Final

SELECTIVE SOURCE RESPONSE ACTION ENGINEERING EVALUATION/COST ANALYSIS NEW WORLD MINING DISTRICT RESPONSE AND RESTORATION PROJECT

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EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) was developed by Maxim Technologies, Inc. (Maxim) 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 New World Mining District (District), which is located north of Cooke City, Montana. The primary environmental issues within the District are associated with impacts from historic and more recent mining activities. 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.

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 Selective Source Response Action to address the immediate threat to human health and the environment posed by certain mine waste piles located on District Property.

Response activities described in this document represent the first response action that will be conducted during this multi-year project. A response action in 1999 was proposed and analyzed in a draft EE/CA prepared in June 1999. That draft was released to the public for comment and numerous comments were received. In August 1999, a decision was made by the USDA-FS to delay the 1999 Response Action. This decision was made to allow additional time to complete the study of potential repository sites and to further consider source area prioritization. As such, many elements of the 1999 response action are included in this EE/CA. Changes incorporated into this EE/CA as a result of comments received on the draft 1999 EE/CA include the following:

- Retaining off-site disposal as an alternative for in-depth analysis.
- Retaining in-situ treatment of mine waste as an alternative for in-depth analysis.
- Modifying Repository Alternative A to include liming of the waste placed in the repository.
- Modifying the cover system for Repository Alternatives B and C to include a geomembrane liner in addition to the geosynthetic clay liner.
- Selecting a preferred alternative.

Waste sources were prioritized in 1999 using the Abandoned and Inactive Mines Scoring System (AIMSS), which was developed by the Montana Department of Environmental Quality. The AIMSS is a modified Hazard Ranking System that takes into consideration a host of factors to rank source areas relative to each other. These factors include source location, source characteristics, contaminant concentrations, waste quantity, proximity to and level of recreational or residential use, and identified impacts to surface water and groundwater. Using the conceptual model outlined in the Overall Project Work Plan in conjunction with the results of the AIMSS source prioritization, the scope of this initial response action will be limited to reducing or eliminating uncontrolled releases of metals from mine waste dump sources that are in direct contact with surface water or groundwater.

Based on the limited scope of the response action described above, the proposed action evaluated in this EE/CA has been titled "selective source". The primary reason for developing a selective source response is a result of the short construction season that exists in the District, allowing only a certain number of mine waste dump source areas that can be practically included in any one annual response action. The mine waste dump source areas included in the Selective Source Response Action were selected from the AIMSS priority list based on several factors including ranking, measured impacts to surface water quality, location on District Property, and assessment status. These sites are listed in Table ES-1. It should be noted that several higher ranking sites are not being addressed in this EE/CA. Work on the higher ranking District Property sites, including the McLaren Pit (ranked No. 1), McLaren Pit spoils (ranked No. 9), McLaren Multicolored Dump (ranked No. 17), Glengarry Dump (ranked No. 15), and higher ranking dumps located in Miller Creek (Miller Creek Headwaters, West Miller Creek, and Alice E dumps) will be delayed for one to two years until assessment work is completed.

TABLE ES-1
Mine Dumps Included in the Selective Source Response Action
New World Mining District – Response and Restoration Project

Waste Dump Name And Designation	AIMSS Rank*	Area hectares (acres)	Volume cubic meters (cubic yards)
Rommel Tailings (SBSI-96-2)	11	0.9 (2.22)	13,730 (17,990)
Lower Spalding Dump (FCSI-96-8)	23	0.13 (0.32)	2,000 (2,630)
Lower Tredennic Dump One (FCSI-96-5)	26	0.16 (0.40)	2,610 (3,430)
Upper and Middle Spalding Dump (FCSI-96-7)	33	0.11 (0.28)	560 (740)
Upper Tredennic – Five Dumps (FCSI-96-15)	36	0.11 (0.28)	375 (495)
Soda Butte Tailings Dump (SBSI-96-1)	39	0.06 (0.14)	330(440)
Middle Tredennic - Dumps One to Three (FCSI-96-6)	45	0.11 (0.28)	620 (845)
Small Como Dump (FCSI-96-9)	96	0.10 (0.25)	310 (410)
TOTALS:		**1.63 (4.02)**	**20,535 (26,980)**
****ADJUSTED TOTALS:**		**1.87 (4.62)**	**24,642 (32,375)**

Note: * - AIMSS - Abandoned and Inactive Mine Scoring System
** - Adjusted totals allow 15% overage on area affected to allow construction staging and access, and 20% overage on volumes to allow over-excavation of mine wastes.

Selecting sites that pose a threat to surface water is an important aspect of the Selective Source Response Action. Because several of the higher ranking sites on the AIMSS list had lower surface water pathway scores (e.g. Soda Butte Dumps One through Eight), lower ranking dumps with higher surface water pathway scores were selected for this initial response action work. The groups of dumps located in upper reaches of Fisher Creek (Tredennic and Spalding dumps) are located in source areas where copper loads to Fisher Creek have been documented. The Rommel tailings directly impact Soda Butte Creek with metals and sediment, and this site has a relatively high surface water pathway score. The two lower ranking sites listed, Soda Butte Tailings Dump and Small Como Dump, were included primarily because of proximity to the Rommel Tailings and Spalding dumps, respectively. Impacts associated with these two smaller sites can easily be addressed in the same response action.

Existing surface water and instream sediment data were reviewed and summarized in order to plan response activities and evaluate risks associated with the aquatic environment. In addition, material samples collected from numerous waste rock dumps in the District 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 dumps. Sediment containing heavy metals can erode from the waste rock dumps, impacting surrounding land, and potentially enter surface water drainages. Water percolating through the waste rock dumps can carry heavy metals into groundwater, which, in some areas, discharges to surface water. The last mechanism is abetted by low pH conditions in the sulfide ores, which promote the solubility of most metals.

A comparison of the waste rock, water and instream sediment data with background concentrations and regulatory standards indicated seven metals were contaminants of concern at this site: aluminum, barium, chromium, 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 indicated that aluminum, copper, iron and zinc pose risk to organisms in the aquatic environment. In addition, copper, lead, and zinc appear at phytotoxic levels in several of the proposed Selective Source Response Action waste dumps.

The objectives of the Selective Source Response Action EE/CA are:

- Minimize phytotoxicity resulting from high concentrations of copper and low pH in mine wastes present at selected dumps

- 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 tailing materials 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 removal 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 the metals posing risk at the site. Ground water and surface water goals are the State of Montana water quality standards. Solid media goals are based on instream sediment and soil guidelines found in the literature.

