 250 meters (820 feet) downstream (to the north) of the headwaters. Contaminated surface and ground water inflow continue to a point about 700 meters (2,300 feet) downstream, suggesting contaminant sources downstream of the McLaren Mine are contributing both surface and ground water contamination. From 700 meters to about 1670 meters (5,475 feet) downstream groundwater inflow into Daisy Creek continues to provide metal and acidity contamination, but there are no surface water inflows. This indicates that additional contaminant sources supply loads to Daisy Creek located below the McLaren Pit. The sediment hosted McLaren ore deposit is known to extend in the subsurface approximately 245 meters (800 feet) to the north of the historic pit boundaries before being cut off by the Crown Butte Fault and the Fisher Mountain Intrusive contact. In addition, untested stratabound exploration targets exist in the Daisy Creek drainage west of Lulu Pass, as indicated by induced polarization exploration geophysical techniques (CBMI, unpublished data).

3.6.4 Transported and Redeposited Sediments

Sediments have been transported downstream of the McLaren Pit site and redeposited as channel fill and over-bank deposits along Daisy Creek. These sediments are locally sulfide and metal-enriched. The distribution of these sediments was mapped and inventoried by Hydrometrics for Crown Butte Mines Baseline Studies (1990) and by CDM for USEPA (1997). These remobilized sediments are considered secondary sources in terms of their contribution to overall loading in Daisy Creek, and are therefore not addressed as part of the McLaren removal action. These sources could be considered for removal at some future time. The composition of these sediments is described above in Section 3.4.

In addition, glacial tills in both the Fisher and Daisy Creek valleys were drilled for various geotechnical purposes and as monitor wells. Glacial tills above the water table are oxidized and contain abundant iron oxides and hydroxides. In a zone of fluctuating water within the till, sulfide minerals are partially oxidized while sediments below the water table in the glacial till contain abundant pyrite. Geotechnical bore holes in Fisher Creek collected samples of pyritic glacial till over intervals as thick as 50 feet with pyrite contents estimated to be as high as 20%.

3.6.5 FERRICRETE DEPOSITS

Ferricrete deposits are alluvial, colluvial or talus deposits that are cemented by iron-manganese-aluminum oxide and hydroxides. The cementing agent (hydroxides) dehydrates over time to form a well-lithified material that typically resembles an iron oxide or rust-cemented breccia. These deposits contain anomalous amounts of other metals that are associated with and adsorbed to or co-precipitated with the iron hydroxides (Table 3). These ferricrete deposits have been, and continue to be deposited along the hydrologic gradient below the McLaren Pit, and elsewhere wherever seeps and springs containing acidic and metal laden waters come to surface. Although the ferricrete (oxide and hydroxide) minerals are relatively stable and the ferricrete deposits are relatively resistant to erosion, they are never the less subject to erosion and are therefore a potential source of contaminants.

Active, historic, and ancient deposition of these chemical precipitates was described by T. S. Lovering, a geologist with the US Geological Survey, during field studies of the New World District conducted early in the last century (Lovering, 1929) in the Daisy and Fisher Creek drainages. Excerpted from that report is the following:

> *"Talus breccias cemented by limonite cover may acres near the headwaters of the Clarks Fork of the Yellowstone* (Fisher Creek). *Large pyritic deposits occur near by, and both surface and ground water move from the sulfides to the breccias, where deposition of iron hydroxide is going on actively",* and
>
> *"Talus and gravel have been thoroughly cemented by iron hydroxide in many places near Red Mountain* (Fisher Mountain*), and areas covering many acres may be found on its western and eastern flanks."*

By definition, the ferricrete deposits described by Lovering on the west side of Fisher Mountain must pre-date open pit mining in the McLaren pit on the Daisy Creek side of Fisher Mountain, which did not begin until 1936.

Furniss and Hinman (1998) mapped ferricrete deposits in the New World District (Figure 8). Ferricrete deposits are relatively common in the upper reaches of the Fisher Creek and Daisy Creek drainages. In the course of their mapping, they locally identified logs and other organic debris contained in these ferricrete deposits. Organic materials were collected from these ferricrete deposits for radiocarbon dating. Sample locations are also shown on Figure 8.

The dates reported from these samples range from 310 to 8,740 years before present (Table 3-9) (Furniss and Hinman, 1998). These dates are clear evidence that acid rock drainage and metal contamination was naturally occurring, in each of these drainages, for approximately the last 9,000 years, long before historical mining activities.

Furniss and Hinman (1998) also chemically analyzed ancient and recent hydroxide cemented material and precipitates. The mean and range of compositions for several elements from each of these types of deposits are shown in Table 3-10. These data clearly indicate that not only were these ferricrete deposits formed long ago, but chemically they also contained anomalous metal concentrations, similar to those of modern chemical precipitates and ferricretes that form from ARD.

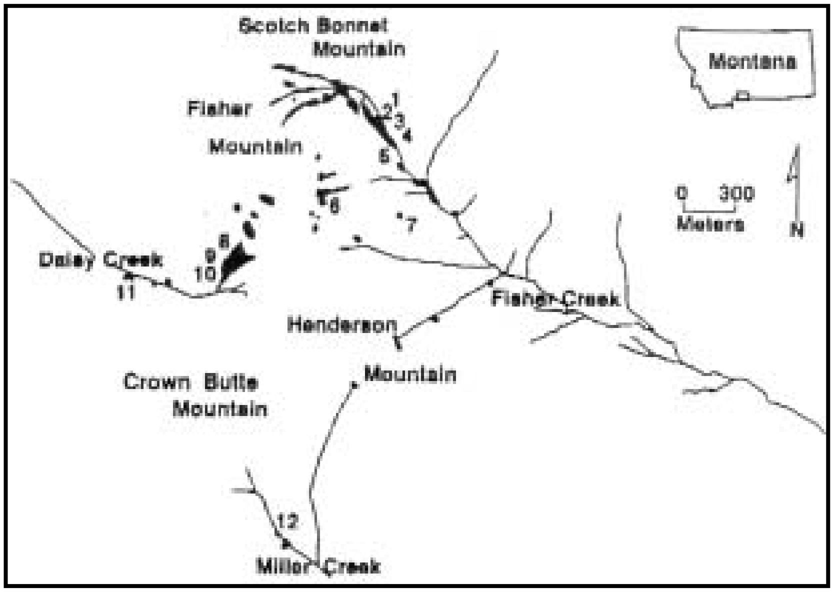

Figure 8. Location of mapped ferricrete deposits in the New World Mining District, Montana. Numbers indicate ferricrete sample locations with radiometric dates. Data from Furniss and Hinman (1998)

3.6.6 Bogs

There are a number of metal-rich bogs developed in conjunction with seeps and springs in both the Daisy and Fisher Creek drainages. These bogs are typically discolored (brown and gray) masses of dead and decaying organic material admixed and interbedded with sediments. They contain abundant anomalous metal concentrations (usually iron and manganese, but locally copper). A particularly large manganese bog lies immediately below the McLaren Pit.

Lovering (1929) describes an unusual copper bog as follows.

> *"The alluvium near the lower Glengarry adit carries spongy nuggets of native copper. Trenches several feet deep expose gravel and slope wash interbedded with a little black mud. Some of the gravel is clean and some contains limonite, but no native copper has been found in it. The dark mud usually contains native copper, but nowhere iron stained. The copper bearing layers do not make up more than 5-8 per cent of the section exposed in the cuts, but …"* and *"The deposit rests in a recently glaciated valley and must be of very late origin. The copper-bearing mud contains blackened blades of grass, partly decomposed twigs, and other organic material that has now lost all form… the conclusion is reached that metallic copper has been precipitated from these solutions by organic material."*

Table 3-9
Radiocarbon Dates for Wood Collected from Ferricrete Deposits in the New World District(1)

Sample Location(2)	Analytical Method(3)	Radiocarbon Date (years before present.)
1	B	6,800 ± 70
2	B	8,690 ± 80
3	B	5,810 ± 80
	B	6,920 ± 80
	B	7,030 ± 60
	B	7,170 ± 70
	B	7,170 ± 70
4	B	5,970 ± 150
	B	8,270 ± 70
5	B	30 ± 50
	B	60 ± 70
	B	100 ± 100
	B	550 ± 80
	B	890 ± 70
6	A	4,000 ± 60
7	B	1,670 ± 40
8	A	8,620 ± 60
9	B	310 ± 110
10	A	8,700 ± 50
	A	8,840 ± 50
11	A	6,490 ± 60
12	B	2,050 ± 50

(1) Data from Furniss and Hinman (1998)
(2) Radiocarbon dates in stratigraphic order where more than one date shown
(3) A = accelerator mass spectrometer; B = beta decay

Table 3-10
Composition of Iron-Oxyhydroxides Collected from Ancient and Modern Ferricrete Deposits

Element	Concentration (milligrams per gram)			
	Mean Ancient Samples	**Mean Modern Samples**	**Range Ancient Samples**	**Range Modern Samples**
Sulfur	6.90	32.00	0.80 – 17.40 (n=30)	1.60 – 49.80 (n=4)
Aluminum	10.80	63.00	0.33 – 55.80 (n=30)	0.750 – 141.0 (n=5)
Copper	2.58	5.80	0.08 – 12.60 (n=30)	0.075 – 21.1 (n=5)
Iron	239.00	236.00	21.8 – 446.0 (n=30)	69.10 – 394.0 (n=5)
Lead	0.13	0.14	0.01 – 1.04 (n=17)	0.12 – 0.16 (n=3)
Magnesium	1.75	1.95	0.16 – 4.10 (n=11)	1.0 – 2.9 (n=2)
Manganese	1.10	0.27	0.01 – 8.01 (n=15)	0.06 – 0.64 (n=4)
Phosphorous	1.80	1.20	0.16 – 10.6 (n=25)	0.76 – 2.0 (n=4)
Potassium	1.24	3.20	0.23 – 2.6 (n-9)	1.3 – 5.0 (n=2)
Zinc	0.20	0.27	0.01 – 2.1 (n=25)	0.001 – 0.75 (n=4)

Notes: Data from Furniss and Hinman (1998)
Samples analyzed by strong acid leach digestion (nitric acid/hydrogen peroxide) and inductively coupled plasma emission spectrophotometry (ICP) (US EPA Method 3050)
(n = number of samples)

3.7 HELP MODELING

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate the amount of seepage (infiltration) percolating through unconsolidated mine waste material in the McLaren Pit area. The infiltration rate calculated from the HELP modeling was combined with water quality data to estimate metal loading to Daisy Creek. The HELP model is a quasi-two-dimensional hydrologic model developed by the U.S. Army Corps of Engineers for the EPA that models water movement across, into, through, and out of landfills. The HELP Users Guide (Schroeder et. al., 1994) states, "The primary purpose of the model is to assist in the comparison of design alternatives as judged by their water balances." The analysis presented in this section characterizes the current conditions in the McLaren Pit. The complete and detailed modeling results are included in Appendix A and a discussion of the HELP modeling is presented in Appendix B.

Static water level measurements made in monitoring wells completed in the vicinity of the backfilled McLaren Pit demonstrate significant large-scale fluctuation in water levels throughout the year (Figure 9). Typically, wells completed in the McLaren Pit backfill material fluctuate on the order of two to three feet in elevation. Wells completed in the bedrock material may exhibit water level fluctuations as large as 48 feet. This fluctuation suggests that the sulfide bearing mine wastes may be subject to periodic oxidation with subsequent flushing of infiltration waters through the material. As a result of oxidation and chemical reaction with the wastes, water that has percolated through the waste may contain considerable acidity and large metal concentrations, and likely is a source of groundwater and surface water contamination.

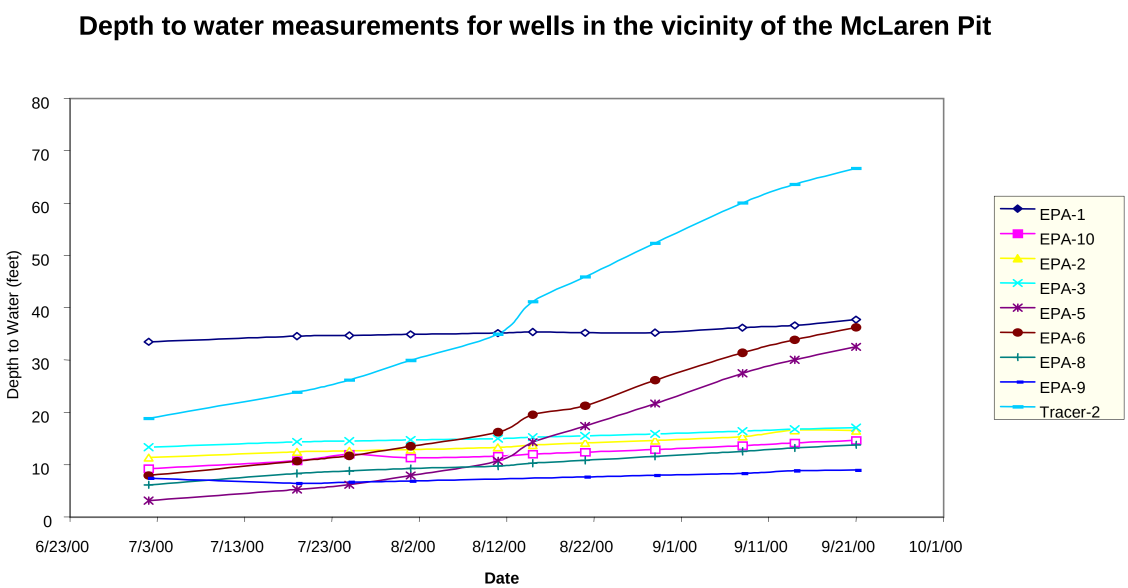

Figure 9

The purpose of this investigation was to attempt to determine whether:

- The observed changes in elevation of the potentiometric surface (groundwater surface elevation) in wells completed in the pit backfill material are the result of groundwater inflow or the result of direct infiltration.
- To use the values calculated for infiltration in conjunction with water quality data to estimate potential loading to Daisy Creek

By quantifying the source of water (i.e. infiltration or groundwater inflows) in the pit, the impact to Daisy Creek from the pit can be determined. Due to the limited quantity of detailed, long-term hydrogeologic and climatic data available, the U.S. EPA HELP3 (Hydrologic Evaluation of Landfill Performance) model was the most appropriate approach to calculation of a water balance for the backfilled McLaren Pit. The HELP3 model simulation results were compared to actual observed potentiometric surface (head) elevation changes. If the model required using unrealistic input values to achieve a reasonable correlation between the predicted and observed head (water table) fluctuations, this would suggest that other sources of water were significant at the site. Conversely, if the model achieved a reasonable correlation between measured and predicted head conditions using realistic input values, it would suggest that infiltration is the primary source of water responsible for the observed head fluctuations.

3.7.1 MODEL INPUTS

Implementation of a HELP3 model requires the following input parameters or variables to be defined (these parameters are described in detail in Appendix B).

- Climatic information, including daily precipitation, daily solar radiation, and daily mean temperature. Data collected at nearby locations were used after proper correction to account for differences in elevation and latitude.

- Evapotranspiration information, including maximum leaf area index (LAI), and starting and ending dates for growing season. LAI was set at zero to simulate the relative lack of vegetation at the site.

- Design information, including layer types and thickness.

- Soil material properties in each layer, including porosity, field capacity, wilting point, saturated hydraulic conductivity, initial water content and SCS curve number. Four waste rock samples were tested for unsaturated hydraulic characteristics. These characteristics included grain size distribution, volumetric water content at field capacity (-1/3 bars suction), volumetric water content at wilting point (–15 bars suction), saturated hydraulic conductivity and porosity

3.7.2 MODEL SETUP AND CALIBRATION

A model of the waste rock system was created using approximately 10 feet (120) inches of waste rock underlain by approximately 6 inches of a barrier soil layer. The actual backfill thickness varies from 0 to 20 feet. However, an average overall depth of 10 feet probably represents conditions in the vicinity of the two monitoring wells chosen for calibration purposes. The barrier soil layer (relatively impermeable layer) was included to model the more limited flow potential from fracture controlled secondary permeability within the bedrock system underlying the McLaren waste rock backfill. Unsaturated hydraulic characteristics for the “bedrock” system were taken from literature values (Tindall, 1999).

An attempt was made to calibrate the model to the 1996-1997 potentiometric-surface data set as it is fairly complete. Wells EPA-3 and EPA-4 were chosen as calibration targets. These wells were completed in the backfill material and have a relatively complete set of water level data records.

3.7.3 RESULTS

In an effort to increase the amount of water predicted in the backfill, to fit the model to observed static levels, the percentage of area allowing runoff was decreased from 100 to 50%. The predicted potentiometric surface elevations were then relatively comparable to measured values for monitoring wells EPA-3 and 4, as shown in Figure 9.

Figure 10 indicates that the amount of measured change in the potentiometric surface observed at the McLaren site can be simulated using a simple infiltration model. However, it was necessary to modify the amount of area producing runoff in order to have the HELP3 model successfully mimic the measured results. The portion of the area producing runoff is commonly used to account for shallow surface storage features that may be present on a re-graded surface. The necessity of reducing the area producing runoff to make the model results converge on the observed data may reflect the effects of preferential flow paths on or below the surface of the back fill. This pattern of flow would tend to result in zones that would preferentially capture runoff from up-gradient areas, thereby enhancing infiltration.

Percolation or infiltration testing performed on-site in the McLaren waste rock material report permeability measurements that range from 0.2 to 500 centimeters per hour (three orders of magnitude). Such a large range in permeability values supports the hypothesis that there are significant local variations in hydraulic conductivity and almost certainly preferential flow within the waste materials.

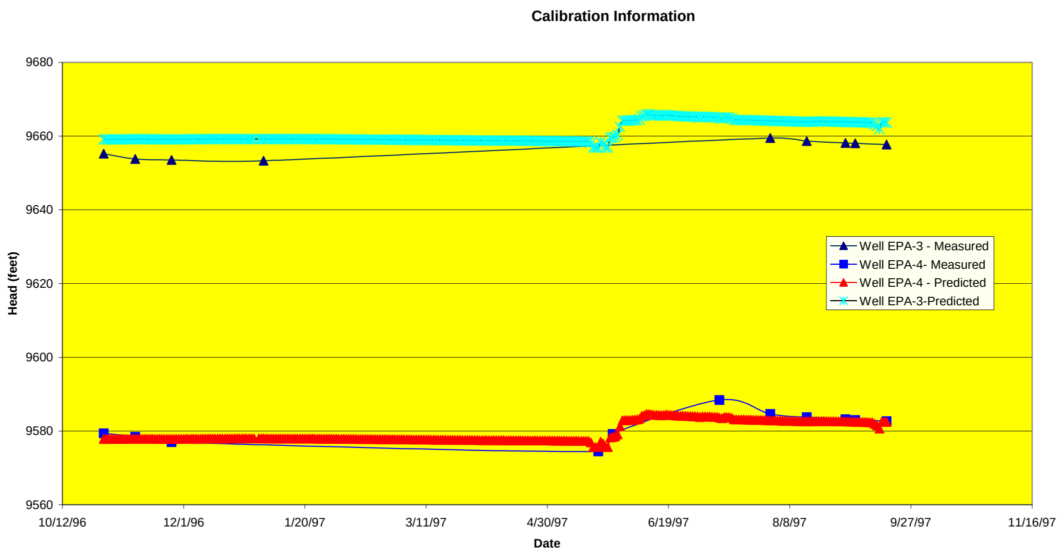

Figure 10. Comparison of HELP3 predicted potentiometric surface values with field measured potentiometric surface values in monitor wells EPA 3 and 4 at the McLaren Pit.

While this interpretation of preferential flow appears reasonable, it should be noted that these results could equally well be explained by a seasonal addition of water to the backfill from the underlying or local groundwater flow system. There is additional evidence to suggest and support a connection between the groundwater flow system and water within the pit backfill material. Tracer studies in the area indicated the presence of tracer dye in pit backfill wells following dye introduction in adjacent bedrock wells. (URS, 1998).

The HELP3 model results indicate that even though the assumed saturated hydraulic conductivity of the bedrock system is low, water does drain through the pit backfill material into the local groundwater system, indicating that some connection between the bedrock groundwater system and the pit backfill system exists (Table 3-11). Given the large fluctuations in heads observed in the groundwater (bedrock) flow system, it is plausible that some amount of groundwater flows upward and enters the backfill material. However, as these modeling results indicate, most if not all of the water in the backfill could result from infiltration alone.

Table 3-11
Base Case (Existing Conditions) of HELP Modeling of Infiltration Through McLaren Wastes.

Annual Precipitation inches	Evapo-Transpiration Inches/year	Run-Off Inches/year	Seepage Inches/year	Seepage Gallons/minute
55	14.7	30.8	9.3	5.5

3.7.4 Uncertainty

It is important to note that the analysis presented thus far has been based on several derived and/or calculated values. This analysis required calculation of several significant climatic variables, including precipitation and mean daily temperature. Although both professional judgment and experience were used in deriving these relationships, these results should be viewed as general results only. Completion of this analysis also required estimation of the unsaturated hydraulic characteristics for both the waste rock backfill and the underlying bedrock system. However, the unsaturated hydraulic characteristics of the waste rock material were measured in both field and laboratory tests. This suggests that the material parameters used in the model are likely to be close to actual values.

A key step in this evaluation is the comparison between measured and predicted head conditions within the backfill. This comparison has been conducted using a relatively limited amount of data. However, data collected from several years indicates similar magnitudes of head changes at approximately the same time, suggesting that the calibration target represents a reasonable annual response. Finally, it should be noted that while the results indicate the infiltration alone may account for the observed head changes, it does not show that groundwater interactions are not also present.

3.8 MODELING OF GEOCHEMICAL MASS-LOADING TO DAISY CREEK

Geochemical mass-load modeling was conducted in an attempt to assess the effects of the seepage from the McLaren Mine waste rock backfill materials on water chemistry conditions in Daisy Creek using a series of mass-loading comparisons. Loads are calculated using the flow rate multiplied by constituent concentration and are often reported in units of pounds of constituent per day. They are useful for gauging the relative magnitude of impacts from various sites or facilities on receiving bodies of water. Load calculations are less accurate in assessing the “actual” constituent concentrations because of the inherent simplicity of the method.

3.8.1 ASSUMPTIONS AND INPUTS

Load analysis for the McLaren Pit is based on several fundamental assumptions. First, it assumes that all water exiting the pit reports immediately to Daisy Creek. It also assumes that water exiting the pit does not mix with regional groundwater. In addition, this direct type of comparison does not take into account possible complex geochemical reactions (i.e. precipitation of minerals en-route and co-precipitation or sorption of trace metals onto precipitated mineral surfaces) that are known to occur between the McLaren Pit and Daisy Creek and along the length of Daisy Creek. Details and a discussion of the Mass Load Modeling are presented in Appendix C.

In order to complete this geochemical loading comparison, the following information was required:

- *Estimation of the rate at which water exits the pit backfill*

  HELP3 was used to calculate mean monthly seepage rates from the pit. The physical model, material properties and initial conditions used for these simulations were identical to those developed during the base case model calibration (as discussed in Section 3.7).

- *Estimation of the constituent concentration exiting the pit*

  Two wells (EPA-3 and EPA-4) are completed in the McLaren Pit backfill. Since the chemistry of solutions exiting the backfilled pit is unknown, seepage chemistry was simulated using data from wells EPA-3 and EPA-4 as separate cases. A linear regression was used to estimate the correlation between head and concentration of constituents in the pit backfill.

- *Estimation of the surface water discharge in Daisy Creek at the station of interest*

  A synthetic mean monthly hydrograph was developed for station DC-5 (9,925 m downstream) to estimate surface water discharge in Daisy Creek.

- *Estimation of the constituent concentration at the surface water station of interest*

  Flow rates and constituent concentration values for the Daisy Creek DC-5 surface water-sampling site are derived from actual measured field parameters and geochemical analyses of water chemistry. These data pairs were then entered into a curve-fitting program and a series of regressions (both linear and non-linear) were evaluated.

3.8.2 LONG-TERM SIMULATIONS RESULTS

Comparison of surface water loads to the calculated loads for water exiting the backfilled pit can be thought of as representing the proportion of the surface water load that may be attributed to McLaren Pit seepage. As the true concentration of constituents in the pit backfill seepage is not known, simulations were conducted using actual measured water constituents from monitoring wells EPA-3 and EPA-4 to estimate the constituent concentration of water exiting the pit backfill. Figure 11 depicts the model results assuming that the pit backfill seepage chemistry was similar to EPA-4. Figure 12 presents the results obtained assuming that the pit backfill seepage chemistry was similar to EPA-3.

The forms of the curves generated by the results of the two analyses are generally similar. In both cases, the proportion of surface water load attributed to pit seepage reaches a low during the summer for all constituents. Another way of illustrating the load prediction results is by calculating the average annual proportion of the surface water load at DC-5 that may be attributed to pit backfill seepage. Table 3-12 presents the results of these calculations.

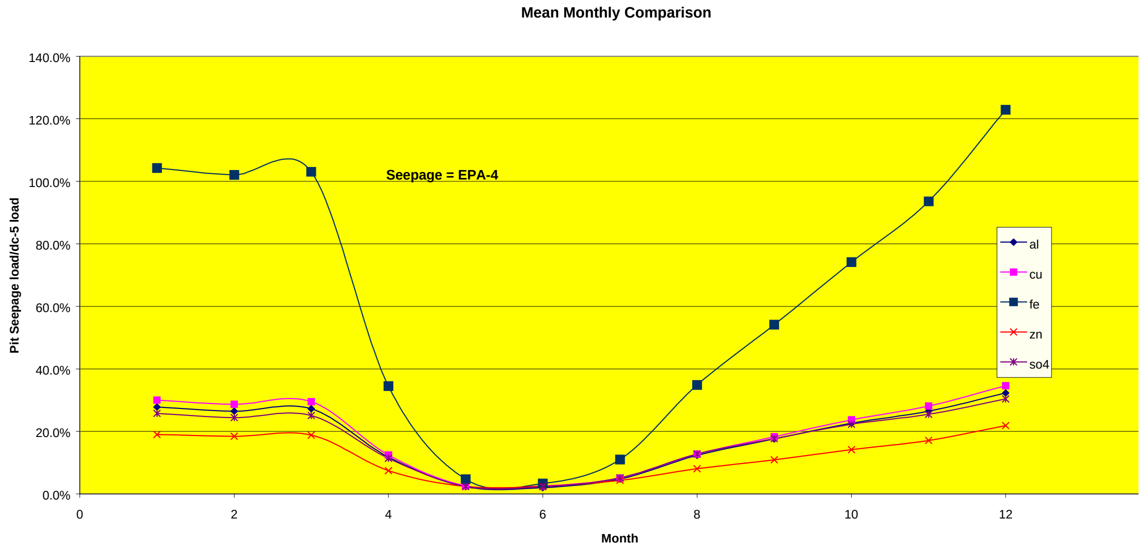

Figure 11. Results of the load comparisons at station DC-5. Loads are depicted as proportion of the load at station DC-5 that may be attributed to McLaren Pit seepage. Pit seepage chemistry is simulated using the results for well EPA-4.

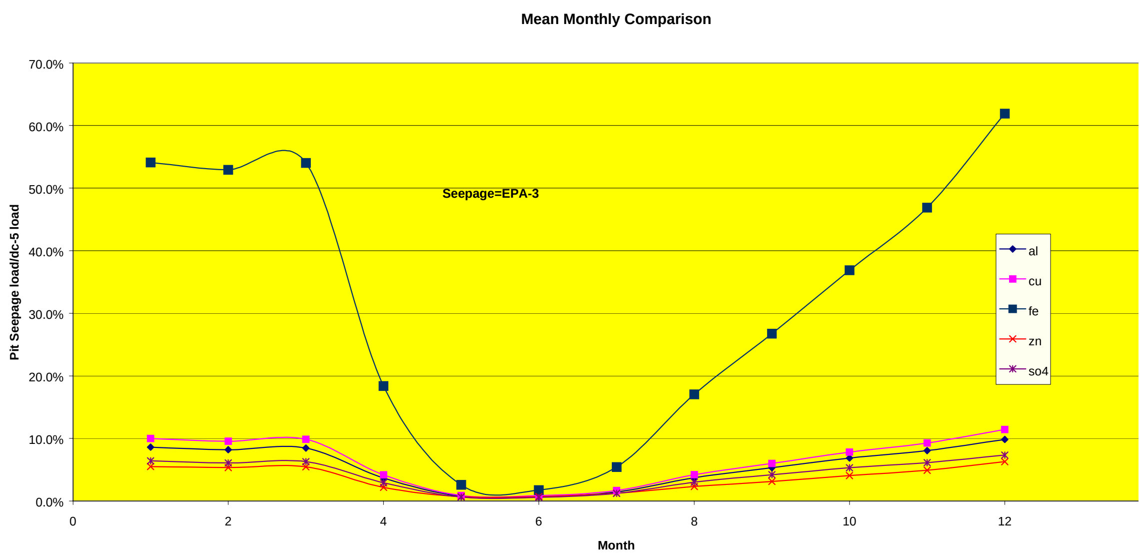

Figure 12. Results of the load comparisons at station DC-5. Loads are depicted as proportion of the load at station DC-5 that may be attributed to McLaren Pit seepage. Pit seepage chemistry is simulated using the results for well EPA-3.

Table 3-12
Percent of Average Annual Surface Water Loads at Station DC-5
Comparison of Pit Seepage Chemistry from McLaren Pit

Station	Pit Seepage chemistry	Parameter (%)				
		Sulfate	Aluminum	Copper	Iron	Zinc
DC-5	EPA-4	17	18	19	62	12
DC-5	EPA-3	4	6	6	32	4

Table 3-12 shows that the portion of the copper load at DC-5 attributable to the McLaren Pit backfill seepage is less than 10% if we assume that the seepage chemistry is like EPA-3 chemistry in composition, and less than 20% if we assume that the seepage chemistry is like that of EPA-4.

The results of this study are dependent on the seepage chemistry exiting the pit. Since the real seepage chemistry is unknown, these results presented above were compared with those of a mass load study of Daisy Creek conducted by Nimick and Cleasby (2001).

In order to use the results of the Nimick and Cleasby (2001) mass load analysis to estimate groundwater flow rates, it is necessary to determine the reach of Daisy Creek that would be expected to exhibit the influence of McLaren Pit seepage. URS (1998) used the available potentiometric (water table elevation) surface data to define groundwater flow vectors in the vicinity of the McLaren pit. By applying this vector to the northern and southern margins of the pit, a zone of potential groundwater influence along Daisy Creek can be estimated. This zone extends from above the Daisy Creek headwater to between stations 691 and 819 (feet downstream from the headwater). For the remainder of the comparisons, station 819 was therefore used as the station of interest on Daisy Creek.

3.8.3 FLOW RESULTS - COMPARISONS OF SHORT-TERM SIMULATIONS TO MEASURED DATA

Nimick (2001) uses measured surface water inflows from tributaries with main-stream Daisy Creek surface water flow measurements to calculate subsurface inflow contributions for each reach of the stream. Assuming that Daisy Creek represents local groundwater control, (i.e., groundwater tends to flow into Daisy Creek from both the McLaren Pit side and the opposite side of the creek), approximately half of the calculated contribution to Daisy Creek may be influenced by the presence of the McLaren Pit. In addition, field evidence suggests that a portion of the inflow reported by Nimick (2001) as surface water inflow actually represents a groundwater discharge to surface water. However, it is also possible these surface water flows represent relatively shallow flow responses to precipitation occurring prior to the field measurements.

If it were assumed that the surface water flows occurring on the McLaren Pit side of Daisy Creek (i.e. right bank looking downstream) represent groundwater flow, then the total groundwater inflow that may be influenced by the McLaren pit would be calculated as the sum of:

- Half the calculated subsurface inflow; and,
- All of the surface water inflow from the right bank.

Using these assumptions, the total groundwater discharge between station 0 and 819 is estimated to be approximately 70 gpm. HELP3 modeling results indicate a seepage rate of 8 gpm from the McLaren pit for the same time period. Therefore, the McLaren waste rock pit seepage represents about 11% (8gpm / 70gpm) of the total flow into this upper reach of Daisy Creek. This is in agreement with the relative portion of the drainage basin that the McLaren mine area represents with respect to the size of the Daisy Creek drainage basin above station 819, again about 10%.

Given the available information, it is difficult to accurately apportion the surface water inflow term into the various possible components. Although the actual amount of groundwater flow that may be attributed to McLaren Pit cannot be completely quantified using the Nimick analysis, the Nimick study appears to support the general seepage rate predicted by the HELP3 model.

3.8.4 LOAD RESULTS - COMPARISONS OF SHORT-TERM SIMULATIONS TO MEASURED DATA

Continuing to use Nimick's analysis, it is possible to calculate the cumulative load of key constituents attributed to the groundwater flow system between station 0 and 819. These load values can then be compared to the load values estimated in the HELP3 analysis to have originated by infiltration through the McLaren wastes, using either EPA-4 and EPA-3 well water quality data. The results of this comparison are presented in Table 3-13. In Table 3-13, Nimick's analysis of the calculated groundwater constituent load shows the total load in Daisy Creek based on the flow rates and regime discussed above. The other two data columns in Table 3-13 show the calculated load contributed to Daisy Creek from waters infiltrating through the McLaren wastes, using waters of two different compositions obtained from wells EPA-3 and EPA-4. The relative amount of load contributed by water flowing through the McLaren wastes is also shown on Table 3-13 as a percent of total load for each of the two water qualities (in wells EPA-3 and EPA-4).

Table 3-13
Summary of constituent loads in groundwater calculated by Nimick, and calculated load contributed by water infiltrating through McLaren wastes in this investigation (HELP-3 modeling) using water compositions from EPA-3 and EPA-4).

Constituent	Load estimated by Nimick (1999)	Load using EPA-3		Load using EPA-4	
	Total Pounds/day	Lbs/day	% of total	Lbs/day	% of total
Sulfate	406	59	14.5	269	66
Aluminum	18.8	2.8	14.8	9.5	50
Copper	5.9	1.2	20	3.7	63
Iron	23.7	14.3	60	31.0	115
Zinc	0.77	0.12	45.6	0.4	52

Using the estimated flow rates for the groundwater system discussed above, and the cumulative constituent load between station 0 and 819, it is possible to calculate a "weighted average" water chemistry for groundwater reporting to Daisy Creek. Table 3-14 compares this calculated chemistry to constituent concentrations for wells EPA-3 and 4 on the same date. These results indicate that the "weighted average" chemistry of groundwater entering Daisy Creek between station 0 and 819 has a chemistry much more similar to the chemistry characterized by well EPA-3 than by well EPA-4. Again, using the chemistry from the EPA-3 well, this data suggests that the load of sulfate, aluminum and copper contributed by waters flowing through the McLaren wastes represents about 15% (within the 10-20% range defined elsewhere) of the total load in Daisy Creek.

Table 3-14
Comparison of calculated average concentration from Nimick and Cleasby (2001) and water chemistry measurements from wells EPA-3 and EPA-4

Constituent	Concentration (milligrams per liter)		
	Concentration calculated from Nimick (2001)	Well EPA-3	Well EPA-4(1)
Sulfate	480	576	2,604
Aluminum	22.2	27	92
Copper	6.9	12	36
Iron	28	139	302
Zinc	0.9	1.13	4.00

Notes: (1) Based on regression results and estimated potentiometric surface elevation

3.8.5 DISCUSSION

This analysis is based on the assumption that constituent loads in Daisy Creek are conservative (i.e. all the metal loads that enter the stream remains in the stream and are not lost). However, there is considerable evidence to suggest that constituent loads are not conservative and that geochemical processes play an important role in determining the observed constituent concentrations in Daisy Creek.

Field observations by a number of investigators have noted the presence of aluminum and iron mineral precipitates deposited along the bed, boulders, banks and substrate of Daisy Creek. This evidence suggests that the system is not conservative for all constituents. In addition, the detailed load analysis indicates that the load of some constituents may decrease between stations. This also supports the contention that the loads are not all conservative.

Using the data collected by Nimick and Cleasby (2001), it is possible to plot both cumulative constituent loads and loads from individual stations moving down stream from Daisy Creek's headwaters to its lower reaches, as shown for copper in Figure 13. Figure 13 shows two distinct relationships between individual station loads and cumulative loads. At locations between 0 and 5,000 feet downstream, the individual station loads and the cumulative loads are essentially identical. This suggests that the majority of the cumulative in-stream load is derived from the individual station loads. However, below approximately 5,000 feet downstream, there is a dramatic decrease in the load from the individual stations, while the cumulative in-stream load remains relatively constant. This suggests that the cumulative load below 5,000 feet is not a function of the inflow loads but is the result of other geochemical processes. The most likely geochemical process is mineral precipitation and sorption, in which constituents are deposited on the streambed and bank materials. This depletion results in constituent concentrations that are a function not of external sources but of the solubility of the deposited minerals and their ability to adsorb metals.

Figure 13 clearly indicates that, at least for copper during the time of the Nimick surface water sampling, the assumption of conservative constituents does not hold true, especially at stations greater than 5,000 ft. downstream in Daisy Creek. If copper were conservative for the Nimick study, one would expect to see individual station load measurements that more closely matched the cumulative load curve.

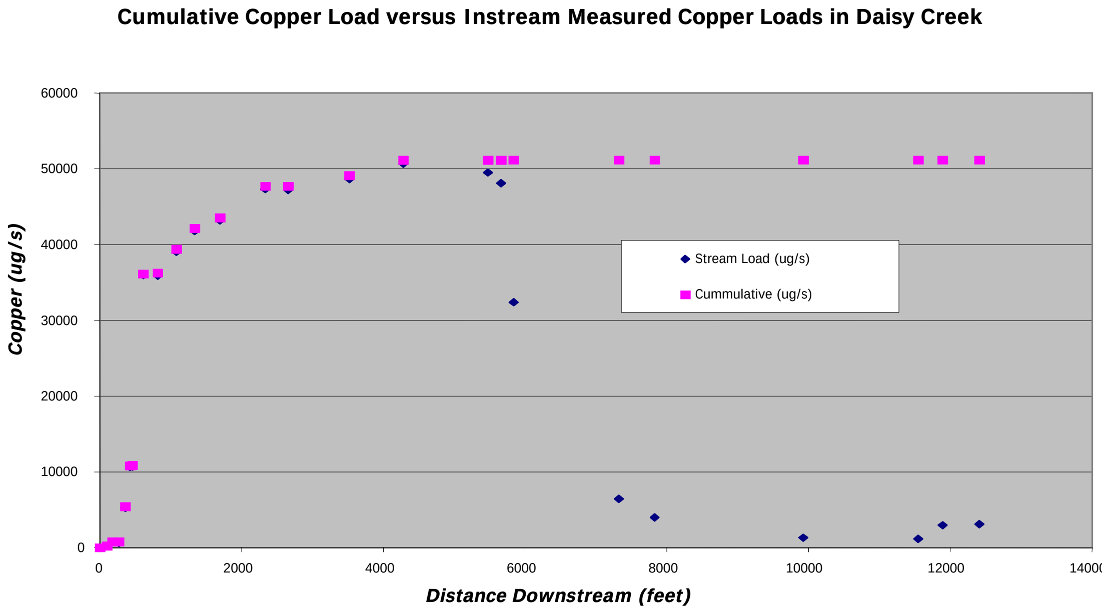

Figure 13 - Cumulative and in-stream copper loads for Daisy Creek (taken from Nimick, 2001)

Mineral precipitation and chemical equilibrium processes appear to be controlling copper loads in Daisy Creek at distances greater than 5,000 feet downstream. The total load of copper measured in the creek is substantially lower than the cumulative load of copper that has entered the creek from upstream sources at this point. Similar trends are also seen for other metals. This result indicates that chemical equilibrium between precipitated minerals and solute constituent concentrations in Daisy Creek is likely a primary control on the resulting chemistry and contaminant level in the creek. This is supported by results of thermodynamic modeling of mineral solubility using PHREEQC (short for pH redox equations computer model) for water from selected stations (Parkhurst, 1995). Furthermore, this data suggest that even a very large reduction in load from the McLaren Pit area will not substantially reduce the concentration of metals at the downstream compliance point (DC-5).

Table 3-15 shows estimated concentrations of select metals at select sampling sites assuming the full 20% metal reduction occurs in the upper reaches of Daisy Creek.

TABLE 3-15
Post Closure Estimates of Select Metal Concentrations in Daisy Creek
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

	Concentration at Selected Sampling Station (milligrams per liter)							
Parameter	DC1 (existing)	DC1 (20% reduced)	DC2 (existing)	DC2 (20% reduced)	DC5 (20% reduced)	SW-7 (existing) (1)	SW-7 (20% reduced)	B-1 Stand-ard
Al	17.3	13.8	12.93	10.34	3.83	0.292	0.234	0.087
Cu	5.646	4.517	3.61	2.888	1.375	0.079	0.063	0.012
Zn	0.732	0.586	0.503	0.402	0.207	0.025	0.020	0.110

Notes: (1) Data collected between 1990-1999 during months of May through September (average values)

As shown in Table 3-15, even at surface water Station SW-7 on the Stillwater River, concentrations of aluminum and copper exceed chronic aquatic life standards. These concentrations will continue to exceed standards until a point is reached downstream where the stability of a new mineral phase precipitates and/or dilution significantly lowers the effective concentration. Monitoring data do show a decrease in zinc concentrations at Station SW-7 below the chronic aquatic life standard.