After screening a variety of response technologies and process options, on-site disposal, off-site disposal, and in-situ treatment were retained for detailed analysis along with the no action alternative. For both on-site and off-site disposal, all wastes identified would be removed. For on-site disposal the following three options were considered for repository construction: a soil cap placed over amended waste; a composite cap; and, a composite cap with a leachate collection system. The alternatives were evaluated for effectiveness, implementability, and cost, and are listed below:

1. No Action

2A. Disposal in an on-site repository constructed with amended waste and covered with a soil cap

2B. Disposal in an on-site repository constructed with a composite cap

2C. Disposal in an on-site repository constructed with a composite cap and leachate collection system

3. Disposal in an off-site repository

4. In-situ treatment

Three repository cap designs were considered as separate alternatives with on-site disposal. The cap designs employ different technologies to minimize migration of metals into the subsurface. Modified Alternative 2A, a soil cap, consists of 60 cm of coversoil planted with appropriate vegetation to encourage uptake of infiltrating water. In addition, wastes would be limed under this alternative to reduce the solubility of copper and zinc.

Modified Alternative 2B includes a geosynthetic clay liner and geomembrane liner in the cover system to create a barrier to infiltration of water into the waste. Modified Alternative 2C consists of the same composite cap as alternative 2B and a leachate collection system. The leachate collection system uses a geomembrane bottom liner to collect leachate generated from the waste and route it to a storage tank. Periodic maintenance would be required to empty the storage tank and transport the leachate to a treatment facility.

Disposal in an off-site repository would require transfer of mine waste from off-road haul trucks, used to bring the wastes from the disperse dump sites, to highway haul trucks. Highway trucks would be used to haul wastes to a hazardous waste landfill in Idaho. About 650 roundtrip truck trips would be made on a route that would transport the wastes through Montana, Wyoming, and Idaho.

In-situ treatment involves mixing a neutralizing amendment with mine waste exhibiting a net positive acid potential. The waste dumps would be regraded prior to mixing to eliminate any steep slopes, and the amendment mixed to the deepest depth possible with standard construction equipment. The surface of the regraded dump would be revegetated.

The alternatives evaluated for the Selective Source Response Action present a range of effectiveness. Alternative 3, off-site disposal, is the most effective of the alternatives evaluated, although a higher risk to human health from potential traffic accidents due to highway haulage is ascribed to this alternative. The overall effectiveness of Alternative 2, on-site disposal, is comparable to Alternative 3 except for modified Alternative 2A, which is less effective because leachate will percolate through the base of the repository into the underlying till. However, because the waste is amended, leachate will likely have a negligible effect on groundwater quality in the near-surface water-bearing unit. Alternative No. 4, in-situ treatment, is less effective than Alternatives 2 and 3 because unamended wastes may still release contaminants to the environment under certain conditions. Overall effectiveness of the no action alternative is poor because the dumps would remain in an unvegetated condition and continue to allow unabated transport of contaminants of concern into the environment.

All the alternatives are implementable, but there is a considerable range in estimated costs. Alternative 3, off-site disposal, is by far the most expensive of the alternatives evaluated. The total cost to implement this alternative is about $6.6 million. The no action alternative is the least expensive of the alternatives as there are no capital costs that will be expended for cleanup. However, there are external costs associated with no action, including the loss of certain ecological functions such as a healthy, viable fishery and aquatic community.

Alternative 4, in-situ treatment, is the least expensive of the three alternatives that include active cleanup. About $410,000 is the estimated cost for Alternative 4. Of the three repository alternatives, modified Alternative 2A is the least expensive (about $1.8 million) and modified Alternative 2C is the most expensive (about $2.5 million). The cost to implement modified Alternative 2B is about $2.0 million.

On March 24, 2000, a draft of this document was released to the public for comment. The preferred alternative selected for the Draft EE/CA was modified Alternative 2B. The USDA-FS tentatively preferred this alternative, removal to an on-site repository with a composite cap, because it best met the objectives of the project as well as effectiveness and cost criteria.

Written comments were received on the draft from several parties including the EPA, Montana DEQ, Department of Interior National Park Service, Environmental Materials Inc., Greater Yellowstone Coalition, Ralph Glidden, and Park County Environmental Council. These comments are attached in Appendix M. While numerous comments were directed at procedural issues, technical issues were primarily related to the preferred design alternative selected in the draft, which was perceived to be less protective of the environment than modified Alternative 2C, and the limited capacity available in the SB-4B site as initially located. One major theme of many of the comments was the need to find a repository site that could accommodate the McLaren Tailings. Because the USDA-FS was limited by the Consent Decree in considering the McLaren Tailings at this juncture in the project, the original repository location selected in the draft did not have the capacity to contain the McLaren Tailings.

In light of the comments received, and in light of new groundwater data that became available after the Draft EE/CA was released, the USDA-FS decided to amend the tentative preferred alternative to modified Alternative 2C. With this change, the USDA-FS also proposed moving the location of the repository to a swale within the SB-4B site. This site would provide the necessary capacity to contain all mine wastes within the District including the McLaren Tailings. By moving to the swale, the total capacity of the repository was increased to 1,000,000 cubic yards, and difficulties previously associated with the construction of the lined repository on a hillslope were alleviated. However, there were several disadvantages to the new repository location in the swale, including the disturbance of about 0.4 hectares of Category II wetland and about 90 meters of perennial stream channel that would be affected by the Selective Source Response Action repository build-out.

A technical meeting was held in Mammoth, Wyoming on June 29, 2000, to discuss these changes with the technical team, agency coordinators, and representatives of several environmental groups. The proposed changes in the preferred repository design and the change in repository location to the swale were supported by the majority of participants at the meeting.

After numerous discussions with MDEQ representatives between July and December 2000, it became clear that filling a portion of the Category II wetland in the swale was unacceptable to the State of Montana. MDEQ also indicated that the State of Montana would take responsibility for final disposition of the McLaren Tailings, thus eliminating the need to provide sufficient capacity to contain all the mine wastes in the District. Moreover, MDEQ made clear that it would not allow disposal of the McLaren tailings in the swale. In view of these positions, the USDA-FS decided to return to the hillside location and eliminate from further consideration the building of a central repository with the capacity to dispose of all District wastes.

The remaining determinations (and their rationales) that were presented in the draft EE/CA on the selection of the preferred alternative remain intact. This information is reiterated in the following discussion.

On-site disposal was preferred to off-site disposal and in-situ treatment of the selected mine waste dumps for the following reasons:

- Effectiveness of on-site disposal is comparable to off-site disposal. Although some risk remains for recontamination of the environment under on-site disposal, this risk is managed through engineering controls employed at the on-site repository. Evaluation and field investigations of potential repository sites in the District led to the selection of a site that has suitable characteristics for mine waste disposal. These characteristics include an appropriate geologic setting, presence of an adequate thickness of low permeable glacial till beneath the repository, suitable hydrogeologic conditions, adequate size, suitable materials for repository construction, and limited visibility from adjacent land.

- Effectiveness of on-site disposal is superior to in-situ treatment for the dumps included in the response action. 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 in-situ treatment. In-situ treatment also does not comply with ARARs to the extent that on-site disposal does.

- Although all the alternatives are technically implementable, administrative concerns remain with off-site disposal. A policy decision by the USDA allows disposal of mining wastes located on federal property only in a hazardous waste managed facility. The primary administrative issue for off-site disposal is the USDA-FS will maintain liability for waste that it will no longer physically control.

- The cost of off-site disposal is about five times higher than the cost of on-site disposal.

Of the three on-site repository alternatives evaluated, modified Alternative 2A, which relies on a soil cap to reduce infiltration of water into waste, is not considered sufficiently protective of the environment because the high precipitation in the District setting results in excessive moisture in the waste. This is balanced to some extent because the wastes are amended with a neutralizing agent, effectively reducing the mobility of copper and zinc. However, the cost associated with obtaining the amendment are high and make the total cost of modified Alternative 2A essentially the same as modified Alternative 2B.

Modified Alternative 2B was preferred to 2A because this design reduces infiltration through the cap and migration of leachate through the base of the repository to very small quantities. Considering that very small quantities of leachate are expected to be generated and adding in the protection afforded to groundwater and surface water quality from where these waste dumps currently are present at the site, modified Alternative 2B was thought to be very effective at protecting the environment. This alternative is less costly and requires less maintenance than modified Alternative 2C. For modified Alternative 2C, the small quantity of leachate generated will have to be managed in perpetuity.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
BMP	best management practice
CBMI	Crown Butte Mines, Inc.
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	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
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
LCS	Leachate Collection System
Maxim	Maxim Technologies, Inc.
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDEQ	Montana Department of Environmental Quality
MP	mile post
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
PRSC	Post Removal Site Control
RAOs	Removal Action Objectives
RCRA	Resource Conservation and Recovery Act
SMP	Shoemaker, McLean, and Pratt
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristics Leaching Procedure
TR	Total Recoverable
UOS	URS Operating Services
USDA-FS	United States Department of Agriculture Forest Service

1.0 INTRODUCTION

This Engineering Evaluation/Cost Analysis (EE/CA) was developed by Maxim Technologies, Inc. (Maxim) 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 response alternatives for response and restoration work proposed for the New World Mining District (District). Response activities will address natural resources 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 and more recent mining 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.

This EE/CA has been written to present potential response alternatives that will be implemented as a Selective Source Response Action. The EE/CA process is described in the *Overall Project Work Plan* (Maxim, 1999a). The USDA-FS has identified Selective Source Response Action to address the immediate threat to the environment posed by certain mine waste piles.

A draft 1999 EE/CA was prepared previously for Response Action activities that were proposed for fall 1999. The response action proposed in 1999 is similar to that proposed in this EE/CA. That draft 1999 EE/CA was released to the public for comment and numerous comments were received. Following the preparation of the draft 1999 EE/CA, a decision was made by the USDA-FS to delay the 1999 Response Action. This decision was made to allow additional time to complete the study of potential repository sites and to further consider source area prioritization. As such, many elements of the 1999 Response Action are included in the Selective Source Response Action EE/CA.

This draft EE/CA incorporates comments received on the 1999 EE/CA that are pertinent to proposed response activities, as well as other modifications that resulted from ongoing discussions with the USDA-FS interdisciplinary team. A summary of the changes made to the 1999 EE/CA and incorporated in this EE/CA include the following:

- Retaining off-site disposal as an alternative for in-depth analysis.

- Retaining in-situ treatment of mine waste as an alternative for in-depth analysis.

- Modifying Repository Alternative A to include liming of the waste placed in the repository.

- Modifying the cover system for Repository Alternatives B and C to include a geomembrane liner in addition to the geosynthetic clay liner.

- Selecting a preferred alternative.

On March 24, 2000, a draft of this document was released to the public for comment. Written comments were received on the draft from the EPA, Montana DEQ, Department of Interior National Park Service, Environmental Materials Inc., Greater Yellowstone Coalition, Ralph Glidden, and Park County Environmental Council. In total, the comments received were primarily related to the preferred design alternative selected in the draft and the limited waste capacity available in the on-site repository. In light of these comments and new information collected since issuing the draft, the USDA-FS amended its tentative preferred alternative and published its decision in an Action Memorandum. This Final EE/CA incorporates changes made to the technical analysis as a result of the comments received on the March 24, 2000 draft, meetings with the technical team and agency coordinators, and subsequent meetings with the Montana Department of Environmental Quality (MDEQ) on issues related to Montana's solid waste laws and regulations.

1.1 PURPOSE AND OBJECTIVES

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).

The data used to support this EE/CA were collected by several investigators, the last being data collected in 1999. Data were used to assess risks posed by various mine wastes present at the mine sites, to evaluate removal methods to alleviate the risks present at the site, and to develop estimates of cost for each removal alternative for comparative purposes. Following receipt of public comment on the preferred response action alternative identified in this document, the USDA-FS will issue a decision 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 mine wastes 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 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 a mixture of National Forest and private lands, is a historic metals mining area generally located near Cooke City, Montana in the Beartooth Mountains (Figure 1). This historic mining district contains hard rock mining wastes and acid discharges that impact the environment. Human health and environmental issues are related to elevated levels of metals present in 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 CBMI and 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 will be 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). As funds are available after District Property is cleaned up to the satisfaction of the United States, other mining disturbances in the District will be addressed.

Mitigation of historic mining wastes has been an on-going interest of numerous parties since the 1970s. One of the first to investigate revegetation in the District was the USDA-FS Intermountain Research Station (Brown, 1995; 1996). This research has focused on reclaiming high elevation mine disturbances, with research focusing 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 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). Other areas of the tailings have been recontoured and revegetated since that time.

Some reclamation work was completed by CBMI on District Property as part of their exploration and proposed mine development work. 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, construction of runon control ditches, treating acid soils with a lime amendment, and fertilizing and seeding with native grasses. Similar reclamation work was completed in the Como Basin area although additional work was done in this area to construct runon controls to prevent water from entering a raise connected to the Glengarry adit. 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 (revegetation success) and through further assessment of the McLaren Pit and Como Basin in future EE/CAs (success in meeting project goals for cleanup).