3.8.6 UNCERTAINTY

As the mass load modeling evaluation assumes conservation of constituents, and there is evidence to suggest that this is not the case (Appendix C), care must be exercised when interpreting these results. Taken at initial face value, and on an intuitive level, it would seem that simply reducing the load of constituents exiting the McLaren Pit would lead to an equal reduction in constituent load (and therefore, constituent concentration or load) in Daisy Creek. This is however, not completely true.

If the geochemical observations discussed above are correct, these relationships may have a profound influence on the effectiveness of McLaren Pit waste remediation. These observations suggest that a decrease in contaminant load from the McLaren waste rock seepage would probably result in a similar magnitude decrease in the in-stream contaminant load in the upper reaches of Daisy Creek only (above 5,000 feet). If the mass-load model is correct, the maximum expected reduction in the concentration of contaminants expected would be about 10-20%.

However, at downstream distances greater than 5,000 feet, the in-stream load drops significantly and no longer tracks with the cumulative load. This loss of in-stream constituents probably results from mineral precipitation and metal sorption onto precipitated mineral phase surfaces. Below this point in the stream, chemical equilibrium processes are active in the system as metals in solution presumably attempt to come into equilibrium with precipitated solid phases. One obvious result of this process is that concentrations of contaminants in Daisy Creek below 5,000 feet are controlled by these equilibrium reactions and not by the cumulative load of upstream contaminant sources. Therefore, any additional reduction in in-stream loads should not be expected until reaching a point downstream where other minerals precipitate and new reactions assume control over metal loads carried in Daisy Creek.

These relationships have a considerable impact on the choice of a compliance point for water quality on Daisy Creek. For, unless and until another mineral phase controls the solubility of the contaminants (copper in this case) the concentration in Daisy Creek will not change downstream except by dilution. These results clearly show that while stopping the seepage from the McLaren Pit waste material may affect the concentration in the upper reaches (5,000 feet) of Daisy Creek (a local reduction of as much as 10-20%), it will probably not change the concentration of contaminants in the lower reaches of Daisy Creek (below 5,000 feet).

Therefore, as Figure 13 and Tables 3-14 and 3-15 indicate, removing some of the metal load point sources (i.e., the seepage from the unconsolidated wastes in the McLaren Pit) may have little effect on water quality in the lower reaches of Daisy Creek at distances greater then 5,000 feet downstream.

3.9 CONCEPTUAL MODEL

The conceptual model presented in the Overall Project Work Plan (Maxim, 1999a) illustrates that the major sources of contaminants are acid-generating, metal-laden mine waste dumps located at or near mine openings, and underground massive sulfide deposits that are exposed to the atmosphere by either mine workings or natural fracturing and faulting. These sources likely interact with infiltrating surface or groundwater. Other secondary sources of contaminants include stream sediments that have been transported downstream from primary sources and redeposited. The principal mechanisms of transport of metal-laden mine wastes include the following:

- Physical erosion of materials into surface water courses
- Dissolution of contaminants into surface water runoff
- Infiltration of dissolved metals into soil and groundwater
- Movement of impacted water through open underground mine workings and improperly abandoned exploratory borings
- Contaminated groundwater discharge into surface water
- Contaminated surface water flow to groundwater.
- Precipitation of iron and aluminum mineral phases with adsorption of trace metals in Daisy Creek along its flow path

Source areas in the headwaters of Daisy Creek (Table 3-2) account for 154,991 cubic meters or about 67% of the District's total waste rock. Most of this waste rock was placed into the excavated open pit mine as backfill material. In addition, at the McLaren Pit there is some 1.7 million metric tons of in-place, massive sulfide, and replacement deposits present in the Meagher Limestone at depths from 0 to 30 meters (0-100 feet). These deposits are enriched in sulfide minerals, principally pyrite and chalcopyrite, with varying amounts of base and precious metals (Au, Ag, Cu, Pb, Zn, Mo, Te, etc.). In an oxidizing weathering or groundwater environment, these sulfide minerals weather and release sulfuric acid, which in turn increases the solubility of metals. At the north end of the pit there is also a historic underground adit with a perennial discharge of water with demonstrated poor quality.

Modeling and quantification of flow volume from waste rock seepage indicates that probably about 11% of the flow volume in the upper reaches of Daisy Creek (downstream to station 819) may be attributable to seepage from the pit backfill material. Mass-load modeling of contaminant constituents suggests that somewhat less than 10% (but maybe as much as 20%) of the load of chemical constituents in these upper reaches of Daisy Creek may also be attributable to seepage from the McLaren Pit wastes.

It appears that the principal controls of water quality in the lower reaches of Daisy Creek can be attributed to iron and aluminum phases precipitating from solution onto the substrate materials of Daisy Creek, with co-precipitation and adsorption of metals to these phases. These reactions control the concentration of metals in the stream. Therefore, it is evident that removing the source of contaminants present in seepage from the McLaren Pit backfill will not likely have any significant impact on downstream water quality (below 5,000 feet) in Daisy Creek, although it may reduce to some extent (10-20%) the load in the upper reaches of Daisy Creek downstream to station 819.

Exposure pathways to humans and animals from mine waste sources are primarily related to direct contact or ingestion of contaminants. As the main sources present in the McLaren Mine area are located away from permanent residents, consumption of groundwater or surface water is not considered an exposure pathway for humans. Exposure of animals and birds to surface water or consumption of surface water has not been quantified, although there is likely some risk to animals and birds through ingestion of surface water in Daisy Creek and the Stillwater River upstream of Station SW-7.

Exposure pathways to aquatic organisms primarily occurs in-stream. Aquatic exposure results from contact with or consumption of metals-laden sediment and surface water. Plants that might re-colonize waste dumps are exposed to metals contaminants primarily from root uptake. These plants are often weakened or absent due to uptake of metals and low pH of waste materials.

4.0 RISK EVALUATION

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

4.1 STREAMLINED HUMAN HEALTH RISK EVALUATION

Risk-based guidelines were developed for abandoned mine sites under a recreational scenario (Tetra Tech, 1996). A *User's Guide,* prepared for use by Montana's Mine Waste Cleanup Bureau (MWCB), summarizes the risk-based guidelines and describes how they were developed (Tetra-Tech 1996). Although this risk evaluation method is not an EPA risk assessment process, it provides an additional level of detail to the process for sites characterized by mine waste and strictly recreational use.

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

4.1.1 CONTAMINANTS OF CONCERN

COCs are contaminants that pose significant potential risks to human health or the environment. Surface water data collected at the site from 1989 through 1998 (Table 3-5) were evaluated to identify the COCs for this media. Samples collected from waste rock sources from the McLaren Pit area (Table 3-3) were evaluated to determine COCs for soil, and samples collected from stream sediments in 1996 were used to determine COCs for stream sediment (Table 3-6).

Standard EPA criteria that must be collectively satisfied to establish a COC are that a contaminant: (1) 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. Based on these criteria, arsenic, cadmium, copper, lead, and zinc were identified as contaminants of concern for waste rock. Contaminants in stream sediment include arsenic, chromium, copper, iron, manganese and zinc.

For surface water risk, background data are not meaningful. Therefore, COCs were identified if average site concentrations exceeded the most restrictive water quality standard, the chronic aquatic standard for metallic contaminants. Average concentrations for chromium and manganese do not exceed the most restrictive water quality standard. Arsenic has historically not been detected in surface water above practical quantification limits (Maxim, 1998). Mean concentrations of aluminum, cadmium, copper, iron, lead, and zinc at stations DC-1, DC-2 and DC-5 on Daisy Creek exceed the chronic water quality standards, and are therefore considered COCs. However, aluminum and iron in surface water are not considered a risk to human health and will only be considered in the ecological risk portion of this evaluation. Iron only affects the aesthetics of water; no human health standards have been listed for aluminum or iron by MDEQ (MDEQ, 1998).

4.1.2 EXPOSURE ASSESSMENT

An exposure assessment identifies potentially exposed human populations, exposure pathways, and typical exposure durations. Analytical results for soil and water samples are then used to estimate COC concentrations at exposure points and the potential intake of contaminants. Current human exposure to site-related contaminants in soil and surface water is via seasonal recreational activities within the Daisy Creek headwaters. There is currently no residential use of District Property in Daisy Creek.

The streamlined risk evaluation uses the exposure assessment developed for abandoned mine sites by the MWCB that employs a recreational scenario (Tetra Tech, 1995; 1996). The scenario 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. The assessment assumed a moderate-to high level of recreational use. The types of activities, exposure pathways, and use levels considered in the recreational scenario are consistent with current recreational uses in the Daisy Creek drainage. Consequently, the recreational scenario exposure assessment is comparable and applicable to current exposure at the site.

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. Individual toxicity profiles for each COC are provided in the reference document (Tetra-Tech, 1996). The COCs for human health risk at this site are arsenic, cadmium, chromium, copper, lead, and zinc. Of these arsenic and cadmium are carcinogens.

4.1.4 RISK CHARACTERIZATION

Findings of the recreational scenario exposure assessment were combined with toxicity data for the COCs to characterize health risks posed to each population through various exposure routes (Tetra Tech, 1995, 1996). The maximum calculated risks were for: (1) a rock hound / gold panner (soil contact and surface water ingestion); (2) a fisherman (soil contact, surface water ingestion, and fish consumption); and (3) an ATV/motorcycle rider (soil contact, dust inhalation).

To ensure the protection of the majority of recreational visitors, MWCB also developed a set of conservative, risk-based cleanup guidelines for abandoned mine sites based on the lowest cleanup concentration calculated for the various types of exposure and the possibility of multiple exposure routes. The guidelines thus account for visitors participating in several activities and metals exposure routes from both soil and surface water. The conservative, risk-based cleanup guidelines for soil and water are presented in Tables 4-1 and 4-2. The guidelines for each medium are based on a hazard quotient (HQ) of 0.5 for non-carcinogens, where a HQ is the ratio of a chemical exposure concentration to a reference dose that represents a threshold level for human health effects. An HQ greater than 1.0 may cause adverse health effects. For carcinogenic risk, an excess cancer risk of $5x10^{-5}$ was used.

TABLE 4-1
Hazard Quotients for Recreational Visitors Exposed to Soil Ingestion and Dust Inhalation
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Contaminant of Concern	Average Waste Rock Concentration (mg/kg) (1)	Average Stream Sediment Concentration (mg/kg) (2)	Soil Ingestion/Dust Inhalation Guideline (mg/kg)(3)	Hazard Quotient(4)
Arsenic	105	25.7	70	1.50
Cadmium	24	1.5	1950	0.012
Chromium	<5	67	735,000 (292)(5)	0.00009 (0.23)
Copper	995	1,947	27,100	0.0072
Lead	204	90	1,100	0.18
Zinc	150	413	220,000	0.0002

Notes:
(1) Data from Maxim Technologies; mg/kg = milligrams/kilogram.
(2) Data from CDM (1997).
(3) Guidelines from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 0.5 or an increased cancer risk of 5x10-5.
(4) Hazard quotient calculated for the greater of the waste rock or in stream sediment concentration.
(5) Guideline based on chromium III risk and chromium VI risk (in parenthesis).

TABLE 4-2
Hazard Quotients for Recreational Visitors Exposed to Water and Fish Ingestion
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Contaminant of Concern	Average Water Concentration (micrograms/liter) (1)	Water and Fish Ingestion Guideline (micrograms/liter)(2)	Hazard Quotient
Arsenic	<1	6.5	-
Cadmium	1.4	66.5	--
Chromium	1	100,246(3)	0.0000099
Copper	1,3875	472	2.9
Lead	2	47.1	0.04
Zinc	207	17.2	12.0

Notes:
(1) Data from Maxim (1998) - mean concentration at DC-5 for period 1989-1998. Guidelines recalculated from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 0.5 or an increased cancer risk of 5x10-5. Guideline based on chromium III risk.
-- Not available or not calculated

Potential health risks for the site are characterized by comparing the risk-based concentrations in Tables 4-1 and 4-2 to site-specific soil and surface water quality data. The solid medium chemistry data used for the comparison are the average values presented in Tables 3-3 and 3-5.

The calculation of the hazard quotient was performed using the greater of the two media values for each constituent. Water quality data used for the calculation are the mean concentrations shown in Table 3-5 at station DC-5, located on Daisy Creek below the McLaren Mine. The total hazard quotient (Table 4-3) includes the soil ingestion/dust inhalation and water ingestion/fish ingestion routes.

TABLE 4-3
Total Hazard Quotients (HQ) for the Recreational Land Use Scenario
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Contaminant of Concern	Soil Ingestion/Dust Inhalation HQ	Water Ingestion/Fish Ingestion HQ	Total HQ for Contaminant
Arsenic	1.50	-	>1.5
Cadmium	0.012	0.02	0.32
Chromium	0.23	0.0000099	0.23
Copper	0.072	2.9	2.97
Lead	0.18	0.04	0.22
Zinc	0.002	12.0	12.0

Notes: -- Indicates data not available to make calculation
> Indicates value may be greater than the indicate value
* Assumes risk associated with chromium VI

The total hazard quotients for cadmium, chromium, and lead do not exceed 1.0, which indicates that these COCs do not pose a human health risk for the McLaren Pit Response Action. The calculation for arsenic is incomplete because recent water quality data for arsenic are not available (historic arsenic data for surface water are all less then laboratory practical quantification limits). However, because the hazard quotient for arsenic exceeds the soil ingestion/dust inhalation HQ, arsenic is considered a risk to human health.

The total hazard quotient for copper is 2.9 and for zinc is 12.0. Both these HQs result from the water component of the calculation. This suggests that copper and zinc are human health concern based on the risk assessment performed by Tetra Tech (1996). In this risk assessment, almost the entire risk of copper and zinc in surface water is posed by ingestion of fish taken from the stream by recreationists. As there are currently no fish in Daisy Creek and Fisher Creek, this risk of exposure to copper and zinc in surface water is probably not a concern at this site. Therefore, based on these limited data, arsenic is the only constituent that presents a human health risk associated with the waste dumps considered for removal under a recreational scenario.

4.2 STREAMLINED ECOLOGICAL RISK EVALUATION

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

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

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

4.2.1 Contaminants of Concern

COCs at the site were identified in Section 4.1.1 as aluminum, arsenic, cadmium, chromium, copper, iron, lead, and zinc. All of these contaminants have the potential to pose ecological risks.

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 and wetlands in Daisy Creek, located down gradient of the McLaren source areas. These receptors are of concern because Daisy Creek tributary provides habitat for aquatic organisms. A waterfall occurs as a physical barrier near the junction of Daisy Creek and the Stillwater River, and this likely precludes the possibility of Daisy Creek being a spawning area for fish migrating from the Stillwater River. Wetlands are of concern because they typically support a diverse ecological community. The second group of receptors is native terrestrial plants at the site whose ability to grow in soil or mine waste is limited by relatively high concentrations of certain metals and low pH.

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

Exposure pathways for aquatic life include: 1) direct exposure of aquatic organisms to metals in surface water that exceed toxicity thresholds; 2) exposure of aquatic organisms (e.g. insect larvae, fish embryos) to sediment pore water that is toxic due to contaminants in the sediments; 3) direct exposure of aquatic insects to metals-enriched sediments; and 4) ingestion of aquatic species (e.g. insects) that have bio-accumulated contaminants to the extent that they are toxic to predators (e.g. fish). Native terrestrial plants could be exposed to phytotoxic effects related to elevated concentrations of metals in soil or mine wastes at the site.

4.2.3 Ecological Effects Assessment

The COCs are known to have toxic effects on plants and animals (EPA, 1986; Long and Morgan, 1991; Kabata-Pendias and Pendias, 1992). No ecological effects data have been collected from the site, and no site-specific toxicity tests have been performed. As a result, this streamlined risk evaluation assesses potential ecological effects using existing and proposed ecological criteria and guidelines. The criteria and guidelines used to evaluate ecological risks from surface water, sediment, and phytotoxic soil at the site are listed in Table 4-4.

TABLE 4-4
Ecological Assessment Guidelines
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Contaminant	Surface Water (1) (micrograms/liter)	Sediment (2) (milligrams/kilogram)	Phytotoxic Soil (3) (milligrams/kilogram)
Aluminum	87	--	--
Arsenic	150	85	15-50
Cadmium	2	9	3-8
Chromium (as III)	86(4)	--	--
Copper	9.3(4)	390	60-125
Iron	1,000	--	--
Lead	3.2(4)	110	100-400
Zinc	120(4)	270	70-400

Notes:
(1) Chronic aquatic life standards from WQB-7, Montana Numeric Water Quality Standards (MDEQ, 1998).
(2) Effect Range - Median from Long and Morgan (1991).
(3) Concentration ranges from Kabata-Pendias and Pendias (1992).
(4) Chronic standard at total hardness of 100 mg/L.
-- Criteria not currently available

Surface water criteria are the Chronic Aquatic Life Standards promulgated by the State of Montana (MDEQ, 1998). Criteria for chromium (III), copper, lead, and zinc are calculated as a function of water hardness while aluminum, arsenic, and iron criteria are fixed numerical standards. The sediment guidelines consist of Effect Range - Median (ER-M) values generated from the pool of national fresh water and marine sediment toxicity information (Long and Morgan, 1991). Guidelines for soil phytotoxicity are from Kabata-Pendias and Pendias (1992). The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species. Applicable guidelines are currently not available for aluminum, chromium, and iron in sediment and soil.

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 and native terrestrial plants. This was accomplished by calculating ecologic-impact quotients (EQs), which are analogous to the HQs calculated for human exposures to non-carcinogens. Site-specific surface water and soil data used in this evaluation are summarized in Tables 3-3, 3-5, and 3-6. Mean concentrations are reported for surface water samples that were collected and analyzed between 1989 and 1998 according to EPA procedures. Waste rock samples were collected in 1996 and 1999. The EQs were generated for each COC in surface water by dividing mean concentrations at Daisy Creek station DC- 5 (Table 3-5) by the chronic water quality criteria (Table 4-4). For soils, dividing the average values from Table 3-3 by the soil phytotoxicity values in Table 4-4 generates EQs. Adverse ecological impacts may occur if an EQ value is 1.0 or greater. Results of the EQ calculations are shown in Table 4-5 and are discussed below.

Surface Water - Aquatic Life

For this scenario, surface water quality data are compared to chronic aquatic life criteria. This comparison is 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 Daisy Creek. In addition, toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of healthy aquatic organisms. The calculated EQ values indicate the potential for aquatic life impacts (EQs greater than 1.0) for aluminum, copper, iron, and zinc in surface water (Table 4-5).

TABLE 4-5
Ecological – Impact Quotients (EQ)
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Contaminant	Surface Water[1]	Sediment[2]	Phytotoxic Soil[3]	Total EQ
Aluminum	44	NC	NC	44
Arsenic	<0.006	.30	7	7.3
Cadmium	0.5	0.17	3	3.67
Chromium	0.02	NC	NC	NC
Copper	148	5	8.0	161
Iron	3.6	NC	NC	3.6
Lead	< 0.625	0.82	0.51	> 1.33
Zinc	1.725	1.53	.375	3.63

Notes (NC) Not calculated or not detected, toxicity data unavailable.
(1) Based on the DC-5 concentrations in Table 3-5
(2) Based on average concentration in Table 3-6
(3) Based on average concentration in Table 3-3

Sediment - Aquatic Life

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

Soil Phytotoxicity - Native Terrestrial Plants

Soil concentration data are compared to the lower values in the range of phytotoxicity guidelines. This comparison is limited because phytotoxicity ranges are not species-specific and thus represent toxicity to species that may or may not be present at the site. Additionally, other characteristics of waste materials, such as soil pH, texture, or nutrient deficiencies, may limit growth of terrestrial plants directly, or in combination with substrate toxicity. EQ values in Table 4-5 indicate the potential for impacts to terrestrial plant communities due to arsenic and copper in soil at the site. Although no data are available to document the release of these metals from waste rock and the subsequent uptake by vegetation, it is likely that a phytotoxic effect is occurring due to low pH. Low pH increases the mobility and bioavailability of metals except for arsenic, which is more mobile at more neutral pH levels.

In summary, most of the ecological risk at this site is in the surface water environment with the contaminants of greatest concern being aluminum, copper, iron, and zinc. Arsenic, cadmium, and copper appear to be phytotoxic in waste rock. Lead may be a potential ecological risk as its total hazard quotient for the three media is greater than one.

5.0 REMOVAL ACTION SCOPE, GOALS, AND OBJECTIVES

The risk evaluation demonstrated that arsenic is the only contaminant that poses a significant risk to human health related to ingestion and inhalation at waste rock dumps included in the McLaren Pit Response Action. Environmental risks associated with mine dumps impact surface water and groundwater due to migration of contaminants from the mine dumps. These contaminants (aluminum, arsenic, copper, iron, and zinc) present ecological risks to aquatic life. Phytotoxicity is a concern in mine waste due to excessive arsenic, cadmium, and copper concentrations and low pH values.

The scope of the McLaren Pit Response Action is to address the release of COCs from mine wastes placed as backfill into the McLaren Pit and in other nearby mine waste dumps. This section of the EE/CA presents the scope of the response action and Removal Action Objectives (RAOs) to meet project goals and applicable or relevant and appropriate requirements (ARARs).

5.1 SCOPE OF THE MCLAREN PIT RESPONSE ACTION

The scope of the McLaren Pit Response Action is limited to reducing or eliminating uncontrolled releases of metals from mine waste dumps in the Daisy Creek headwaters. Addressing environmental impacts associated with solid wastes presumes that some reduction in contaminant concentrations will occur in surface water, groundwater, and new stream sediment accumulation as a result of removing or controlling the primary sources of contamination present in solid mine wastes. Surface water run-on controls will be implemented in the source areas using best management practices; these should result in a decrease in potential metals loading to groundwater.

Contaminated sediments that have been historically deposited in and along Daisy Creek are considered second order contaminate sources (in terms of impact) that may need to be addressed in future response actions. Sediments are not being addressed under this response action because the McLaren Mine adit discharge and elevated levels of contaminants in other natural discharges will continue to contaminate sediment in Daisy Creek and the upper portion of the Stillwater River. Only when all discharge sources are controlled in the headwaters of Daisy Creek will a sediment response action be effective.

The scope of this response action does not include directly addressing contaminated groundwater or the McLaren Mine adit discharge. More comprehensive analysis of response technologies applicable to the McLaren Mine adit discharge will be completed on a District-wide basis following the detailed and on-going assessment of the Glengarry Adit discharge. Response actions associated with adit discharges in the District will likely be evaluated in a separate EE/CA. More direct active efforts to capture and treat groundwater would involve considerable additional expense and infrastructure development, and are not considered further at this time. This decision may need to be revisited as second order removal actions are considered and evaluated in future years. The performance of source control options will be assessed, and strategies for groundwater migration control/in-situ treatment and downstream contaminated sediment sources will be revisited when this performance assessment is complete.

5.2 REMOVAL ACTION OBJECTIVES

As outlined in the Overall Project Work Plan (Maxim, 1999a), 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. Based on the risk evaluation, the primary goals of the McLaren Pit Response Action are to protect the environment by minimizing plant uptake of contaminants and reducing the migration of contaminants into the environment.

The overall scope of the project is described in the Consent Decree (pp. 12-13, . VII.7(a)), which directs the project work to address the following:

- Releases or threats of release of hazardous substances, pollutants or contaminants that are related to District Property.

- Natural resources lost as a result of, or injured or destroyed by, releases or threats of release of hazardous substances, pollutants or contaminants that are released to District Property.

- Conditions affecting water quality and natural resources in Miller, Fisher, and Daisy creeks, and their tributaries.

The Overall Project Work Plan (Maxim, 1999a) identifies 11 objectives to achieve project goals. The plan also recommends supplementing those objectives to correspond to response actions proposed for a given year. The project specific RAOs for the McLaren Pit Response Action, which is focused on removing select waste rock dumps in Daisy Creek headwaters and minimizing impacts from the McLaren Pit waste rock are:

- Minimize phytotoxicity resulting from high concentrations of arsenic and copper and low pH in selected waste rock dumps and mine backfill waste material

- Prevent soluble contaminants or contaminated solid materials from migrating in either surface or groundwater into adjacent drainages to the extent practicable.

- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or metals contamination in adjacent surface water and groundwater to the extent practicable.

- Prevent potential exposure to metal contaminants through the food chain from acid discharges and waste rock to the extent practicable.

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

- Comply with ARARs to the extent practicable, considering the exigencies of the circumstances.

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

5.3 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, the primary contaminant-specific ARARs apply to groundwater and surface water. There are no contaminant-specific ARARs for soil media. A preliminary list of ARARs specific to the McLaren Pit Response Action is presented in Appendix D.

5.3.1 GROUNDWATER

The ARAR-based reclamation goals for groundwater are Montana Human Health Standards. Using these standards, ARAR-based goals for the COCs in groundwater are shown in Table 5-1. Site-specific groundwater quality data are available for the District, and locally, dissolved concentrations of arsenic, cadmium, copper, iron, lead, and zinc exceed the established standards. In general, cleanup of potential contamination in groundwater is not being directly addressed by the proposed response action. However, removing or treating local sources of contaminants should provide a beneficial effect on the quality of groundwater.

TABLE 5-1
ARAR-Based Reclamation Goals for Groundwater
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Chemical	Type (1)	Concentration (μg/L) (2)
Arsenic	HHS/MCL	18 (50)
Cadmium	HHS/MCL	5
Copper	HHS/MCL	1,300 (1,000)
Iron	HHS/MCL	300(3)
Lead	HHS/MCL	15
Manganese	MCL	50(3)
Zinc	HHS/MCL	2,100 (5,000)

Notes: (1) HHS = Human Health Standard (MDEQ, 1998); MCL = Maximum Contaminant Level (EPA, 1996)
(2) μg/L = micrograms per liter
(3) Secondary standard for taste, odor, color

5.3.2 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. As the aquatic life standards are more stringent than the human health standards for the COCs (except for arsenic), and ecological risks predominate at this site, aquatic standards represent the surface water ARARs for this site. These goals are presented in Table 5-2. Those goals that are hardness dependent have been calculated based on a hardness of 100 mg/L. Hardness in the District's surface water generally ranges from 100 to 200 mg/L so these hardness-based goals are conservative. Enforcement of cleanup goals may be executed at specific water quality stations (compliance points), in which case the cleanup standard for the hardness dependent contaminants should be calculated based on the hardness at those specific stations.

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 Daisy Creek, and the headwaters of the Stillwater River on June 4, 1999.

TABLE 5-2
ARAR-Based Reclamation Goals for Surface Water
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

	Total Recoverable Metals (micrograms/liter)[(1)]							
	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Zinc
Goal	87	18	2	89	9.3	300	3.2	120

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

Although cleanup actions need not immediately achieve surface water quality standards for B-1 streams, the most restrictive standards (Table 5-2) remain the ultimate cleanup goals for the District. Temporary standards are listed in Table 3-5.

5.4 SOLID MEDIA CLEANUP GOALS

As discussed in Section 4.1, arsenic is the only contaminant that presents a human health risk in the headwaters of Daisy Creek. Recreational cleanup goals for solid mine wastes have been adopted by MDEQ in the form of cleanup guidelines. Cleanup guidelines for COCs are listed in Table 5-3.

Ecological risk from the McLaren Pit and other Daisy Creek dumps results from arsenic, cadmium, and copper phytotoxicity. As high metals concentrations, in conjunction with low soil pH, limit plant establishment on waste dumps, other criteria could apply to soil cleanup in the District. Reclamation criteria have been adopted for the Remedial Action underway on the Streamside Tailings Operable Unit near Butte, Montana. These criteria are also listed in Table 5-3 along with phytotoxicity data from the literature. Finally, in lieu of removing metals from the soil, amending the soil to neutralize potential acid generation may reduce phytotoxicity without reducing metals concentrations. Soil cleanup guidelines should be balanced with the goals for the project rather than used as numeric action levels.

TABLE 5-3
Cleanup Guidelines for Mine Waste
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

	pH (s.u.)[(4)]	Total Metals (milligrams/kilogram)				
		As	Cd	Cu	Pb	Zn
Human Health Guideline[(1)]	--	70	1,950	27,100	1,100	220,000
Reclamation Criteria[(2)]	5.5-8.5	<30	<4	<100	<100	<250
Phytotoxicity Guideline[(3)]	--	15-50	3-8	60-125	100-400	70-400

Notes: (1) Guidelines recalculated from Tetra Tech (1996). The guidelines are based on a Hazard Index of 0.5 or an increased cancer risk of $5x10^{-5}$ for the recreational visitor scenario.
(2) Criteria used for backfill materials at the Silver Bow Creek/Butte Area Streamside Tailings Operable Unit Remedial Action (ARCO, 1997).
(3) Concentration ranges from Kabata-Pendias and Pendias (1992).
(4) pH in standard units; -- indicates not applicable for this parameter

6.0 SCREENING AND DEVELOPMENT OF RESPONSE ALTERNATIVES

The conceptual model that portrays contaminant sources, release mechanisms, and exposure pathways (Section 3.4) and the RAOs developed for this phase of the project (Section 5.0) provide the basis for screening and development of response alternatives for the McLaren Pit wastes and other nearby waste rock dumps. The process presented in this section follows EPA guidance for non-time-critical removal actions (EPA, 1993) by first identifying potential response technologies and process options, screening these options through consideration of practical applications of the technologies to the scope of the removal action, and then assembling the remaining technologies and options into response alternatives.

This section of the report presents the potential response technologies, screens the technologies, and then develops the remaining technologies into alternatives. The alternatives are then evaluated in detail against three primary economic and environmental 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 the mitigation of contaminant release from waste rock in the Daisy Creek headwaters. No evaluation was conducted for technologies that directly address adit discharges, contaminated groundwater, or transported contaminated stream sediments, as these environmental media may be addressed in future response actions. Addressing environmental impacts associated with solid wastes presumes that some reduction in contaminant concentrations will occur in surface water, groundwater, and newly transported stream sediment as a result of removing or controlling the primary waste rock source of contamination. 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.

General response actions potentially capable of achieving RAOs and goals at the McLaren Pit are screened for applicability in Table 6-1. Response actions include no action, institutional controls, engineering controls, excavation and treatment, in-situ treatment, and migration treatment. The general response actions, technology types, and process options are discussed in text following the table. Screening comments are found in Table 6-1, and the logic and reasons for screening out technologies or process options are discussed in the text. Technologies and options retained for alternative development are shaded in Table 6-1.

6.1.1 NO ACTION

No action involves no further response or monitoring. No action is generally used as a baseline against which other response options are compared and is therefore ***retained*** as an alternative.

TABLE 6-1
Response Technology Screening Summary
New World Mining District – Response and Restoration Project
McLaren Pit Response Action EE/CA

General Response Action	Response Technology	Process Option	Description	Screening Comment
NO ACTION	None	Not Applicable	No Action	Retained for comparison to other options.
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing and Gates	Install fences around contaminated areas to limit access. Gating of access roads	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.
ENGINEERING CONTROLS	Containment	Soil Cover	Native or imported soil used to cover waste; soil vegetated; covers contaminant source to prevent direct contact and reduces infiltration.	Reduces surface infiltration by evapotranspiration; not effective in early spring or late fall when plants are dormant, or under conditions of peak infiltration; acid wastes may contaminate soil cover; readily implementable.
		Multi-layered Cap	Geomembrane layer covered with growth media and vegetation in contaminated surface areas.	Effective in isolating wastes from infiltration; site characteristics key to success; readily implementable; not cost effective for small sites.
		Asphalt or Concrete Cover	Apply asphalt or concrete over areas of exposed ore/waste rock.	Limited feasibility due to cracking over the long term under thermal extremes; long-term maintenance required.
	Surface Controls	Consolidation	Consolidate mine waste into single area.	Consolidation of small outlying mine dumps into larger areas of disturbance; readily implementable.
		Grading and Compaction	Level and compact waste dump surfaces to reduce slopes for managing runoff, erosion and surface infiltration.	Grading alone does not reduce contaminant mobility; potentially effective if combined with other process options; compaction helps to reduce infiltration to some degree: readily implementable.
		Revegetation	Seed mine waste with adaptive plants; controls or reduces water infiltration by evapotranspiration and controls erosion.	Effective in stabilizing wastes which do not contain phytotoxic contaminant concentrations; acid soils affect plant establishment; readily implementable.

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

TABLE 6-1 (continued)
Response Technology Screening Summary
New World Mining District – Response and Restoration Project
McLaren Pit Response Action EE/CA

General Response Action	Response Technology	Process Option	Description	Screening Comment
ENGINEERING CONTROLS (continued)	Surface Controls (Continued)	Erosion Protection Run-on / Run-off Control	Erosion resistant materials and/or commercial fabrics placed over mine wastes; storm-water diversion structures constructed to channel water away from mine wastes; lined and armored surface channels to maximize run-off from waste surfaces.	Potentially effective at reducing lateral contaminant migration; does not reduce contaminant mobility; potentially effective if combined with other process options; readily implementable.
	In Situ Capping	Soil Cover	Cover mine wastes with a soil cover.	Potentially effective. Readily implementable.
		Composite Cover	Cover mine waste with composite cover; geomembrane and growth media cover system design.	Potentially effective. Readily implementable.
	On-site Disposal	Composite Cover Repository with Leachate Collection System	Excavate mine waste and dispose in on-site repository with composite cover and leachate collection system; liners included in both cover system and at base of repository.	Potentially effective. Readily implementable.
		RCRA Designed Containment Facility	Excavate mine waste and dispose in on-site repository.	Potentially effective; higher costs associated with cover system and liner installations; implementable.
	Off-site Disposal	RCRA Landfill	Excavate mine waste and dispose in RCRA-C permitted facility.	Potentially effective because contaminant sources would be removed; high costs associated with transportation, and tipping fees; implementable.
		Solid Waste Landfill	Excavate mine waste and dispose in non-hazardous solid waste facility.	Potentially effective for non-hazardous materials or residue from other treatment options; readily implementable; cost very high due to long haul distances and tipping fees. An administrative policy by the USDA does not allow disposal of mining wastes at a solid waste facility.

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

TABLE 6-1 (continued)
Response Technology Screening Summary
New World Mining District – Response and Restoration Project
McLaren Pit Response Action EE/CA

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

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

TABLE 6-1 (continued)
Response Technology Screening Summary
New World Mining District – Response and Restoration Project
McLaren Pit Response Action EE/CA

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

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

6.1.2 INSTITUTIONAL CONTROLS

Institutional controls are used to restrict or control access to or use of a site. Land use and access restrictions are potentially applicable institutional controls. Land use restrictions would limit the possible future uses of the land through the local forest management plan. Institutional controls involving access restrictions via fencing and gates and/or land use controls do not achieve a clean-up goal, however. These options are ***retained*** to complement clean-up actions and will be combined with other process options.

6.1.3 ENGINEERING CONTROLS

Engineering controls are used to reduce the mobility of contaminants by establishing barriers that limit contaminant exposure, reduce contaminant reactivity, and prevent migration. Engineering controls typically include containment, capping, run-on/runoff controls, revegetation and/or disposal. Engineering controls generally do not reduce the volume or toxicity of hazardous materials.

Containment

Containment technologies are used as source control measures. These technologies are designed to eliminate direct contact and fugitive emissions from contaminated materials. In addition, such controls are used to divert and minimize infiltration of surface water/precipitation that may contribute to erosion and/or leachate formation. The cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary from a simple soil cover to a multi-layered Resource Conservation and Recovery Act (RCRA) hazardous waste cap. Specific RCRA landfill closure design criteria are promulgated in 40 CFR 264.310, although such designs are typically not applied to Bevill amendment RCRA-excluded mine wastes that can be placed on land.

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

Surface Controls

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

Consolidation involves grouping wastes of similar type in a common area for more efficient management or treatment. Consolidation may be important in the McLaren Mine area where multiple smaller waste sources are present nearby and can be consolidated into one disturbed area.

Grading and compaction are used to reshape and compact waste areas in order to reduce slopes, manage the run-on/run-off and infiltration of surface water, and control erosion. Depending on site conditions, periodic maintenance may be necessary to control subsidence and erosion problems after closure.

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

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

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

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

On-Site Disposal

On-site disposal can be used as a permanent source control measure. This reclamation technology involves placing the untreated or treated contaminated materials in an engineered repository located on-site. An on-site repository was selected as the preferred alternative in the initial response action proposed for the District. This repository was designed to contain additional mine wastes and could be used as a repository for mine wastes present in the McLaren area.

Contaminated media failing to meet toxicity characteristic leaching procedure (TCLP) criteria may require disposal in a RCRA hazardous waste-type repository and could be subject to RCRA landfill closure performance standards. Solid wastes from the beneficiation of ores and minerals, however, are not considered hazardous wastes under RCRA regulations (CFR 261.4 (b) (7). ***On-site disposal technologies are retained*** for further analysis.

Off-site Disposal

Off-site disposal involves excavating the contaminated materials and transporting them to an existing engineered repository permitted to accept such materials. Off-site disposal options include a centralized repository constructed for disposal of mine waste, a RCRA-permitted repository, or a solid waste landfill. Materials classified as hazardous waste as defined in RCRA would require disposal in a RCRA-permitted facility. Less toxic materials could possibly be disposed of in a permitted solid waste or sanitary landfill. ***Off-site disposal in a RCRA repository is not retained*** for further analysis.

Off-site disposal was evaluated in detail in the initial response action considered for the District (Maxim 2001), but was dropped because of high cost. Off-site disposal at a *solid waste facility is not retained* because the USDA has made an administrative policy decision that does not allow disposal of mining wastes at a solid waste facility. Also in this regard, there is a general reluctance of these facilities to accept mining wastes and there remains a liability to the government if such a facility were used.

6.1.4 EXCAVATION AND TREATMENT

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

<u>Reprocessing</u>

Reprocessing involves excavation and either on-site processing and the shipping of a concentrate, or direct transportation of all contaminated materials to an existing mill or smelter for processing and recovery of valuable metals. Reprocessing of mine/mill wastes from outside sources is not commonly practiced due to the low concentrations of metals in source materials, operating permits limiting processing of off-site materials, and liability issues. Applicability of this option is dependent on the concentration of economically viable elements and the ability and willingness of the facility to process the material and dispose of the waste. The McLaren Pit waste material is, however, known to contain valuable gold, copper, and silver credits. Therefore, it may be possible to process these wastes on-site, ship a concentrate to a processing facility, and retain the reprocessed waste to be used as a cap for closure of the McLaren Pit.

On-site reprocessing would involve obtaining portable equipment including a crusher, screening plant, ball mill (grind to 80% less than 180 mesh), and floatation mill. The waste rock would be crushed to produce a pyrite and chalcopyrite concentrate (about 32,215 tons) that could be shipped off site to a processing facility to recover the gold, copper, and silver. The concentrate would be high enough grade to ship direct to a smelter.

Reprocessing of the wastes greatly reduces contaminant content and acidity of the wastes and improves the texture of remaining waste rock for use in reclamation and as a possible cover material. To evaluate this process option in more detail, a preliminary analysis of the value of the precious minerals was done, along with the cost to reprocess the material.

The average grade of the McLaren Pit waste is 2.2 grams per ton (g/t) or 0.07 ounces per ton (opt) gold, 10.98 g/t (0.38 opt) silver, and 0.38% copper. Assuming the presence of approximately 136,495 cubic meters (178,529 cubic yards) of waste material with a density of about 0.44 cubic meters/metric ton (14 cubic feet per ton), there are about 312,348 metric tons (344,305 tons) of waste material in the pit. Therefore, this material contains 24,101 ounces of gold, 130,836 ounces of silver and 2,616,718 pounds of copper. Assuming gold values of $250/ounce, copper values of $1 per pound and silver values of $5 per ounce, the gross value of these materials is $ 9,296,148 ($6,025,250 in gold, $654,180 in silver, and $2,616,718 in copper).

The flotation process produces a waste tailing with a fine silt texture and a pH ranging from 10 to 11. The concentration of sulfides in the pit waste would be reduced from 3 to 4% to less than about 0.3%, and with further refinement of the processing to about 0.01%. The tailing could be dried and placed back in the pit as a relatively impermeable capping material and a base for a growth media. The tailing cap would be amended, and nutrients added as needed and revegetated . Process water, capital costs, and power are potential problems that are not evaluated further at this point. If milling and shipping were to prove viable, the portable mill could be used to process the McLaren Tailings, which may make the option more feasible. The McLaren Tailings are of comparable grade and tonnage to those of the McLaren pit.

In considering final closure of the pit with the reprocessed waste, HELP modeling was conducted to evaluate the amount of seepage that would be produced through the waste. Results of this analysis are shown in Table 6-2. The existing condition is 9.3 gallons per minute seepage. Seepage would be reduced and water quality of the seepage through the processed waste would be substantially better than the current condition.

Table 6-2
Results of HELP Modeling
Infiltration Through Reprocessed McLaren Wastes

Annual Precipitation inches	Evapo-Transpiration Inches/year	Run-Off Inches/year	Seepage Inches/year	Seepage Gallons/minute
55	14.0	35.9	5.2	8.9

Table 6-3 presents the results of the preliminary cost analysis. The principal costs involved are capital costs for the equipment used in the processing facility, the cost of which cannot be recouped against such a small tonnage of rock. Another costly element of this alternative is in the failure of the smelter to return full value of the contained metals, because of smelter penalties associated with particular aspects of the ore (high iron, low silica). The cost of reprocessing to produce a relatively uncontaminated tailing material for use in reclamation is about $7,352,400, which includes recovered value of the metals. ***On-site reprocessing is not retained*** for further evaluation due to high capital costs.

<u>Fixation/Stabilization</u>

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

Table 6-3
Cost analysis for onsite reprocessing of waste rock, McLaren Mine area.

Activity	Amount	Units	(Cost) or Revenue
Waste rock in McLaren Pit			
Pyrite content	4%		
Gold content	0.07	ounces/ton	
Silver content	0.38	ounces/ton	
Silica content of host rock	30%		
Tonnage	344,305	tons	
Total pyrite	13,772	tons	
Total gold	24,101	ounces	
Total silver	130,836	ounces	
Concentrate from waste rock (assuming 90% pyrite in concentrate and 99% pyrite recovery)			
Tonnage	15,149	tons	
Pyrite content	90%		
Gold content	1.56	ounces/ton	
Silver content	8.46	ounces/ton	
Silica content	3%		
Total pyrite	13,634	tons	
Total gold	23,622	ounces	
Total silver	128,232	ounces	
Plant Capital Cost (1,100 tons per day capacity)			**($8,150,029)**
Net Smelter Return			
Gold value	$250	/ounce	$5,905,433
Gold ounce deduction	0.02	oz./ton	($68,172)
Silver value	$5.00	/ounce	$641,161
Silver ounce deduction	1.00	oz./ton	($68,172)
Payment deduction	5%		($320,512)
Treatment charge	$50	/ton	($757,471)
Iron deduction	$1.00	/%>10%	($560,529)
Silica deduction	$1.00	/%<60%	($867,649)
NSR			**$3,904,089**
Plant Operating Costs (1,100 tons per day capacity)			
Operating cost	$9.24	/ton	**($3,182,284)**
Transportation costs			
One-way distance	350	miles	
Truck capacity	25	tons	
Cost	$2.00	/loaded mile	**($424,184)**
Plant Salvage Value			**$500,000**
TOTAL UNDISCOUNTED CASH COST			**($7,352,407)**

Sources: WME, Inc. Mining Cost Services, Western Mine Engineering, Inc. (1998)
ASARCO: ASARCO East Helena Smelter Schedule (2000)

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

Fixation with lime is retained for further consideration. ***Stabilization using pozzolans is not retained*** due to higher costs associated with the process.

Physical/Chemical Treatment

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

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

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

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

Thermal Treatment

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

6.1.5 IN-SITU TREATMENT

In-situ treatment involves treating contaminated materials in place with the objective of reducing mobility and toxicity of problem constituents. In-situ treatments provide less control than excavation and treatment options because it affords less efficient mixing of additives. In-situ treatment technologies include physical/chemical and thermal treatment processes. Physical/chemical treatment technologies include stabilization/solidification and soil flushing while thermal treatment technology relies on the process of vitrification.

Physical/Chemical Treatment

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

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

Thermal Treatment

In-situ vitrification is an innovative process used to melt contaminated solid media in place to immobilize metals into a glass-like, inert, non-leachable solid matrix. Vitrification requires significant energy to generate sufficient current to force the solid media to act as a continuous electrical conductor. This technology is seriously inhibited by high-moisture content. Gases generated by the process must be collected and treated in an off-gas treatment system. In-situ vitrification has only been demonstrated at pilot scale, and treatment costs are extremely high compared to other treatment technologies. ***Thermal Treatment is not retained*** for further consideration because of the difficulty in implementing this technology at disperse sites that are situated in less than ideal environmental settings. The cost of this technology is expected to be high.

Reactive Barrier Wall

This treatment technology is applied here as a migration and treatment control for infiltration or percolation waters that have been contaminated by passage through the waste materials. Some surface and/or groundwater components would also be treated by this treatment technology, because it could not be separated from infiltration waters at the point of treatment. A permeable barrier wall is constructed downgradient of the contamination source, to force surface and/or groundwater to flow through the wall. The wall is constructed as a thick and hollow wall that is filled with reactive material (iron filings, organic material, limestone or various other reactive agents) that reacts with contaminated water as it flows through the wall. The wall is isolated from atmospheric conditions and thermal stresses with a cover of low permeability material. Contaminants including sulfate, nitrate, and a variety of metals have been successfully removed in this way. Reactive barrier walls have been shown to be effective in the treatment of migrating contaminated groundwater on both pilot and full-scale field-testing projects, and a dozen or more are currently in use on various projects at the present time. There is established EPA guidance for their application. They are cost effective to construct and an excellent method to treat contaminated surface or groundwater along its migration pathway. Long term maintenance is required as the agent filling the wall must be replaced periodically over time as it loses its reactive properties or becomes plugged with precipitated contaminants and can no longer effectively remove contaminants.

The University of Waterloo holds the patent for the reactive barrier technology for treating acidic mine waters. Reactive barriers consists of four main components; an organic carbon source, a bacterial source, a neutralizing source and a non-reactive porous medium. The organic source is usually made up of composted leaf mulch, composted municipal sewage waste, sawdust, composted manure and delignified cellulose, either placed alone or in some sort of a mixture. The bacterial source consists of sulfate reducing bacteria that are either cultured and grown in a laboratory or obtained from natural occurring sources. The neutralizing source is usually limestone and usually added at approximately 1-2% by volume, 2-7% by weight. Sand or gravel is mixed with the mixture to increase permeability of the mixture and is usually 5-10% by volume. The permeability of the mixture is an important parameter that must be considered while designing a reactive wall. The mixtures should be designed such that the permeability is the same as, or slightly greater than, that of the surrounding aquifer material. The permeability usually ranges from 10-3 cm/sec to 10-4 cm/sec. In order for the sulfate reducing bacteria to work, a clay cap (typically 25 to 40 cm of clay) needs to be placed on the barrier to prevent diffusion of oxygen and allow reducing conditions to develop. Bacteria are tolerant to a temperature range of 23 to 150 °F. The optimum temperature range for sulfate reducing bacteria is 60 to 80 °F. Low temperatures reduce the efficiency of the reactive barriers drastically.

A detailed pilot-scale study would be required in order to evaluate the effectiveness and applicability of this technology at the New World Site. A better understanding of the groundwater flow and velocity is also needed to accurately design this remedial system.

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

6.2 RESPONSE ALTERNATIVE DEVELOPMENT

The most promising technologies and process options were identified and retained through the screening process and are summarized in Table 6-4. These options appear to be effective and readily implementable for a reasonable cost and will be used to develop response action alternatives for further consideration. EPA guidance for non-time-critical removal actions suggests that only the most qualified technologies that apply to the media or source of contamination be evaluated in detail in the EE/CA. Using this guidance, response action alternatives for the McLaren Pit Response Action were developed by combining reclamation technologies and process options such that each alternative fulfilled in whole or part the RAOs and goals for the project. The No Action alternative is the one exception to this statement but the No Action alternative is used in the detailed analysis as a baseline against which the other alternatives can be compared. Assembling the alternatives was accomplished by combining process options so that each alternative either offered a distinct benefit over another alternative, or provided a different approach to meeting the RAOs and goals. The alternatives also cover a reasonable range of costs, an important factor that will be considered in the detailed analysis.

Table 6-5 lists four response action alternatives that will be considered in the detailed analysis. Also listed in the table are the process options and technologies that constitute each alternative. A brief description of each of the alternatives is presented below. A schematic representation of the closure alternatives and sub-alternatives is shown in Figure 14.

1. *No Action* – This alternative requires no removal, treatment or revegetation of waste. Site conditions remain unaltered and risks to human health and the environment persist.

2. *In-Situ Treatment of Waste* - In-situ treatment combines the three surface control process options with in-situ lime fixation. This alternative involves consolidating mine wastes in the Daisy Creek headwaters into the McLaren Pit regrading the waste to a stable configuration, amending varying amounts of the waste with a neutralizing lime amendment, and then revegetating the amended waste. Three sub-alternatives propose to amend different amounts or the waste materials (Figure 14). In each alternative, all wastes transported to the pit for disposal will be fully amended with lime to achieve neutrality. Alternative 2A proposes to amend the entire surface of the McLaren wastes to a depth of 30 cm. Alternative 2B proposes to amend the entire surface to a depth of 1.0 meter, and Alternative 2C proposes to excavate and amend all unconsolidated waste rock backfill in the McLaren Pit. In-situ shallow treatment has been used in the past by CBMI in the District to reclaim the McLaren Pit and the Como Basin, with limited success (Maxim 1999f). The USDA-FS has also been studying revegetation of amended waste dumps in the District since the late 1970s.

   Engineering controls including grading, compaction, surface water diversion, shallow lime amendment, nutrient additions and revegetation are common to sub-alternatives. The difference between the three sub-alternatives is in the amount of waste rock material to be amended.

   - *Alternative* 2A – *In-Situ Treatment of Select Waste and Shallow Amendment:* Waste materials will be amended with lime as required to achieve neutralization. The upper surface of the dump (30 cm) will be amended with lime and regraded/compacted. Nutrient and organic additions will be added to the waste rock surface and it will be seeded. Erosion control protection (blankets, surface water diversion and lined run-off ditches, hay bales) will be used as needed to provide for a stable surface.

TABLE 6-4
Process Options Retained From Technology Screening
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

General Response Action	Reclamation Technology	Process Option
No Action	None	Not Applicable
Institutional Controls	Access Restrictions	Fencing/Signage
		Land Use Controls
Engineering Source Controls	Surface Controls	Grading/Compaction
		Revegetation
		Erosion Protection/Run-on Control
	Waste Consolidation	Consolidate Local Wastes to McLaren Pit Area
	In-Situ Capping	Soil Cover
		Composite Geomembrane and Amended Waste Cover
		Composite Geomembrane and Soil Cover
	On-Site Disposal	Disposal in an On-Site Repository with Leachate Collection System
Excavation and Treatment	Fixation/Stabilization	Lime Fixation
In-Situ Treatment	Physical/Chemical Treatment	Lime Fixation

TABLE 6-5
Response Action Alternatives
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Alternative	Response Technology/Process Options
1. No Action	None
2A. In-Situ Treatment of Select Waste with Shallow Amendment	Consolidation of local wastes onto the McLaren Pit, regrading and compaction of waste in-situ, amendment of the upper 30 cm of the regraded surface with lime, addition of nutrients, and revegetation on a waste rock surface.
2B. In-Situ Treatment of Select Waste with Deep Amendment	Consolidation of local wastes onto the McLaren Pit, regrading and compaction of waste in-situ, amendment of consolidated wastes and the upper 0.5 to 1.0 m of the regraded surface, addition of nutrients, and revegetation on a waste rock surface.
2C. In Situ Treatment of All Wastes	Excavation of all unconsolidated waste rock, lime amendment of all waste rock, placing waste back into the pit, compaction, regrading, addition of nutrients, and revegetation on a waste rock surface.
3A. In-Situ Treatment with Soil Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, shallow amendment of waste rock (upper 30 cm), constructing a soil cover or cap, addition of nutrients and revegetation.
3B. In-Situ Treatment with Geomembrane Cover and Amended Waste Rock Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, constructing a geomembrane cover with a drain layer and an amended waste rock cap, addition of nutrients, and revegetation on a waste rock surface.
3C. In-Situ Treatment with Geomembrane Cover and Soil Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, constructing a geomembrane cover with a drain layer and a soil cap, addition of nutrients, and revegetation.
3D. In-Situ Treatment with Geomembrane Cover, Composite Waste Rock and Soil Cap	Consolidation of wastes onto the McLaren Pit, regrading waste in-situ, constructing a geomembrane cover with a drain layer and a composite amended waste rock and soil cap, addition of nutrients, and revegetation on a soil surface.
4. Disposal of McLaren Waste Rock in On-Site Repository	Partial removal (80%) of waste rock to the SB-4B repository; closure of the removed wastes with a composite cover, a bottom liner, and a leachate collection system; closure of the pit and remaining waste with alternative 2, 3A, 3B, 3C or 3D.

- Alternative 2B - *In-Situ Treatment of Select Waste and Deep Amendment: Waste* materials will be amended with lime as required to achieve neutralization. The surface of the dump will be regraded and compacted and the upper surface (50 to 100 cm) previously untreated surface material will be amended with lime. Nutrient and organic additions will be added to the waste rock surface and it will be seeded. Erosion control protection (blankets, surface water diversion and lined run-off ditches, hay bales) will be used as needed to provide for a stable surface.

Figure 14

Figure 14 – Back Page

- *Alternative 2C – In Situ Treatment of All Wastes*: All of the waste rock (pit backfill) material will be excavated and mixed with local wastes (including the multicolored dump and the spoils below the main county road and other smaller waste rock dumps). The waste rock material will be amended with a neutralizing agent (lime product, lime kiln dust, or limestone) and placed back into the pit. The waste rock surface of the pit will be regraded and compacted. Nutrient and organic additions will be added to the waste rock surface and it will be seeded. Erosion control protection (blankets, surface water diversion and lined run-off ditches, hay bales) will be added as required.

3. *In Situ treatment with a Cap* – There are four variations of this alternative. The following engineering controls are common to each of the three sub-alternatives: consolidation and regrading of wastes onto the McLaren Pit; amending the surface with nutrient and organic additions; and revegetation. The four sub-alternatives differ in the cap/cover design placed on the waste rock materials.

- *Alternative* 3A – *In-Situ Treatment with Soil Cap:* In this alternative the upper 30 cm (1 foot) will be amended with lime, and regraded waste rock will be capped with 60 cm (2 feet) of soil. Soil will be obtained from the SC-4B(I) repository site (Maxim, 2001) or other nearby, suitable source.

- *Alternative* 3B – *In-Situ Treatment with Geomembrane Cover and Amended Waste Rock Cap:* In this alternative, waste rock will be capped with a geomembrane liner material and a 60 cm (2 feet) thick gravel drain layer. The gravel drain will be covered with filter fabric and 150 cm (5 feet) of totally amended waste rock.

- *Alternative* 3C – *In-Situ Treatment with Geomembrane Cover and Soil Cap:* In this alternative, the shallow amended and regraded waste rock surface will be capped with a geomembrane liner material and a 60 cm (2 feet) thick gravel drain layer. The gravel drain will be covered with filter fabric and 90 cm (3 feet) of soil obtained from the SB-4B(I) repository site or other nearby, suitable source of soil material.

- *Alternative* 3D – *In-Situ Treatment with Geomembrane Cover and Composite Amended Waste Rock and Soil Cap:* In this alternative the shallow amended and regraded waste rock surface will be capped with a geomembrane liner material, a 60 cm (2 feet) thick gravel drain layer, overlain by a layer of a filter fabric and 60 cm (2 feet) of totally amended waste rock. A topsoil cap 30 centimeters (12 inches) thick will be placed on the amended waste rock to enhance revegetation conditions.

4. *Disposal of Waste Rock in On-Site Repository* – This alternative calls for excavation of 80% of the waste rock material from the McLaren Pit and surrounding area, and transporting it to the SB-4B repository site (Maxim, 2001). The waste will be placed on a bottom liner with a leachate collection system, and capped with a composite cap design. Final closure of the McLaren Pit and the remaining waste, which will be used to cover the exposed bedrock surface, will need to be accomplished using one of sub alternatives of either Alternative 2 or Alternative 3.

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7.0 DETAILED ANALYSIS OF RESPONSE ALTERNATIVES

Response alternatives developed in the previous section are analyzed and compared in detail in this section. Response alternatives represent a range of potential actions that can meet, to some degree, RAOs for this portion of the project, and achieve distinct levels of protectiveness to human health and the environment for a reasonable range of costs.

7.1 EVALUATION CRITERIA

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

1. Effectiveness
2. Implementability
3. Cost

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

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required to accomplish its implementation. Technical feasibility considerations include the applicability of the alternative to the waste source, availability of the required equipment and expertise to implement the alternative, and overall reliability of the alternative. Implementability also considers the appropriateness of combinations of alternatives based on site-specific conditions. Administrative feasibility evaluates logistical and scheduling constraints.

Evaluating the cost of alternatives involves developing conservative cost estimates based on the materials needed and the construction elements associated with implementing the alternative. These costs do not necessarily represent the cost that may actually be incurred during construction of the alternative because many design details are preliminary at this stage. However, a similar set of assumptions is used for all the alternatives so that the relative differences in cost between alternatives are fairly represented. Unit costs were developed by analyzing data available from USDA-FS and 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 alternatives. These PRSC costs were estimated using reasonable assumptions for likely and potential maintenance and monitoring requirements. Groundwater monitoring may be necessary to monitor changes in groundwater quality or quantity within waste rock pit backfill material and downgradient of the McLaren Pit. Groundwater monitoring may involve installing monitoring wells in the pit area and downgradient of the pit, with water quality samples and other measurements collected on a regular basis.

Due to the fact that the reclamation alternatives considered for the McLaren Pit Response Action depend almost completely on the success of revegetation and erosion control, it is difficult to determine the actual maintenance that may be needed to ensure that the alternative are successful. However, it was felt that the PRSC for Alternatives 2, 3, and 4 would be similar, and therefore a single PRSC cost was calculated for these alternatives. A separate PRSC cost was calculated for the No Action Alternative using the same monitoring costs as the other three alternatives, but without the costs for monitoring and maintenance of revegetation.

Average annual PRSC costs are estimated for a 30-year period. The present worth for PRSC is calculated using a discount rate factor of 4.9% (OSWER, 1993). The PRSC cost determined for Alternatives 2, 3, and 4 is about $112,000, and for the No Action Alternative is about $60,000. The details of this calculation are presented in Appendix E.

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.

Costs presented in this section are based on waste volumes determined from Maxim's 1999 field investigation, and supplemented, corroborated or modified by detailed volume calculations prepared by CBMI in preparing ore reserve calculations. Areas were calculated from aerial photographic interpretation (Table 3-2). Summary cost tables are presented in the cost discussion for each alternative with the supporting unit cost spreadsheets presented in Appendix F.

7.2 ANCILLARY CONSTRUCTION ACTIVITIES

Except for the no action alternative, ancillary construction activities will be necessary in addition to the primary reclamation actions associated with each alternative. These ancillary activities are described separately in this section. For Alternatives 2, 3, and 4, a temporary haul road will need to be constructed below the McLaren Pit in order to access and remove mine spoils located between the main county road and the valley floor. A separate cost for ancillary construction activities is included as a line item in the alternative cost estimates.

- *Road Improvements* - Considerable road improvements were made in 1999 on the Daisy Pass and Lulu Pass main access roads. The proposed alignment of the temporary haul road access from the McLaren Pit to the Daisy Creek valley bottom will likely spur off of the Lake Abundance Road below the Multicolor Dump (Figure 7). Much of this road can follow pre-existing but reclaimed roadways. For portions requiring new road construction, a disturbed road width of 6 meters (20 feet) would be stripped of topsoil and stockpiled along the road. Dozer grading would be used to establish a 3.7 meter (12 feet) wide travel width with periodic turnouts. This new access road will be fully reclaimed after removal of the McLaren Spoils is completed and revegetation is established on the valley slopes. Cost of the ancillary construction activities are presented in Table 7-1.

TABLE 7-1
Summary of Total Estimated Costs for Ancillary Construction
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Ancillary Activities	Quantity	Unit	Unit Cost	Total Cost
Construct Road to McLaren Spoils	915	meter	$3.28	$ 3,000
Reclaim road	915	meter	$8.20	$ 7,500
Revegetate road	0.45	hectare	$20,852	$ 9,200
TOTAL ESTIMATED COST				**$ 19,700**

7.3 CONSTRUCTION ELEMENTS COMMON TO ALL ALTERNATIVES

There are a number of construction elements that are common to all alternatives. These include: consolidation of other local wastes to the McLaren Pit, regrading and compaction of the final waste rock surface in the McLaren Mine area, soil amendment with nutrient and organic material additions, revegetation and erosion control. The tasks involved in completing these elements are described below.

Task Description

- *Site Preparation:* Clearing and grubbing of outlying waste rock dump sites; separating combustible and non-combustible debris; and, debris disposal.

- *Consolidation of Wastes*: Outlying, waste rock dumps including the Multicolored Dump and McLaren Spoils would be excavated, moved, and placed onto the McLaren Pit. These outlying sites would be graded and revegetated.

- *Regrade Waste Dumps:* Consolidated waste backfill material would be regraded to a stable configuration as allowed by the constraints of the site. Any wastes that are in contact with surface water would be pulled back so that the wastes are out of the stream's floodway and lined and armored surface water diversion ditches would be constructed on the surface of the waste rock material. Regrading would be done to blend with the surrounding topography.

- *McLaren Mine Adit Discharge* - As described in Section 5.1, which presents the scope of the removal action, response technologies will not be applied to the adit discharge present at the McLaren Mine. At a later timeframe in the overall process for the New World site, all adit discharges, including the McLaren Mine adit, will be evaluated, and further actions will be determined. However, each of the alternatives in this EE/CA will involve closing the adit by backfilling and regrading. To facilitate regrading, the adit drainage will be routed from the current point of discharge to a percolation basin constructed in front of the existing adit. A drainage channel will also be constructed to route any seasonal overflows from the percolation basin and around the area treated or capped. The historic point of discharge where the existing adit flows leave the waste site will be constructed in the same or near-by location as exists under current conditions. This construction element will prevent the untreated discharge from percolating through the mine wastes that remain at the site, or from percolating into clean backfill materials that will be brought in to replace removed wastes. The existing character and condition of the adit discharge will be essentially unchanged except for improvements that may be gained in water quality by eliminating any discharge from percolating through mine waste prior to entering a receiving stream.

- *Revegetate Waste Dump Sites:* Regrade outlying excavated areas; truck and place 15 cm (0.5 feet) of cover-soil obtained from SB-4B repository site or other nearby source. Prescriptions for revegetation will follow those developed by the USDA-FS Rocky Mountain Research Station specifically for revegetating amended mine wastes in the District. These prescriptions are summarized in the *1999 Revegetation Monitoring Report* (Maxim, 1999f). Revegetation prescriptions for mine waste specify amount and types of amendments recommended for organic matter, fertilizer, seeding, mulching, and use of erosion control blankets.

- *PRSC*: Monitoring and maintenance of vegetation on removal areas and at the McLaren Pit. Monitoring of surface water and groundwater quality downgradient of the mine site to monitor cap performance. Monitoring of groundwater in the reclaimed backfill material. Monitoring of surface erosion.

As these tasks are common to each of the alternatives described in detail below, the cost analysis for these tasks is presented in Table 7-2. These costs are added as a line item to the costs of individual alternatives and sub-alternative when presented later in this section.

7.4 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of alternatives listed in Table 6-5. A list of ARARs is presented in Appendix D.

7.4.1 NO ACTION - ALTERNATIVE NO. 1

The no action alternative involves leaving the McLaren Pit, the pit backfill material, and other nearby waste rock dumps in their existing condition. No further reclamation would be attempted at the site to control contaminant migration or to reduce toxicity or volume. The reclamation work done previously by CBMI in the McLaren Pit would be monitored, but no further investigations would be conducted. Monitoring of surface water would be conducted on a yearly basis.

Effectiveness

Overall effectiveness of the no action alternative is poor. Under existing conditions, metals will continue to migrate from the waste dumps at the headwaters of Daisy Creek into surface water and groundwater. The No Action Alternative does not address surface water impacts, nor does it provide any controls on contaminant migration via direct contact or particulate emissions. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative, although contaminant sources will diminish over time as oxidation of sulfides depletes the source.

Protection of the environment would not be achieved under this alternative. While slopes are stable in the McLaren Pit as a result of CBMI's reclamation, the unvegetated McLaren Spoils and Multicolor Dump will continue to erode into Daisy Creek tributaries. The McLaren Mine adit discharge will continue to flow through the Multicolor Dump, leaching additional metals into surface water. The declining vegetation condition and cover in the McLaren Pit will likely continue to decline over time as acid conditions in the regraded and amended surface soil worsen.

TABLE 7-2
Summary of Total Estimated Costs for Construction Common to All Alternatives
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Ancillary Activities	Quantity – units	Cost/unit	Total Cost
Clear and Grub	3.35 ha	$3,700	$12,400
Excavate, Compact, and Place Outlying Wastes			
Multicolored Dump	2,360 cm	$8.20	$19,400
McLaren Spoils	16,053 cm	$8.20	$131,700
Haul Outlying Wastes			
Multicolored Dump	2,360 cm	$1.00	$2,400
McLaren Spoils	16,053 cm	$0.40	$6,500
Regrade Outlying Areas			
Multicolored Dump	0.24 ha	$15,830	$3,800
McLaren Spoils	1.12 ha	$15,830	$19,200
Revegetate Outlying Areas			
Multicolored Dump	0.24 ha	$20,852	$5,100
McLaren Spoils	1.12 ha	$20,852	$25,300
Regrade McLaren Wastes	3.35 ha	$15,830	$53,100
Erosion Channels	1,200 m	$30	$36,000
Silt Fence	2,000 m	$16	$32,000
TOTAL ESTIMATED COST			**$ 346,400**

Note: ha = hectare; cm = cubic meter; m = meter

No action is currently in compliance with both narrative and numeric temporary water quality standards at the two stations monitored in Daisy Creek (DC-2 and DC-5) and at the station monitored on the Stillwater River (SW-7). 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.

Implementability

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

Cost

No capital costs would be incurred under this alternative. However, annual monitoring costs would be incurred for both surface water and groundwater monitoring. Long-term costs associated with No Action are unknown since there is an on-going risk that mine wastes may erode, resulting in further damage to other resources and requiring action. There are also external costs associated with no action, including the loss of certain ecological functions. Using the PRSC costs presented in Appendix E, the total monitoring cost for monitoring over a 30-year period is about $60,000.

7.4.2 In Situ Treatment of waste – Alternative No. 2

The principal process technology associated with this alternative involves in-place treatment of waste rock with a neutralizing amendment. Other aspects of this alternative are described under elements common to all alternatives and include consolidation of other local wastes to the McLaren Pit, regrading and compaction, soil amendment with nutrient and organic material, revegetation and erosion control. The three sub-alternatives evaluated under this alternative consider the addition of a neutralizing amendment to varying amounts of waste rock material. Figure 14 shows a schematic of the alternative components and sub-alternatives. A description of the alternative is presented below, followed by the detailed analysis.

<u>Alternative Task Description</u>

- *Ancillary Construction Activities (see section 7.2)*

- *Elements Common to all Alternatives (see section 7.3)*

- *Treat Waste with Neutralizing Amendment*: A neutralizing amendment, such as agricultural limestone, lime kiln dust, or calcium oxide, would be mixed into the waste according to the rate calculated for the waste material shown in Table 7-3.

  - *Alternative 2A* involves shallow lime amendment of the upper 30 cm (12 inches) of waste rock consolidated in the pit. This will involve amending approximately 10,100 cubic meters (13,200 cubic yards) or 15% of waste material with about 2,345 metric tons (mtons) of lime. This will be accomplished by amending the amount of material actually necessary, specifically the volume of material excavated from the outlying dumps, followed by placing this as a compacted layer across the surface of the waste material.

  - *Alternative 2B* involves deeper lime amendment of the upper 1.0 meter (40 inches) of waste rock consolidated in the pit. This will involve amending approximately 33,600 cubic meters (44,000 cubic yards) or 21.7% of the waste material with about 7,800 metric tons of lime.

  - *Alternative 2C* involves complete excavation of all of mine backfill material and the outlying wastes (154,911 cubic meters), amending the entire volume with a neutralizing amendment, and placing the amended material back into the McLaren Pit. Neutralization of this entire volume of material with a lime amendment would require mixing approximately 36,218 m tons of lime, which is a 19% increase in the total volume of waste materials present in the McLaren Pit area.

TABLE 7-3 Lime Requirement for Alternative 2 New World Mining District Response and Restoration Project McLaren Pit Response Action EE/CA				
Waste Dump Name And Designation	**Area hectares (acres)**	**Volume (cubic meters)**	**Lime Req[(1)] (t/1000t)**	**Lime[(2)] (mtons)**
McLaren Pit Waste Rock	3.35 (8.3)	136,495	93.8	31,667
McLaren Multicolored Dump	0.24 (0.6)	2,360	140.6	822
McLaren Spoils (wastes below road)	1.2 (2.98)	16,056	93.8	3,729
TOTALS	**4.8 (11.9)**	**154,911**	**--**	**36,218**

Notes: 1 - Lime requirement in tons of calcium carbonate equivalent amendment per 1000 tons waste.
2 - Total lime for each waste dump in metric tons (mtons); total lime calculated according to the following formula: ([{volume cubic meters x 1.31} x 1.9 tons per cubic yard]/ 1000 tons soil per ton of lime) x lime rate) x 1.1 x 0.9 mtons/ton

Help Modeling

As described in Section 3.7 for existing conditions at the site, HELP modeling was conducted on the alternative scenarios as an additional means of evaluating effectiveness (defined as reduction in the predicted amount of seepage) of the alternatives. For Alternative 2, it was assumed that regrading and compaction of the final waste rock surface in the McLaren Pit area would result in an effective increase in run off and minimize channelized flow or short-circuiting of flow through the waste rock. In the HELP model run for the existing condition, this effect was addressed in the factor “percent of area producing run-off”, which had to be reduced to 50% in order to get the model to calibrate with the measured water table fluctuations in adjacent monitoring wells. For Alternative 2 simulations, this factor was increased to 100%. The resulting seepage rate for Alternative 2 is presented in Table 7-4.

Table 7-4 Comparison of HELP Modeling Results - Infiltration through McLaren Wastes under Existing Conditions and Alternative 2					
Condition	**Annual Precipitation inches**	**Evapo-Transpiration inches/year**	**Run-Off inches/year**	**Seepage inches/year**	**Seepage gallons/minute**
Alternative 2	56	14.6	36.8	3.4	2.0
Existing	56	14.7	30.8	9.3	5.5

❖ *EFFECTIVENESS*

For each of the Alternative 2 sub-alternatives, HELP modeling indicates a decrease in the seepage rate from mine wastes from that of the existing condition. This does not have any implication with respect to the water quality of the seepage; in fact, it is possible that the seepage rate would decrease but that the concentration of contaminants within the seepage could increase. This could occur because products of sulfide oxidation will continue to dissolve into seepage until the solubility of secondary minerals is reached. It is likely that solute load would be reduced to some extent by lime amendment, particularly for Alternative 2C, where the pH of amended waste will be raised above the critical threshold of pH 5.

For Alternatives 2A and 2B, in-situ treatment would be only somewhat effective. This is because these alternatives limit the volume of waste that would be treated, and untreated wastes will remain at relatively shallow depths below the surface. Implementation of any one of the Alternative 2 sub-alternatives will not significantly affect the rate or volume of infiltration through waste rock materials. For Alternatives 2A and 2B, water will be infiltrating and percolating through non-amended waste rock. Under certain conditions during moderate to extreme weather or during snowmelt, infiltration will exceed the capability of cover soils to store and evapotranspire water so that untreated wastes will likely become saturated. Under these conditions, which can be expected to occur several times a year at the McLaren Pit, infiltrating water would flush accumulated contaminants to shallow groundwater and surface water environments.

The greatest positive impact of Alternatives 2A and 2B is the reduction of phytotoxicity at the waste rock surface, allowing establishment of vegetation. The vegetated cover uses water by evapotranspiration processes, reducing to a very limited extent the rate of infiltration into the wastes. More importantly however, the vegetative cover stabilizes the waste surface, prevents erosion and off-site transportation of the wastes, and helps to reduce the amount of contaminant transport off-site in surface waters. As each of the sub-alternatives in this analysis provides for successful revegetation of the waste surface, these benefits are also realized for Alternative 2C.

For Alternative 2C, in which all wastes are lime amended, it is presumed that most, if not all, of the contaminant migration from the unconsolidated wastes could be eliminated within a short period of time. Although infiltration and percolation rates remain the same, the treated wastes will not form acid that releases contaminants to shallow groundwater or surface water. Once existing oxidation products have been flushed from the waste, and assuming that excess alkalinity will exist to buffer any future acidity, no further sulfide oxidation will occur.

For each of the Alternative 2 sub-alternatives, control of sulfide oxidation and infiltration through the backfilled wastes will most likely only address a portion of the contamination affecting groundwater impacted by sulfide mineralization in the McLaren Pit area. Because the base of the pit beneath unconsolidated waste rock material is made up of a large volume (1.7 million metric tons) of in-place massive sulfide deposits hosted in fractured and faulted bedrock, other sources of acid and metals remain unaffected by Alternative 2.

❖ *REMOVAL ACTION OBJECTIVES*

For each Alternative 2 sub-alternative, in-situ treatment meets RAOs to varying degrees. By neutralizing the upper 30 cm of waste to a more neutral pH (Alternative 2A), phytotoxicity of the waste will be reduced to the extent that plants will grow directly in the amended waste. Alternative 2B amends the surficial waste rock materials to a greater depth, allowing for the extension of roots to a greater depth. Revegetating the waste dumps will greatly reduce soluble metals that can migrate from the dumps to surface water. Soluble metals will not be eliminated under Alternatives 2A and 2B because some portion of wastes in the dump will remain untreated and in contact with infiltrating precipitation.

Alternative 2C should greatly decrease or virtually eliminate the formation of acid, and minimize the formation of soluble metals from the unconsolidated wastes as well as allow for vegetation to be established on the surface of the amended wastes. The RAO of reducing or eliminating concentrated runoff and sediment discharges will be met through the establishment of a viable vegetative cover. Potential exposure of metal contaminants to the food chain will be reduced to a large extent in the treated waste dumps. Burrowing animals that penetrate the amended waste layer are the only remaining pathway for this exposure.

❖ *OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT*

In-situ treatment provides a reasonable measure of control of exposure to contaminated materials and reduces risk to human health and the environment. It reduces the potential for further erosion and migration of contaminants from source areas near surface water drainages by stabilizing the wastes with vegetation. The amount of contaminated leachate formed, and its potential to migrate, varies between the three Alternative 2 sub-alternatives based on the amount of waste material treated, with Alternative 2C being most effective and 2A being least effective.

A moderate protection to human health would be achieved under this alternative. As people visiting the reclaimed McLaren Pit will still be exposed to the same concentrations of metals present under existing conditions, human health exposure will not be eliminated. However, by removing the outlying waste rock material from the Multicolored Dump and McLaren Spoils, the area of total contaminated waste rock exposed will be reduced by about 30%. This represents a clear reduction in the potential for exposure to human health risks.

A 30% reduction in the surface area of waste exposed will also lessen exposure of the environment to contaminated media. However, reductions in environmental exposure of contaminants to surface water and groundwater will be minimal (maximum of 20%) due to the continued impacts from the McLaren Mine adit discharge, and contaminated groundwater from both seepage through unamended waste rock (Alternatives 2A and 2B) and natural sources of contaminated groundwater. Of the three sub-alternatives, Alternative 2C provides a high level of protection to the environment exposed to historic mining impacts.

❖ *COMPLIANCE WITH ARARS*

Temporary water quality standards are currently being met in Daisy Creek and the Stillwater River under existing conditions. However, contaminant-specific standards associated with the Montana Water Quality Act, with the exception of chromium (which is already in compliance), will not be achieved under Alternative 2. The reasons for this are discussed in some detail in Section 3.8.5. Some improvement in surface water quality in the uppermost reaches of Daisy Creek (0-5,000 feet downstream) is expected because soluble concentrations of copper and zinc would be slightly reduced. However, HELP and load modeling studies suggest that the unconsolidated McLaren Pit wastes only contribute 10-20% of the total load to Daisy Creek and even a reduction of the full 20% will not bring the waters into compliance with the established surface water ARARs. As shown in Table 3-15, even at surface water station SW-7 on the Stillwater River, concentrations of aluminum and copper will still exceed chronic aquatic life standards. Concentrations of metals downstream of the 5,000 foot mark in Daisy Creek currently exceed water quality standards and will continue to exceed standards until a point is reached downstream at which the stability of a new mineral phase precipitates and/or dilution significantly lowers the effective concentration. In addition, under higher flow conditions, some load from the McLaren Pit area will be released due to saturation and seepage from non-amended wastes under Alternatives 2A and 2B.

Although contaminant leaching should be eliminated or greatly reduced from the waste rock under Alternative 2C, contaminant-specific ARARs for Daisy Creek will still not be met during high or low flow conditions, as even a reduction of the full 20% will not bring the waters into compliance with the established ARARs. Waste rock in and around the McLaren Pit is not the only source of contaminants in the Daisy Creek headwaters area. There are naturally occurring bedrock sources of metals and acidity present in the 1.7 million metric tons of massive sulfide deposits immediately underlying and adjacent to the McLaren wastes. Massive sulfides are also exposed in the highwall of the McLaren Pit. Also, at least 40 million tons of Fisher Mountain Intrusive that makes up the mass of Fisher Mountain contains an average of about 2% disseminated sulfides. Groundwater migration out of these sulfide and metals-bearing bedrock units into surface water and groundwater supplying base flow to Daisy Creek is an additional potential and probably significant source of metals (Nimick, 1999) and acidity contamination. There are also sulfide and metal bearing sediments, as well as chemical precipitates that have been deposited along Daisy Creek that represent secondary sources of contamination. Finally, there are ferricrete deposits (iron and manganese oxide cemented colluvial deposits containing considerable metals concentrations) that have been and are being deposited downgradient of the McLaren Pit where seeps and springs containing metals-enriched groundwater surface. Radiocarbon dating of organic materials in ferricrete deposits provides clear evidence that acid rock drainage and metal contamination occurred naturally prior to historic mining.

Surface water quality at station DC-5 will improve slightly as a direct result of treating the McLaren wastes under Alternative 2. This slight improvement in water quality is limited by control of water chemistry at DC-5 by mineral precipitates and metals sorption, as well as local groundwater contributions, rather than by upstream loading. Erosion from the revegetated waste dumps would also be greatly reduced, reducing sediment loading that currently reports to Daisy Creek. A reduction of precipitates in Daisy Creek would also be achieved under the Alternative 2 sub-alternatives.

Groundwater has not been investigated sufficiently in the vicinity of the McLaren Pit to identify the exact sources and relative amount of contamination for any particular source. However, groundwater studies are ongoing, as a series of hydrologic study wells will be completed in, around, and downgradient of the McLaren Pit during the summer of 2001. Groundwater quality is known to be impacted downgradient from the pit and the degree to which groundwater is contaminated can be documented (Nimick, 1999). In-situ treatment of unconsolidated wastes will likely have only a minor positive and very local effect on groundwater. It will likely have no effect on groundwater for those times when non-amended wastes become saturated under Alternatives 2A and 2B. Local groundwater ARARs have the greatest possibility to be met under Alternative 2C, at least for groundwater contamination associated with the waste rock.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because the wastes will be revegetated. Although dust and problems with PM-10 airborne contaminants have not been investigated, air quality should improve to some extent because the unvegetated dumps will be revegetated. The very limited time during which dry conditions exist in the McLaren Pit area suggest that this reduction in human health risk is quite minor.

Location-specific ARARs are expected to be met to a substantial degree. Certain cultural and historic features may be affected if this alternative is implemented. Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed adits; and regrading mine dumps. Historic structures and debris located adjacent to the dumps will be protected. Historic structures and debris that can be easily salvaged will be moved off the dumps and protected to represent elements of the former mining features. Requirements of the National Historic Preservation Act and the Archaeological and Historic Preservation Act will be met through consultation with the State Historic Preservation Office by the USDA-FS, and mitigation of cultural and historic impacts on the District as a whole.

Threatened and endangered species are present in or near the District. During development of the Draft Environmental Impact Statement for CBMI's proposed mine in the District, consultation with the U.S. Fish and Wildlife Service identified the grizzly bear, bald eagle, peregrine falcon, and gray wolf as threatened and endangered species that may be present in the project area. No critical habitat was designated or proposed in the project area. Threatened and endangered species (primarily the grizzly bear) will not likely be impacted as new disturbances will be limited to upgrading existing roads and constructing a spur road below the McLaren Pit. Disturbances from increased traffic during the construction portion of implementing the sub-alternatives are short-term, and there are no permanent facilities required under this alternative. Due to the limits of project activities in current disturbed and traveled areas; bald eagles and migratory birds will not be impacted by project activities. Although construction and implementation of the various sub-alternatives will require an increased level of activity, long-term maintenance will not require a level of activity that is greater than that existing under current conditions.