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 restoration and reclamation of the historic abandoned mining operations.

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 is 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 northeast 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 two routes of travel are open on a year-round basis to the District: the Sunlight Basin road, which allows access to within a few miles of the District in the winter time; and the highway between Mammoth and Cooke City. The Beartooth Highway is closed during the winter.

The District covers an area of about 100 square kilometers (40 square miles). Historic mining disturbances affect about 20 hectares (50 acres) 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 glaciation. 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 mining disturbances are located.

The District is situated at the headwaters of three river systems that all eventually flow into the Yellowstone River. The three tributary rivers are the Clark's Fork of the Yellowstone, the Stillwater, and the Lamar. The Lamar River flows through Yellowstone Park. The major 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 established in 1869, although prospecting was the only form of any mining development at that time. By 1876, a smelter was built in Cooke City for the reduction of silver-lead ore by the Eastern Montana Mining and Smelting Company. 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 in that year (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 and operated during this period, most only 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 floatation mill on the south side of Scotch Bonnet Mountain in the 1920s to process copper-gold ores from the Como ore body on Fisher 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, an open pit gold 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. With the closure of the McLaren pit in 1953, mining in the District ceased. Exploration of the area continued until 1996, however, with CBMI as the last major company to hold an interest in mine development. CBMI executed an exploratory drilling program in the District from 1987 to 1993.

2.4 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.

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, with elevations ranging from 2,400 meters (7,900 feet) at Cooke City to 3,200 meters (10,500 feet) at District Property in the higher elevations. 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).

2.5 HYDROLOGY

Surface water resources in the District are generally defined by three separate watersheds: Daisy Creek, Fisher Creek, and Miller Creek (Figure 1). The flow and water quality characteristics of these drainages are presented below.

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 from the historic McLaren open pit mining operation. 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).

Fisher Creek drains the south side of Lulu Pass, the east flanks of Fisher and Henderson Mountains, and the west flanks of Scotch Bonnet and Sheep Mountains. Fisher Creek flows generally to the southeast for approximately 5.5 kilometers (3.5 miles) to its confluence with the Clarks Fork of the Yellowstone River. The Clarks Fork enters the Yellowstone River near Laurel, Montana. The Glengarry adit is situated between the confluence of the two main headwater (first order) tributaries of Fisher Creek. Discharge from the Glengarry adit provides a sustained flow to Fisher Creek throughout the year, whereas the headwater tributaries may go dry during some winter months. Measured discharge from the adit ranges from 0.0011 m^3/s (0.04 cfs) on June 18, 1975 and on June 13, 1995 to 0.014 m^3/s (0.5 cfs) on June 5, 1991. High flow measurements in Fisher Creek were 2.59 m^3/s (91.6 cfs), taken on June 5, 1991 just upstream from Fisher Creek's confluence with the Clarks Fork River and 3.18 m^3/s (112.4 cfs), taken on June 26, 1990 where the Lulu Pass road crosses Fisher Creek. Water in Fisher Creek has been moderately to severely impacted by a combination of natural acid rock drainage and acid mine drainages from numerous mine workings. These discharges include acid mine drainage from the Glengarry adit, smaller discharging adits on Henderson and Scotch Bonnet mountains, and seasonal discharge from the disturbed area near Lulu Pass (UOS, 1998).

Miller Creek drains the south side of Daisy Pass, the west flank of Henderson Mountain, and the east flank of Miller Mountain. Miller Creek flows southeastward for approximately two miles to its confluence with Soda Butte Creek, which in turn flows west into Yellowstone National Park where it enters the Lamar River. Immediately above Miller Creek's confluence with Soda Butte Creek a measured low flow of 0.012 m^3/s (0.44 cfs) was recorded on September 25, 1997. The measured high flow at this location was 1.57 m^3/s (55.5 cfs) on July 2, 1990. Although several minor historic mine disturbances are present in the Miller Creek drainage basin, Miller Creek water is largely unimpacted by acid rock or acid mine drainage (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. Significant diurnal variations occur particularly during the peak snowmelt periods. The three drainage basins are geomorphically similar and relatively small in areal extent. Although a substantial number of summer and fall flow measurements have been made on streams in these drainages, winter and spring flow measurements have largely been restricted to those made at selected locations on Daisy Creek, Fisher Creek and Soda Butte Creek during the 1974-75 hydrograph year and a few late spring measurements made in 1995 on Daisy and Fisher Creek (UOS, 1998).

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3.0 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

Numerous environmental samples have been collected within the District to support various studies and investigations at the site. The data used to support this EE/CA include solid samples collected from waste rock dumps included in the Selective Source Response Action, relevant surface water quality data, and stream sediment data. This section of the EE/CA presents site-specific data for source areas that will be included in the Selective Source Response Action.

3.1 POTENTIAL SELECTIVE SOURCE AREAS

Source areas that are being considered for the Selective Source Response Action were chosen from the list of prioritized sites that was created using the Abandoned and Inactive Mines Scoring System (AIMSS). This modified hazard ranking system (HRS) was developed for the MDEQ Mine Waste Cleanup Bureau (Pioneer, 1994) to prioritize abandoned mine sites in Montana. AIMSS scoring was completed on 132 source areas using data collected in 1999. Table 3-1 lists the top 20 sites in the District along with numerous other dumps that are being considered for selective source removal. Results of the AIMSS scoring are included in Appendix A.

AIMSS ranks waste sources relative to each other using site specific data and the HRS scoring algorithm. In AIMSS, four exposure pathways are evaluated -- groundwater, surface water, air, and direct contact. For each exposure pathway, three factors are evaluated: 1) likelihood of release; 2) waste characteristics; and, 3) potential receptors. The scores for the three factors are multiplied to derive a pathway score. Pathway scores are weighted more heavily toward certain situations and types of impacts. Higher weights are ascribed to the following: observed releases to groundwater and surface water, especially where an exceedance of a standard is documented; sources that are closer to a population base; and, higher contaminant concentrations, large contaminant quantities, and/or large areas of disturbance.

Due to the short construction season that exists in the District, only a certain number of mine waste dump source areas can be practically included in the annual response actions. Therefore, source areas were chosen from the list presented in Table 3-1 based on several factors. These factors include the following (listed in relative order of importance):

- Sites included in the Selective Source Response Action must be located on District Property. This is a primary criterion for cleanup according to the provisions of the Decree.

- Assessment work must be completed before a source area can be included in a response action. Several of the higher ranking District Property sites require further assessment before response actions can be considered. Work on the higher ranking sites, including the McLaren Pit (No. 1), McLaren Pit spoils (No. 9), McLaren Multicolored Dump (No. 17), Glengarry Dump (No. 15), and higher ranking dumps in Miller Creek (Miller Creek Headwaters Dump One, West Miller Creek dumps, and Alice E dumps) will be delayed for one to two years until assessment work is completed.

- Selecting mine waste dump source areas that pose a threat to surface water is an important aspect of response actions. The Soda Butte dumps (one through eight in Table 3-1) have lower surface water pathway scores than some of the lower ranking dumps (e.g. Rommel tailings and Spalding dumps). For the initial response action, the higher surface water pathways will be considered first.

Table 3-1
Potential Selective Source Response Action Source Areas
New World Mining District Response and Restoration Project

Site Name	AIMSS Rank*	Area (hectares)	Volume (cu. meters)**	Adit Discharge I
McLaren Open Pit Mine	1	4.60	243,200	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	1.19	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
Lower Spalding Dump	23	0.13	2,000	Yes
Gold Dust Mine and Dump	24	0.22	4,330	Yes
Lower Tredennic Dump One	26	0.16	2,610	Yes
Upper and Middle Spalding Dump	33	0.11	560	No
Upper Tredennic – Five Dumps	36	0.11	375	Yes
Soda Butte Tailings Dump	39	0.06	330	No
Middle Tredennic - Three Dumps	45	0.11	620	Yes
Small Como Dump	96	0.10	310	No
Upper Glengarry	104	0.02	80	No

Notes:
* AIMSS - Abandoned and Inactive Mines Scoring System
** cu. meters - cubic meters
I Adit discharge associated with waste dump from adit, collapsed adit, or seep

- Where possible, higher priority source areas will be grouped on a watershed or sub-watershed basis. The Spalding and Tredennic dumps are examples of high priority dumps that are located in the same sub-watershed.

- Other source areas located proximal to higher ranking source areas may be included in a response action if the response action considered for the higher ranking sites is applicable to the lower ranking sites and inclusion of the lower ranking sites provides an overall efficiency in cost.

The majority of the sites listed in Table 3-1 directly impact surface water, as shown by higher surface water pathway scores (see Appendix A). This is not true of some of the remaining higher ranking sites on the list (e.g. Soda Butte Dumps One through Eight). The two lower ranking sites listed (Small Como Dump and Upper Glengarry Dump) were included primarily because of proximity to the Spalding Dumps. Impacts associated with these two smaller sites could easily be addressed in the same response action.

Table 3-2 lists those sites that meet the above-described criteria for the Selective Source Response Action. These sites are located on Figure 3. Except for the Rommel Tailings, the top 20 sites are not included in the selective source removal because one or more of the selection criteria were not met. The Rommel Tailings site is included as the tailings directly impact Soda Butte Creek with metals and sediment. The group of dumps located in upper reaches of Fisher Creek (Tredennic, Spalding, and Small Como dumps) are in source areas where copper loads to Fisher Creek have been documented (Amacher, 1998; Kimball, et al, 1997).

TABLE 3-2
Mine Dumps Included in the Selective Source Response Action
New World Mining District – Response and Restoration Project

Waste Dump Name And Designation	Area Hectares (acres)	Volume Cubic meters (cubic yards)
Rommel Tailings (SBSI-96-2)	0.90 (2.22)	13,730 (17,990)
Lower Spalding Dump (FCSI-96-8)	0.13 (0.32)	2,000 (2,630)
Lower Tredennic Dump One (FCSI-96-5)	0.16 (0.40)	2,610 (3,430)
Upper and Middle Spalding Dump (FCSI-96-7)	0.11 (0.28)	560 (740)
Upper Tredennic – Five Dumps (FCSI-96-15)	0.11 (0.28)	375 (495)
Soda Butte Tailings Dump (SBSI-96-1)	0.06 (0.14)	330(440)
Middle Tredennic - Dumps One to Three (FCSI-96-6)	0.11 (0.28)	620 (845)
Small Como Dump (FCSI-96-9)	0.10 (0.25)	310 (410)
TOTALS:	**1.63 (4.02)**	**20,535 (26,980)**
****ADJUSTED TOTALS:**	**1.87 (4.62)**	**24,642 (32,375)**

Note: ** - Adjusted totals allow 15% overage on area affected to allow construction staging and access, and 20% overage on volumes to allow over-excavation of mine wastes.

Several other sites listed will be not be addressed in this initial response action. The Upper Glengarry Dump, although it is in close proximity to the Spalding dumps, does not appear to directly effect surface water quality (i.e. it is not in waters way). Direct impacts from the Upper Glengarry Dump on groundwater quality are not known, but, due to the small size of the dump and low ranking relative to the Como Basin, impacts to groundwater that may be ascribed to the dump are likely immeasurable. With minimal impacts at this site, no further action is required, allowing the USDA-FS to leave the dump as a feature of historic mining.

The Gold Dust Mine and Dump will also be dropped from the Selective Source Response Action because the need for cleanup must be studied further at this site, and balanced with the desire to preserve cultural and historic attributes. If cultural/historic values can be preserved on the site, the site may be included in a future response action. Last, the Little Daisy Adit and Dump will not be included in the Selective Source Response Action pending the results of further studies on Miller Creek. These studies are scheduled for the 2000 field season, and the results will be used to provide better information on appropriate response actions for this site.

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. Site sketches of the dumps listed in Table 3-2 are included in Appendix B. Site sketches show site features, plan and profile views of the dumps, and sample locations. A description of cultural and historic features associated with these sites is included in Appendix C.

Dump volumes and areas are listed in Table 3-2. Volumes were calculated from a field reconnaissance conducted in August 1999. Area estimates were interpreted from aerial photography by the Gallatin National Forest Interagency Spatial Analysis Center in Bozeman, Montana.

Mine waste samples were collected from waste rock dumps, mill tailings, and other identified mine wastes in the District following standard operating procedures referenced in the Site-Wide Sampling and Analysis Plan (Maxim, 1999b). Due to the large number of dumps (over 150) and relative small quantities present in many of the dumps, about 60 representative dumps were selected for sampling. Representative dumps were selected by first grouping the dumps into like types of waste based on existing geochemical data and mapped information on geology and ore typed at each waste dump location. Twenty-one statistical groups were identified using this method.

Ninety-three samples were collected from about 60 discrete waste dumps in the District. A minimum of three samples was collected for each statistical group. Each mine waste sample consisted of three to five composite samples that were collected at evenly spaced distances along a transect established on the dump. The transect was located by crossing the dump in a longitudinal direction from the head to the toe of the waste pile or in discrete waste types if more than one waste lithology was identified at a dump. 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.