Other location-specific ARARs, particularly the Floodplain and Floodway Management Act, the Natural Streambed and Land Preservation Act, and location specific ARARs associated with the Montana Solid Waste Act do not apply. No floodplains, wetlands, or streambeds will be impacted by the alternative action. On-site treatment of waste under CERCLA does not fall under solid waste management rules. However, transported and deposited wastes derived from the McLaren Mine area will be left in the floodplain of Daisy Creek. Removal of these sediments may be considered in the future under a separate response action that looks at second order contaminant sources.

Action-specific ARARs are expected to be substantially met by this alternative. Action-specific ARARs for storm water runoff will be complied with through the use of best management practices (BMPs) at the McLaren Pit. No groundwater will be wasted and all wells used in the monitoring of the response action will be appropriately maintained to prevent waste, contamination, or pollution of groundwater in accordance with the Groundwater Act. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment. The Montana Water Quality Act will not be fully complied with under this alternative. Non-amended wastes will likely remain in contact with groundwater during periods of high water tables and during periods of high infiltration or percolation through wastes. However, under Alternative 2C, all the wastes will be amended, which should effect a lesser impact on groundwater that come into contact with the waste. A portion of elevated levels of metals measured in groundwater has been shown to be caused by natural sources.

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

Regrading and amending treated sites would substantially meet revegetation requirements contained in the Surface Mining Control and Reclamation Act, Montana Strip and Underground Mine Reclamation Act and Metal Mining Act. Native species have been selected through many years of USDA-FS research in the District on amended wastes. BMPs for seeding, planting, mulching, soil amendments, control of noxious weeds, and erosion control will also be followed under this alternative.

Hydrological regulations contained in the Montana Strip and Underground Mine Reclamation Act would be met by minimizing any changes to the hydrologic balance. Other requirements for treating surface drainage, sediment control, construction and maintenance of sedimentation ponds, discharges from sedimentation ponds, and provisions for groundwater will be met by using best available technologies.

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

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

❖ *LONG-TERM EFFECTIVENESS AND PERMANENCE*

As the entire package of waste materials at the McLaren Pit is not fully amended under Alternatives 2A and 2B, on-site treatment may not be a permanent solution. Acidity from non-amended wastes lying below the amended zone has the potential to move upward into the treated zone through capillary action. This has occurred using a similar but more limited approach for the reclamation work completed in 1996 by CBMI. If this condition occurs, retreatment of the wastes may be necessary, especially if vegetation is impacted through a reduction in cover or vigor. Amended wastes are also subject to erosion and non-amended wastes may eventually be exposed. PRSC monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term. Since all wastes are amended under Alternative 2C, long-term performance should be quite effective in minimizing contaminant migration from the wastes.

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

There will be some variable amount of reduction in mobility depending on the sub-alternative selected but no reduction of toxicity or volume under this alternative. Reduction in the mobility of contaminants will be achieved through consolidation of wastes in the pit and amendment with a neutralizing agent. With a 30% reduction in the surface area of wastes exposed through consolidation, all the sub-alternatives provide a considerable reduction in mobility. Further reductions in mobility will vary between the sub-alternatives as the volume of waste amended is different. Alternative 2A (15% of the waste amended) and Alternative 2B (22% of the waste amended) effect much less further reductions in mobility than Alternative 2C, in which all wastes are amended.

❖ *SHORT-TERM EFFECTIVENESS*

Implementation of either Alternative 2A or 2B should allow completion of the McLaren Pit Response Action in a single construction season of not more than 60 days. Therefore, impacts associated with construction activities are considered short-term, and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures. Implementation of Alternative 2C will likely require at least two construction seasons to complete.

The major short-term impact to the surrounding community, residents, and wildlife involves increased vehicle traffic and temporary closures of some forest roads. An increase in traffic will occur during mobilization and demobilization of construction equipment. It is estimated that about 26 pieces of construction equipment will be mobilized to the site for the removal action. Equipment will include bulldozers (2), excavators (2), backhoes (2), loaders (2), haul trucks (4), transports (4), and miscellaneous light duty trucks (10). Transports and trucks that periodically travel to and from the site will supply materials. Additional trucks will be required to transport lime amendment, fertilizer, seed, and erosion control materials on a daily basis.

To construct Alternative 2A, 2,345 metric tons of neutralizing amendment will be hauled to the McLaren Pit site by truck over the course of the project. About 175 truck trips will be needed for this function over a period of 30 days. To construct Alternative 2B, 7,800 metric tons of neutralizing amendment will be hauled to the McLaren Pit by truck over the course of the project. About 575 truck trips will be needed for this function over a period of 30 to 60 days. To construct Alternative 2C, 36,220 metric tons of neutralizing amendment will be hauled to the McLaren Pit by truck over the course of the project. About 2,680 additional truck trips will be needed for this function over a period of 90 days, assuming 30 truck trips per day. Lime amendment materials could come from various locations in Montana or Wyoming.

Short-term road closures in the project area may be necessary, limiting access to the forest. Increased traffic may impact wildlife by either changing daily migration patterns or exposing wildlife to a higher potential for injury or death due to collisions with vehicles.

Short-term air quality impacts to the immediate environment may occur during regrading and mixing of neutralizing amendment. Control of fugitive dusts will require the use of best management practices. Dust control on designated truck routes is an expected requirement.

Road improvements needed to implement this alternative may have some short-term impacts on the watershed. Increased sedimentation may result from road improvements due to an increased sediment load from exposed widened roads and deeper and wider borrow ditches. Implementing best management practices for storm-water runoff will mitigate these impacts.

Implementability

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

Difficulties may be encountered with complete mixing of the lime amendment, especially for Alternative 2C. Specialized equipment such as a pug mill or other device may be required, and strict quality control measures will be needed to insure complete mixing.

Cost

Estimated costs for Alternative No. 2 sub-alternatives are shown in Table 7-5. The detailed cost analysis can be found in Appendix F.

TABLE 7-5
Summary of Total Estimated Costs for Alternative 2
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Item	Alt. 2A	Alt. 2B	Alt. 2C
Ancillary Activities	$19,700	$19,700	$19,700
Activities Common to All Alternatives	$346,400	$346,400	$346,400
Excavate/Load/Haul Waste			$567,800
Amend Waste	$145,400	$484,600	$2,245,600
Place Waste			$1,463,774
Revegetate	$69,900	$69,900	$69,900
SUBTOTAL FOR ALL ITEMS:	**$581,300**	**$920,600**	**$4,456,600**
Mobilization (10%):	$58,200	$92,100	$445,700
Contingency (12%):	$69,800	$110,500	$534,800
TOTAL CONSTRUCTION ESTIMATE:	**$709,200**	**$1,123,100**	**$5,437,100**
Engineering Evaluation and Design (8%):	$56,800	$89,900	$435,000
Construction Oversight (5%):	$35,500	$56,200	$271,900
Present Worth Post-Removal Site Control Estimate:	$112,300	$112,300	$112,300
TOTAL ESTIMATED COST:	**$913,700**	**$1,381,400**	**$6,256,200**

7.4.3 COVERING OR CAPPING WASTES WITH OR WITHOUT LIME AMENDMENT – ALTERNATIVE NO. 3

This alternative involves construction of a cover or cap on the wastes with or without waste amendment. There are four variations of this alternative. For each of the four sub-alternatives, the following engineering controls are common to each alternative: consolidation of outlying wastes onto the McLaren Pit, final regrading, nutrient and organic additions, and revegetation. The four sub-alternatives differ in the cap/cover design placed on the waste rock materials and the amount of wastes amended with lime. A description of the alternative is presented below, followed by the detailed analysis. The components of this sub-alternative are presented graphically in Figure 14.

<u>Alternative Task Description</u>

- *Ancillary Construction Activities (see section 7.2)*
- *Elements Common to all Alternatives (see section 7.3)*
- *Borrow Area Development*: A soil borrow area will be needed to supply cover materials for cap construction. Adequate soil materials are available at the SB-4B repository area. The soil borrow area would likely be located at the (I) site, which is a glacial till hill located east of the Lulu Pass road, about 1½ miles north of US Highway 212. Because the haul distance, about 6½ km (4 miles) is considerable, there may be other nearby sources of glacial till material in the headwaters of Daisy Creek or Miller Creek. Potential source areas for soil cap material will be considered in detail during the design phase of the project if Alternative 3 is selected. Development of the soil borrow area will involve excavating borrow to a depth of about 3 to 6 meters (10 to 20 feet). The area of disturbance will vary based on quantity of soil needed for each alternative. Construction elements will include

developing sufficient access to the borrow site, clearing and grubbing vegetation, stockpiling topsoil, excavating borrow, regrading the borrow area, respreading stockpiled topsoil, revegetating the site with native grasses and forbs, and providing erosion controls.

- *Covering or Capping Wastes with or without Lime Amendment –*

  - *Alternative 3A – Shallow In-Situ Lime Amendment of Waste with Soil Cover:* Consolidated wastes will be amended with a neutralizing amendment (such as agricultural limestone, lime kiln dust, or calcium oxide), compacted, and graded. The consolidated waste material from the McLaren Spoils and Multicolored Dump will be spread out over the pit area, and the regraded surface will be shallow lime amended to a depth of 30 centimeters (12 inches). Total lime required (calcium carbonate equivalent) is 2,345 metric tons. The cap for this alternative would be constructed with 60 centimeters of soil obtained from a local borrow area and transported to the McLaren Pit. The quantity of cap material needed is about 20,000 cubic meters.

  - *Alternative 3B – Non-amended Waste Covered with a Geomembrane and an Amended Waste Rock Cover:* This alternative would use a synthetic liner in the cover system, consisting of a 60 mil HDPE geomembrane liner used as a barrier layer (Figure 14). The synthetic liner would be placed on non-amended waste rock. A 60 centimeter (2 feet) thick, coarse sand and gravel drainage layer would be placed on top of the liner. The drainage layer requires about 20,500 cubic meters (26,800 cubic yards) of material to construct. The gravel of the drainage layer will be covered with an amended waste rock cover. The amended waste rock cover thickness would be about 1 meter (3.3 feet) to provide a total cover thickness of 1.6 meters (5.3 feet). Adequate cover is needed to prevent the drainage layer from freezing and damaging or puncturing the liner.

  - *Alternative 3C - Non-amended Waste Covered with a Geomembrane and an Imported Soil Cover:* Alternative 3C involves consolidation of wastes onto the McLaren Pit and regrading waste in-situ. This alternative uses a 60 mil HDPE synthetic liner in the cover system as a barrier layer (Figure 14). The synthetic liner would be placed on non-amended waste rock. A 60 centimeter (2 feet) thick coarse sand and gravel drainage layer and 90 centimeters (3 feet) of borrowed soil will be placed on top of the liner. The cover system for this sub-alternative requires about 20,500 cubic meters (26,800 cubic yards) of gravel for the drainage layer and about 33,600 cubic meters (44,000 cubic yards) of soil. Filter fabric would be placed over the drainage gravel to prevent piping of fines from the coversoil into the gravel.

  - *Alternative 3D – Non-amended Waste Covered with a Geomembrane and a Composite Amended Waste Rock and Soil Cover:* This alternative is a hybrid of Alternatives 3B and 3C. The cover system consists of a synthetic liner (60 mil HDPE) placed on non-amended waste rock, 60 centimeter drainage layer, 60 centimeters of amended waste rock placed on the drainage layer, and 30 centimeters of coversoil. Materials needed to construct this alternative include about 20,500 cubic meters (26,800 cubic yards) of gravel for the drainage layer, 4,550 metric tons of lime to amend the waste rock placed in the cover, and about 10,000 cubic meters (13,000 cubic yards) of soil. Total cover thickness would be 1.5 meters (5 feet) to prevent the drainage layer from freezing and damaging or puncturing the liner. The entire amount of amended waste rock required for the cap can be obtained from totally amending the outlying wastes that will be consolidated on the McLaren Pit.

<u>HELP Modeling</u>

The Hydrologic Evaluation of Landfill Performance (HELP) model (described in Section 3.6) was used to compare the effectiveness of the four cover designs (sub-alternatives) using average annual leachate generated as one measure of effectiveness. Detailed modeling results are presented in Appendix A and a discussion of model parameters are included in Appendix B.

Unsaturated hydraulic characteristics for each of the four types of materials proposed for use in the cover were evaluated. For the waste rock, measured laboratory values of unsaturated hydraulic conductivity were used. Two types of soils were evaluated, one with an unsaturated hydraulic conductivity greater than the wastes and one about equal to the wastes. Soil types were also selected from general classes to match those that might be available on-site for reclamation purposes, a silty loam and silty clay. Drain material was assumed to be gravel. A published literature value for unsaturated hydraulic conductivity was used for the geomembrane in the model.

The model was run for variable soil and waste rock thickness. While conclusions resulting from these model runs are summarized here, and the model outputs are included in Appendix B, actual model results are only presented for the cases proposed in Alternatives 3A, 3B, 3C, and 3D (Tables 7-6 through 7-8).

With respect to the soil and waste rock aspect of the covers, the following observations can be made:

- Soil type does not significantly affect the results
- Soil thickness does not reduce the predicted seepage rate, although, soil thickness may be required to protect liner integrity.
- Although soil cover (Alternative 3A) appears to increase seepage compared to the no cover soil alternatives because more water is stored in the soil cap, soil additions may increase the speed of revegetation and effective cover of vegetation in the long term
- Silty clay soil, with a permeability equal to the permeability of waste rock, retains more water and therefore produces more seepage than the waste rock alone
- Silty loam with a permeability much greater than the permeability of waste rock produces an amount of seepage that is about equal to the waste rock cover. Therefore silty loam performs about as well as waste rock.
- Increasing waste rock thickness to 1.5 meters (5 feet) in the cover does not significantly affect results
- Increasing K_{sat} (by grading and compaction) does appear to affect the predicted results
- Alternatives 3B, 3C, and 3D result in very little seepage from the pit

Results of the HELP modeling for Alternative 3 sub-alternatives are shown in Tables 7-6, 7-7, and 7-8. Alternative 3D will perform most similarly to Alternative 3C with respect to seepage and movement of water through the lateral drain (Table 7-8).

Table 7-6
Alternative 3A HELP Model Results
Predicted seepage rate for the McLaren Pit using a 2foot thick soil cap

Soil Type 2 feet thick	Evapo-transpiration In/year	Runoff In/year	Seepage In/year	Seepage Gallons per minute
Silty clay	13.4	36.6	4.6	7.8
Silt loam	14.6	36.1	4.07	6.9

Table 7-7
Alternative 3B HELP Model Results
Geomembrane with 2 foot thick drain layer and 3 foot thick amended waste rock cap

Drain Layer 2 feet thick	Soil Material 3 feet thick	Evapo-transpiration In/year	Runoff In/year	Seepage Gallons per minute	Lateral Drainage Gallons per minute
24" total	(K_{sat} = 1.8E-5 cm/sec)	14.5	38.7	0	3.1
24" total	Waste rock with reduced K_{sat}(K_{sat}= 1.0 E-5 cm/sec) Regraded and compacted	13.8	40.3	0	1.44

Table 7-8
Alternative 3C HELP Model Results
Geomembrane with 2-foot thick drain layer and 3-foot thick soil cap

Drain Layer 2 feet thick	Soil Material 3 feet thick	Evapo-transpiration In/year	Runoff In/year	Seepage Gallons per minute	Lateral Drainage Gallons per minute
24" total	(K_{sat} = 2.5 E-5 cm/sec)	13.5	38	0	6.1
24" total	Soil with reduced K_{sat} (K_{sat}= 1.2 E-5 cm/sec) Regraded and compacted	13.5	39.9	0	2.2

As expected, percolation through the waste rock decreases considerably from Alternative 3A (without a geomembrane) to Alternatives 3B and 3C that use a geomembrane liner in the cap design. Using the liner in the composite cover system of Alternatives 3B and 3C, the HELP model shows a virtual elimination of percolation into the waste below the liner and, consequently, into the mineralized bedrock from the overlying waste rock source. Some water will flow through the amended waste cap (Alternative 3B) or through the soil layer (Alternative 3C) and into the underlying drain layer where it will flow laterally to the downgradient edge of the liner where it will discharge either below grade or into constructed surface drainage pathways. This discharge is calculated by the HELP model and expressed as "lateral drainage" in Tables 7-6, 7-7, and 7-8. The effectiveness of these various sub-alternatives is discussed in greater detail below.

Effectiveness

Alternative 3A, in-situ treatment of the upper 30 centimeters of waste rock and covering with a 60 cm thickness of soil will be only somewhat effective at limiting seepage of water through the waste. This is because this sub-alternative limits the volume of waste that would be treated, and untreated wastes will remain at relatively shallow depths below the surface. Under certain conditions during moderate to extreme weather or during snowmelt conditions, untreated wastes will likely become saturated and this water would flush accumulated contaminants to the shallow groundwater and surface water environments. In addition, as can be seen from the HELP modeling, placing the soil cover in this sub-alternative actually increases the rate of percolation of water through the waste materials. This is because the soil's ability to retain or hold water is greater than that of the waste rock alone. During a rainfall event, the soils take less time to become saturated and are thus more likely to transmit water through the soil to the underlying wastes. The greatest positive impact of this sub-alternative is that, with the placement of the soil cover, the phytotoxic surface of the waste rock is covered with a growth media that allows for an easier reestablishment of a vegetative cover, as well as providing a protective layer separating contaminated wastes from direct exposure at the surface. This vegetation cover uses water by evapotranspiration processes, thereby reducing to a very limited extent the rate of infiltration to the wastes. More importantly however, the vegetative cover stabilizes the surfaces material, prevents erosion and off-site transportation of the wastes, and helps to reduce the amount of contaminant transport off-site in surface water. As each of the sub-alternatives in this analysis proposes a vegetated surface of the McLaren wastes, this benefit is realized by the other Alternative 3 sub-alternatives as well.

Alternatives 3B, 3C, and 3D are considerably more effective. This is principally because of the addition of the geomembrane in the cover design. The geomembrane effectively eliminates the downward percolation of surface water into the underlying material. These sub-alternatives also call for a lateral drain layer of gravel immediately overlying the geomembrane, which allows water entering through the cover material to flow laterally in the gravels along the membrane surface to its discharge along the downgradient edge of the liner. The sub-alternatives differ in type and amount of cover placed on top of the membrane. In Alternative 3B, this cover is 1.5 meters of amended waste rock.

For Alternative 3B and 3D, where all wastes above the liner are lime amended, it is presumed that most of the contaminant migration from the unconsolidated wastes could be eliminated. The wastes below the liner are protected from infiltration by the liner. Wastes placed above the liner are amended and the treated wastes will not readily form acid and release contaminants to shallow groundwater or surface water.

For Alternative 3C, all of the wastes are below the liner and protected from infiltration by the liner. The material above the liner consists only of the gravel lateral drain layer and coversoil. Under this closure option it is assumed that all of the contamination from the unconsolidated wastes in the McLaren Pit could be protected from infiltrating surface water and precipitation, thereby eliminating contaminant leaching from the unconsolidated wastes generated by percolation of water through the waste. Vegetation will be able to be established, and will provide the benefits of a revegetated surface as described above.

Alternative 3D is a mixed alternative that combines amended wastes over the membrane with a soil cover for final reclamation purposes. Although this sub-alternative is no more effective than either 3B or 3C, it may offer benefits in using less expensive on-site materials (amended wastes) with a 30-centimeter thick soil cover. The soil cover should greatly increase the success of revegetation.

For each of these alternatives, it should be noted that beneath the unconsolidated pit waste lies a large volume of in-place massive sulfide deposits hosted in fractured and faulted bedrock. Some undefined quantity of groundwater is believed to flow laterally across this surface and downward through bedrock towards Daisy Creek during some times of the year.

❖ *REMOVAL ACTION OBJECTIVES*

For each sub-alternative, capping meets RAOs to varying degrees. The RAO of reducing or eliminating concentrated runoff and sediment discharges will be met by each of the sub-alternatives through the establishment of a viable vegetative cover on a regraded surface. Each of the four sub-alternatives reduces phytotoxicity by providing suitable conditions for establishment of vegetation.

In terms of infiltration and subsequent release and migration of contaminants, Alternative 3A is clearly inferior for the reasons described above under effectiveness, although some improvement (decrease) in contaminant migration from waste rock could be expected, especially during drier periods. However, soluble metals and acidity will not be eliminated under Alternative 3A, because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation.

Alternatives 3B, 3C, and 3D will likely locally meet the RAO for migration of contaminants from the unconsolidated waste materials. These sub-alternatives should greatly decrease or virtually eliminate the formation of acid and minimize the formation of soluble metals from the unconsolidated wastes. However, waste rock in and around the McLaren Pit is not the only source of contaminants in the Daisy Creek headwaters area., as was described previously for Alternative 2.

Contaminant concentrations may be slightly reduced in the upper reaches (0-5,000 feet downstream) of the Daisy Creek drainage as a result of implementation of Alternatives 3B, 3C or 3D, and each of these alternatives will clearly perform better than Alternative 3A.

Potential exposure to the food chain to metal contaminants will be reduced to a large extent in the treated or capped waste materials. Burrowing animals that penetrate the amended waste layer are the only remaining pathway for this exposure.

❖ *OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT*

This alternative, covering or capping wastes with or without lime amendment, provides a reasonable measure of control of exposure to contaminated materials and reduces risk to human health and the environment. It reduces the potential for further erosion and migration of contaminants from source areas near surface water drainages by stabilizing the wastes with vegetation. The amount of contaminated leachate formed and its potential to migrate varies between the four proposed sub-alternatives based on the amount of waste material treated and the specific capping design. In these terms, Alternative 3A performs more poorly than Alternatives 3B, 3C, or 3D. Alternative 3C has an advantage of having all wastes materials below the geomembrane liner.

Significant protection of human health will be attained under Alternative 3, in general, by removing outlying waste rock material. The area of total contaminated waste rock exposed will be reduced by 30%. This represents a clear reduction in the potential for exposure to human health risks. Alternatives 3A, 3C, and 3D also offer significant protection to human health by capping the uppermost surface of the waste materials with a soil layer, thereby eliminating direct exposure of humans to contaminated waste materials. A moderate protection to human health would be achieved under Alternative 3B, as people visiting the reclaimed McLaren Mine area will still be exposed to the same concentrations of metals present under existing conditions.

A 30% reduction in the surface area of waste exposed will lessen exposure of the environment to contaminated media. However, reductions in environmental exposure of contaminants to surface water and groundwater will be minimal (maximum of 20%) due to the continued impacts from the McLaren Mine adit discharge, and contaminated groundwater from both seepage through unamended waste rock (Alternatives 2A and 2B) and natural sources of contaminated groundwater. Of the three sub-alternatives, Alternative 2C provides a high level of protection to the environment exposed to historic mining impacts.

❖ *COMPLIANCE WITH ARARS*

Temporary water quality standards are currently being met in Daisy Creek and the Stillwater River under existing conditions. However, contaminant-specific standards associated with the Montana Water Quality Act, with the exception of chromium (which is already in compliance), will not be achieved under Alternative 3. The reasons for this are discussed in some detail in Section 3.8.5. Some improvement in surface water quality in the uppermost reaches of Daisy Creek (0-5,000 feet downstream) is expected because soluble concentrations of copper and zinc would be slightly reduced. However, HELP and load modeling studies suggest that the unconsolidated McLaren Pit wastes only contribute 10-20% of the total load to Daisy Creek and even a reduction of the full 20% will not bring the waters into compliance with the established surface water ARARs. As shown in Table 3-15, even at surface water station SW-7 on the Stillwater River, concentrations of aluminum and copper will still exceed chronic aquatic life standards. Although under Alternatives 3B, 3C, and 3D, contaminant leaching should be eliminated or greatly reduced from the waste rock, contaminant-specific ARARs for Daisy Creek will still not be met. Under higher flow conditions, some load from the McLaren Pit area will be released due to saturation and seepage from non-amended wastes, particularly under Alternative 3A.

Surface water quality at station DC-5, will improve slightly as a direct result of treating the McLaren wastes under Alternative 3. This slight improvement in water quality is limited by control of water chemistry at DC-5, as the water chemistry at DC-5 appears to be controlled by mineral precipitates and metals sorption rather than by upstream loading (Section 3.8.5). Erosion from the revegetated waste dumps would also be greatly reduced, reducing sediment loading that currently reports to Daisy Creek. A reduction of precipitates in Daisy Creek would also be achieved under the Alternative 3 sub-alternatives.

Failure to meet surface water standards is principally due to the fact that waste rock is not the only source of contaminants in the headwaters of Daisy Creek (i.e. bedrock sources, groundwater migration sources, and transported sediment sources). Therefore, cleaning up or preventing seepage from wastes in the McLaren Pit area does not address the larger sources (natural bedrock sources) or other smaller transported sediment or chemical precipitate sources in the Daisy Creek drainage.

Groundwater has not been investigated sufficiently in the vicinity of the McLaren Pit to identify the exact sources and relative amount of contamination for any particular source. Groundwater quality is however, known to be impacted downgradient from the mine site and the degree to which it is contaminated can be documented (Nimick, 1999). Groundwater studies are ongoing, as a series of hydrologic study wells will be completed in, around, and downgradient of the McLaren Pit during the summer of 2001. Capping and in-situ treatment of unconsolidated wastes will likely have only a minor positive and very local effect on groundwater. It will likely have no effect on groundwater for those times when non-amended wastes become saturated under Alternative 3A. Groundwater ARARs locally may or may not be met under Alternative 3.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because the wastes will be revegetated. Although dust and problems with PM-10 airborne contaminants have not been documented, air quality should improve to some extent because the unvegetated dumps will be revegetated.

Location-specific ARARs are expected to be met to a substantial degree. Certain cultural and historic features may be affected if Alternative 3 is implemented. Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed adits; and, regrading mine dumps. Historic structures and debris located adjacent to the dumps may be protected. Historic structures and debris that can be easily salvaged will be moved off the dumps and protected to represent elements of the former mining features. Requirements of the National Historic Preservation Act and the Archaeological and Historic Preservation Act will be met through consultation with the State Historic Preservation Office by the USDA-FS, and mitigation of cultural and historic impacts on the District as a whole.

Threatened and endangered species are present in or near the District. During development of the Draft Environmental Impact Statement for CBMI's proposed mine in the District, consultation with the U.S. Fish and Wildlife Service identified the grizzly bear, bald eagle, peregrine falcon, and gray wolf as threatened and endangered species that may be present in the project area. No critical habitat was designated or proposed in the project area. Threatened and endangered species (primarily the grizzly bear) will not likely be impacted, as new disturbances will be limited to upgrading existing roads and constructing a spur road below the McLaren Pit. Disturbances from increased traffic during the construction portion of implementing the sub-alternatives are short-term, and there are no permanent facilities required under this alternative. Due to the limits of project activities in current disturbed and traveled areas, bald eagles and migratory birds will not be impacted by project activities. Although construction and implementation of the various sub-alternatives will require an increased level of activity, long-term maintenance will not require a level of activity that is greater than that existing under current conditions.

Other location-specific ARARs, particularly the Floodplain and Floodway Management Act, the Natural Streambed and Land Preservation Act, and location specific ARARs associated with the Montana Solid Waste Act do not apply. No floodplains, wetlands, or streambeds will be impacted by the alternative action. On-site treatment of waste under CERCLA does not fall under solid waste management rules. However, transported and deposited wastes derived from the McLaren Mine area will be left in the floodplain of Daisy Creek. Removal of these sediments may be considered as a secondary response to control of contaminant sources under a future action.

Action-specific ARARs are expected to be substantially met by this alternative. Action-specific ARARs for storm water runoff will be complied with through the use of best management practices (BMPs) at the McLaren Pit. No groundwater will be wasted and all wells used in the monitoring of the response action will be appropriately maintained to prevent waste, contamination or pollution of groundwater in accordance with the Groundwater Act. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment. The Montana Water Quality Act will not be fully complied with under this alternative. Non-amended wastes may be in contact with groundwater during periods of high water tables.

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

Regrading and amending treated sites would substantially meet revegetation requirements contained in the Surface Mining Control and Reclamation Act, Montana Strip and Underground Mine Reclamation Act and Metal Mining Act. Native species have been selected through many years of USDA-FS research in the District on amended wastes. BMPs for seeding, planting, mulching, soil amendments, control of noxious weeds, and erosion control will also be followed under this alternative.

Hydrological regulations contained in the Montana Strip and Underground Mine Reclamation Act would be met by minimizing any changes to the hydrologic balance. While use of a geomembrane will locally change infiltration and runoff characteristics, these changes will not diminish flows in Daisy Creek. Other requirements for treating surface drainage, sediment control, construction and maintenance of sedimentation ponds, discharges from sedimentation ponds, and provisions for groundwater will be met by using best available technologies.

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

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

❖ *LONG-TERM EFFECTIVENESS AND PERMANENCE*

Removing the outlying wastes from current locations should be a permanent solution requiring little maintenance and providing long-term effectiveness at the outlying waste sites. PRSC involving monitoring and maintenance will be done at the removal areas. Monitoring and maintenance will improve the chances for achieving long-term effectiveness.

Under Alternative 3A, the entire package of waste materials at the McLaren Mine is not fully amended, on-site treatment with a soil cap may not be a permanent solution. Water will continue to migrate downward to some extent. Acidity from non-amended wastes lying below the amended zone has the potential to move upward into the treated zone and the overlying soils through capillary action. If this condition occurs, retreatment may be necessary, especially if vegetation is impacted through a reduction in cover or vigor. PRSC monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term.
Alternatives 3B and 3D should provide long-term effectiveness by adding enough neutralizing amendment to fully eliminate future acid production from waste material overlying the liner. However, quality control during mixing operations will be needed to insure the wastes are mixed properly with the amendment. Waste below the liner will also be protected from infiltrating waters by the liner. For Alternative 3C, all of the wastes are below the liner, and therefore protected from infiltrating waters.

For Alternatives 3B, 3C, and 3D, geomembrane liners require proper installation and sequencing for the alternatives to be considered effective in the long-term. The multi-layer caps in these sub-alternatives could be impacted by environmental factors such as wetting/drying, freeze/thaw, erosion, plant intrusion, and burrowing animals, each of which could affect the long-term effectiveness of the capping alternatives. Continued PRSC monitoring and maintenance will be a factor in insuring long-term effectiveness.

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

The amount of reduction in mobility will range from some to considerable depending on the sub-alternative selected, but there will be no reduction of toxicity or volume under Alternative 3. Reduction in the mobility of contaminants will be achieved through treatment with a neutralizing amendment of a small amount of the wastes for Alternatives 3B and 3D (12% and 6%, respectively). Covering the wastes with a soil cap or by the placement of a geomembrane will also reduce mobility of contaminants because the HDPE liner will be a barrier to infiltrating water. With respect to mobility, Alternative 3A is the least effective and Alternative 3C is the most effective. Alternative 3D is only slightly less effective than Alternative 3C in this regard.

❖ *SHORT-TERM EFFECTIVENESS*

Implementation of Alternative 3A will probably allow for the completion of the McLaren Pit Response Action in a single construction season of not more than 90 days. Therefore, impacts associated with construction activities are considered short-term, and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. Implementation of Alternatives 3B, 3C, and 3D may require more than one construction season to complete due to the large amounts of materials that are required for the alternatives.

The major short-term impact to the surrounding community, residents, and wildlife involves increased vehicle traffic and temporary closures of some forest roads. An increase in traffic will occur during mobilization and demobilization of construction equipment. It is estimated that about 26 pieces of construction equipment will be mobilized to the site for the removal action. Equipment will include bulldozers (2), excavators (2), backhoes (2), loaders (2), haul trucks (4), transports (4), and miscellaneous light duty trucks (10). Transports and trucks that periodically travel to and from the site will supply materials. Much of the materials will be acquired on-site, with the exception of the lime amendment, and so much of the traffic associated with the project will occur on the Daisy and Lulu Pass roads.

To construct Alternative 3A, 20,160 cubic meters of soil and 2,350 metric tons of neutralizing amendment will be hauled to the McLaren Pit by truck over the course of the project. About 1,200 truck trips will be needed for this function that will occur over a period of 45 days. To construct Alternative 3B, about 20,500 cubic meters of drainage sands and gravels, and 11,700 metric tons of lime will be needed for cap construction. This will require up to 1,900 truckloads over a period of 60 days. To construct Alternative 3C will involve hauling the same amount of drainage sand as Alternative 3B, and about 33,600 cubic meters of coversoil. About 3,550 truckloads will be required to haul these materials for Alternative 3C. Alternative 3D requires more lime amendment (4,500 metric tons) than the other alternatives, but less coversoil than Alternatives 3A and 3C. Truck transport of materials for Alternative 3D is estimated to require 2,300 truck trips. Lime amendment materials would come from a variety of sources in Montana and Wyoming.

Short-term road closures in the project area may be necessary, limiting access to the forest. Increased traffic may impact wildlife by either changing daily migration patterns or exposing wildlife to a higher potential for injury or death due to collisions with vehicles.

Short-term air quality impacts to the immediate environment may occur during regrading and mixing of neutralizing amendment. Control of fugitive dusts may thus require the use of best management practices. Dust control on designated truck routes is an expected requirement.

Road improvements needed to implement this alternative may have some short-term impacts on the watershed. Increased sedimentation may result from road improvements due to an increased sediment load from exposed widened roads and deeper and wider borrow ditches. Implementing best management practices for storm-water runoff will mitigate these impacts.

Implementability

Placing a multi-layer cap (soil, amended waste, and/or a membrane) with or without on-site lime amendment of wastes is both technically and administratively feasible. Key project components such as equipment, materials, and construction expertise, although distant from the site, are available and would allow the timely implementation and successful execution of the alternative. Availability of these items will allow the timely implementation and successful execution of the alternative.

Most activities associated with waste rock cap construction can be implemented with conventional construction techniques and equipment that are readily available in the region. Geomembrane liner installation for Alternative 3B, 3C, and 3D requires specialized equipment and labor including seam welders and seam test equipment. Quality Assurance/Quality Control for geomembrane liner installation is very strict, requiring experienced personnel and specialized equipment. Liners are available in-state, but available specialized labor may be limited. Lime amendment can be accomplished with conventional equipment although incorporation of lime may be best performed with specialized equipment.

There are some inherent difficulties with the placement of a geomembrane liner on the McLaren Pit site. Most of these difficulties have to do with the site itself. Although regrading will be completed prior to placement of the liner, some high slope angles will remain that may make it difficult to place the cover system on the liner in a stable fashion. This is because there may already be too much material on the McLaren site to provide slopes with suitable angles for the liner, while staying within the existing footprint of the McLaren wastes. As a result, some removal of material to the SB-4B on-site repository may be required in the final construction phase. In addition, the liner will need to be keyed carefully to bedrock along its margins to minimize lateral infiltration into the wastes. This may require a cut off wall (concrete or clay) along the upgradient margin of the wastes to prevent water moving down the high wall from entering the wastes. On the downgradient edge of the liner, the liner and the drainage layer must be terminated below grade to prevent any direct discharge to the surface. Alternatively, lateral flow along the liner could be diverted into constructed drainage pathways. Finally, a uniform and suitable depth of material must be placed over the liner to prevent damage to the liner by freezing and thawing events. On steeper slopes this cover material may locally need to be talus sized rock material rather than soil in order to hold the material on the liner on the steeper slopes.

Cost

A summary of the total estimated costs for Alternatives 3A, 3B, 3C, and 3D are shown on Table 7-9. The detailed cost analysis is contained in Appendix F.

TABLE 7-9
Summary of Total Estimated Costs for Alternative 3
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Item	Alt. 3A	Alt. 3B	Alt. 3C	Alt. 3D Mixed
Ancillary Activities	$19,700	$19,700	$19,700	$19,700
Activities Common to All Alternatives	$346,400	$346,400	$346,400	$346,400
Amend Wastes	$145,400	$725,900	$0	$295,200
Regrade Remaining McLaren Wastes	$0	$53,100	$0	$53,100
Install Geomembrane Liner	$0	$283,300	$283,300	$283,300
Construct Gravel Drainage Layer	$0	$1,452,200	$1,452,200	$1,452,200
Place Wastes	$0	$413,300	$0	$168,000
Install Filter Fabric	$0	$0	$79,700	$0
Cover Soil	$705,6300	$0	$1,176,000	$352,800
Revegetate McLaren Wastes	$35,000	$69,900	$35,000	$35,000
SUBTOTAL FOR ALL ITEMS:	$1,252,000	$3,363,600	$3,392,100	$3,005,400
Mobilization (10%):	$125,200	$336,400	$339,300	$300,600
Contingency (12%):	$150,300	$403,700	$407,100	$360,700
TOTAL CONSTRUCTION ESTIMATE:	$1,527,500	$4,103,600	$4,138,300	$3,666,500
Engineering Evaluation and Design (8%):	$122,200	$328,300	$331,100	$293,400
Construction Oversight (5%):	$76,400	$205,200	$207,000	$183,400
Present Worth Post-Removal Site Control Estimate:	$112,300	$112,300	$112,300	$112,300
TOTAL ESTIMATED COST:	**$1,838,300**	**$4,749,300**	**$4,676,300**	**$4,255,500**

7.4.4 Partial Removal of McLaren Waste Rock to the SB-4B Repository – Alternative No. 4

Alternative 4 involves removal of waste rock from the outlying dumps in the vicinity of the McLaren Pit to the SB-4B repository located about 7.6 kilometers (4 miles) from the pit. All the outlying waste rock dumps will be fully removed. Waste rock within the McLaren Pit will be only partially removed (about 80%), as the remaining material will be used to construct a cap or cover over the exposed bedrock deposit. The selection of this alternative requires the use of one of the sub-alternatives of Alternative 2 or 3 for final closure of the McLaren Pit.

Alternative Task Description

In addition to the ancillary and common items described in Section 7.2 and 7.3, the following work activities are included in the construction of Alternative 4:

- *Excavate/Load Waste:* Excavate and load all waste from selected dumps. About 18,416 cubic meters (24,087 cy) of mine waste from outlying dumps would be loaded onto haul trucks. The area of disturbance would cover approximately 1.44 hectares (3.58 acres). In addition, approximately 107,509 cubic meters (140,616 cubic yards) of McLaren Pit backfill would also be loaded onto trucks.

- *Repository Construction:* The existing leachate collection system and cover systems would be extended to enclose the McLaren Pit wastes.

- *Haul Waste to Repository:* Haul the 125,925 cubic meters (164,704 cubic yards) of wastes to the SB-4B on-site repository and place and compact the waste.

- The remaining 28,997 cubic meters (37,913cubic yards) of material in the McLaren Pit would be used to close the mine site using one of the sub-alternatives of Alternative 2 or 3 described above.

Effectiveness

Under this alternative, about 80% of the mine wastes in the vicinity of the McLaren Pit are removed and disposed in an engineered on-site repository. As these wastes are isolated from the environment, this alternative is highly effective in controlling future migration of contaminants from this portion of the wastes. The repository design is the key element that isolates the wastes from the environment. It will be constructed with a composite cover, a bottom liner, and a leachate collection system. The remaining wastes would be used in closure of the McLaren Pit using a sub-alternative of Alternative 2 or 3. Overall effectiveness of the alternative would depend on the sub-alternative selected for final closure of the pit.

- *REMOVAL ACTION OBJECTIVES*

Removal to an on-site repository would meet RAOs to the maximum extent because the majority of the wastes would be disposed in an engineered repository.

- *OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT*

Removal to an on-site repository would provide considerable additional protection of human health and the environment because most of the contaminants (80%) would no longer be exposed at uncontrolled sites. In addition, by removing the outlying waste rock, the area of total contaminated waste rock exposed will be reduced by some 30%. This represents a clear reduction in the potential for exposure to the human health risk.

A 30% reduction in the surface area of waste exposed will also lessen exposure of the environment to contaminated media. However, reductions in environmental exposure of contaminants to surface water and groundwater will still not likely be reduced more than 20% due to the continued impacts resulting from the McLaren Mine adit discharge. The seepage of contaminated groundwater from historic mining impacts, would be largely eliminated by this alternative, however, because most of the wastes would be removed, and a portion to all of the wastes remaining would be amended in-situ. Remaining natural sources of contaminated groundwater will continue to impact the environment unabated.

❖ COMPLIANCE WITH ARARS

Temporary water quality standards are currently being met in Daisy Creek and the Stillwater River under existing conditions. However, contaminant-specific standards associated with the Montana Water Quality Act, with the exception of chromium (which is already in compliance), will not be achieved under Alternative 4. The reasons for this are discussed in some detail in Section 3.8.5. Some improvement in surface water quality in the uppermost reaches of Daisy Creek (0-5,000 feet downstream) is expected because soluble concentrations of copper and zinc would be slightly reduced. Even though as much as 80% of the McLaren waste rock material will be removed to a on-site repository, surface water ARARs will not be met. This is because the HELP and load modeling studies suggest that the unconsolidated McLaren Pit wastes only contribute 10-20% of the total load to Daisy Creek. Even a reduction of the full 20% will not bring the waters into compliance with the established surface water ARARs.