Figure 3 - Location Map for Waste Rock Dumps Identified for Response in 2000

Back of Figure 3

Waste rock and soil samples were placed in one gallon, heavy-duty, polyethylene bags and labeled with the 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. Data results for all samples analyzed in 1999 are included in Appendix D.

Data in Table 3-3 show that the elements arsenic, copper, lead, and zinc exceed average background concentrations by more than three times. Copper was measured at concentrations more than three times background in most of the dumps sampled, with the highest copper concentration measured in the lower Spalding dump. Except for the Rommel and Soda Butte tailings and small Como dump, samples collected from the dumps shown in Table 3-3 were acidic.

TABLE 3-3
Waste Rock Sample Analytical Results - pH and Total Metals
New World Mining District – Response and Restoration Project
Selective Source Response Action

Waste Dump Name	pH	Total Metals (milligrams per kilogram)					
		As	Cd	Cr	Cu	Pb	Zn
Rommel Tailings	7.3	7	5	6	1580	110	366
	7.4	7	8	6	1360	280	631
	--	11.2	3.4	37.7	1450	155	369
Lower Spalding Dump	2.1	240	34	6	17600	110	49
Lower Tredennic Dump One	3.2	58	18	14	167	188	84
Upper and Middle Spalding Dump	2.2	310	75	6	2120	130	28
Upper Tredennic Dump Two	3.4	120	<1	5	518	492	88
Soda Butte Tailings Dump	7.3	14	8	6	2950	280	491
Middle Tredennic Dump One	2.4	60	<1	5	170	383	42
Small Como Dump	7.1	6	<1	5	120	20	42
Average	**--**	**83**	**15**	**10**	**2,804**	**215**	**219**
Average background concentration*	**--**	**2**	**5**	**13**	**63**	**51**	**31**

Notes:
-- Not analyzed or applicable
< less than the indicated value
J Data flag for estimated value
* Based on mean concentrations from five natural samples collected by Furniss (see Appendix A)

Data summarized in Table 3-4 indicate that a considerable amount of lime (153 tons per 1000 tons), on average, would be needed to adjust the pH of the waste rock materials to a pH of 7.0 s.u. Several of the dumps, however, exhibit an excess of neutralization potential with neutral pH and, consequently, require no lime addition. Most 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 jarosite sulfur fractions. Pyritic sulfur forms were more prevalent than either sulfate or jarosite sulfur forms.

TABLE 3-4
Waste Rock Sample Analytical Results - Sulfur Fractions and Lime Requirement
New World Mining District – Response and Restoration Project
Selective Source Response Action

Waste Dump Name	NP[1] (t/1000t)	Sulfur Fraction (%)					Lime Req[2] (t/1000t)	
		Total	Sulfate	Pyritic	Jarosite	Residual	SMP[3]	Total
Rommel Tailings	90	0.41	<0.1	<0.1	<0.1	0.4	0	-93
	80	0.25	<0.1	<0.1	<0.1	0.2	0	-88
Lower Spalding Dump	<3	7.17	<0.1	2.1	0.4	5.1	17	314
Lower Tredennic Dump One	34	1.78	0.1	0.7	0.3	0.7	0	21
Upper and Middle Spalding	<3	23.99	<0.1	3.4	<0.1	24.3	21	1109
Upper Tredennic Dump Two	10	4.25	0.1	1.3	0.1	2.9	6	159
Soda Butte Tailings Dump	79	1.12	<0.1	<0.1	<0.1	1.1	0	-52
Middle Tredennic Dump One	<3	0.95	0.1	0.4	0.3	0.2	13	48
Small Como Dump	50	0.45	<0.1	0.1	0.1	0.4	0	-40
Average	**39**	**4.5**	**0.1**	**0.9**	**0.2**	**3.9**	**6**	**153**

Notes:
1 NP = neutralization potential in tons per 1000 tons
2 Lime requirement in tons per 1000 tons calculated according to the formula {(pyritic + residual)*31.25 + (Jarosite*23.44) + SMP - NP} *1.25
3 SMP = Shoemaker, McLean and Pratt single buffer test method
-- Not analyzed or applicable
< less than the indicated value

3.3 SURFACE WATER QUALITY

Surface water in the District has been impacted by runoff from mine waste dumps and other disturbances as well as discharges from adits and seeps that carry high metal loads. Mean concentrations of selected parameters for the 1989-1998 period for sample sites located on Daisy Creek and Fisher Creek are summarized in Table 3-5. Several of these parameters, including total recoverable aluminum, copper, iron, and zinc, exceed Montana's water quality standards (MDEQ, 1998). Temporary standards shown in Table 3-5 were approved by MDEQ for particular stream reaches. These standards are twice the standard deviation of the mean shown in the table at a particular sampling station. Locations of sampling stations are shown in the Long-Term Surface Water Quality Monitoring Plan (Maxim, 1999c).

Adit discharges are present at four of the waste sites included in the Selective Source Response Action (Upper Spalding, and Upper, Middle, and Lower Tredennic). Historically, flow from these adits has always been seasonal, with flows generally absent in the latter parts of summer and fall. In 1999 and 2000, flow was not present at the Upper Spalding, Upper Tredennic, and Middle Tredennic in late August. Based on historic data, seasonal flow from these adits is generally less than a few gallons per minute. Flow during the winter is unknown because the adits are buried under several feet of snow from November to May. Average chemistry data compiled from historic baseline data (Hydrometrics, 1989; 1993; UOS, 1998) are shown in Table 3-5. Further assessment of potential impacts that result from these discharges will be evaluated in 2001 in conjunction with the on-going assessment of the Glengarry Adit discharge.

TABLE 3-5
MEAN SURFACE WATER CONCENTRATIONS OF SELECTED PARAMETERS
New World Mining District – Response and Restoration Project
Selective Source Response Action

Location	Total Recoverable Metals (milligrams/liter)								pH[1] (su)
	Al	Cd	Cr	Cu	Fe	Pb	Mn	Zn	
Daisy Creek @ DC-5[2]	4.37	0.001	0.002	1.598	4.195	<0.002	0.653	0.237	6.6
Temporary Standard @ DC-5	9.51	0.004	--	3.530	6.830	--	1.710	0.540	4.6
Fisher Creek @ SW-3[2]	2.53	0.001	0.001	0.684	4.489	0.004	0.659	0.104	3.6
Fisher Creek @ SW-4[2]	0.30	<0.001	0.001	0.093	0.486	0.002	0.035	0.082	6.6
Fisher Creek @ CFY-2[2]	0.18	<0.001	--	0.051	0.258	<0.001	0.039	0.021	7.1
Temporary Standard @ CFY-2	0.47	--	--	0.110	0.750	0.002	0.082	0.044	5.7
Rommel Tailings (RR-SBSW-101)[3]	0.02	<0.0001	--	0.004	0.120	<0.001	0.006	0.010	8.0
Lower Spalding adit (LSA-1)[4]	3.5	0.001	<0.01	11.3	122	<0.01	4.64	0.33	--
F-9 (Lower Tredennic adit)[5]	--	0.0015	<0.02	1.26	3.225	--	1.215	0.145	3.15
Tredennic Tributary (FCT-2)[6]	0.10	<0.003	--	0.008	0.024	<0.002	0.002	0.035	6.4

Notes:
1 pH in standard units
2 Mean concentrations from those calculated in Implementation Plan (Maxim, 1998)
3 Results for one sample collected by Maxim, July 1999
4 Data from UOS (1998); results for one sample collected on 9/7/97
5 Data from Hydrometrics (1992); average for three samples collected during 1989-1991 time period
6 Data from Kimball et al (1997)
-- Not calculated or not measured

The single most significant source of contaminants to Fisher Creek is the Glengarry Adit (UOS, 1998). Surface restoration and drainage ditches constructed at the site by CBMI in the mid-1990s resulted in an apparent 40% reduction in water discharging from the adit. This did not, however, translate into an improvement in water quality in Fisher Creek (UOS, 1998).

Kimball et al (1997) noted an increase in copper load to Fisher Creek from tributary station FCT-2. Water quality in this tributary is likely affected somewhat by the Tredennic dumps, which are situated at the head of the tributary. The mean dissolved load to Fisher Creek from this tributary was calculated to be 1.09% for copper, 3.94% for aluminum, and 4.01% for manganese (Amacher, 1998). Concentrations of aluminum, copper, iron, and zinc were considerable in samples collected from the Spalding and lower Tredennic adits.

Water quality results for one sample collected from surface water flowing through the Rommel Tailings had relatively low concentrations of aluminum, copper, iron, manganese, and zinc (Table 3-5). Flow at this station was 5.6 liters per second (0.2 cubic feet per second).

3.4 STREAM SEDIMENT DATA

Stream sediment data were collected from Daisy Creek, the upper Stillwater River, Fisher Creek, and the Clarks Fork of the Yellowstone in 1996 by CDM (1997). At most sites, samples were collected during high and low flow conditions. Sixteen elements were analyzed using X-ray fluorescence. Of these 16 elements, 11 correspond to elements for which comparison background data are available from native soils collected from the Glengarry Mine area (Pioneer, 1994). Sediment data and background levels are summarized in Table 3-6.

TABLE 3-6
MEAN CONCENTRATIONS OF SELECTED ELEMENTS IN STREAM SEDIMENT
New World Mining District – Response and Restoration Project
Selective Source Response Action

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
SW-3 (Fisher Creek)	43	24	1,821	2	142	310
SW-4 (Fisher Creek)	0.5	5	1,443	0.3	16	1,176
CFY-1 (Clark Fork)	--	4	1,644	1	28	1,370
SW-6 (Clark Fork)	--	1	1,723	1	35	1,162
Average	**9**	**21**	**1,680**	**1.5**	**69**	**1,744**
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
SW-3 (Fisher Creek)	85,274	816	6.9	45	2.5	73
SW-4 (Fisher Creek)	61,264	1,868	16	78	3.7	143
CFY-1 (Clark Fork)	59,365	3,368	24	84	0.9	255
SW-6 (Clark Fork)	58,302	3,092	11	69	0.3	263
Average	**83,211**	**1,782**	**17**	**91**	**3.1**	**357**
Background Concentration*	**17,100**	**461**	**24**	**51**	**5**	**31**

Notes: 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 (Appendix A)

Stream sediment data indicate that arsenic, copper, manganese, and lead concentrations are considerably higher in sediment than in waste rock. These data also indicate that barium and chromium in stream sediments may be significantly above background levels for these elements in soil. Because background levels are for soil samples, direct comparison between soil and sediment data may be misleading.

3.5 CONCEPTUAL MODEL

The overall site conceptual model for the District is complex, and site investigations are ongoing to provide insight into the primary sources of mining related contaminants, the likely mechanisms that are involved in releasing contaminants into the environment, and the exposure pathways that present risks to humans and the environment. The conceptual model presented in the Overall Project Work Plan (Maxim, 1999a) illustrates that the major sources of contaminants are acidic, metal-laden mine waste dumps located at mine openings and massive sulfide ore deposits underground that are exposed to the atmosphere by either mine workings or natural fracturing and faulting. Other secondary sources of contaminants include stream sediments that have been transported downstream from other sources. The primary mechanisms of movement of metal-laden mine wastes include the following:

- Erosion into surface water courses
- Dissolution of contaminants in runoff
- Infiltration of dissolved metals into soil and groundwater
- Movement of impacted water through open underground mine workings and improperly abandoned exploratory borings
- Groundwater discharge into surface water
- Contaminated surface water flow to groundwater.

Mine waste sources in the District are many and widely scattered throughout the 64 square kilometer (40 square mile) area that the District encompasses. Not only are there in excess of over 150 mine dumps on District Property totaling about 330,000 cubic meters (430,000 cubic yards) of solid waste, but there are more than 20 mine discharges, many acid seeps, and numerous kilometers of contaminated instream sediments.

Except for some of the larger waste dumps, individual contributions of specific mine waste sources via the pathways identified above will be difficult to quantify because of the wide distribution of sources. Quantification of metal loading has been done to a certain degree by previous investigators for Daisy Creek and Fisher Creek (Amacher, 1998; Kimball, et al, 1997; Nimick, 1999, in progress), although there remains a large discrepancy in the remainder terms (the balance of the metal loads that cannot be assigned to defined point or non-point sources).

These studies, however, do give some indication of how metal loads are distributed for some of the source types. That is, metal loadings have been ascribed to groundwater inflow (Daisy Creek), adit discharges (e.g. Glengarry, Gold Dust, and McLaren adits), tributary inputs, and leachate from waste dumps (e.g. Glengarry and McLaren pit), and remaining loads. The study completed by Amacher (1998) provides some guidance on how the effects of response and restoration activities may be partitioned among the various sources and pathways. For instance, dissolved copper load was apportioned to the Glengarry adit (20%), leachate from the Glengarry dump (14%), tributary input from the Como Basin (21%), and tributary input from Fisher Mountain (14%). About 30% of the dissolved copper load could not be ascribed to any particular source.