Surface water quality at station DC-5 will slightly improve as a direct result of removing 80% of the McLaren wastes. Because the water chemistry at DC-5 appears to be controlled by mineral precipitates and sorption of metals rather than by upstream loading, failure to meet surface water standards results principally because waste rock is not the only source of contaminants in the headwaters of Daisy Creek. Therefore, cleaning up or preventing seepage from wastes in the McLaren Pit area does not address the larger sources in the Daisy Creek drainage.

Groundwater has not been investigated sufficiently in the vicinity of the McLaren Pit to identify the exact sources and relative amounts of contamination for any particular source. However, groundwater quality is known to be impacted downgradient from the mine-site and the degree to which it is contaminated can be documented. Removal of as much as 80% of the total unconsolidated wastes will likely have only a minor positive and very local effect on groundwater.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because most of the wastes will be capped in an engineered repository. Although dust and problems with PM-10 airborne contaminants have not been documented, air quality should improve to some extent because outlying areas where waste rock is proposed for removal and remaining wastes in the McLaren Pit area will be revegetated.

Location-specific ARARs are expected to be met to a substantial degree. Certain cultural and historic features may be affected if Alternative 4 is implemented. Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed adits; and, regrading mine dumps. Historic structures and debris located adjacent to the dumps may be protected. Historic structures and debris that can be easily salvaged will be moved off the dumps and protected to represent elements of the former mining features. Requirements of the National Historic Preservation Act and the Archaeological and Historic Preservation Act will be met through consultation with the State Historic Preservation Office by the USDA-FS, and mitigation of cultural and historic impacts on the District as a whole.

Threatened and endangered species are present in or near the District. During development of the Draft Environmental Impact Statement for CBMI’s proposed mine in the District, consultation with the U.S. Fish and Wildlife Service identified the grizzly bear, bald eagle, peregrine falcon, and gray wolf as threatened and endangered species that may be present in the project area. No critical habitat was designated or proposed in the project area. Threatened and endangered species (primarily the grizzly bear) will not likely be impacted new disturbances will be limited to upgrading existing roads and constructing a spur road below the McLaren Pit. Disturbances from increased traffic during the construction portion of implementing the sub-alternatives are short-term, and there are no permanent facilities required under this alternative. Due to the limits of project activities in current disturbed and traveled areas, bald eagles and migratory birds will not be impacted by project activities. Although construction and implementation of the alternative will require an increased level of activity, long-term maintenance will not require a level of activity that is greater than that existing under current conditions.

Other location-specific ARARs, particularly the Floodplain and Floodway Management Act, the Natural Streambed and Land Preservation Act, and location specific ARARs associated with the Montana Solid Waste Act do not apply. No floodplains, wetlands, or streambeds will be impacted by the alternative action. On-site treatment of waste under CERCLA does not fall under solid waste management rules and disposal of wastes at the SB-4B repository was found to be in compliance with these rules under the Selective Source Response Action (Maxim, 2001). However, transported and deposited wastes derived from the McLaren Mine area will be left in the floodplain of Daisy Creek.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with through the use of best management practices (BMPs) at the McLaren Pit. No groundwater will be wasted and all wells used in the monitoring of the response action will be appropriately maintained to prevent waste, contamination or pollution of groundwater in accordance with the Groundwater Act. Substantive MPDES permit regulations will be met, as no facilities require a discharge of waste to the environment. The Montana Water Quality Act should be met under this alternative if the remaining wastes are fully amended. Non-amended wastes may be in contact with groundwater during periods of high water tables and cause non-compliance with this ARAR.

It should be noted that mine and mill wastes are excluded from regulation under the Montana Solid Waste Management Act (75-10-214 (1)(b) MCA. Substantive requirements of this act are met at the repository site through siting and design criteria. Also, because mine wastes are derived from the beneficiation and extraction of ores, District Property wastes generally are exempt from federal and state regulation under RCRA as a hazardous waste (42 U.S.C. 6921 (b) (3) (A)(iii)(1994); MCA § 75-10-401 <u>et seq</u>).

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

Hydrological regulations contained in the Montana Strip and Underground Mine Reclamation Act would be met by minimizing any changes to the hydrologic balance.

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

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

❖ *LONG-TERM EFFECTIVENESS AND PERMANENCE*

Removing a large portion of the wastes from current locations should be a permanent solution requiring little maintenance at the pit and provide long-term effectiveness at the repository site. Remaining waste at the McLaren Pit will be treated using a sub-alternative of Alternative 2 or 3 and the long term effectiveness of these closure alternatives are discussed in previous sections. PRSC involving monitoring and maintenance will be done in the removal and reclamation areas. Monitoring and maintenance will improve the chances for achieving long-term effectiveness.

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

There will be a considerable reduction in mobility but no reduction of toxicity or volume if on-site disposal is implemented. Reduction in the mobility of the contaminants would be achieved by removing a large portion of the wastes to an on-site repository. Reduction in mobility through treatment or containment of the remaining wastes at the McLaren Pit also occurs under one of the sub-alternatives through treatment with a neutralizing amendment and/or capping of the residual wastes.

❖ *SHORT-TERM EFFECTIVENESS*

Alternative 4 will likely require two years to construct. However, the impacts associated with construction activities are considered short-term, and should not significantly impact human health. On-site workers will be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.

The major short-term impact to the surrounding community, residents, and wildlife involves increased on-site vehicle traffic and temporary closures of some forest roads. An increase in traffic will occur during mobilization and demobilization of construction equipment. It is estimated that about 40 pieces of construction equipment will be mobilized to the site for the removal action. Equipment will include bulldozers (3), excavators (2), backhoes (3), loaders (2), haul trucks (10), transports (4), and miscellaneous light duty trucks (15). Transports and trucks that periodically travel to the site will supply materials. An estimate of five truck or transport trips per day is anticipated for the construction season.

To remove the material from outlying waste rock dumps and the McLaren Pit area (a total of 125,925 cubic meters) will require about 6,600 25-yard truck loads of material. Assuming a one-hour round-trip cycle and 10-cycles per day, this move will take 659 truck days, or 65.9 days if 10 trucks are used. Closure of the wastes at the repository will likely require another 30 to 60 days. The length of the construction season in the New World District is realistically about 100 days.

Road closures in the project area may be necessary, limiting access to the forest. Increased traffic may impact wildlife by either changing daily migration patterns or exposing wildlife to a higher potential for injury or death due to collisions with vehicles.
Short-term air quality impacts to the immediate environment may occur during excavation and placement of wastes. Control of fugitive dusts may thus require the use of best management practices. Dust control on designated haul routes is an expected requirement.

Road improvements needed to implement this alternative may have some short-term impacts on the watershed. Increased sedimentation may result from road improvements due to an increased sediment load from exposed widened roads and deeper and wider borrow ditches. Implementing best management practices for storm-water runoff will mitigate these impacts.

Implementability

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

Cost

A summary of the total estimated costs for Alternatives 4 is shown on Table 7-10. The detailed cost analysis is contained in Appendix F. Alternative 4 is not a stand-alone alternative, and the wastes remaining in the McLaren Mine area will need to be closed using a sub-alternative of Alternative 2 or 3 in order to cap the underlying bedrock deposit. The costs of Alternative 4 with these other sub-alternative closure options are shown on table 7-11.

TABLE 7-10
Summary of Total Estimated Costs for Alternative 4*
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Item	Cost
Ancillary Activities	$19,700
Activities Common to All Alternatives	$346,400
Excavate/Load/Haul Waste	$2,350,200
Place Waste	$889,800
Repository Cost	$3,797,900
SUBTOTAL FOR ALL ITEMS:	**$ 7,403,900**
Mobilization (10%):	$740,400
Contingency (12%):	$888,500
TOTAL CONSTRUCTION ESTIMATE:	**$9,032,700**
Engineering Evaluation and Design (8%):	$722,700
Construction Oversight (5%):	451,700
Present Worth Post-Removal Site Control Estimate:	$112,300
TOTAL ESTIMATED COST:	**$10,319,200**

Note: *Alternative 4 must be completed with Alternative 2 or 3 to close the McLaren Mine area.

TABLE 7-11
Summary of Total Estimated Costs for Alternative 4 and Various Closure Alternatives
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Closure Alternative	Closure Alt. Cost	Alt. 4 Cost	Total Cost
Alternative 2A	$ 913,700	$ 10,319,200	$ 11,232,900
Alternative 2B	$ 1,381,300	$ 10,319,200	$ 11,700,500
Alternative 2C	$ 1,351,000	$ 10,319,200	$ 11,670,200
Alternative 3A	$ 1,838,300	$ 10,319,200	$ 12,157,500
Alternative 3B	$ 4,749,300	$ 10,319,200	$ 15,068,500
Alternative 3C	$ 4,676,300	$ 10,319,200	$ 14,995,500
Alternative 3D	$ 4,255,500	$ 10,319,200	$ 14,574,700

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8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the alternatives evaluated in detail in Section 7.0. The comparative analysis is performed for each of the three primary criteria -- effectiveness, implementability, and cost. A preferred alternative is identified at the end of the section.

8.1 EFFECTIVENESS

The alternatives evaluated for the McLaren Pit Response Action present a wide range of effectiveness. In terms of reducing contaminant seepage and migration from the McLaren waste rock material, Alternative 3C (and alternative 4 if combined with Alternative 3C) is the most effective of the alternatives evaluated. This is because all of the wastes are below a geomembrane liner and therefore protected from infiltrating waters. The soil cap placed over the waste provides a suitable medium to promote vegetation growth. Alternatives 3B and 3D are only somewhat less effective as most of the wastes are protected under the liner with the remainder of the waste completely neutralized and amended. Alternative 3A is much less effective because the soil cap, although providing for vegetation reestablishment, does not reduce the rate of infiltration and does not significantly diminish the risk for contaminant migration out of the waste rock. Unamended waste rock present below the soil cap in Alternative 3A will likely still release contaminants to the environment.

The overall effectiveness of Alternative 2C, a totally amended waste rock cover, may be as effective as 3B or 3D in controlling contaminant migration out of the McLaren wastes. This is true, not because it eliminates seepage, but rather because the seepage should not contain high acidity or significant metal concentrations. The effectiveness of Alternative 2C may be somewhat affected by the ability to thoroughly mix the amendment with the waste rock. Alternatives 2A and 2B are much less effective than the other alternatives for several reasons: 1) smaller volumes of waste material are amended; 2) the seepage rate remains about the same as under existing conditions; and 3) non-amended wastes will likely still release contaminants to the environment. From this point of view, with the exception of the benefits of a soil cover, Alternative 3A will probably be little more effective than Alternative 2A. Alternatives 2A, 2B, and 2C, because they do not include a soil cover, do not eliminate the direct contact pathway for human health risk.

Effectiveness of the composite cover system (Alternatives 3B, 3C, and 3D) is superior to either shallow (30 cm) or deep (100cm) in-situ treatment for the McLaren Pit wastes. This difference in effectiveness is primarily a result of the difficult site conditions present at the larger mine waste dumps that limit the effectiveness of partial in-situ treatment. Although presenting more difficulty in final revegetation, Alternative 2C has the potential to be almost as effective as Alternatives 3B, 3C, and 3D.

Alternative 4, on-site disposal of a select portion of the wastes, is effective from the point of view that 80% of the source material in the McLaren Pit is removed and place in a proper storage facility. The remaining effectiveness is totally dependent on the alternative selected for final closure of the remaining wastes in the pit.

It should be noted that for all alternatives, including the No Action alternative, the seepage volume is very small, ranging from 1.4 to 8.9 gallons per minute. Overall effectiveness of the No Action alternative is poor compared to other alternatives.

8.1.1 REMOVAL ACTION OBJECTIVES

Alternatives 2C, 3B, 3C, and 3D achieve RAOs to a similar degree. By combining methods of either total amendment or capping, these alternatives prevent the migration of contaminated seepage out of the waste materials. Alternative 3C, with all of the wastes below the liner, may be perceived as less risky from a seepage point of view, but if the alternatives are implemented correctly probably offers no distinct advantage over the others.

Alternatives 2A, 2B, and 3A do not meet RAOs primarily because non-amended wastes are left on the McLaren site and will remain subject to infiltration that can produce acidic, metal- laden seepage.

Alternative 4 offers the advantage of removal of 80% of the wastes in the vicinity of the McLaren Pit, but ultimate contaminant seepage control depends upon the alternative selected to close the remaining wastes in the pit area (Alternative 2 or 3).

The No Action alternative does not meet any RAOs except the RAO of preserving the existing undeveloped character of the District and surrounding area.

8.1.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The greatest risk to human health is exposure to dust and direct contact with wastes that result from recreational uses in the areas where waste rock is exposed. All the alternatives call for consolidation of the wastes, reducing the surface area of exposed waste by 30%. All of the alternatives also call for a vegetated surface on the waste rock areas. This vegetative cover is of great benefit in reducing the risk to human health, although none of the surface amendment treatment alternatives (Alternatives 2A, 2B, 2C, and 3B) eliminate toxicity to humans. Alternatives 3A, 3C, and 3D call for a soil cap on the waste rock, and this clearly offers an additional reduction of risk to human health by providing a barrier layer to direct contact with the wastes.

The greatest risk to the environment comes from degraded surface and groundwater quality and its impact to aquatic life. Vegetated surfaces will reduce the potential for further erosion and migration of contaminants from source areas by stabilizing the wastes, resulting in a reduction in sediment transport in Daisy Creek. However, none of the alternatives will have a significant impact (improvement) on surface or groundwater quality with respect to dissolved metals in the Daisy Creek or upper Stillwater drainages.

8.1.3 COMPLIANCE WITH ARARS

Temporary water quality standards are currently being met in Daisy Creek and the Stillwater River under existing conditions. However, none of the alternative actions proposed will achieve compliance with surface water standards, as HELP and load modeling studies suggest that the McLaren Pit wastes only contribute 10 to 20% of the total load to Daisy Creek. Even a reduction of the full 20% will not bring surface water in Daisy Creek into compliance with the established surface water standards. Specifically, Montana surface water quality standards for aluminum, copper, and zinc cannot be met for surface water in the reach of stream above surface water Station SW-7 on the Stillwater River.

Some improvement in surface water quality in the uppermost reaches of Daisy Creek (0-5,000 feet downstream) is expected for alternatives that involve in-situ amendment or capping with a geomembrane because soluble concentrations of copper and zinc would be somewhat reduced. Under Alternatives 2C, 3B, 3C, and 3D, contaminant leaching may be eliminated from the waste rock, with a consequent reduction in load to Daisy Creek. Surface water quality at station DC-5 will slightly improve as a direct result of treating or removing the McLaren wastes, but the water chemistry in the reaches below Station DC-5 appears to be controlled by mineral precipitates and sorption of metals, and by downgradient groundwater contributions rather than by upstream loading. In addition, under higher flow conditions, some load from the McLaren Pit area will be released due to saturation and seepage from unamended waste rock remaining under Alternatives 2A, 2B, and 3A.

Groundwater standards locally may or may not be met under the alternatives proposed (some are met locally already). Groundwater has not been investigated sufficiently in the vicinity of the McLaren Pit to identify the exact sources and relative amount of contamination for any particular source. However, groundwater quality is known to be impacted downgradient from the mine and the degree to which it is contaminated can be documented. Capping and in-situ treatment of unconsolidated wastes will likely have only a minor positive and very local effect on groundwater. It will likely have very little effect on groundwater for those times when the non-amended portions of wastes become saturated under Alternatives 2A, 2B, and 3A.

Failure to meet surface and groundwater standards is principally due to the fact that waste rock is not the only source of contaminants in the McLaren Pit area (i.e. bedrock sources, groundwater migration sources, and transported sediment sources). Therefore, cleaning up or preventing seepage from wastes in the McLaren Pit area does not address the larger sources in the Daisy Creek drainage.

Despite the fact that none of the proposed McLaren Pit Response Action alternatives will meet surface water standards and may or may not meet groundwater standards, there is probably not a single better action that could be taken to effect changes in the Daisy Creek drainage other than addressing historical mine wastes in the vicinity of the McLaren Pit. Actions that involve the consolidation of outlying wastes and attempt to reduce the impacts from seepage from these wastes will have a net positive effect on the environment and will slightly improve water quality conditions in Daisy Creek.

All the alternatives will have about the same impacts to threatened and endangered species. Alternatives 2C, 3C, or 4 will have relatively greater impacts because these alternatives require more than one construction season to complete and considerably more construction traffic. Traffic impacts are greater to threatened and endangered species because of the greater amount of materials moved or required.

All alternatives will meet action-specific ARARs equally. The No Action alternative is the least compliant with ARARs of the alternatives considered.

8.1.4 LONG-TERM EFFECTIVENESS AND PERMANENCE

The No Action alternative is neither effective in the long-term nor permanent. On-site treatment may not be a permanent solution because the wastes will not be fully amended under Alternatives 2A, 2B, and 3A. Monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term.

For Alternatives 2A, 2B, and 3A, there are some concerns that the long-term effectiveness could be compromised by capillary action bringing acidity and metals up into the surface layer and negatively affecting vegetative success. This is probably less important for Alternative 3A with a soil cap. Long-term erosion is also a potential problem under Alternatives 2A, 2B, and 3A, as weathering could expose non-amended wastes. Alternatives 2C, 3B, 3C, and 3D are expected to perform comparably over the long term and each should perform equally well.

Alternatives 2C (full amendment), 3B, and 3D (full amendment above the geomembrane liner) should provide long-term effectiveness by adding enough neutralizing amendment to fully eliminate future acid production that could result from reaction of sulfide minerals with infiltrating water. However, quality control during mixing operations will be needed to insure the wastes are mixed properly with the amendment.

The multi-layer caps in alternatives 3B, 3C, and 3D could be impacted by environmental factors such as wetting/drying, freeze/thaw, erosion, plant intrusion, and burrowing animals. Long-term monitoring and maintenance will be a factor in the long-term effectiveness of these closure alternatives.

For Alternative 4, the placement of material in the on-site repository should be considered the best alternative with respect to long-term effectiveness and performance. Unfortunately, not all of the wastes are removed from the site under this alternative, leaving some wastes that will require long-term maintenance and monitoring at a similar level as for the other alternatives.

8.1.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives reduce the volume of the contaminants. All of the alternatives, except the No Action alternative reduce the mobility of contaminants to some degree. Alternatives 2A, 2B, 2C, 3A, 3B, and 3D rely on treatment of wastes with a neutralizing amendment to reduce mobility. Alternatives 3A, 3C, and 3D use a soil cover to reduce mobility. Alternatives 3B, 3C, and 3D use a geomembrane liner as a part of a composite cover system to reduce mobility. The greatest reduction in mobility through treatment is achieved by Alternatives 2C, 3B, 3C, and 3D, since all the wastes are either amended above the liner or are capped below a liner. Alternative 3C is probably the most effective at reducing the risk of mobility. Reduction in plant toxicity through treatment or providing coversoil for vegetation establishment is achieved by all alternatives except the No Action alternative.

8.1.6 Short-Term Effectiveness

Short-term effectiveness of alternatives 2A, 2B, 3A, and 3B is similar in that construction will be completed in a period of no more than 90 days. Alternatives 2C, 3C, 3D, and 4 will likely require more than one construction season. Although there would be no construction-related impacts from the No Action alternative, the impacts from contaminant source releases would continue in both the short- and long-term.

The types of short-term impacts associated with Alternatives 2C, 3B, 3C, 3D, and 4 are similar. These alternatives place more impacts on the local community and roads due to the thousands of truck trips that will be made hauling materials to McLaren Pit or to the repository site (Alternative 4). Because of this, these five alternatives pose the greatest risk to wildlife and the public from vehicle accidents. Much less materials are needed to implement Alternatives 2A and 3A so the short-term impacts associated with these alternatives are considerably less than the other alternatives.

8.2 IMPLEMENTABILITY

All of the alternatives are technically and administratively feasible. Essential project components such as equipment, materials, and construction expertise, although distant from the site, are available.
Alternative 2 and Alternatives 3A, 3B, and 3D require some specialized construction techniques, but these techniques are proven, available and can be implemented at the site. Geomembrane liner installation for Alternatives 3B, 3C, and 3D require specialized equipment and labor including seam welders and seam test equipment. Quality Assurance/Quality Control for geomembrane liner installation

is very strict, requiring experienced personnel and specialized equipment. Liners are available in-state, but available specialized labor may be limited. Difficulties may be encountered with complete mixing of the lime amendment, especially for Alternative 2C. Specialized equipment such as a pug mill or other device may be required, and strict quality control measures will be needed to insure complete mixing.

Some of the trucking requirements for Alternatives 2C, 3B, 3C, 3D, and 4 are very large, as are the earth-moving requirements of Alternatives 2C and 4, but these requirements should be able to be accommodated.

8.3 COST

Table 8-1 summarizes costs for the various alternatives and sub-alternatives. The McLaren Pit under Alternative 4 must be closed with one of the sub-alternatives of Alternatives 2 or 3 (Table 7-11). Alternative 4 is prohibitively expensive, and involves a considerable amount of additional on-site trucking.

TABLE 8-1
Summary Cost Analysis of Response Action Alternatives
New World Mining District Response and Restoration Project
McLaren Pit Response Action EE/CA

Alternative	Cost (millions $)
1. No Action	**$ 0.06**
2A. In-Situ Treatment Shallow Amendment	**$ 0.91**
2B. In-Situ Treatment Select Waste with Deep Amendment	**$ 1.38**
2C. In Situ Treatment of All Wastes	**$ 6.26**
3A. In-Situ Treatment with Soil Cap	**$ 1.84**
3B. In-Situ Treatment with Geomembrane Cover and Amended Waste Rock Cap	**$ 4.75**
3C. In-Situ Treatment with Geomembrane Cover and Soil Cap	**$ 4.68**
3D. In-Situ Treatment with Geomembrane Cover Composite Waste rock and Soil Cap	**$ 4.26**
4. Disposal of McLaren Waste Rock in On-Site Repository	**$ 11.2 to $ 15.1**

For Alternatives requiring lime amendments, it should be noted that a difference of 1% in the estimated pyrite content results in a 30% increase in lime amendment costs ($62/m ton treated). It is essential that prior to actual amendment accurate pyrite (pyritic sulfur) contents be measured.

8.4 PREFERRED ALTERNATIVE

None of the alternatives considered in this evaluation will meet Montana's B1 standards for surface water quality in Daisy Creek. All the alternatives evaluated provide some measure of mitigation to man-caused mining impacts. Alternative 2A, which involves simple consolidation of outlying wastes, amendment of the upper 30 cm of waste rock on the McLaren site, and revegetation, will do much to reduce the impact of erosion of sediments into Daisy Creek and would reduce the total area of waste rock exposed on the McLaren site.

Given what is known about the source of metals impacts in Daisy Creek, the fact that natural sources contribute a considerable metals load to the creek via groundwater and surface water pathways, and the difficult environmental conditions, eliminating metals impacts from mining related activities will not allow achievement of water quality standards. However, short of water treatment, Alternatives 3B, 3C, and 3D would be the most effective at reducing mining related metals impacts. Each of these three sub-alternatives uses a geomembrane liner in different positions in a composite cover system to confine the wastes and reduce the mobility of contaminants. Alternative 3B (with fully amended waste rock at the surface) will present more difficulty in the establishment of a vegetative cover as compared with either Alternatives 3C or 3D that have soil covers. Alternatives 3B and 3D also have fully amended waste rock above the liner, which in an ideal situation should pose no additional risk. However, because there is potential for incomplete mixing of neutralizing amendments, there remains the possibility of leaching of small amounts of metals and acidity from inadequately amended portions of the wastes.

Of the alternatives considered, Alternative 3C is the preferred alternative because all wastes materials would be protected from contact with surface water below a liner, and would likely achieve the greatest reduction in potential loading to Daisy Creek. Alternative 3C will meet most project ARARs with the exception of surface water and groundwater quality.

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APPENDIX A

HELP MODELING RUN RESULTS
McLaren Pit Response Action Engineering Evaluation/Cost Analysis
New World Mining District Response and Restoration Project

APPENDIX B

HELP MODELING DISCUSSION AND SUMMARY RESULTS
McLaren Pit Response Action Engineering Evaluation/Cost Analysis
New World Mining District Response and Restoration Project

Draft

HYDROLOGIC EVALUATION OF MCLAREN PIT BACKFILL

Prepared for:

United States Department of Agriculture
Forest Service

Prepared by:

Maxim Technologies, Inc.
303 Irene Street
P.O. Box 4699
Helena, Montana 59604

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1.0 INTRODUCTION

Review of available hydrogeochemical data for the McLaren Pit area was completed during 1999. This review, along with results from previous studies by others (Nimick, et al, in progress), suggests that, while the McLaren Pit is a primary point source for metal releases to Daisy Creek, remaining point sources and non-point groundwater sources may contribute a large percentage of the metals load to Daisy Creek. To better evaluate potential effectiveness and cost-benefit of various closure options, a mass load model was developed to consider management options on a semi-quantitative basis. This mass load model was developed using available data.

The McLaren Pit was ranked as the highest priority of all the District Property waste sources using the score calculated by the Abandoned and Inactive Mines Scoring System (AIMSS). The high ranking of the pit results from a combination of specific site features including the following: large volume of waste rock present in the pit; relatively high metals concentrations in the waste; size and extent of the pit disturbance; and, measured impact on groundwater and surface water quality in the vicinity of the pit. Because of this, evaluating potential response actions for final closure of the pit requires a detailed understanding of the geotechnical, geochemical, and hydrogeological characteristics that interact to form current conditions present at the site.

Static water levels in monitoring wells completed in the vicinity of the backfilled McLaren pit demonstrate significant large-scale fluctuation in water levels throughout the year. This fluctuation is most pronounced in wells completed in the underlying and surrounding bedrock material, where changes in static water levels may be as large as 60 feet. Significant fluctuations, although of a smaller magnitude, were also observed in wells completed in the pit backfill material. The purpose of this investigation was to attempt to determine whether:

- Observed changes in elevation of the potentiometric surface in wells completed in the pit backfill material are the result of groundwater inflow, or;

- Observed changes are the result of direct infiltration.

2.0 APPROACH

The approach used for this evaluation was to use site specific information to predict the potential rate of flow and timing of infiltration through the pit backfill, and to compare the predicted potentiometric surface fluctuations with actual measured potentiometric surface information collected from monitoring wells.

The model used for this study was the U.S. EPA HELP3 (Hydrologic Evaluation of Landfill Performance) model. Although generally used for landfills, the HELP3 model has also been successfully used for a variety of mining-related projects. HELP3 is a quasi-two dimensional mass-balance model used to estimate the movement of water into and through a waste pile. Although HELP3 relies on analytical or semi-analytical approximations, experience has indicated that when properly applied and interpreted, HELP3 results are often similar to results obtained using more rigorous numerical techniques. Due to the limited quantity of data available, the HELP model was the most appropriate approach to calculate a water balance for the backfilled McLaren pit.

HELP3 model simulation results were compared to actual observed potentiometric surface (head) elevation changes. If the model required using unrealistic input values to achieve a reasonable correlation between the predicted and observed head fluctuations, this would suggest that other sources of water were significant at the site. Conversely, if the model achieved a reasonable correlation between measured and predicted head conditions using realistic input values, it would suggest that infiltration is the primary source of water responsible for the observed head fluctuations.

3.0 INPUT PARAMETERS AND CALIBRATION TARGETS

Implementation of a HELP3 model requires the following input parameters or variables to be defined:

- Climatic information, including daily precipitation, daily solar radiation, and daily mean temperature
- Evapo-transpiration information, including maximum leaf area index (LAI), and starting and ending dates for growing season
- Design information, including layer types and thickness
- Soil material properties in each layer, including porosity, field capacity, wilting point, saturated hydraulic conductivity, initial water content and SCS curve number.

Values used for each of these input parameters are discussed below.

3.1 Climatic Information

3.1.1 Precipitation

Daily precipitation data for the sites were collected from July 10, 2000 to September 26, 2000 at a weather station located adjacent to the McLaren pit site. In addition, a SNOTEL site is maintained by the USFS on Fisher Creek (Station FSHM8, station elevation = 9,100 feet) and is located about one-half a mile northeast of the McLaren pit site. Measured precipitation data at the McLaren site was compared to data collected at the Fisher Creek SNOTEL site for the same period of record. Although the McLaren site and the Fisher Creek SNOTEL site are in close proximity to each other, it was anticipated that a direct daily comparison of measured precipitation data would be problematic because of differences in elevation, prevailing wind directions and local topography. Therefore, precipitation data at the McLaren pit was compared to measured precipitation values at the Fisher Creek SNOTEL site between sites using monthly values and a linear regression approach. The results of this comparison is:

Precipitation at McLaren Pit$_{(inches)}$ = Precipitation at Fisher Creek Snotel site$_{(inches)}$ X 1.11.

In addition, a regional precipitation lapse rate was calculated using five SNOTEL stations in the vicinity of the site. Data from 10/1/93 through 9/30/2000 was gathered and a mean annual precipitation value for each station was calculated. A linear regression was used to determine the relationship between elevation and mean annual precipitation. The pertinent station information and the resulting lapse rate calculation are presented in Table 1.

TABLE 1
Data From Selected SNOTEL Station Sites in the Vicinity of the McLaren Pit

Station Name	Station Number	Elevation (feet)	Mean Annual Precipitation (inches)
Northeast Entrance	NORM8	7350	27.4
Cole Creek	CLCM8	7850	31.9
White Mill	WHTM8	8700	41.8
Monument Peak	MNPM8	8850	39.4
Fisher Creek	FSHM8	9100	51.4

A linear regression between station elevation and mean annual precipitation indicates the following relationship:

Mean Annual Precipitation = Elevation X 0.012 – 60.33 (r^2=0.88).
Comparison of the measured mean annual precipitation at Fisher Creek SNOTEL site and the mean annual precipitation calculated for the McLaren site indicates that annual precipitation at the McLaren site should be 1.04 times the annual precipitation at the Fisher Creek SNOTEL site. This is very close to the ratio calculated above (1.11) using the measured short-term data collected from both sites.

Using the regional relationship developed with the five SNOTEL stations, the average annual precipitation at the McLaren pit (at an elevation of approximately 9,650 feet) is estimated to be 55 inches. Using the Fisher Creek SNOTEL site only and the actual measured precipitation data from McLaren, the average annual precipitation at the McLaren site is estimated to be 57 inches. The similarity of these two calculated annual precipitation values lends credibility to both techniques in predicting mean annual precipitation. In addition, their convergence on essentially the same number suggests we have a valid number for use in the estimation of mean annual precipitation.

For purposes of this modeling effort, daily precipitation inputs were obtained by taking the Fisher Creek SNOTEL precipitation data for the calibration period and multiplying them by 1.11 to calculate daily precipitation values for the McLaren pit site.

3.1.2 Solar Radiation

Default solar radiation data from Billings Montana was used as an input term. Station latitude was set to the approximate site latitude of 45.08 degrees.

3.1.3 Mean Daily Temperature

The approach used to estimate mean monthly temperature at the site was similar to the one used to estimate precipitation. In this case, the regional regression analysis indicated the following relationship:

Mean annual temperature (° F) = -0.00147 X Station Elevation + 44.735. (r^2=0.87).

In this case, the mean annual temperature at the Fisher Creek site is estimated to be 31.36 °F and the mean annual temperature at the McLaren site is estimated to be 30.35° F. This suggests that the ratio of temperature at McLaren pit is 0.97 X temperature at Fisher Creek SNOTEL site.

Mean monthly temperatures for May and June were calculated from the actual measured data at the McLaren site. These mean monthly values for May and June (the only complete months of record available from McLaren), were compared with the mean monthly temperatures measured at the Fisher Creek SNOTEL site. The relationship indicates that the mean monthly temperature at McLaren is approximately 0.97 times the mean monthly temperature at the SNOTEL site. Thus, results of the two methods of calculation agree with one another.

3.1.4 SCS Curve Number

An SCS curve number of 70 was used in this modeling effort.

3.1.5 Percent of area allowing runoff

Initially, the model runs used an assumed value of 100% for percent of area allowing runoff. However, model calibration required modification of this percentage to a lower value.

3.1.6 Leaf Area Index

A value of 0 was used for the leaf area index to simulate the relative lack of vegetation at the McLaren pit site. This may be somewhat conservative given the fact that there is a limited amount of grass cover on the backfilled pit surface.

3.1.7 Growing Season

A growing season should be expected to extend from Julian day 214 (July 1) to 278 (September 3). However, since the leaf area index is 0, this likely has no impact on the model results.

3.2 Design Parameters

3.2.1 Soil Material Properties

Four waste rock samples were collected and submitted for unsaturated hydraulic characteristics testing. Sample locations are shown on Figure A-1, in Appendix A. These characteristics included grain size distribution, volumetric water content at field capacity (-1/3 bars suction), volumetric water content at wilting point (–15 bars suction), saturated hydraulic conductivity and porosity.

ASTM test procedures call for the separation of coarse fragments from the finer matrix material prior to conducting the unsaturated hydraulic tests. The distinction between coarse and fine fragments for the ASTM tests is made on a #10 screen (2 mm), with fine fragments passing the #10 and coarse fragments retained on #10 or coarser screens. The influence of the coarse fragments on the bulk behavior of the material is then estimated using the measured results of the fine fraction and the volume fraction of the coarse fragments. This approach assumes that the coarse fragments contain little or no water retention capacity.

In the case of waste rock, experience elsewhere has indicated that the coarse fraction may in fact have a significant water retention capacity. For this modeling effort, water retention of the coarse fraction was measured for one sample. These results, in conjunction with the grain size distribution data, were then used to estimate the unsaturated hydraulic characteristics of the total sample. A summary of the test results is presented in Table 2. The complete laboratory report is attached in Appendix A.

TABLE 2
Summary of Unsaturated Hydraulic Characteristics for McLaren Pit Backfill Material

Parameter	**DR-5**	**DR-6 [1]**	**DR-10**	**Dr-11 fine**	**DR-11 coarse**
% passing number 10 Screen	32.1	52.4	46.3	53.7 for composite sample	
Field Capacity (vol/vol)	36.6	41.5	32.2	33.7	23.1
Wilting Point(vol/vol)	20.2	18.6	18.1	15.4	15.4
Calculated Porosity (%)	48.3	46.4	46.0	48.8	47.0
Saturated Hydraulic Conductivity (cm/sec)	4.7E-05	2.6E-05	6.9E-05	2.5E-04	Not measured

[1] Sample DR-6 was evaluated at 8 different suction levels. Van Genuchten parameters for a head-volumetric water content relationship were determined and these parameters used to estimate the field capacity and wilting point values.

Measured unsaturated hydraulic characteristics following the gravel correction calculations are presented in Table 3.

TABLE 3

Summary of Unsaturated Hydraulic Characteristics for McLaren Pit Backfill After Applying a Gravel Correction

Sample	DR-5	DR-6	DR-10	DR-11
Porosity	0.476	0.466	0.464	0.482
Field Capacity (vol/vol)	0.295	0.355	0.287	0.305
Wilting Point (vol/vol)	0.177	0.176	0.146	0.173
Saturated Hydraulic Conductivity (cm/sec)	1.8E-05	1.5E-05	3.6E-05	1.5E-04

In addition, a series of infiltration tests were also conducted at the McLaren Mine site. Table 4 presents a summary of these test results. The test locations are depicted on Figure A-1, Appendix A. The measured data is also presented in Appendix B.

TABLE 4

Summary of Infiltration Test Results From the McLaren Pit Backfill Material

Test Number	Type of Test	Depth	Approximate Infiltration Rate (cm/hour) [1]
DR-1	Double Ring	Surface	3.5
DR-2	Double Ring	Surface	0.5
DR-3	Double Ring	Surface	0.5
DR-4	Double Ring	Surface	8.5
DR-5	Double Ring	Surface	1
DR-6	Double Ring	Surface	22
DR-7	Double Ring	Surface	0.6
DR-8	Double Ring	Surface	2
DR-9	Double Ring	Surface	15
DR-10	Double Ring	Surface	1.5
DR-11	Double Ring	Surface	1.5
DR-1 Deep	Double Ring	2’ deep	0.5
DR-4 Deep	Double Ring	2’ deep	6
DR-5 Deep	Double Ring	2’ deep	22
DR-9 Deep	Double Ring	2’ deep	500-3000
DR-11 Deep	Double Ring	2’ deep	1.5
Basin	Flooding Basin	Surface Staff	0.2
Basin	Flooding Basin	Tensiometers	1.9-84

[1] Rate based on examination of infiltration data plots.

A physical model domain was created using approximately 10 feet (120 inches) of waste rock underlain by approximately 6 inches of a barrier soil layer. Actual backfill thickness varies from 0 to 20 feet according to the URS report (URS, 1998). However, it was assumed that an average overall depth of 10 feet probably represented conditions in the vicinity of the two monitoring wells chosen for calibration purposes. The barrier soil layer was included to model the more limited flow potential from fracture controlled secondary permeability within the underlying bedrock system. Unsaturated hydraulic characteristics for the “bedrock” system were taken from literature values (Tindall, 1999).

Model input parameters are summarized in Table 5.

TABLE 5

Summary of HELP3 Model Input Parameters Selected for Soil Material

Parameter	Waste rock	Barrier Soil Layer
Layer Type	Vertical Percolation	Barrier Soil
Layer Thickness (inches)	120 total	6
Porosity	0.4820	0.10
Field Capacity (vol/vol)	0.2950	0.0031
Wilting Point (vol/vol)	0.1770	0.0030
Saturated Hydraulic Conductivity (cm/sec)	1.8E-5	1E-7
Initial Water content (vol/vol)	0.3772	0.1

3.2.2 Calibration targets

Static water level data were collected during the summer and fall of 2000. However, a review of historical data indicates that a more complete set of data exists for the years 1996-1997. Therefore, an attempt was made to calibrate the model to the 1996-1997 potentiometric-surface data set.

Climatic data (daily precipitation and mean daily temperature data) for the 1996-1997 period were obtained from the Fisher Creek SNOTEL site. These values were corrected to correspond to the McLaren pit conditions using elevation correction factors identified previously. A review of the SNOTEL data indicates that approximately 25 equivalent water inches of snow was present on the ground at the SNOTEL site at the beginning of 1996 (January). The model was modified to account for this pre-existing snow depth.

Wells EPA-3 and EPA-4 were chosen as calibration targets (See Figure A-1, Appendix A). These wells are completed in the backfill material. Hydrographs for wells EPA-3 and EPA-4 for the 1996-1997 period are presented in Figures 1 and 2, respectively.

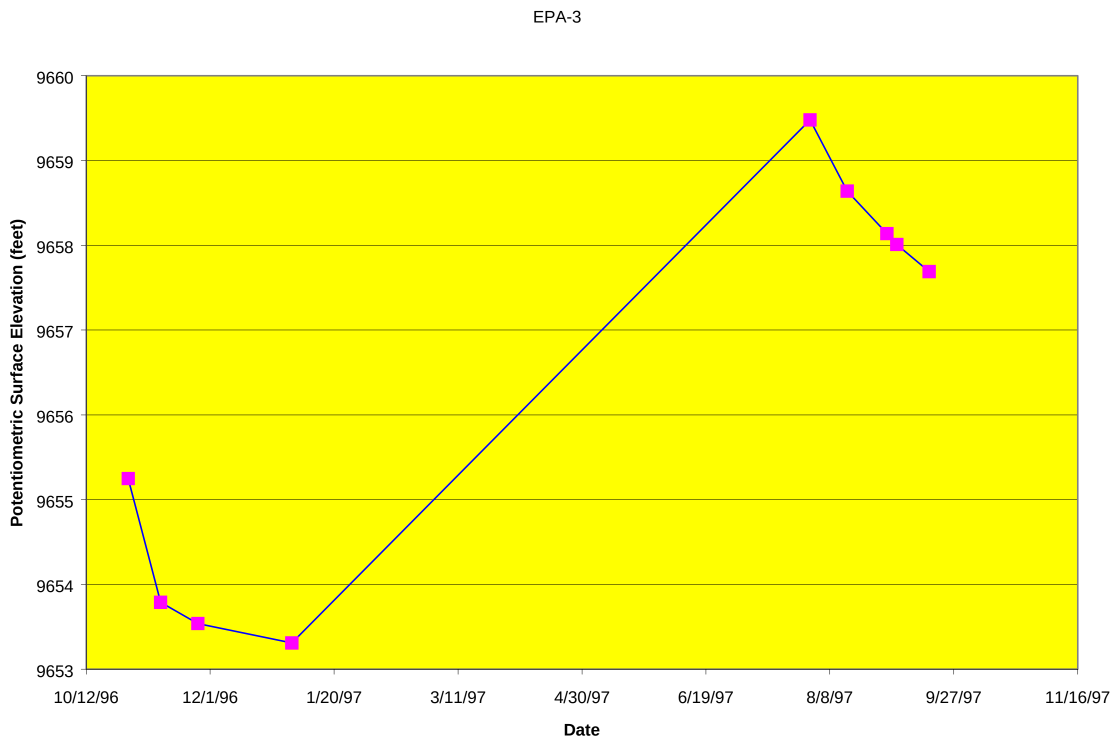

Figure 1 **Hydrograph for well EPA-3 1996/1997.**

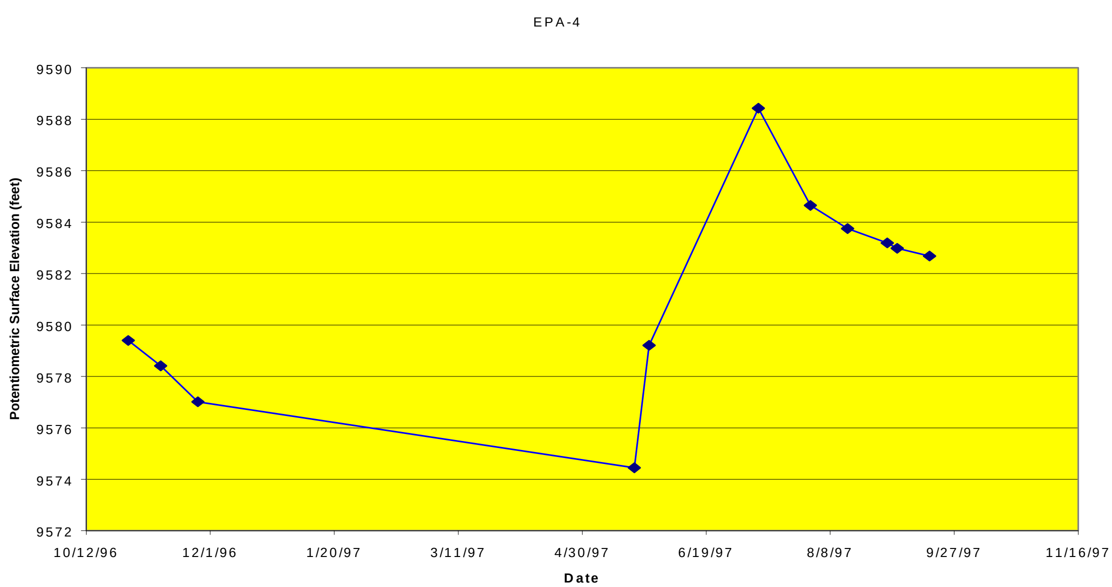

Figure 2 **Hydrograph for well EPA-4 1996/1997.**

4.0 RESULTS

Initial model efforts, assuming 100% of the area produces runoff, generated static water levels in the waste rock material lower than those actually measured at the site. In an effort to increase the amount of water predicted in the backfill to match observed static levels, the percentage of area allowing runoff was decreased from 100 to 50%. The modeled water levels were then relatively comparable to measured values for monitoring wells EPA-3 and 4, as shown in Figure 3. The calibration calculations used to march EPA –3 and 4 are presented in Appendix D.

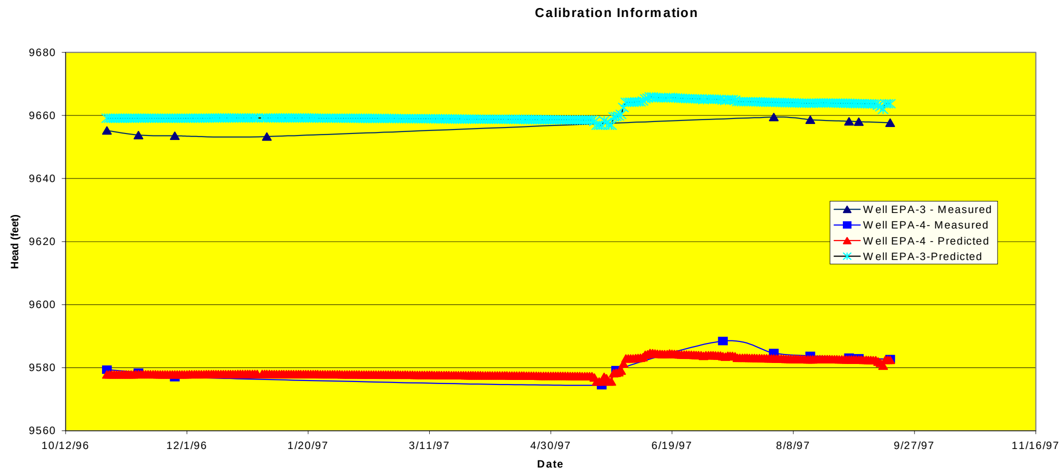

Figure 3. Comparison of HELP3 predicted potentiometric surface values with field measured potentiometric surface values in monitor wells EPA 3 and 4 at the McLaren Mine site.

Figure 3 indicates the amount of measured change in the potentiometric surface at the McLaren site can be simulated using a simple infiltration model. However, it was necessary to modify the amount of area producing runoff in order to have the HELP3 model successfully simulate the measured results. The results of the HELP3 output are presented in Appendix C.

The portion of the area producing runoff is commonly used to account for shallow surface storage features that may be present on a regraded surface. However, from a physical examination of this site it does not appear that shallow surface detention would be significant. The necessity of reducing the area producing runoff to make the model results converge with measured data, may reflect the effects of preferential flow paths on or below the surface of the backfill. This preferential flow would tend to result in zones that would preferentially capture runoff from up-gradient areas.

There is field evidence to support the hypothesis that there are significant local variations in hydraulic conductivity. Double ring infiltration tests conducted at the site indicated a range of infiltration rates from 0.5 cm/hour to as much as 3000 cm/hour. This variability is likely a reflection of preferential flow paths. While this interpretation of preferential flow appears reasonable, these results could also be explained by a seasonal addition of water to the backfill from the underlying or local groundwater flow system.

There is additional evidence to suggest and support a connection between the groundwater flow system and water within the pit backfill material. Tracer studies in the area indicated the presence of tracer dye in pit backfill wells following dye introduction in adjacent bedrock wells. (URS, 1998).

The HELP3 model results indicate that even though the assumed saturated hydraulic conductivity of the bedrock system is low, water does drain through the pit backfill material into the local groundwater system, suggesting connection between the bedrock groundwater system and the pit backfill system. Given the large fluctuations of heads observed in the bedrock groundwater system, it is plausible that some amount of groundwater flows upward and enters the backfill material. However, as these modeling results indicate, most if not all of the water in the backfill appears to be able to be generated by infiltration alone.

5.0 CONCLUSION

It is important to note that the analysis presented thus far has been based on several derived and/or calculated values. Although both professional judgement and experience were used in deriving these relationships, these results should be viewed as general results only.

This analysis required estimation of several significant climatic variables, including precipitation and mean daily temperature. Although the estimations were made using two different approaches, it is possible that the estimated values are incorrect. However, the estimated values appear to agree with observed information, adding credence to the values.

Completion of this analysis also required estimation of the unsaturated hydraulic characteristics for both the waste rock backfill and the underlying bedrock system. However, the unsaturated hydraulic characteristics of the waste rock material were measured in both field and laboratory tests. This suggests that the material parameters used in the model are likely close to actual values. The unsaturated hydraulic characteristics of the bedrock system fit both measured field conditions and appeared reasonable given professional judgement and experience. Initial flow calibration results indicate that changing the saturated hydraulic conductivity of the bedrock system significantly decreases or increases head conditions in the backfill and makes calibration difficult. Thus, this value appears reasonable. However, it should be noted that this does not imply that there are not preferential zones of higher conductivity material underlying the pit.

This analysis was conducted using a water balance model and not a full solution to the unsaturated –saturated flow equations. The semi-analytical nature of the water balance model could also be a source of uncertainty. However, professional experience indicates that in most cases, the differences between the two estimation methods are relatively minor.

A key step in this evaluation is the comparison between measured and predicted head conditions within the backfill. This comparison has been conducted for a relatively limited amount of data. It is possible that head changes greater than those recorded occurred during the calibration year but were not measured. If this were the case, the calibration effort may have failed or may have required more significant parameter changes. However, data collected from several years indicates similar magnitudes of head changes at approximately the same time, suggesting that the calibration target represent a reasonable annual response.

6.0 REFERENCES

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Appendix A

Unsaturated Hydraulic Characteristics Laboratory Report and Sample Location

Figure A-1

Sample Locations

Note: Samples Collected at Double-Ring Inflatrometer test sites Dr-5, Dr-6, Dr-10, and Dr-11

Appendix A-2

Unsaturated Hydraulic Characteristics

Laboratory Report

Appendix B

Infiltration Test Result

SUMMARY OF INFILTRATION TESTING

MCLAREN PIT AREA

NEW WORLD RESPONSE AND RESTORATION PROJECT

Test Number	Type of Test	Depth	Approximate Infiltration Rate (cm/hour) (1)
DR-1	Double Ring	Surface	3.5
DR-2	Double Ring	Surface	0.5
DR-3	Double Ring	Surface	0.5
DR-4	Double Ring	Surface	8.5
DR-5	Double Ring	Surface	1
DR-6	Double Ring	Surface	22
DR-7	Double Ring	Surface	0.6
DR-8	Double Ring	Surface	2
DR-9	Double Ring	Surface	15
DR-10	Double Ring	Surface	1.5
DR-11	Double Ring	Surface	1.5
DR-1 Deep	Double Ring	2' deep	0.5
DR-4 Deep	Double Ring	2' deep	6
DR-5 Deep	Double Ring	2' deep	22
DR-9 Deep	Double Ring	2' deep	500-3000
DR-11 Deep	Double Ring	2' deep	1.5
Basin	Flooding Basin	Surface Staff	0.2
Basin	Flooding Basin	Tensiometers	1.9-84

Note 1. Rate based on examination of plots of infiltration data.

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-1 Inner Ring Area = 113 in2
Date: July 12, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed (hours)	Incremental (hours)	(inches)	(ml)	Volume (ml/min)	Volume cm/hour	Staff cm/hour
10:28	0.00	0.00	4.95	0			
10:44	0.27	0.27	4.4	1050	66	5.4	5.2
11:05	0.62	0.35	4.5	1000	48	3.9	3.3
11:27	0.98	0.37	4.5	1100	50	4.1	3.1
12:00	1.53	0.55	4.15	1800	55	4.5	3.7
12:27	1.98	0.45	4.2	1400	52	4.3	4.2
1:00	2.53	0.55	4.4	1200	36	3.0	2.5
1:30	3.03	0.50	4.15	1350	45	3.7	4.1
2:00	3.53	0.50	4.2	1300	43	3.6	3.8
2:30	4.03	0.50	4.25	1500	50	4.1	3.6
3:00	4.53	0.50	4.25	1250	42	3.4	3.6
3:30	5.03	0.50	4.25	1350	45	3.7	3.6
4:00	5.53	0.50	4.3	1350	45	3.7	3.3
4:30	6.03	0.50	4.35	1350	45	3.7	3.0

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-2 Inner Ring Area = 113 in2
Date: July 12, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed	Increment			Volume		Staff
	(hours)	(hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
12:39	0.00	0.00	4.1	0			
12:59	0.33	0.33	3.8	550	28	2.3	2.3
1:45	1.10	0.77	4	250	5	0.4	0.3
2:45	2.10	1.00	3.9	350	6	0.5	0.5
3:45	3.10	1.00	4	250	4	0.3	0.3
4:45	4.10	1.00	3.95	300	5	0.4	0.4
5:45	5.10	1.00	4	250	4	0.3	0.3
6:45	6.10	1.00	3.9	450	8	0.6	0.5

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-3 Inner Ring Area = 113 in2
Date: July 13, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed (hours)	Incremental (hours)	(inches)	(ml)	Volume (ml/min)	Volume cm/hour	Staff cm/hour
8:08	0.00	0.00	5.4	0			
8:38	0.50	0.50	5.1	700	23	1.9	1.5
9:08	1.00	0.50	5.2	300	10	0.8	1.0
9:38	1.50	0.50	5.4	150	5	0.4	0.0
10:38	2.50	1.00	5.2	300	5	0.4	0.5
11:38	3.50	1.00	5.2	300	5	0.4	0.5
12:45	4.62	1.12	5.1	400	6	0.5	0.7
1:38	5.50	0.88	5.2	300	6	0.5	0.6
2:38	6.50	1.00	5.2	300	5	0.4	0.5

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-4 Inner Ring Area = 81.5 in2
Date: July 13, 2000

Time			Head	Water Added	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Increment (hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
8:45	0.00	0.00	1.5	0			
8:52	0.12	0.12	0.8	900	129	14.7	15.2
9:02	0.28	0.17	0.8	900	90	10.3	10.7
9:12	0.45	0.17	0.8	900	90	10.3	10.7
9:22	0.62	0.17	0.9	800	80	9.1	9.1
9:32	0.78	0.17	1	700	70	8.0	7.6
9:42	0.95	0.17	1	700	70	8.0	7.6
9:57	1.20	0.25	0.65	1100	73	8.4	8.6
10:12	1.45	0.25	0.65	1100	73	8.4	8.6
10:27	1.70	0.25	0.65	1100	73	8.4	8.6
10:42	1.95	0.25	0.6	1200	80	9.1	9.1
10:57	2.20	0.25	0.6	1150	77	8.7	9.1
11:12	2.45	0.25	0.65	1100	73	8.4	8.6
11:27	2.70	0.25	0.65	1100	73	8.4	8.6
11:42	2.95	0.25	0.65	1100	73	8.4	8.6
11:57	3.20	0.25	0.65	1000	67	7.6	8.6
12:12	3.45	0.25	0.65	1100	73	8.4	8.6
12:27	3.70	0.25	0.6	1200	80	9.1	9.1
12:42	3.95	0.25	0.65	1000	67	7.6	8.6
12:57	4.20	0.25	0.6	1200	80	9.1	9.1
1:12	4.45	0.25	0.65	1000	67	7.6	8.6
1:27	4.70	0.25	0.6	1150	77	8.7	9.1
1:42	4.95	0.25	0.65	1100	73	8.4	8.6
1:57	5.20	0.25	0.65	1100	73	8.4	8.6
2:12	5.45	0.25	0.65	1100	73	8.4	8.6
2:27	5.70	0.25	0.65	1100	73	8.4	8.6

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-4 Deep		Inner Ring Area = 113 in2
Date: July 11, 2000

Time			Head	Water Added	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Incremental (hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
1:31	0.00	0.00	4.35	0			
1:38	0.12	0.12	3.4	1500	214	17.6	20.7
1:45	0.23	0.12	3.3	1650	236	19.4	22.9
1:56	0.42	0.18	2.3	2400	218	17.9	28.4
2:05	0.57	0.15	3.3	1500	167	13.7	17.8
2:17	0.77	0.20	2.9	2200	183	15.1	18.4
2:31	1.00	0.23	3.1	1800	129	10.6	13.6
2:44	1.22	0.22	3	1800	138	11.4	15.8
3:06	1.58	0.37	2.4	2700	123	10.1	13.5
3:24	1.88	0.30	2.9	2350	131	10.7	12.3
3:47	2.27	0.38	2.6	2650	115	9.5	11.6
4:18	2.78	0.52	2.4	2700	87	7.2	9.6
4:54	3.38	0.60	2.5	2700	75	6.2	7.8
5:20	3.82	0.43	2.8	2200	85	7.0	9.1
6:00	4.48	0.67	2.5	2650	66	5.4	7.0
6:20	4.82	0.33	3.3	1350	68	5.5	8.0
7:00	5.48	0.67	2.5	2600	65	5.3	7.0

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-5 Inner Ring Area = 81.5 in2
Date: July 12, 2000

Time			Head	Water Add	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Increment (hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
10:30	0.00	0.00		0			
10:45	0.25	0.25	2.6	0	0	0.0	
11:10	0.67	0.42	2.4	300	12	1.4	1.2
12:00	1.50	0.83	2.4	300	6	0.7	0.6
1:00	2.50	1.00	2.45	300	5	0.6	0.4
1:50	3.33	0.83	2.45	250	5	0.6	0.5
2:50	4.33	1.00	2.55	100	2	0.2	0.1
3:50	5.33	1.00	2.35	350	6	0.7	0.6
4:50	6.33	1.00	2.25	450	8	0.9	0.9
5:50	7.33	1.00	2.2	600	10	1.1	1.0
6:20	7.83	0.50	2.4	275	9	1.0	1.0

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-5 Deep Inner Ring Area = 113 in2
Date: July 11, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed	Incremental			Volume		Staff
	(hours)	(hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
5:40	0.00	0.00	3.1	0			
5:45	0.08	0.08	2	2650	530	43.6	33.5
5:50	0.17	0.08	2.2	1600	320	26.3	27.4
5:55	0.25	0.08	2.3	2200	440	36.2	24.4
6:00	0.33	0.08	2.4	1550	310	25.5	21.3
6:05	0.42	0.08	2.35	1900	310	25.5	22.9
6:10	0.50	0.08	2.5	1550	380	31.3	18.3
6:15	0.58	0.08	2.5	1700	310	25.5	18.3
6:20	0.67	0.08	2.5	1800	340	28.0	18.3
6:25	0.75	0.08	2.5	1500	360	29.6	18.3
6:30	0.83	0.08	2.5	1600	300	24.7	18.3
6:35	0.92	0.08	2.55	1550	320	26.3	16.8
6:40	1.00	0.08	2.5	1500	310	25.5	18.3

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-6 Inner Ring Area = 113 in2
Date: July 12, 2000

Time			Head	Water Added	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Incremental (hours)	(inches)	(ml)	(ml/min)	(cm/hour)	(cm/hour)
11:45	0.00	0.00	5.4	0			
12:05	0.33	0.33	5.3	250	12	1.0	0.8
1:05	1.33	1.00	5.2	300	5	0.4	0.5
2:15	2.50	1.17	5.15	350	5	0.4	0.5
3:15	3.50	1.00	5.25	250	4	0.3	0.4
4:15	4.50	1.00	5.3	200	4	0.3	0.3
5:15	5.50	1.00	5.25	250	3	0.3	0.4

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-7 Inner Ring Area = 113 in2
Date: July 13, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed	Incremental			Volume		Staff
	(hours)	(hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
8:45	0.00	0.00	4.2	0			
9:23	0.63	0.63	3.95	550	14	1.2	1.0
10:08	1.38	0.75	4	350	8	0.6	0.7
10:53	2.13	0.75	4	350	8	0.6	0.7
11:38	2.88	0.75	4	300	7	0.5	0.7
12:23	3.63	0.75	4	250	6	0.5	0.7
1:08	4.38	0.75	4	300	7	0.5	0.7
1:59	5.23	0.85	4	300	6	0.5	0.6

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-8 Inner Ring Area = 113 in2
Date: July 12, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed	Incremental			Volume		Staff
	(hours)	(hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
8:02	0.00	0.00	3	0			
8:32	0.50	0.50	2.05	1550	52	4.3	4.8
9:02	1.00	0.50	2.65	650	22	1.8	1.8
9:36	1.57	0.57	2.55	950	28	2.3	2.0
10:06	2.07	0.50	2.7	600	20	1.6	1.5
10:36	2.57	0.50	2.65	650	22	1.8	1.8
11:06	3.07	0.50	2.65	650	22	1.8	1.8
11:37	3.58	0.52	2.65	600	19	1.6	1.7
12:06	4.07	0.48	2.7	600	21	1.7	1.6
12:36	4.57	0.50	2.65	600	20	1.6	1.8
1:06	5.07	0.50	2.65	650	22	1.8	1.8
1:36	5.57	0.50	2.7	550	18	1.5	1.5
2:06	6.07	0.50	2.65	650	22	1.8	1.8
2:36	6.57	0.50	2.7	550	18	1.5	1.5
3:06	7.07	0.50	2.65	600	20	1.6	1.8
3:36	7.57	0.50	2.6	750	25	2.1	2.0

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-9 Inner Ring Area = 113 in2
Date: July 12, 2000

Time			Head	Water Added	Infiltration Rate		
Actual	Elapsed	Incremental			Volume		Staff
	(hours)	(hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
8:37	0.00	0.00	4.8	0			
8:42	0.08	0.08	3.7	2200	440	36.2	33.5
8:47	0.17	0.08	3.85	1950	390	32.1	29.0
8:52	0.25	0.08	4	1700	340	28.0	24.4
8:57	0.33	0.08	4	1450	290	23.9	24.4
9:02	0.42	0.08	4	1400	280	23.0	24.4
9:08	0.52	0.10	4	1500	250	20.6	20.3
9:13	0.60	0.08	4.15	1300	260	21.4	19.8
9:23	0.77	0.17	3.6	2400	240	19.8	18.3
9:33	0.93	0.17	3.7	2550	255	21.0	16.8
9:43	1.10	0.17	3.8	2200	220	18.1	15.2
9:53	1.27	0.17	3.8	1900	190	15.6	15.2
10:03	1.43	0.17	3.8	1850	185	15.2	15.2
10:13	1.60	0.17	3.85	1800	180	14.8	14.5
10:23	1.77	0.17	3.85	1650	165	13.6	14.5
10:33	1.93	0.17	3.85	1700	170	14.0	14.5
10:43	2.10	0.17	3.85	1700	170	14.0	14.5
10:53	2.27	0.17	3.85	1650	165	13.6	14.5
11:03	2.43	0.17	3.85	1700	170	14.0	14.5
11:13	2.60	0.17	3.85	1650	165	13.6	14.5
11:23	2.77	0.17	3.85	1700	170	14.0	14.5
11:33	2.93	0.17	3.85	1650	165	13.6	14.5
11:43	3.10	0.17	3.85	1700	170	14.0	14.5
11:53	3.27	0.17	3.85	1700	170	14.0	14.5
12:03	3.43	0.17	3.85	1650	165	13.6	14.5

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-9 Deep Inner Ring Area = 113 in2
Date: July 11, 2000

Time			Head	Water Added	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Incremental (hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
4:10	0.00	0.00	4.8	0			
4:11	0.02	0.02	1.8	37800	37800	3111.1	457.2

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-10 Inner Ring Area = 113 in2
Date: July 13, 2000

Time			Head	Water Add	Infiltration Rate		
Actual	Elapsed	Increment			Volume		Staff
	(hours)	(hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
7:55	0.00	0.00	2.9	0			
8:35	0.67	0.67	2.8	250	6	0.5	0.4
9:20	1.42	0.75	2.8	175	4	0.3	0.3
10:05	2.17	0.75	2.85	100	2	0.2	0.2
10:50	2.92	0.75	2.85	100	2	0.2	0.2
11:35	3.67	0.75	2.85	50	1	0.1	0.2
12:20	4.42	0.75	2.85	50	1	0.1	0.2
1:05	5.17	0.75	2.85	50	1	0.1	0.2
1:53	5.97	0.80	2.85	75	2	0.1	0.2

Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

Location: DR-11 Inner Ring Area = 113 in2
Date: July 13, 2000

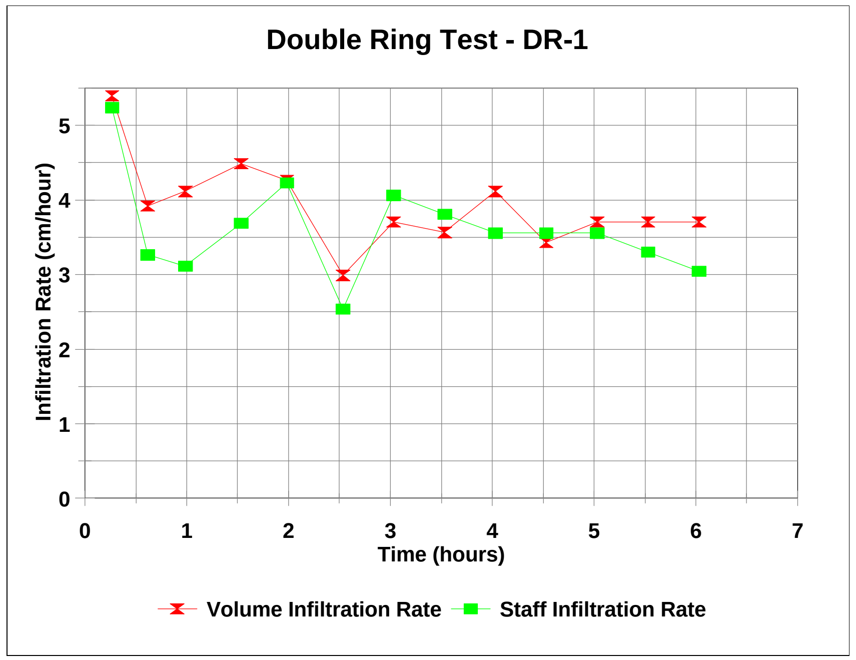
Time			Head	Water Add	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Increment (hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
7:47	0.00	0.00	5.3	0			
8:33	0.77	0.77	4.8	1500	33	2.7	1.7
9:15	1.47	0.70	4.8	1050	25	2.1	1.8
10:00	2.22	0.75	4.8	900	20	1.6	1.7
10:45	2.97	0.75	4.95	750	17	1.4	1.2
11:30	3.72	0.75	5	650	14	1.2	1.0
12:15	4.47	0.75	4.9	700	16	1.3	1.4
1:00	5.22	0.75	4.9	800	18	1.5	1.4
1:45	5.97	0.75	4.8	800	18	1.5	1.7

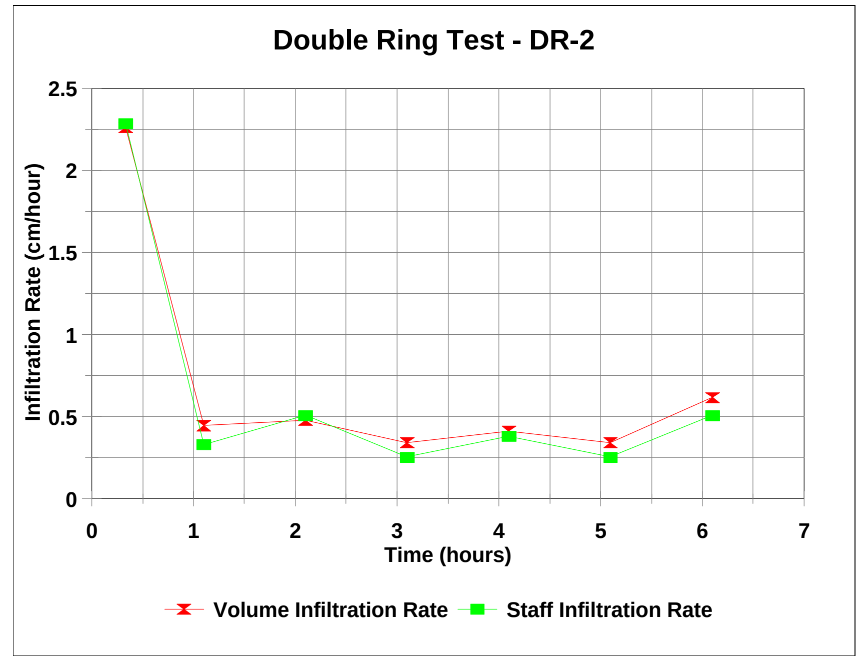
Double Ring Infiltration Data
Mclaren Pit Area
New World Response and Restoration Investigation

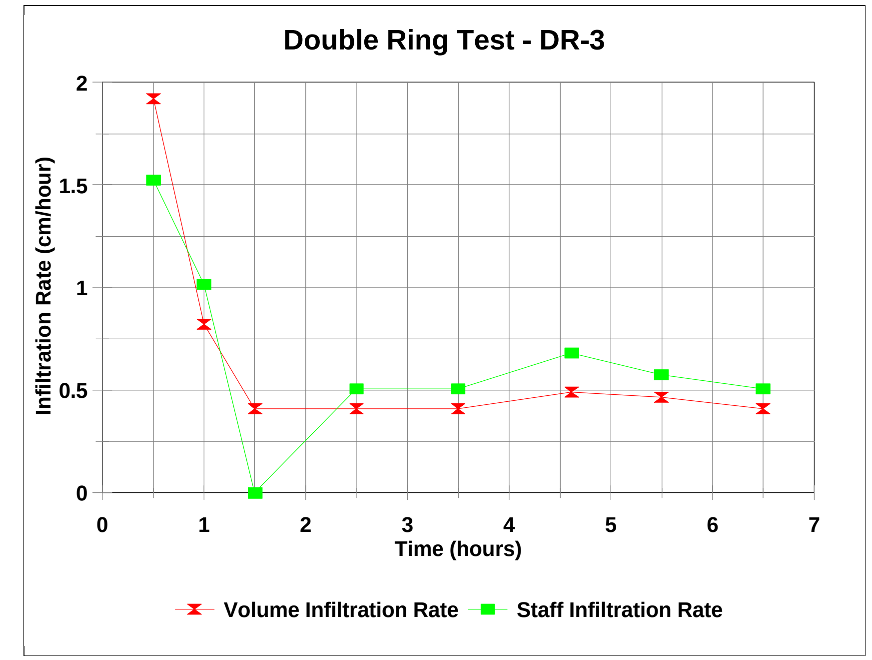
Location: DR-11 Deep   Inner Ring Area = 113 in2
Date: July 11, 2000

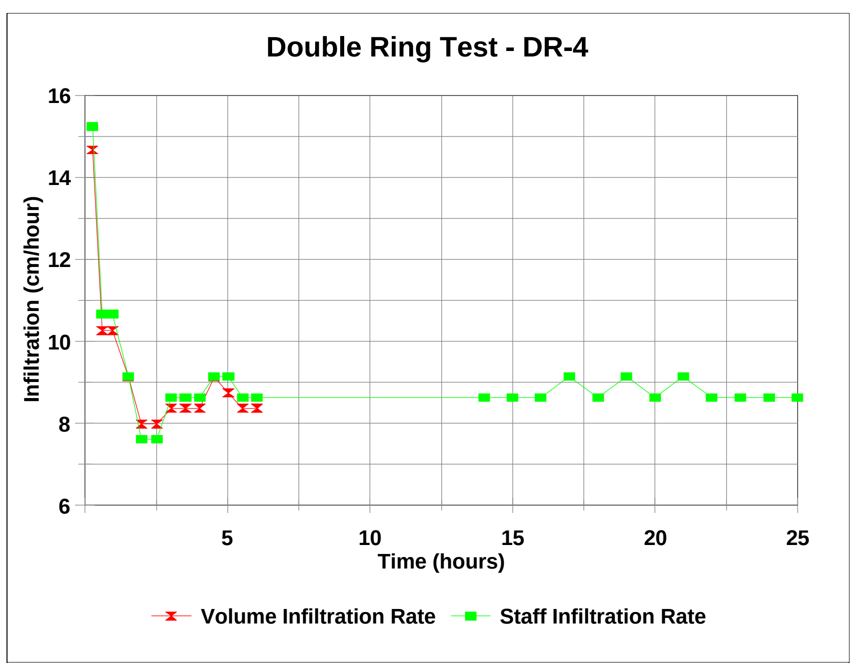
Time			Head	Water Added	Infiltration Rate		
					Volume		Staff
Actual	Elapsed (hours)	Increment (hours)	(inches)	(ml)	(ml/min)	cm/hour	cm/hour
9:34	0.00	0.00	2.2	0			
10:32	0.97	0.97	1.3	2020	35	2.9	2.4
11:02	1.47	0.50	2.05	450	15	1.2	0.8
11:32	1.97	0.50	2	300	10	0.8	1.0
12:07	2.55	0.58	1.9	900	26	2.1	1.3
12:34	3.00	0.45	2	500	19	1.5	1.1
1:08	3.57	0.57	2.1	450	13	1.1	0.4
1:50	4.27	0.70	2.1	350	8	0.7	0.4
2:24	4.83	0.57	2.15	250	7	0.6	0.2
3:15	5.68	0.85	2.1	300	6	0.5	0.3
4:10	6.60	0.92	1.7	1200	22	1.8	1.4
5:15	7.68	1.08	1.9	600	9	0.8	0.7
6:14	8.67	0.98	2	600	10	0.8	0.5
6:52	9.30	0.63	1.7	650	17	1.4	2.0

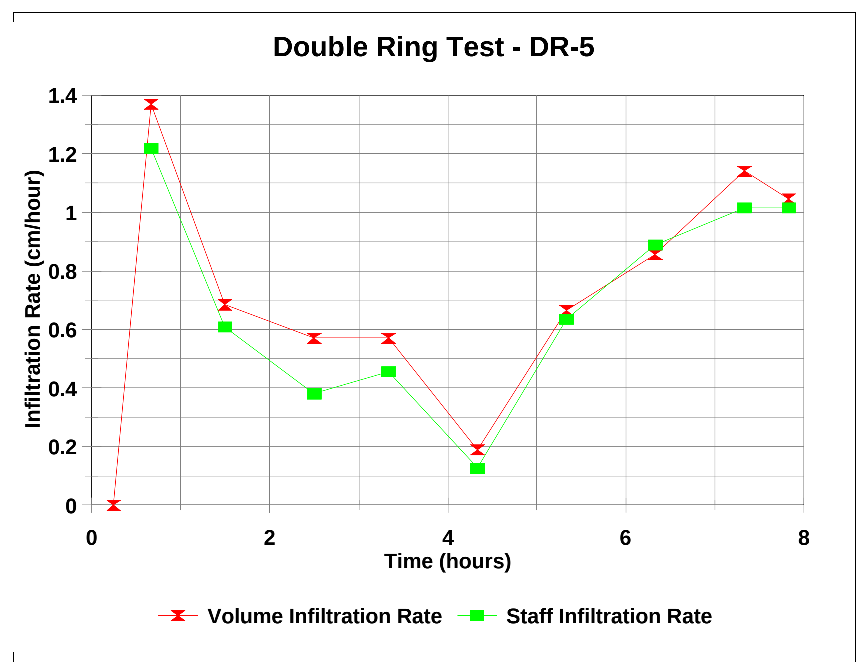
DOUBLE RING INFILTROMETER TESTS
MCLAREN PIT AREA
NEW WORLD RESPONSE AND RESTORATION PROJECT

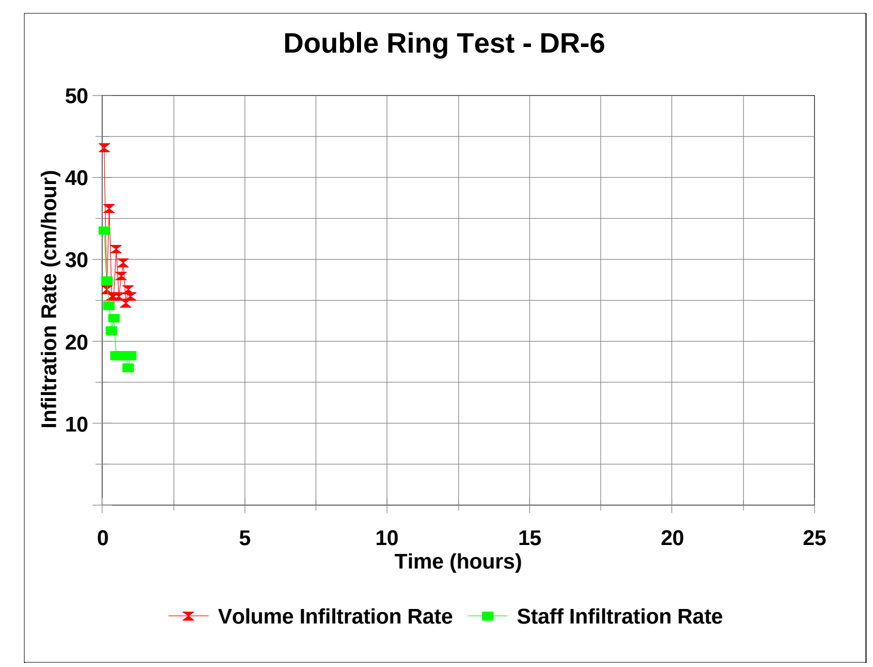




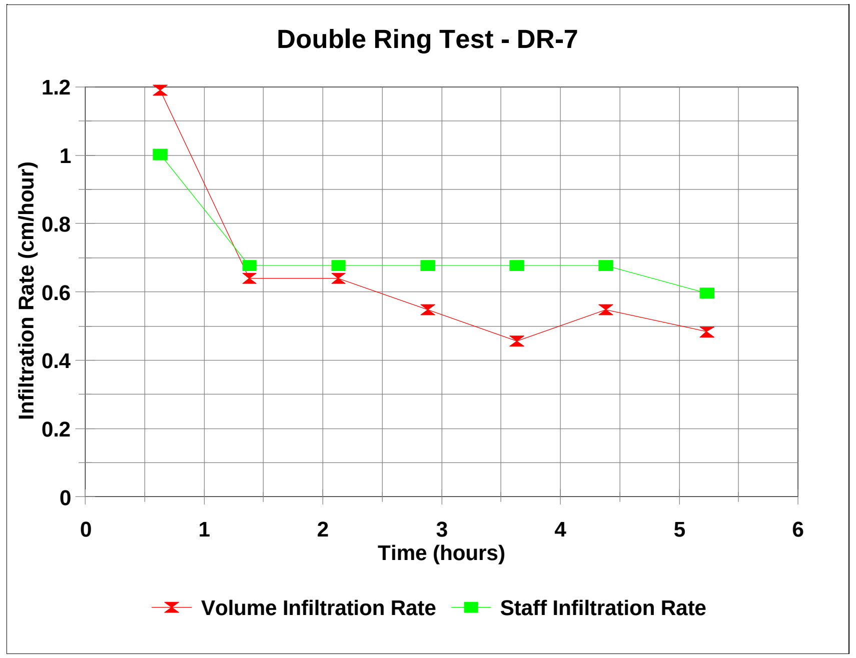


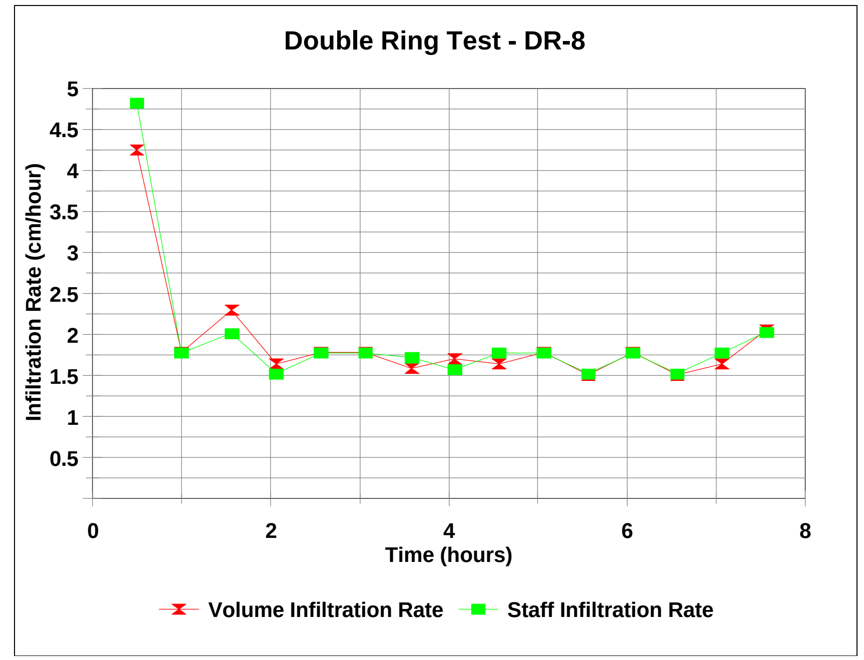


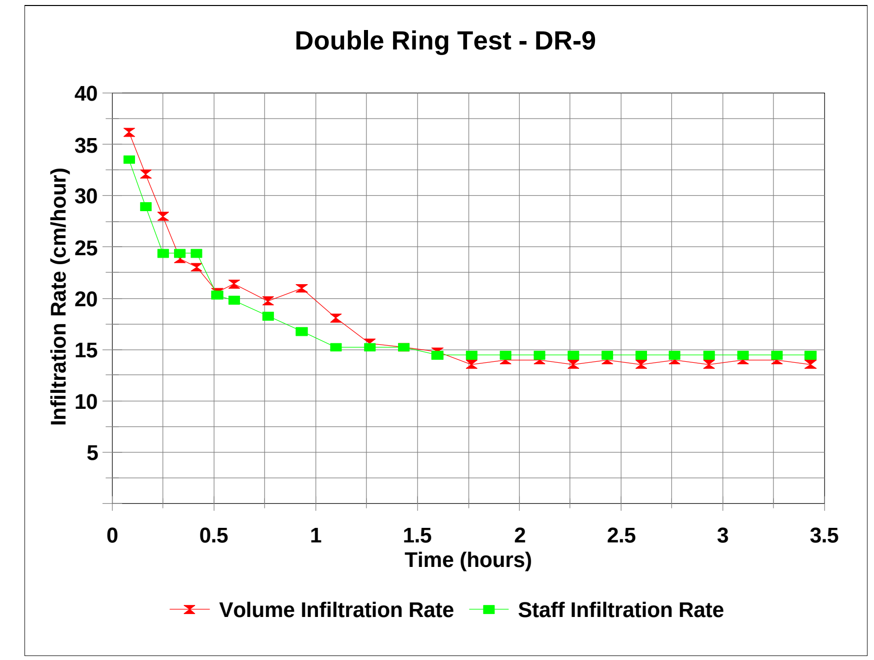


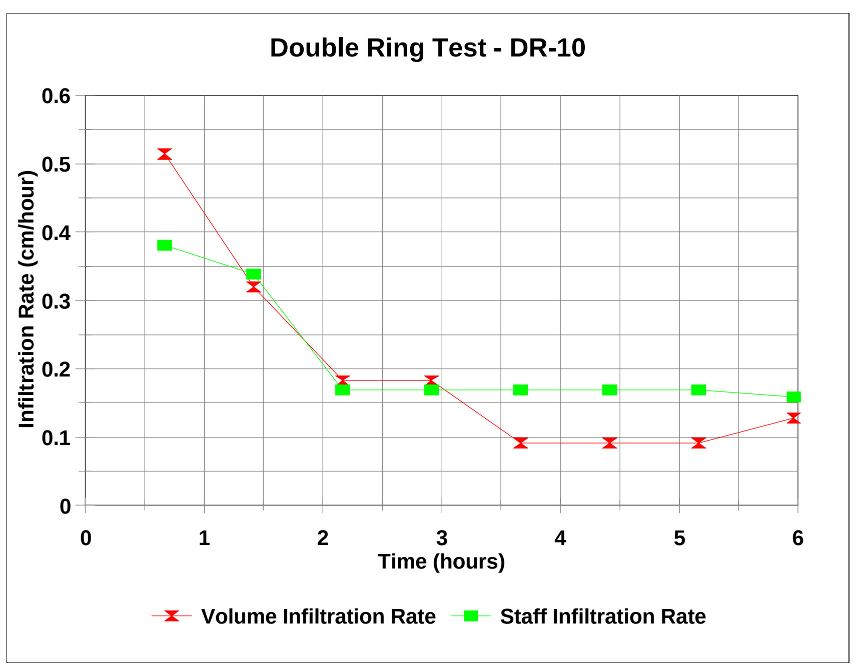


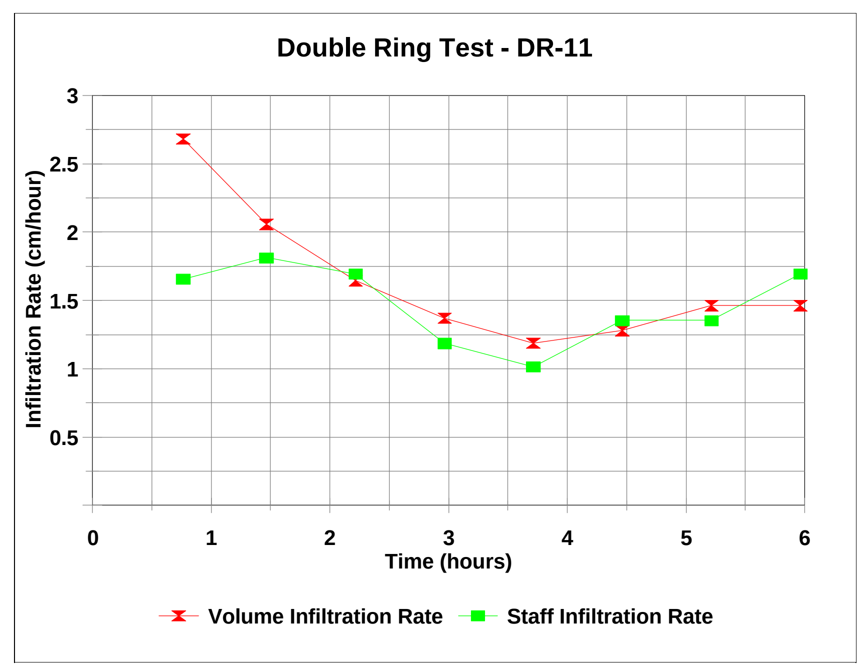
DOUBLE RING INFILTROMETER TESTS
MCLAREN PIT AREA
NEW WORLD RESPONSE AND RESTORATION PROJECT



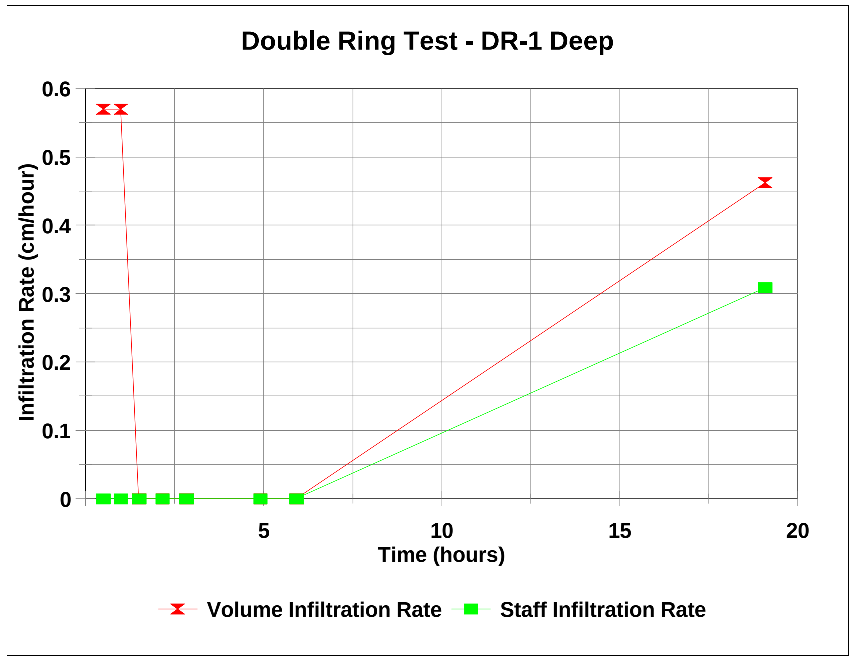


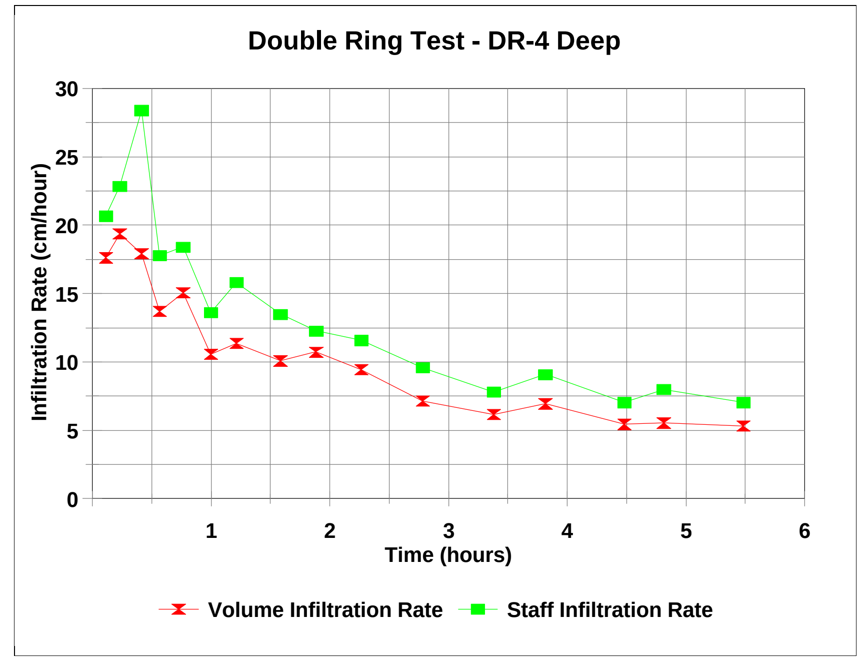


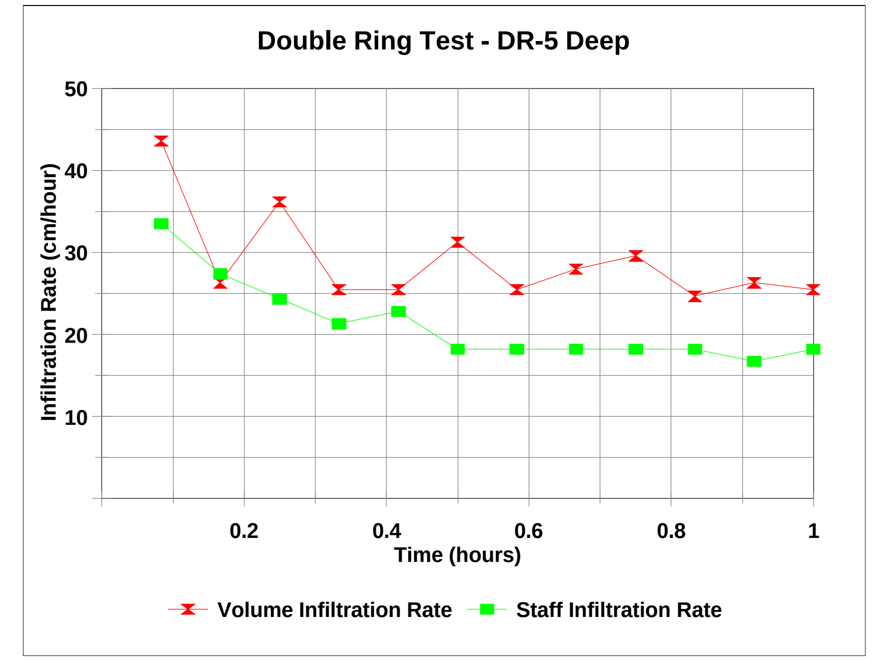


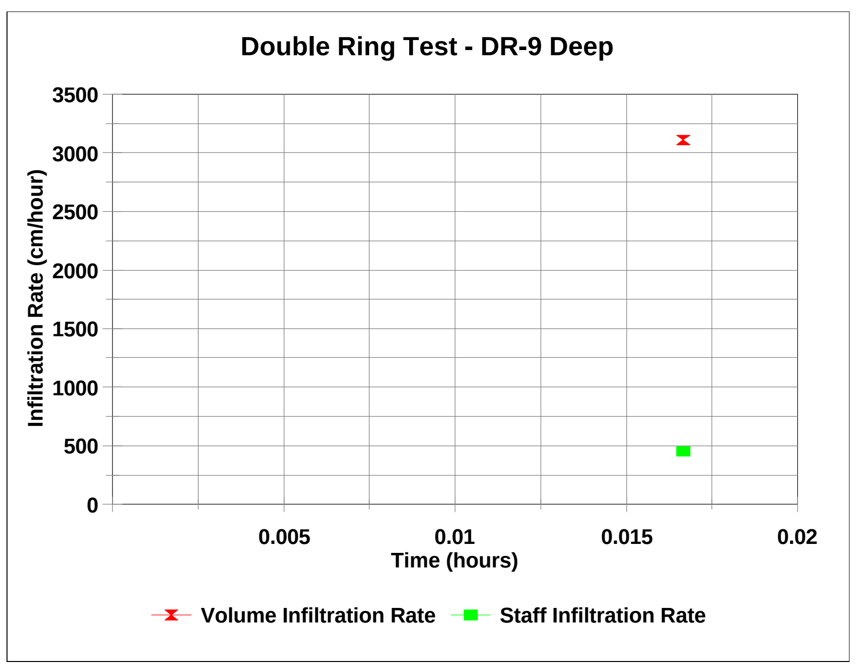


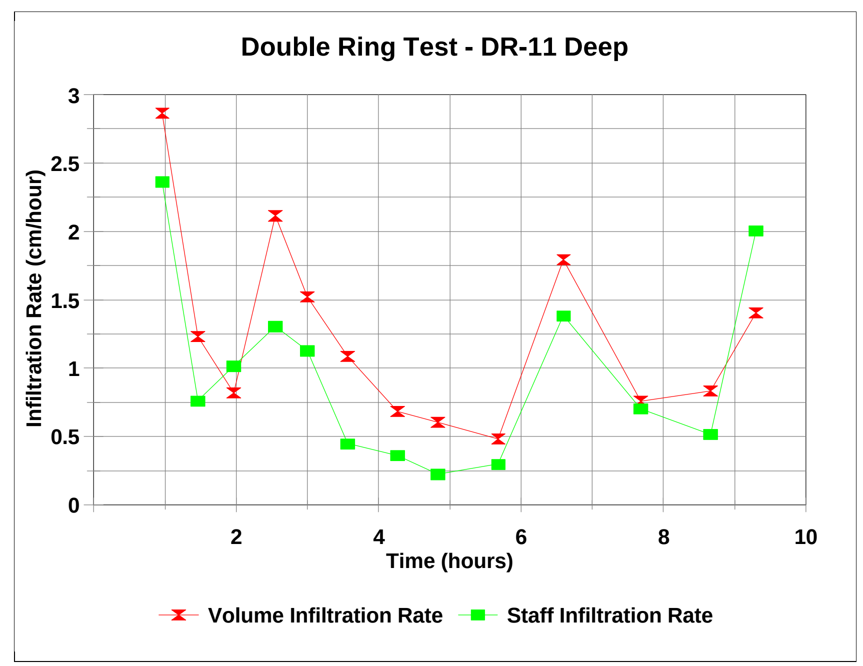
DOUBLE RING INFILTROMETER TESTS
MCLAREN PIT AREA
NEW WORLD RESPONSE AND RESTORATION PROJECT











Flooding Basin Infiltration Test
Mclaren Pit Area
New World Response and Restoration Project

Location: Flooding Basin Test Ring Area = 11,310 in2
Date: July 11-13, 2000

Time				Head	Water Added	Infiltration Rate	Tensiometer Readings (centibars)						
Actual		Elapsed	Incremental				1	2	3	4	5	6	7
Date	Hour	(hours)	(hours)	(inches)	(gallons)	(cm/hour)	12in	24 in	32 in	16 in	22 in	34 in	16 in
07/11/00	9:50	0.01	0.00	3.2	0		11	6	7	12	8	7	8
07/11/00	10:04	0.23	0.22	3.2			10	6	7	12	9	6	0
07/11/00	10:19	0.48	0.25	3.2			2	7	7	2	9	6	0
07/11/00	11:06	1.27	0.78	3.1		0.20	2	7	7	0	5	6	0
07/11/00	11:36	1.77	0.50	3		0.29	0	6	7	0	4	7	0
07/11/00	12:08	2.30	0.53	2.9		0.33	0	6	7	0	4	7	0
07/11/00	12:38	2.80	0.50	2.9			0	3	7	0	4	7	0
07/11/00	1:12	3.37	0.57	2.8		0.30	0	3	7	0	4	7	0
07/11/00	1:53	4.05	0.68	2.7		0.31	0	3	7	0	4	7	0
07/11/00	2:27	4.62	0.57	2.7			0	3	7	0	4	7	0
07/11/00	3:10	5.33	0.72	2.7			0	3	7	0	4	7	0
07/11/00	4:14	6.40	1.07	2.5		0.28	0	3	7	0	4	7	0
07/11/00	5:20	7.50	1.10	2.4		0.27	0	2	7	0	2	7	0
07/11/00	6:10	8.33	0.83	2.3		0.27	0	2	7	0	2	7	0
07/11/00	6:51	9.02	0.68	2.3			0	2	7	0	2	7	0
07/12/00	8:03	22.22	13.20	1.3		0.22	0	3	4	0	2	7	0
07/12/00	1:53	28.05	5.83	1.2		0.18	0	2	4	0	2	7	0
07/12/00	3:00	29.17	1.12	1.2	80		0	3	4	0	2	6	0
07/12/00	3:10	29.33	0.17	2.6			0	2	4	0	2	6	0
07/12/00	6:00	32.17	2.83	2.4		0.18	0	2	4	0	2	6	0
07/12/00	6:04	32.23	3.07	2.9	30		0	2	4	0	2	6	0
07/13/00	7:38	45.80	13.57	2		0.17	0	2	3	0	2	5	0
07/13/00	1:16	51.43	5.63	1.7		0.16	0	2	4	0	2	5	0
					Tensiometer Infiltration Rate (cm/hour)		63.1	21.8	3.7	84.1	44.1	1.9	174.2

Note: No corrections for precipitation or evaporation applied to infiltration rate calculations. Rainfall over the period recorded was approximately 0.05 inches.
Evaporation rate from pan was approximately 1 inch during the period.
Shaded cells are time picks for tensiometer saturation time.

Appendix C

HELP3- Output

Appendix D

Calibration Calculations

Appendix D-1

Well EPA-4 Calibration Calculations

Appendix D-2

Well EPA-3 Calibration Calculations

APPENDIX C

LOAD MODELING DISCUSSION AND RESULTS
McLaren Pit Response Action Engineering Evaluation/Cost Analysis
New World Mining District Response and Restoration Project

Draft

DAISY CREEK LOAD EVALUATION

Prepared for:

United States Department of Agriculture
Forest Service

Prepared by:

Maxim Technologies, Inc.
303 Irene Street
P.O. Box 4699
Helena, Montana 59604

March 6, 2001

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1.0 INTRODUCTION

Review of available hydrogeochemical data for the McLaren Pit area was completed during 1999. This review, along with results from previous studies by others (Nimick, et al, in progress), suggests that, while the McLaren Pit is a primary point source for metal releases to Daisy Creek, remaining point sources and non-point groundwater sources may contribute a large percentage of the metals load to Daisy Creek. To better evaluate potential effectiveness and cost-benefit of various closure options, a mass load model was developed to consider management options on a semi-quantitative basis. This mass load model was developed using available data.

The McLaren Pit was ranked as the highest priority of all the District Property waste sources using the score calculated by the Abandoned and Inactive Mines Scoring System (AIMSS). The high ranking of the pit results from a combination of specific site features including the following: large volume of waste rock present in the pit; relatively high metals concentrations in the waste; size and extent of the pit disturbance; and, measured impact on groundwater and surface water quality in the vicinity of the pit. Because of this, evaluating potential response actions for final closure of the pit requires a detailed understanding of the geotechnical, geochemical, and hydrogeological characteristics that interact to form current conditions present at the site.

2.0 APPROACH

2.1 General Approach

Factors controlling hydrologic conditions within the McLaren pit backfill were evaluated using a water balance modeling approach (Maxim 2001a). As part of this evaluation, a potential rate of seepage from the backfilled pit was estimated. This investigation attempts to assess the effects of this seepage on water chemistry conditions in Daisy Creek using a series of load comparisons. Loads, which are calculated as flow rate multiplied by concentration and are often reported in units of pounds of constituent per day, are useful for gauging the relative magnitude of impacts from various facilities. Since the load calculation is based on a simplistic approach, it is less appropriate for estimating constituent concentrations from some system alteration.

The use of a load analysis is based on several fundamental and potentially questionable assumptions. First, it assumes that all water exiting the pit reports immediately to Daisy Creek. It also assumes that water exiting the pit does not mix with regional groundwater. In addition, this direct type of comparison does not take into account possible geochemical reactions (i.e. precipitation of minerals and relative co-precipitation/sorption of trace metals) that may occur between the McLaren pit and Daisy Creek or along the length of Daisy Creek.

After review of available data, a flow chart showing the analytical approach to be used for this comparative investigation was developed. This flow chart is presented on Figure 1.

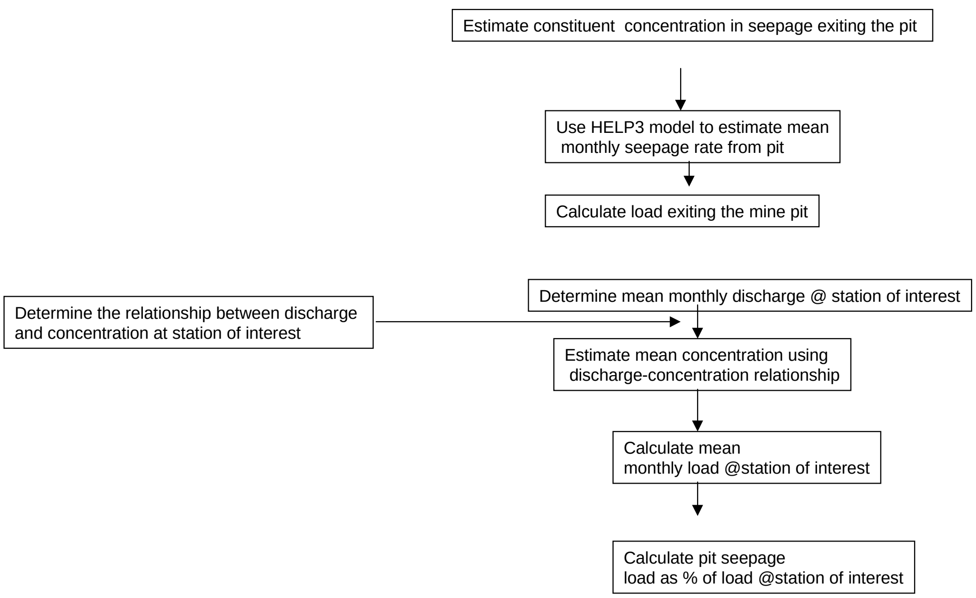

Figure 1. Flow chart of steps required to complete the Phase II comparison of constituent load exiting the McLaren Pit and the constituent load in Daisy Creek.

In order to complete this comparison, the following information was required:

- Estimation of the rate at which water exits the pit backfill;
- Estimation of the constituent concentration exiting the pit;
- Estimation of the surface water discharge in Daisy Creek at the station of interest; and,
- Estimation of the constituent concentration at the surface water station of interest.

Following load calculations, the relative proportion of the load in Daisy Creek at the station of interest that may be attributed to seepage from the McLaren pit can be calculated. Figure A-1 (Appendix A) shows surface water monitoring stations and McLaren pit.

Water levels in wells completed in the McLaren pit backfill exhibit relatively large seasonal fluctuations. Discharge and constituent concentrations in Daisy Creek also exhibit seasonal variations. Given these fluctuations, load calculations based on average annual values would tend to over-simplify any relationship between pit seepage and conditions in Daisy Creek. An alternative approach, based on mean monthly load values, was considered more representative of actual site conditions.

There is limited data available for formal model calibration. Rather than conduct formal calibration, a series of simulations were conducted covering a reasonable range of potential input values.

In the long-term surface water quality monitoring plan for the New World Mining district Response and Restoration Project (Maxim, 1999), a specific list of constituents were identified for evaluation, including pH, specific conductance, total dissolved solids, major ions, and aluminum, cadmium, copper, iron, lead, manganese, and zinc. Based on review of available chemistry data, the decision was made to complete the load comparison for aluminum, iron, copper, zinc, and sulfate.

2.2 Analysis Approach

An initial step in completing this analysis was selection of the surface water station at which calculated loads would be compared. Since simulations were to be conducted on monthly basis, it was necessary to have sufficient information at the selected station to define the relationship between discharge and water chemistry. In addition, sufficient discharge information at the selected station to allow at least a qualitative comparison between predicted and actual flow conditions was also required. Given the available information, station DC-5 was selected as the in-stream station of interest.

Since the amount of available information is limited, formal model calibration was not possible. Instead, different input parameters were used for different model runs. Of the four input conditions (rate of seepage from the pit, chemistry of the seepage, rate of discharge at station DC-5, chemistry at DC-5), chemistry of water exiting the backfilled pit was the least well known.

Two wells (EPA-3 and EPA-4) are completed in the McLaren pit backfill. Since the chemistry of solutions exiting the backfilled pit are unknown, seepage chemistry was simulated using data from wells EPA-3 and EPA-4 as separate cases.

In 1999, detailed water chemistry and flow data was collected along Daisy Creek by the USGS (Nimick, 2000). A version of the load analysis was developed using 1999 information. The results of this simulation were then compared to measured and calculated values presented in the Nimick report. Results of these comparisons are presented in Section 4.

3.0 LONG-TERM SIMULATIONS

3.1 Load Model Input Parameters

3.1.1 Estimation of the Rate at Which Water Exits the Pit Backfill Material

To evaluate load to Daisy Creek on a mean monthly basis, it was necessary to calculate the pit seepage rate on a mean monthly basis. HELP3 was used to calculate mean monthly seepage rates from the pit.

Ten-year synthetic climatic data sets were generated using the WGEN component of HELP3. Mean monthly precipitation and temperature values were taken from the Fisher Creek SNOTEL site and these were corrected to account for the elevation difference between Fisher Creek and the McLaren pit area (see Maxim, 2001a). The mean annual precipitation used for model development was 55 inches.

The physical model, material properties and initial conditions used for these simulations were identical to those developed during model calibration (Maxim, 2001a).

3.1.2 Estimation of the Constituent Concentration Exiting the Pit

Two simulation cases were run using the water chemistry data from two wells completed in the pit backfill, EPA-3 and EPA-4.

Well EPA-4

Review of existing geochemical data indicate that constituent concentrations in water from well EPA-4 varied between different sampling events. Therefore, constituent concentrations and head were compared to test for a possible correlation. Since the purpose of this effort was to compare constituent loads exiting the pit backfill with those in Daisy Creek, total recoverable metal and sulfate concentrations were used rather than dissolved concentrations. Linear regression was used to estimate the correlation between head and concentration of constituents in the pit backfill. Table 1 presents a summary of the regression results. Plots of the measured concentrations and the regression results for each of the constituents of concern are presented in Appendix A, Figures A2-A5.

TABLE 1
Results of Regression Comparisons Between Potentiometric Surface Elevation and Constituent Concentrations for Well EPA-4

Constituent	Regression	Correlation coefficient (r^2)
Sulfate	137.4343*elevation-1314005	0.9957
Aluminum	2.5414*elevation-24254	0.7962
Copper	0.4786*elevation-4549.1	0.8406
Iron	16.639*elevation-159098	0.9657
Zinc	0.0515*elevation-489.39	0.5067

For most constituents, the r^2 values indicate a relatively good correlation between head and constituent concentration. However, it should be noted that only three data points were available for comparison.

Well EPA-3

This case was based on constituent concentrations in well EPA-3 to characterize seepage from the backfilled McLaren pit. Since the available data include only one measurement for well EPA-3, these values were used for model inputs.

3.1.3 Estimation of the Discharge at the Station of Interest

The United States Geological Survey maintains a stream gauging station on Soda Butte Creek, about three miles south of the McLaren pit (station number 06187950, drainage basin area = 99 mi^2, site elevation = 6,600 feet). Mean monthly discharge values for the period of record (1989-1998) for this site were obtained. Unfortunately, the drainage basin area for station DC-5 is approximately two (2) mi^2. The difference in drainage basin area between the two sites meant that the mean monthly hydrograph for Soda Butte Creek required significant modification for use at station DC-5.

One method that can be used to modify a mean monthly hydrograph is to estimate the annual average flow at the ungauged station and to calculate the annual flow at a gauged station in the area. The ratio of these average annual flows is then used to scale (adjust) the mean monthly hydrograph.

The average annual flow at Soda Butte Creek is reported to be 156 cubic feet per second (cfs). Using the relationship described in Cunningham (1983), the average annual flow at an ungauged station can be estimated using the following relationship:

$$Q_{aa} = 0.737\ A*R_o$$

where Q_{aa} is the average annual discharge, A is the drainage basin area in mi^2 and R_o is the annual runoff, which is derived from annual precipitation data. Assuming an average annual precipitation of 55 inches, the term R_o can be estimated using the relationship:

$$R_o=0.810*ppct-15.0$$

for annual precipitation values between 40 and 60 inches (U.S.D.A. - SCS, 1978). Using these relationships, the estimated average annual flow at station DC-5 is estimated to be 4.42 cfs.

Parrett and Hull (1985) also provide a method to estimate average annual discharge of ungauged sites, using active channel width. Assuming the 4.42 cfs average annual discharge calculated above is correct, the active channel width can be estimated to be approximately 7.5 feet. Recent stream gauging notes indicate a measured channel width of 6.5 feet at station DC-5. This suggests that the average channel width is slightly greater than the currently measured width, and indicates that the estimated average annual discharge at station DC-5 is reasonable.

As a final additional check of this calculation, drainage basin area ratios were calculated. In order to modify the Soda Butte Creek average annual discharge to the calculated average annual discharge at DC-5, the drainage basin ratio would have to be raised to the 0.91 power. This value agrees well with peak flow estimation methods, based on professional experience.

Once the average annual discharge at station DC-5 was estimated, the mean monthly discharge values for the Soda Butte station were used to estimate mean monthly discharge values at station DC-5. Mean monthly discharges at the Soda Butte station were divided by the average annual discharge at the Soda Butte station. This ratio was then multiplied by the average annual discharge at DC-5 to estimate the mean monthly discharge at station DC-5.

3.1.4 Estimation of the Constituent Concentration at Surface Water Stations

Flow rates and constituent concentration values for the Daisy Creek DC-5 surface water-sampling site are derived from actual measured field parameters and geochemical analyses of water chemistry. These data pairs were then entered into a curve-fitting program and a series of regressions (both linear and non-linear) were evaluated. In general, relatively good correlation was obtained between discharge and concentration using one of two curve-fitting equation forms. The regression results were then plotted with the measured concentrations and the equation form that most closely fit the observed data was selected. Results of the regression analysis are presented in Table 2 and the plots of estimated and measured concentrations are presented in Appendix A, Figures A6-A10.

TABLE 2
Results of Regression for Flow and Constituent Concentration at Station DC-5

Constituent	Reciprocal Straight Line	R^2	Linear and Reciprocal	R^2
Sulfate	Y=1/(0.007+0.001*Q)	0.865	**Y=90.493-915*Q+ 42.048/Q**	0.868
Aluminum	Y=1/(0.154+0.015*Q)	0.902	**Y=3.552-0.065*Q+1.197/Q**	0.940
Copper	Y=1/(0.379+0.067*Q)	0.949	**Y=1.410-0.034*Q+0.385/Q**	0.985
Iron	No suitable Correlation for any form			
Zinc	**Y=1/(2.649+0.444*Q)**	0.985	Y=0.222+.006*Q+.056/Q	0.943

Y = constituent concentration in mg/l.

Q= Discharge in cubic feet per second.

Note: The boldface equation was selected for use with each respective constituent in the model based on plots of estimated concentration against discharge.

In general, the results indicate relatively good correlation between discharge and constituent concentration.

3.2 Long-Term Simulation Results

Input terms were combined into a spreadsheet. The surface water load at station DC-5 was then divided by the calculated load for water exiting the backfilled pit. This ratio can be thought of representing the potential proportion of the surface water load that may be attributed to McLaren pit seepage. Since the true concentration of constituents in the pit backfill seepage is not known, simulations were conducted using wells EPA-3 and EPA-4 to estimate the constituent concentration. Figure 2 presents the simulation results obtained assuming that the pit backfill seepage chemistry was similar to EPA-4. Figure 3 presents the simulation results obtained assuming that the pit backfill seepage chemistry was similar to EPA-3. HELP3 output for these simulations is presented In Appendix B, Section B-1. Load calculations are presented in Appendix B, Section B-2

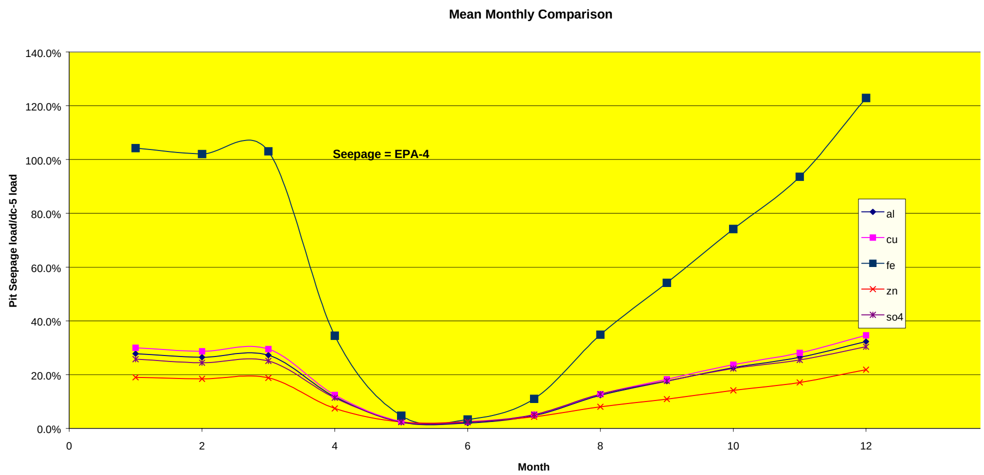

Figure 2. Results of the load comparisons at station DC-5. Loads are presented as proportion of the load at station DC-5 that may be attributed to McLaren pit seepage. Pit seepage chemistry simulated using the results for well EPA-4.

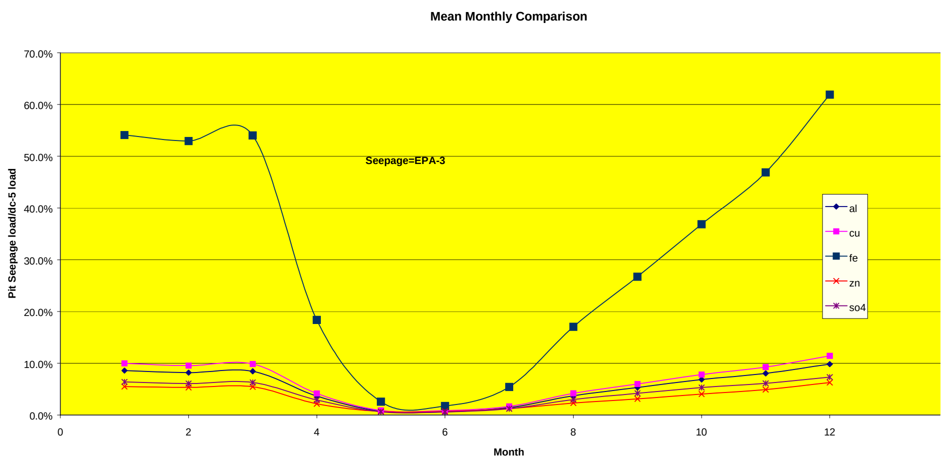

Figure 3. Results of the load comparisons at station DC-5. Loads are presented as proportion of the load at station DC-5 that may be attributed to McLaren pit seepage. Pit seepage chemistry simulated using the results for well EPA-3.

In general, the forms of the two analysis results are similar. In both cases, the proportion of surface water load attributed to pit seepage reaches a low during the summer for all constituents. In both cases, the iron load is generally above 100%, suggesting that some reduction in the pit seepage load may occur along the pathway. Figures 2 and 3 clearly indicate the seasonal nature of the potential influence of seepage from the McLaren pit.

The load prediction results can also be compared by calculating the average annual proportion of the surface water load that may be attributed to pit backfill seepage. Table 3 presents the results of these calculations.

TABLE 3
Comparison of Average Annual Surface Water Loads at Station DC-5 and Load Exiting McLaren Pit Backfill for Constituents of Interest.

		Proportion of annual load at station of interest that can be attributed to seepage from the McLaren pit backfill (%)				
Station of Interest	**Pit Seepage chemistry**	**Sulfate**	**Aluminum**	**Copper**	**Iron**	**Zinc**
DC-5	EPA-4	17	18	19	62	12
DC-5	EPA-3	4	6	6	32	4

3.3 Uncertainty

It is important to note that the analysis presented in Section 3.2 has been based on several derived and/or calculated values. Although both professional judgement and experience were used in deriving these relationships, these results should be viewed as general results that provide a probable range of impacts to Daisy Creek that may be attributed to the McLaren pit.

One key step in reviewing this type of analysis is determining the inputs that significantly affect model results. This type of evaluation is routinely conducted in a sensitivity analysis. However, a load analysis of this type is linear, meaning that the results are essentially linear combinations of the various input terms. Since the model is linear and since the model is also relatively simple, a sensitivity analysis was not conducted. However, there are four major inputs required for the model. These are:

- Estimation of the rate at which water exits the pit backfill;
- Estimation of the constituent concentration exiting the pit;
- Estimation of the surface water discharge in Daisy Creek at the station of interest;
- Estimation of the constituent concentration at the surface water station of interest.

The relative uncertainty associated with each of these estimates is to be discussed in the following sections.

3.3.1 Estimation of the Rate at Which Water Exits the Pit Backfill

A more thorough discussion of the uncertainty associated with estimation of this value is presented in the model report (Maxim, 2001a). In general, the attempt to calibrate model results to measured field data suggests that the selected values are reasonable and proper. It is felt that the degree of uncertainty associated with this prediction is relatively low.

3.3.2 Estimation of Surface Water Discharge in Daisy Creek at the Station of Interest

There is an inherent uncertainty associated with regionalizing hydrographs from one basin to another. This uncertainty is compounded when there is a large difference in significant factors, including drainage basin size. However, comparison of measured field flow parameters and discharge calculations suggests that these estimates are reasonable. Although changes in the mean monthly hydrograph for the system would affect the relative impacts associated with the McLaren pit seepage, it is unlikely that the mean monthly flow estimates would significantly alter the overall conclusions.

3.3.3 Estimation of the Constituent Concentration at the Surface Water Station of Interest

Regression results were used to estimate the constituent concentrations in Daisy Creek at mean monthly flow levels. Although daily concentrations (and therefore, loads) will exceed this mean monthly value, this is a reasonable estimation method. It should be noted that determining a relationship does not imply causality.

3.3.4 Estimation of the Constituent Concentration Exiting the Pit

This value probably represents the largest source of potential uncertainty of the model. Depending on the chemistry used to simulate the seepage term, the potential effects of the McLaren pit can range from relatively minor or relatively significant. Therefore, it seemed prudent to conduct additional evaluations in an attempt to gain a qualitative feel for the most likely seepage chemistry. This additional evaluation was based on the results of the Nimick 1999 investigation.

This analysis also assumes that constituent concentrations in the seepage and in the surface water system may be estimated using head or discharge data. While the r^2 values for these comparisons are generally good, the results are based on a very limited number of data points and the results should therefore be viewed with caution.

4.0 COMPARISONS OF SHORT-TERM SIMULATION TO MEASURED DATA

The comparisons presented in Section 3 indicate that seepage from the McLaren pit may influence water chemistry conditions in Daisy Creek. However, the magnitude of the predicted effects appears to be very dependent on seepage chemistry. Since there is insufficient available information to conduct a formal calibration of the model, the actual magnitude of the potential influence is difficult to determine. Although a formal calibration of the model is not possible, it is possible to use the results of the Nimick (2000) investigation to gauge the relative accuracy of the estimated pit seepage contributions to Daisy Creek.

Nimick (2000) collected a body of interesting and useful data on flow and load relationships in Daisy Creek in 1999. In particular, he conducted tracer dye tests and synoptic surface water measurements and sample collections that allow an evaluation of mass and water balance conditions along the length of the stream. Although these measurements represent a single data point in time, they form a basis for qualitative or quantitative comparison with model results.

In order to compare model results with Nimick's (2000) information, it is first necessary to understand the approach used in the Nimick (2000) evaluation. A brief discussion of the data collected by Nimick (1999) and the analytical approach is presented below. This is followed by a brief description of the HELP3/Load model implemented in an attempt to match model and field conditions at the time of Nimick's measurements. Finally, the results of the comparison are presented.

4.1 Nimick Data and Approach

The study conducted by Nimick used a combination of field measurements and calculations to estimate the relative magnitude of potential constituent load sources along Daisy Creek. Discharge in the mainstream of Daisy Creek was estimated using tracer dye study results.

A general schematic of the steps presented in the Nimick report is presented in Figure 4. As Figure 4 indicates, the Nimick evaluation assumes that within each reach (defined as stream segment between mainstream stations), the groundwater/subsurface flow rate is estimated by the following relationship:

$$Q_{\text{groundwater/subsurface}} = Q_{\text{at the reach end on Daisy Creek}} - Q_{\text{at reach start on Daisy Creek}} - \Sigma\, Q_{\text{from surface water inflows}}$$

Once the various discharge terms are estimated, Nimick balanced constituent loads using a similar approach. Constituent loads at the upstream and downstream ends of each reach are calculated, as well as the constituent loads from surface water inflow. The remaining loads are then assumed to be the result of groundwater/subsurface flow. Once the groundwater/subsurface flow and loads have been estimated, it is possible to then estimate the concentration of various constituents in the groundwater/subsurface flow system.

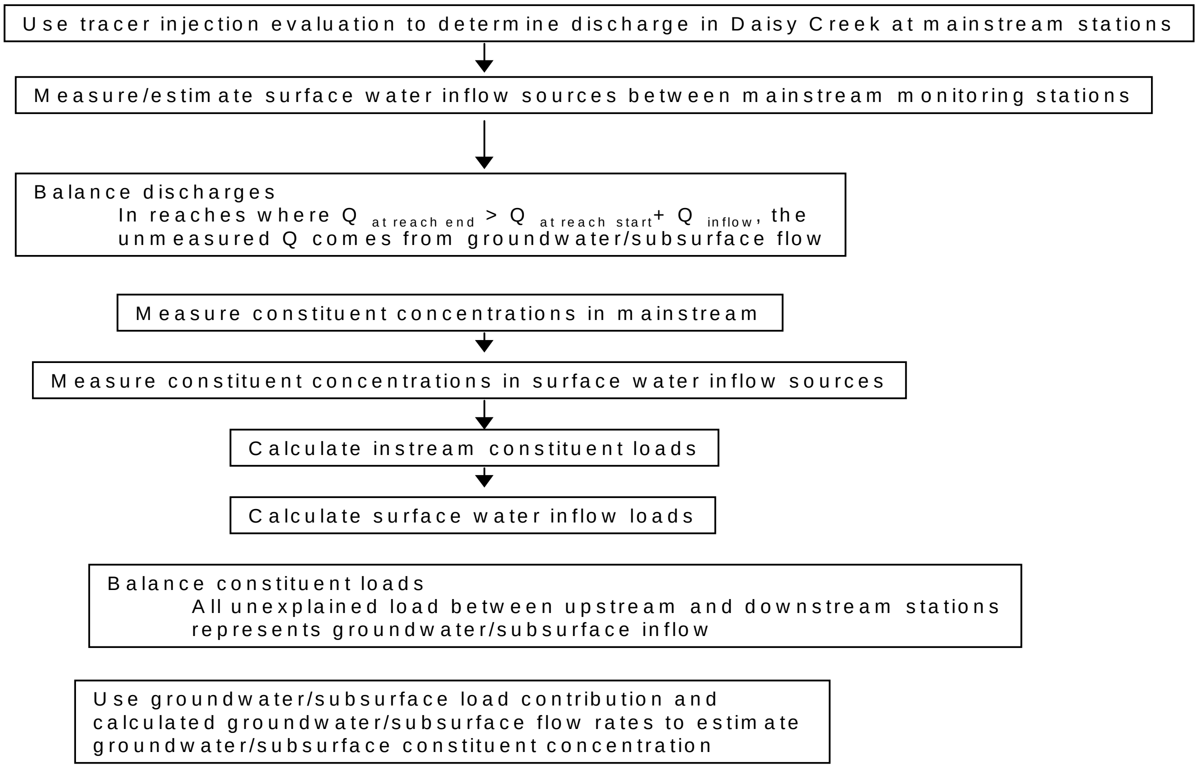

Figure 4. General Approach used for the Nimick calculations

4.2 Comparison of Nimick Results with the present HELP3/Load Analysis

The Nimick evaluation presents several options for comparing model results with measured or calculated data. Seepage rates from the McLaren pit predicted by the HELP3 model can be compared to the groundwater/subsurface inflow rates calculated by Nimick. In addition, the Nimick results can also be used to evaluate the relative magnitude and importance of the various load sources and values.

In order to use the results of the Nimick analysis to estimate groundwater flow rates, however, it is necessary to determine the portions of Daisy Creek that would be expected to exhibit the influence of McLaren pit seepage. URS (1998) used the available potentiometric surface data to define groundwater flow vectors in the vicinity of the McLaren pit. This plot indicates that the general groundwater flow is orientated S 15° W. By applying this vector to the northern and southern margins of the pit, a zone of potential groundwater influence along Daisy Creek can be estimated. This zone extends from above the Daisy Creek headwater to between stations 691 and 819. For the remainder of the comparisons, station 819 was therefore used as the station of interest on Daisy Creek.

Since a major source of uncertainty in the long-term analysis is the chemistry of water reporting to the stream, two cases were evaluated. In the first case, the chemistry of pit seepage was estimated using results for well EPA-4. In the second case, the chemistry of seepage was characterized using the results for well EPA-3.

4.3 HELP3/LOAD Model Implementation

In order to complete this analysis, a HELP3 model was developed. To reduce the potential effects of initial condition selection, the HELP3 simulation was conducted for the period extending from 1/1/ 1998 to 12/31/1999.

Daily precipitation values at the Fisher Creek SNOTEL site were obtained for the simulation period. These values were corrected for the McLaren pit conditions using the approach outlined above. In addition, mean daily temperature values were obtained for the simulation period and were also corrected for McLaren pit conditions. Snow depth at the start of 1998 was obtained form the SNOTEL site was used as an input parameter. The HELP3 model was allowed to establish the initial water content in the backfilled pit. Material layers, parameters, PET values were identical to previous simulations.

The HELP3 simulation result was used to estimate head in the backfilled portion the day of the Nimick measurements (taken as August 26, 1999). This head value was then used to estimate constituent concentration in the pit backfill water for the simulations using well EPA-4. Simulations using well EPA-3 used the results of the single water chemistry measurement from well EPA-3. HELP3 results were also used to predict the rate of seepage from the backfilled pit. Mean monthly discharge values were used to characterize flow in Daisy Creek. Chemical conditions in Daisy Creek were estimated using regression results discussed in Section 3

4.4 Results

The results of the HELP3 simulation are presented in Appendix C, Section C-1. Subsequent load calculations are presented in Appendix C- Section C-2.

4.4.1 Pit Seepage Rate

The Nimick data can be used to estimate the amount of subsurface and surface water inflows into Daisy Creek along a particular reach of interest. Based on the data collected on August 26, 1999, the cumulative groundwater (subsurface) inflow between the upper-most station and station 819 is approximately 24 gallons per minute (gpm). Assuming that Daisy Creek represents local groundwater control, (i.e., groundwater tends to flow into Daisy Creek from both the McLaren Pit side and the opposite side of the creek), approximately half of this cumulative flow may be influenced by the presence of the McLaren pit.

In addition to the calculated groundwater flow rate, it is possible that inflows reported as surface water actually represent shallow groundwater that is expressed as surface water flow. If this flow does represents some form of groundwater, it is not known whether this flow represents flow in the shallow alluvial system or flow in the deeper “bedrock” system.

A precipitation event was recorded at the Fisher Creek SNOTEL site on August 23, approximately 3 days prior to collection of the Nimick data. Between August 1, 1999 and August 26, 1999, approximately 2.7 inches of precipitation were recorded at the Fisher Creek SNOTEL site. While this suggests that some precipitation may have occurred at the McLaren pit site in the days immediately before collection of Nimick’s data, the magnitude of this precipitation is not known. The fact that precipitation may have occurred at the McLaren site prior to the collection of the Nimick data may only serve to cloud the relationship between the various potential flow components.

Given the available information, it is difficult to accurately apportion the surface water inflow term into the various possible components. Nonetheless, the Nimick can be used to qualitatively evaluate the result of the HELP3 model. If the HELP3 model predicted seepage rates greater than those measured by Nimick, the results would have to viewed with a great deal of skepticism. If, however, the model predicts reasonable seepage rates that are less than the total amount of potential cumulative inflow at station 819, the model can be considered reasonable.

Nimick reports surface water inflows as issuing from either the right (north) side or the left (south) side of Daisy Creek. Assuming that all surface water inflow from the north (McLaren) side of Daisy Creek represents groundwater and that half the calculated groundwater inflow is derived from the north side of Daisy Creek, the total cumulative inflow into Daisy Creek is approximately 70 gallons per minute (gpm). Using the predicted seepage rate on August 26, 1999 and a backfilled pit area of 11.4 acres, a seepage rate of 8 gpm can be calculated.

The McLaren pit covers an estimated area of approximately 11.4 acres. The total drainage basin area at station 819 is approximately 115 acres. McLaren pit area represents approximately 10 percent of the total drainage basin area. The backfilled pit is estimate to produce approximately 9 percent of the total flow. This result appears to support the predicted seepage rate.

Given the fact that the actual amount of groundwater flow that may be attributed to the McLaren pit can not be completely quantified using the Nimick analysis, the Nimick information appears to support the general seepage rate predicted by the HELP3 model. If the HELP3 analysis had predicted seepage rates substantially greater than the estimated total groundwater flow, it would have supported the contention that the model results were erroneous. Since this is not the case, it appears that the HELP3 model results are reasonable.

4.4.2 Groundwater/Seepage Loads

Using the Nimick analysis, it is possible to calculate the cumulative loads of key constituents attributed to the groundwater flow system between station 0 and 819. This calculation was completed assuming that the loads calculated for the main-stem surface water stations are correct. Using the in-stream flow values, the cumulative load for each constituent can then be calculated using the difference in the surface water station calculations. Note that using this approach, it is possible to calculate a negative load for certain constituents over certain reaches. These negative loads represent reaches in which constituent loads do not balance, i.e. the sum of the upstream loads and the inflow loads are greater than the in-stream load measured at the downstream station. For the comparison values, these negative loads are treated as real values and are included in the cumulative total. These cumulative loads at station 819 can then be compared to the loads estimated to be derived from the McLaren pit using the seepage chemistry predicted by wells EPA-3 and EPA-4. The results of this comparison are presented in Table 4.

TABLE 4

Summary of Constituent Loads in Groundwater Calculated by Nimick and This Investigation

	Load estimated to be exiting the backfilled McLaren pit		
Constituent	**Load using EPA-4**	**using EPA-3**	**Load estimated by Nimick (1999)**
	Pounds/day		
Sulfate	269	59	406
Aluminum	9.5	2.8	18.8
Copper	3.7	1.2	5.9
Iron	31.0	14.3	23.7
Zinc	0.4	0.12	0.77

The results indicate for most constituents, the total measured load values are greater than the loads predicted using wells EPA-4 or EPA-3. There are several possible explanations for this result. First, it is possible that the HELP3 simulation under-predicted the seepage rate from the backfilled pit. Assuming that the Nimick values are correct, it can be assumed that the HELP model under-predicted the flow by two to seven times. However, the estimate seepage rate appears to conform with drainage basin estimates, making it unlikely that the model under-predicted the seepage rate by two to seven times.

In completing the load calculations estimated from the HELP3 simulations, the seepage rate predicted on August 26 was used. It is also possible that the "under-prediction of seepage from the pit is not the result of a faulty model implementation but instead is a result of the fact that there is likely a natural lag between seepage reporting the stream.

An alternative explanation is that the model predictions are correct and that the difference between measured and estimated loads is a function of a single data collection point in time. Under this scenario, the Nimick load values would not represent a rigorous or critical comparison target.

Finally, it is possible that the results are essentially correct. As indicated above, the calculated groundwater contribution to Daisy Creek at station 819 is approximately 62 gpm. Of this, approximately 8 gpm is predicted to be seepage from the backfilled McLaren pit. Using the loads and the cumulative flow at station 819 (taken from Nimick), it is possible to calculate an estimated chemistry for all water reporting to Daisy Creek. These estimated concentrations can then be compared to estimated chemistry values for wells EPA-3 and EPA-4. The results of these estimates are presented in Table 5.

TABLE 5
Comparison of Calculated Average Concentration From Nimick and Water Chemistry Measurements From Wells EPA-3 and EPA-4

	Concentration calculated from Nimick (2001) Evaluation	Concentrations for well EPA-3	Concentrations for well EPA-4 (based on regression results and estimated potentiometric surface elevation)
	Mg/l		
Sulfate	480	576	2604
Aluminum	22.2	27	92
Copper	6.9	12	36
Iron	28	139	302
Zinc	0.9	1.13	4.00

These results indicate that the chemistry of water reporting to the stream between the headwaters and station 819 appears to be more closely related to the chemistry of water in well EPA-3.

5.0 DISCUSSION

This analysis is based on the assumption that constituent loads in Daisy Creek are conservative (I.e. all the metal loads that enter the stream remains in the stream and are not lost). However, there is evidence to suggest that constituent loads are not conservative and that geochemical processes play a large role in determining constituent concentrations in Daisy Creek.

First, the trend of iron loads through time on a mean monthly basis suggest that the load of iron exiting the McLaren pit is greater than the total iron load measured in Daisy Creek for part of the year. This result strongly indicates that some additional geochemical processes are occurring along the surface and/or groundwater flow-path. Field observations by a number of investigators have noted the presence of aluminum and iron precipitates along Daisy Creek. This evidence also supports the contention that the system is not conservative for all constituents.

Using the data collected by Nimick, it is possible to plot both cumulative copper load and copper load from individual stations moving from the Daisy Creek headwaters to the lower reaches. Copper was selected as representative of the spatial trend of other constituents. This plot is presented as Figure 5 and clearly indicates that, at least for copper during the time of the Nimick evaluation, the assumption of conservative constituents does not hold true, especially at stations greater than 5000 ft. downstream in Daisy Creek. If copper were conservative for the Nimick study, one would expect to see individual stations load measurements that more closely matched the cumulative load curve. Geochemical and equilibrium processes seem to be controlling copper loads in the creek beyond that distance and the total load of copper measured in the creek is substantially lower than the cumulative load of copper that has entered the creek up to this point. These kinds of trends are also seen for other metals. This result indicates that equilibrium between precipitated minerals and the creek is likely a primary control of solute concentrations in the creek.

Since this evaluation assumes conservation of constituents and there is evidence to suggest that this is not the case, care must be exercised when interpreting these results. On an initial review, these results may suggest that simply reducing the load of constituents exiting the McLaren pit would lead to an equal reduction in constituent load (and therefore, constituent concentration) in Daisy Creek. However, if geochemical processes are active in the system, very large reductions in contributed load may be required to change the existing constituent concentrations.

As Figure 5 indicates, removing some of the metal load point sources (for example, the McLaren Pit) may not have any measurable effects on the metal loadings in the creek. This is especially true to points located more than 5000 feet downstream in Daisy Creek (DC-5), due to the potential influence of pother unidentified load sources.

For certain constituents, significant load reductions may be required to shift equilibrium below the solubility limits of aluminum sulfate, aluminum oxide, and iron oxide phases. These phases in turn are the likely substrates for sorptive control of copper and zinc at the observed range of pH conditions (> 6) at DC-5.

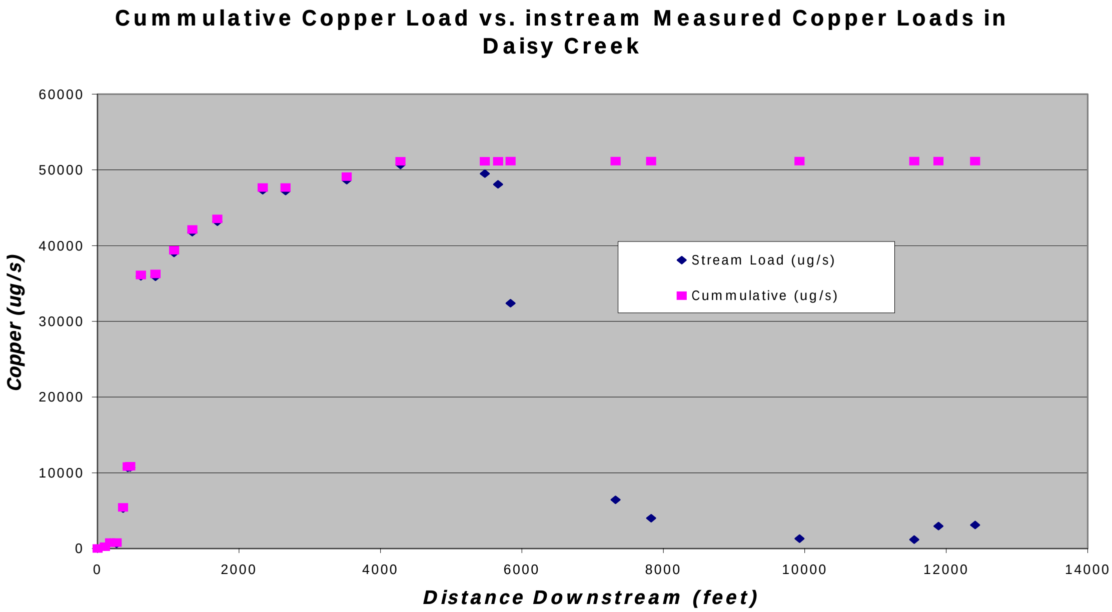

Figure 5 Cumulative and instream copper loads for Daisy Creek (taken from Nimick, 2001)

For the mean monthly simulations, regression estimates were used and were based on total metal concentrations. The total metal concentrations were used to include as many data points as possible. It would be unwise to attempt to use this analysis to estimate the concentration of other metal forms or species.

A number of regional and regression relationships have been used in these analyses. Like all estimation techniques, these results do not necessarily imply causality. Additional information collected at later dates may modify or refute these estimated relationships. Using relationships to estimate site parameters contributes to the uncertainty of the results.

6.0 REFERENCES

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APPENDIX A

FIGURES

Figure A-1 – Location map

FIGURES A-2 THROUGH A-5

PLOTS OF CONSTITUENT CONCENTRATION
VS
DISCHARGE STATION DC-5

FIGURES A-6 THROUGH A-10

PLOTS OF HEAD

VS

CONSTITUENT CONCENTRATION FOR WELL EPA-4

APPENDIX B

LONG TERM SIMULATION RESULTS

Appendix B-1 – HELP3 OUTPUT

Appendix B-2a – Load Calculations

Using Well EPA-4

Appendix B-2b – Load Calculations

Using Well EPA-3

APPENDIX C

1998-1999 SIMULATION RESULTS

Appendix C-1 – HELP3 OUTPUT

APPENDIX D

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

McLaren Pit Response Action Engineering Evaluation/Cost Analysis

New World Mining District Response and Restoration Project

Preliminary Identification of Applicable or Relevant and Appropriate Requirements
McLaren Pit 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.	Not Applicable
Migratory Bird Treaty Act	16 USC § 703 et seq.	Establishes a federal responsibility for the protection of international migratory bird resource.	Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit 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.	Not Applicable
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
Surface Mining Control and Reclamation Act	30 CFR Parts 816, 784	Reclamation requirements for coal and certain non-coal mining.	Relevant and Appropriate
Resource Conservation and Recovery Act	42 USC § 6901	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270 and 271.	Not Applicable
	40 CFR Part 257.3	Governs waste handling and disposal	Applicable
	40 CFR Part 264.228	Provisions regarding run-on and run-off controls	Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
FEDERAL ACTION-SPECIFIC (continued)			
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
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 Standards	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 17.30.1011	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to state water	Applicable
	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

Preliminary Identification of Applicable or Relevant and Appropriate Requirements
McLaren Pit Response Action

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE CONTAMINANT-SPECIFIC (continued)			
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.	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 specified levels.	Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements
McLaren Pit Response Action

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE LOCATION-SPECIFIC			
Floodplain and Floodway Management Act	76-5-401, MCA	Lists the uses permissible in a floodway and generally prohibits permanent structures, fill, or permanent storage of materials or equipment.	Not Applicable
	76-5-402 MCA	Lists the permissible permanent structures that are allowed in the floodplain excluding the floodway, if they are permitted and meet certain minimum standards.	Not Applicable
	76-5-403, MCA	Lists certain uses which are prohibited in a designated floodway, including any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to flotation or movement during flood level periods.	Not Applicable
Floodplain Management Regulations	ARM 36.15.216	The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section.	Not Applicable
	ARM 36.15.602	Specifies uses requiring permits for allowing obstructions in the floodway.	Not Applicable
	ARM 36.15.603	Proposed diversions or changes in place of diversions must be evaluated by the DNRC to determine whether they may significantly affect flood flows and, therefore, require a permit.	Not Applicable
	ARM 36.15.604	Prohibits new artificial obstructions or nonconforming uses that will increase the upstream elevation of the base flood 0.5 of a foot or significantly increase flood velocities.	Not Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE LOCATION-SPECIFIC (continued)			
Floodplain Management Regulations (continued)	ARM 36.15.605	Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway..." Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited.	Not Applicable
	ARM 36.15.606	Identifies flood control works that are allowed with designated floodways pursuant to permit and certain conditions including: flood control levies and flood walls, rip rap, channelization projects, and dams.	Not Applicable
	ARM 36.15.701 and 703	Describes allowed uses in the flood fringe. Prohibited uses within the flood fringe (i.e., areas in the floodplain, but outside of the designated floodway) areas including solid waste disposal and storage of highly toxic, flammable or explosive material.	Not Applicable
	ARM 36.15.801	Allowed uses where floodway is not designated.	Not Applicable
Montana Solid Waste Management Act and Regulations	75-10-201, MCA ARM 17.50.505	Specifies the requirements that apply to the location of any solid waste management facility.	Not Applicable
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

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE LOCATION SPECIFIC (continued)			
Natural Streambed and Land Preservation Act	75-7-101, et seq., MCA	The adverse affects of any action shall minimize alteration or affects to a streambed or its banks	Not Applicable
Natural Streambed and Land Preservation Standards	ARM 36.2.404, 405, 406, and 410	Proposed projects are to be evaluated by the appropriate conservation district based on criteria including: 1) whether the project will pass anticipated sediment loads without creating harmful flooding or erosion problems upstream or downstream; 2) whether the project will minimize the amount of stream channel alteration; 3) whether the project will be as permanent a solution as possible and whether the method used will create a reasonably permanent and stable situation; 4) whether the project will minimize effects of fish and aquatic habitat: 5) whether the project will minimize turbidity or other water pollution problems; and, 6) whether the project will minimize adverse effects on the natural beauty of the area	Not 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.	Not Applicable
	ARM 17.30.1203 and 1344	Technology-based treatment for MPDES permits.	Not Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements
McLaren Pit Response Action

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE ACTION-SPECIFIC (continued)			
Nondegradation of Water Quality	75-5-303, MCA	States that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected. Provides exemption which allows changes of existing water quality resulting from emergency or remedial activity designed to protect the public health or the environment.	Not Applicable
	ARM 17.30.705	Provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed.	Not Applicable
	ARM 17.30.1011	Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA and ARM 17.30.701, et seq.	Not Applicable
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 17.8.308	No person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.	Applicable
	ARM 17.8.604	Lists certain wastes that may not be disposed of by open burning.	Applicable
	ARM 16.8.1401-1404	Sets forth emission standards for hazardous air pollutants	Applicable
Montana Solid Waste Management Act	75-10-201, et seq, MCA	Public policy is to control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible.	Not Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE ACTION-SPECIFIC (continued)			
Solid Waste Management Regulations	ARM 17.50.505 and 508-509	The standards for solid waste disposal are set forth in this provision.	Not Applicable
	ARM 17.50.511	General operational and maintenance requirements for solid waste management systems are established pursuant to this section. This section requires that solid waste disposal be confined to areas within the disposal site that can be effectively maintained and operated.	Not Applicable Not Applicable
	ARM 17.50.523	Solid waste must be transported In such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Relevant and Appropriate
Montana Hazardous Waste And Underground Storage Tank Act	75-10-401, et seq, MCA	State's policy to protect the public health and safety, the health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous wastes.	Not Applicable
Montana Hazardous Waste Regulations	ARM 17.54.701-703	By reference to federal regulatory requirements, these sections establish standards for all permitted hazardous waste management facilities. 1) 40 CFR 264.111 (referenced by ARM 17.54.720) establishes that hazardous waste facilities must be closed in such a manner as to minimize the need for further maintenance and control, minimize or eliminate, to the extent necessary to protect public health and the environment, post closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or the atmosphere. Such closure must comply with the closure requirements of 40 CFR 264 Subpart G.	Not Applicable Not Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements
McLaren Pit Response Action

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE ACTION-SPECIFIC (continued)			
Montana Hazardous Waste Regulations (continued)	ARM 17.54.701-703 (continued)	2) 40 CFR 264.228(a)(2) (incorporated by reference by ARM 17.54.702) requires that at closure, free liquids must be removed or solidified, the wastes stabilized and the wastes management unit covered	Not Applicable
		3) 40 CFR 264.228(a)(2) and 310 (incorporated by reference in ARM 17.54.702) requires that surface impoundments and landfill caps must: (a) provide long-term minimization of migration of liquids through the unit; (b) function with minimum maintenance; (c) promote drainage and minimize erosion or abrasion of the final cover; (d) accommodate settling and subsidence; and (e) have a permeability less than or equal to the permeability of the natural subsoils present.	Not Applicable
		4) 40 CFR 264.228 and 310 (incorporated by reference in ARM 17.54.702) requires that a map be provided showing the dimensions of waste disposal units, together with the types and amounts of waste disposed of in each unit. Additionally, the owner must record a deed restriction, in accordance with state law, that will in perpetuity notify potential purchasers that the property has been used for waste disposal and that its use is restricted.	Not Applicable
	ARM 17.54.109-113	Establishes permit conditions, duration of permits, schedules.	Not Applicable
<u>Montana Strip and Underground Mine Reclamation Act</u>	82-4-231, MCA	Sets forth objectives that require the operator to prepare and carry out a method of operations plan to reclaim and revegetate the land affected by his operation	Relevant and Appropriate
	82-4-233, MCA	Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator shall establish a vegetative cover on all impacted lands. Specifications for the vegetative cover and performance are provided.	Relevant and Appropriate

Preliminary Identification of Applicable or Relevant and Appropriate Requirements
McLaren Pit Response Action

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE ACTION-SPECIFIC (continued)			
Backfilling and Grading Requirements	ARM 17.24.501	Gives general backfilling and grading requirements.	Relevant and Appropriate
	ARM 17.24.504	Provides that permanent impoundments may be retained under certain circumstances.	Not Applicable
	ARM 17.24.514	Gives contouring requirements.	Relevant and Appropriate
	ARM 17.24.519	Operator may be required to monitor settling of regraded areas.	Relevant and Appropriate
	ARM 17.24.520	Spoil material may be disposed of on-site in accordance with requirements of this section. Contains specific requirements for siting, surface runoff, construction of underdrains and revegetation.	Not Applicable
Hydrology Requirements	ARM 17.24.631	Reclamation operations must be planned and conducted to minimize disturbance and prevent damage to the prevailing hydrologic balance.	Relevant and Appropriate
	ARM 17.24.633	Specifies that sediment controls must be maintained until the disturbed area has been restored and revegetated.	Relevant and Appropriate
	ARM 17.24.634	Drainage design shall emphasize premining channel and floodplain configurations that blend with the undisturbed drainage system above and below; will meander naturally; remain in dynamic equilibrium with the system; improve unstable premining conditions, provide for floods, provide for long term stability of the landscape; and establish a premining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate
	ARM 17.24.635-637	Sets forth requirements for temporary and permanent diversions.	Relevant and Appropriate
	ARM 17.24.641	Sets methods for preventing drainage from acid-and toxic-forming wastes into ground and surface waters.	Relevant and Appropriate

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE ACTION-SPECIFIC (continued)			
Hydrology Requirements (continued)	ARM 17.24.642	Prohibits permanent impoundments with certain exceptions, and sets standards for temporary and permanent impoundments.	Relevant and Appropriate
	ARM 17.24.643-646	Provides for groundwater and groundwater recharge protection, and surface and groundwater monitoring.	Relevant and Appropriate
	ARM 17.24.650	All permanent sedimentation ponds, diversions, impoundments, and treatment facilities must be renovated postmining and regraded to the approximate original contour.	Relevant and Appropriate
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations	ARM 17.24.701-702	Requirements for stockpiling soil.	Relevant and Appropriate
	ARM 17.24.703	Materials other than, or along with, soil for final surfacing of spoils or other disturbances must be capable of supporting the approved vegetation and postmining land use.	Relevant and Appropriate
	ARM 17.24.711	The section requires “a diverse, effective, and permanent vegetative cover of the same seasonal utility native to the area of and to be affected and capable of meeting the criteria set forth in 82-4-233 shall be established on all areas of land affected except water areas and surface areas of roads.”	Relevant and Appropriate
	ARM 17.24.713	Specifies that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation; but not longer than 90 days after top soil placement.	Relevant and Appropriate
	ARM 17.24.714	According to this section, as soon as practical, a mulch or cover crop must be used on all regraded and resoiled areas to control erosion, to promote germination of seeds, and to increase moisture retention of soil until permanent cover is established.	Relevant and Appropriate
	ARM 17.24.716	Establishes methods of revegetation	Relevant and Appropriate

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE ACTION-SPECIFIC (continued)			
	ARM 17.24.717	Relates to the planting of trees and other woody species to establish a diverse, effective, and permanent vegetative cover.	Not Applicable
	ARM 17.24.718	Soil amendments must be used as necessary to aid in the establishment of permanent vegetation; irrigation, management, fencing, or other measures may also be used after review and approval by the dep't.	Relevant and Appropriate
	ARM 17.24.719	Livestock grazing on reclaimed land is prohibited until revegetation is established and can sustain managed grazing.	Not Applicable
	ARM 17.24.720	Sets annual department inspection requirements.	Not Applicable
	ARM 17.24.721	Section specifies that rills and gullies greater than 9 inches which form on the reclaimed area may need to be filled, graded or otherwise stabilized and the area reseeded or replanted.	Relevant and Appropriate
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 17.24.723	Monitoring of vegetation, soils and wildlife.	Relevant and Appropriate
	ARM 17.24.724	Success of revegetation shall be measured on the basis of unmined reference areas.	Not Applicable
	ARM 17.24.725	Sets periods of responsibility and evaluation.	Not Applicble
	ARM 17.24.726	Sets means of measuring productivity.	Not Applicable
	ARM 17.24.728	Sets requirements for composition of vegetation.	Not Applicable
	ARM 17.24.730-731	Revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference area.	Not Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements McLaren Pit Response Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
STATE ACTION-SPECIFIC (continued)			
	ARM 17.24.733	Sets requirements and measurement standards for trees, shrubs and half-shrubs.	Not Applicable
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 17.24.751	Required site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened or endangered species identified at the site.	Relevant and Appropriate
	ARM 17.24.761	Section requires fugitive dust control measures for site preparation and reclamation operations.	Relevant and Appropriate

APPENDIX E

POST REMOVAL SITE CONTROL COSTS
McLaren Pit Response Action Engineering Evaluation/Cost Analysis
New World Mining District Response and Restoration Project

McLAREN PIT RESPONSE ACTION POST REMOVAL SITE CONTROL MAINTENANCE AND MONITORING COST						
Year	**Excavation and Dirt Work $/year**	**Fertilizer Reapplication $/year**	**Seed Reapplication $/year**	**Monitoring Wells (8)**	**Monitoring (labor + analyses)**	**TOTAL COST $/year**
1	$5,000	$2,500		$22,000	$2,400	$31,900
2	$5,000	$2,500	$5,000		$2,400	$14,900
3	$3,000	$2,500	$2,500		$2,400	$10,400
4	$3,000		$1,000		$2,400	$6,400
5	$3,000	$2,500			$2,400	$7,900
6	$3,000				$2,400	$5,400
7	$1,500	$2,500			$2,400	$6,400
8	$1,500				$2,400	$3,900
9	$1,500				$2,400	$3,900
10	$1,500	$2,500			$2,400	$6,400
11	$1,500				$2,400	$3,900
12	$1,500				$2,400	$3,900
13	$1,500				$2,400	$3,900
14	$1,500				$2,400	$3,900
15	$1,500	$2,500			$2,400	$6,400
16	$1,000				$2,400	$3,400
17	$1,000				$2,400	$3,400
18	$1,000				$2,400	$3,400
19	$1,000				$2,400	$3,400
20	$1,000	$2,500			$2,400	$5,900
21	$1,000				$2,400	$3,400
22	$1,000				$2,400	$3,400
23	$1,000				$2,400	$3,400
24	$1,000				$2,400	$3,400
25	$1,000				$2,400	$3,400
26	$1,000				$2,400	$3,400
27	$1,000				$2,400	$3,400
28	$1,000				$2,400	$3,400
29	$1,000				$2,400	$3,400
30	$1,000				$2,400	$3,400
Totals	$50,500	$20,000	$8,500	$22,000	$72,000	$173,000
		Net Present Value (Discount Rate = 4.9%)			($58,291)	($112,270)

APPENDIX F

COST ESTIMATES
McLaren Pit Response Action Engineering Evaluation/Cost Analysis
New World Mining District Response and Restoration Project

McLaren Pit Response Action - Alternative Cost Analysis

Alt #	Alternative/Task #	Task	Units	Quantities	Rate $/unit	Cost $
Alt 1	**No Action**	PRSC Monitoring	ls	1	$58,300.00	$58,300
Alt 2	**In-Situ Treatment**					
	Construction Components Required for All Sub-Alternatives					
	2-1	Clear and Grub	ha	3.35	$3,700.00	$12,395
	2-2	Excavate/Place and Compact Outlying Waste - not including transportation				
		McLaren Multicolor Dump	m^3	2360	$8.20	$19,350
		McLaren Spoils	m^3	16053	$8.20	$131,635
	2-3	Haul Outlying Waste				
		McLaren Multicolor Dump	m^3	2360	$1.00	$2,360
		McLaren Spoils	m^3	16053	$0.40	$6,421
	2-4	Regrade Out-lying areas				
		McLaren Multicolor Dump	ha	0.24	$15,830.00	$3,799
		McLaren Spoils	ha	1.21	$15,830.00	$19,154
	2-5	Revegetate Outlying Sites				
		McLaren Multicolor Dump	ha	0.24	$20,852.00	$5,004
		McLaren Spoils	ha	1.21	$20,852.00	$25,231
	2-6	Regrade McLaren Wastes	ha	3.35	$15,830.00	$53,031
	2-7	Channels	m	1200	$30.00	$36,000
	2-8	Silt Fence	m	2000	$16.00	$32,000
	2-9	Ancillary Activities	ls	1	$19,675.00	$19,675
					SUBTOTAL	$366,055
Alt 2 A	**Shallow Neutralization**					
	2-10A	Amend Upper 30 cm				
		McLaren Wastes	Metric Tons Lime	2345	$62.00	$145,390
	2-11A	Revegetate McLaren Wastes	ha	3.35	$20,852.00	$69,854
				Alternate 2 A SubTotal:		$581,300
				Mobilization (10%)		$58,130
				Contingency 12%)		$69,756
			TOTAL CONSTRUCTION ESTIMATE			$709,185
				Eng Eval and Design (8%)		$56,735
				Const Oversight (5%)		$35,459
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 2A			$913,680
Alt 2 B	**Deep Neutralization**					
	2-10B	Amend Upper 1.0 meter				
		McLaren Wastes	Metric Tons Lime	7816	$62.00	$484,592
	2-11B	Revegetate McLaren Wastes	ha	3.35	$20,852.00	$69,854
				Alternate 2 B Sub Total:		$920,502
				Mobilization (10%)		$92,050
				Contingency 12%)		$110,460
			TOTAL CONSTRUCTION ESTIMATE			$1,123,012
				Eng Eval and Design (8%)		$89,841
				Const Oversight (5%)		$56,151
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 2B			$1,381,303

McLaren Pit Response Action - Alternative Cost Analysis

Alt #	Alternative/Task #	Task	Units	Quantities	Rate $/unit	Cost $
Alt 2 C	**Total Neutralization**					
	2-10C	Excavate McLaren Wastes	m^3	136480	$4.16	$567,757
	2-11C	Amend All Wastes (154,900 m^3)	Metric Tons Lime	36218	$62.00	$2,245,516
	2-12C	Place Wastes back into Pit	m^3	147241	$8.20	$1,207,376
	2-13C	Revegetate McLaren Wastes	ha	3.35	$20,852.00	$69,854
				Alternate 2 C Sub Total:		$4,456,559
				Mobilization (10%)		$445,656
				Contingency 12%)		$534,787
			TOTAL CONSTRUCTION ESTIMATE			$5,437,001
				Eng Eval and Design (8%)		$434,960
				Const Oversight (5%)		$271,850
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 2C			$6,256,112
Alt 3	**Cap Waste In-Place**					
	Construction Components Required for All Sub-Alternatives					
	3-1	Clear and Grub	ha	3.35	$3,700.00	$12,395
	3-2	Excavate/Place and Compact Outlying Waste - not including transportation				
		McLaren Multicolor Dump	m^3	2360	$8.20	$19,350
		McLaren Spoils	m^3	16053	$8.20	$131,635
	3-3	Haul Outlying Waste				
		McLaren Multicolor Dump	m^3	2360	$1.00	$2,360
		McLaren Spoils	m^3	16053	$0.40	$6,421
	3-4	Regrade Out-lying areas				
		McLaren Multicolor Dump	ha	0.24	$15,830.00	$3,799
		McLaren Spoils	ha	1.21	$15,830.00	$19,154
	3-5	Revegetate Outlying Sites				
		McLaren Multicolor Dump	ha	0.24	$20,852.00	$5,004
		McLaren Spoils	ha	1.21	$20,852.00	$25,231
	3-6	Regrade McLaren Wastes	ha	3.35	$15,830.00	$53,031
	3-7	Channels	m	1200	$30.00	$36,000
	3-8	Silt Fence	m	2000	$16.00	$32,000
	3-9	Ancillary Activities	ls	1	$19,675.00	$19,675
					SUBTOTAL	$366,055
Alt 3 A	**Amended Waste with**					
	Soil Cap					
	3-10A	Amend Upper 30 cm				
		McLaren Wastes	Metric Tons Lime	2345	$62.00	$145,390
	3-11A	Cover Soil (60 cm thick)	m^3	20160	$35.00	$705,600
	3-12A	Revegetate McLaren Soil Cover	ha	3.35	$10,426.00	$34,927
				Alternative 3A Sub Total:		$1,251,972
				Mobilization (10%)		$125,197
				Contingency 12%)		$150,237
			TOTAL CONSTRUCTION ESTIMATE			$1,527,406
				Eng Eval and Design (8%)		$122,193
				Const Oversight (5%)		$76,370
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 3A			$1,838,269

McLaren Pit Response Action - Alternative Cost Analysis

Alt #	Alternative/Task #	Task	Units	Quantities	Rate $/unit	Cost $
Alt 3 B	**Geomembrane with**					
	Amended Waste Cap					
	3-11B	Amend Excavated Wastes	Metric Tons Lime	11708	$62.00	$725,896
	3-12B	Regrade remaining wastes	ha	3.35	$15,830.00	$53,031
	3-13B	Install liner	m^2	33600	$8.43	$283,248
	3-14B	Drainage Gravel, 2 ft thick	m^3	20482	$70.90	$1,452,174
	3-15B	Place Amended Waste (1.5 m)	m^3	50400	$8.20	$413,280
	3-16B	Revegetate McLaren Waste Cover	ha	3.35	$20,852.00	$69,854
				Alternative 3B Sub Total:		$3,363,538
				Mobilization (10%)		$336,354
				Contingency 12%)		$403,625
			TOTAL CONSTRUCTION ESTIMATE			$4,103,516
				Eng Eval and Design (8%)		$328,281
				Const Oversight (5%)		$205,176
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 3B			$4,749,273
Alt 3 C	**Geomembrane with**					
	Drain Layer & Soil Cap					
	3-10C	Install liner	m^2	33600	$8.43	$283,248
	3-11C	Drainage Gravel, 2 ft thick	m^3	20482	$70.90	$1,452,174
	3-12C	Install Filter Fabric	m^2	33600	$2.37	$79,632
	3-13C	Cover Soil (3 feet thick)	m^3	33600	$35.00	$1,176,000
	3-14C	Revegetate McLaren Soil Cover	ha	3.35	$10,426.00	$34,927
				Alternative 3C Sub Total:		$3,392,036
				Mobilization (10%)		$339,204
				Contingency 12%)		$407,044
			TOTAL CONSTRUCTION ESTIMATE			$4,138,284
				Eng Eval and Design (8%)		$331,063
				Const Oversight (5%)		$206,914
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 3C			$4,676,261
Alt 3 D	**Geomembrane with**					
	Amended Waste Cap & Soil Cover					
	3-11M	Amend Excavated Wastes	Metric Tons Lime	4760	$62.00	$295,120
	3-12M	Regrade remaining wastes	ha	3.35	$15,830.00	$53,031
	3-13M	Install liner	m^2	33600	$8.43	$283,248
	3-14M	Drainage Gravel, 2 ft thick	m^3	20482	$70.90	$1,452,174
	3-15M	Place Amended Waste (2')	m^3	20482	$8.20	$167,952
	3-16M	Cover Soil (1 feet thick)	m^3	10080	$35.00	$352,800
	3-17M	Revegetate McLaren Soil Cover	ha	3.35	$10,426.00	$34,927
				Alternative 3D Mixed Sub Total		$3,005,307
				Mobilization (10%)		$300,531
				Contingency 12%)		$360,637
			TOTAL CONSTRUCTION ESTIMATE			$3,666,475
				Eng Eval and Design (8%)		$293,318
				Const Oversight (5%)		$183,324
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 3D			$4,255,416

McLaren Pit Response Action - Alternative Cost Analysis

Alt #	Alternative/Task #	Task	Units	Quantities	Rate $/unit	Cost $
Alt 4	**On-site Disposal**					
	with Alt 2 or 3 above					
	4-1	Load Waste	m^3	107509	$4.16	$447,237
	4-2	Haul Waste to Repository	m^3	107509	$17.70	$1,902,909
	4-3	Spread Waste	m^3	108509	$8.20	$889,774
	4-4	Repository Cost	m^3	108509	$35.00	$3,797,815
	4-5	Ancillary Activities	ls	1	$19,675.00	$19,675
	4-6	Common Activities	ls	1	$346,400.00	$346,400
				Subtotal Alternative 4		$7,403,811
				Mobilization (10%)		$740,381
				Contingency 12%)		$888,457
			TOTAL CONSTRUCTION ESTIMATE			$9,032,649
				Eng Eval and Design (8%)		$722,612
				Const Oversight (5%)		$451,632
					PRSC	$112,300
			TOTAL ESTIMATED COST ALT 4			$10,319,193
			WITH ALTERNATIVE 2A			$11,232,873
			WITH ALTERNATIVE 2B			$11,700,497
			WITH ALTERNATIVE 2C			$11,670,148
			WITH ALTERNATIVE 3A			$12,157,462
			WITH ALTERNATIVE 3B			$15,068,467
			WITH ALTERNATIVE 3C			$14,995,454
			WITH ALTERNATIVE 3D			$14,574,610