Using this information as a rough approximation of the effect of response and restoration actions, it is evident that adit discharges contribute a considerable amount of metals to Fisher Creek and response actions directed at reducing or treating flows from the more substantial adit discharges like the Glengarry should directly result in water quality improvements. This is also true of leachate generated from waste dumps that directly impact surface water, as shown in the example of the Glengarry dump. The effect on surface water or groundwater quality resulting from response actions directed at mine waste sources located further from surface water drainages or in areas where groundwater is deeper is much harder to quantify. These sources may or may not contribute to tributary inputs that can be measured in Fisher Creek, for example, and may or may not be part of the load that can not be ascribed to any particular point or non-point source. The effect of response or restoration actions on other sources, such as stream sediments, cannot be quantified at this time. Metals sorbed, precipitated, or coprecipitated in or on stream sediment have complicated reactions with surface water and are transient because fine-grained sediment generally move downstream and may be continually replenished from upstream sources.

Exposure pathways to humans and animals from mine waste sources are primarily related to direct contact or ingestion of contaminants. Because the main sources present on District Property are located away from permanent residents, consumption of groundwater or surface water is not considered a significant exposure pathway for humans. The exposure of animals to surface water or consumption of surface water has not been quantified.

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 recolonize 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.

Using the conceptual model to guide response actions, the highest priorities will be to reduce or eliminate uncontrolled releases of metals from waste sources that are in direct contact with surface water or groundwater. Because the effectiveness of individual response actions on human health, surface water quality, groundwater quality, and aquatic health will be difficult to judge until after each response action is completed, a District-wide reclamation plan will be completed in the near future to enable evaluation of how multiple response actions will impact human health and the environment at the completion of this eight-year project.

4.0 RISK EVALUATION

A streamlined risk evaluation process is used to assess threats to human health and the environment associated with exposure to mine wastes in the District. 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, 1995). 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. These documents were used to complete the human health risk evaluation for proposed response activities.

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

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 included in the Selective Source Response Action (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, barium, chromium, copper, iron, 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, lead, and manganese do not exceed the most restrictive water quality standard. Arsenic has historically not been detected in surface water above practical quantitation limits (Maxim, 1998). Mean concentrations of aluminum, copper, iron, lead, and zinc at station SW-3 on Fisher 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 by MDEQ (MDEQ, 1998).

In summary, COCs identified for the Selective Source Response Action were based on comparisons of site data with background data or water quality standards. The COCs are aluminum, arsenic, barium, chromium, copper, iron, lead, and zinc.

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 on and near the site. There is currently no residential use of District Property.

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/rockhounds, and ATV/motorcycle riders. Evaluated exposure pathways included soil and water ingestion, dermal contact, dust inhalation, and fish consumption. The assessment assumed a moderate to high level of recreational use. The types of activities, exposure pathways, and use levels considered in the recreational scenario are consistent with current recreational uses of District Property. 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 noncarcinogenic 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, barium, chromium, copper, and zinc. Arsenic is the only COC that is a carcinogen.

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 rockhound/gold panner (soil contact and surface water ingestion); (2) a fisherman (soil contact, surface water ingestion, and fish consumption); and (3) an ATV/motorcycle rider (soil contact, dust inhalation).

To ensure the protection of the majority of recreational visitors, MWCB also developed a set of conservative, risk-based cleanup guidelines for abandoned mine sites based on the lowest cleanup concentration calculated for the various types of exposure and the possibility of multiple exposure routes. The guidelines thus account for visitors participating in several activities and metals exposure routes from both soil and surface water. The conservative, risk-based cleanup guidelines for soil and water are presented in Tables 4-1 and 4-2. The guidelines for each medium are based on a hazard quotient (HQ) of 1.0 for noncarcinogens, 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.

TABLE 4-1
Hazard Quotients for Recreational Visitors Exposed to Soil Ingestion and Dust Inhalation
New World Mining District- Response and Restoration Project
Selective Source Response Action

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	83	21	70	1.18
Barium	--	1,680	9,950	0.17
Cadmium	15	1.5	1,950	0.008
Chromium	10	69	1,470,000 (292)(5)	0.00005 (0.2)
Copper	2,804	1,744	54,200	0.05
Lead	215	114	2,200	0.09
Zinc	219	357	440,000	0.001

Notes: (1) Data from Maxim Technologies Laboratories; mg/kg = milligrams/kilogram.
(2) Data from CDM (1997).
(3) Guidelines recalculated from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 1.0 or an increased cancer risk of $5x10^{-5}$.
(4) Hazard quotient calculated for the greater of the waste rock or instream sediment concentration.
(5) Guideline based on chromium III risk and chromium VI risk (in parenthesis).
-- Not available.

TABLE 4-2
Hazard Quotients for Recreational Visitors Exposed to Water and Fish Ingestion
New World Mining District- Response and Restoration Project
Selective Source Response Action

Contaminant of Concern	Average Water Concentration (micrograms/liter) (1)	Water and Fish Ingestion Guideline (micrograms/liter)(2)	Hazard Quotient
Arsenic	<1	6.5	0.15
Barium	--	4,200	--
Cadmium	1	66.5	0.015
Chromium	1	200,492(3)	<0.00001
Copper	684	944	0.7
Lead	4	47.1	0.08
Zinc	104	34.4	3.0

Notes: (1) Data from Maxim (1998) - mean concentration at SW-3 for period 1989-1998
(2) Guidelines recalculated from Tetra Tech, (1996). The guidelines are based on a Hazard Index of 1.0 or an increased cancer risk of $5x10^{-5}$.
(3) 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. The water quality data used for the calculation are the mean concentrations shown in Table 3-5 at station SW-3, which is on Fisher Creek below the Glengarry Adit. The total hazard quotient, which is calculated in Table 4-3, includes the soil ingestion/dust inhalation and water ingestion/fish ingestion routes.

TABLE 4-3
Noncarcinogenic Total Hazard Quotients (HQ)
Recreational Land Use Scenario
New World Mining District- Response and Restoration Project
Selective Source Response Action

Contaminant of Concern	Soil Ingestion/Dust Inhalation HQ	Water Ingestion/Fish Ingestion HQ	Total HQ for Contaminant
Arsenic	1.18	0.15	1.33
Barium	0.17	--	>0.17
Cadmium	0.008	0.015	0.023
Chromium	0.2*	<0.00001	0.2
Copper	0.03	0.70	0.73
Lead	0.07	0.08	0.15
Zinc	0.001	3.0	3.0

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 barium, cadmium, chromium, copper, and lead do not exceed 1.0, which indicates that these COCs do not pose a human health risk for the Selective Source Response Action. The calculation for arsenic and barium is incomplete because recent water quality data for arsenic are not available and no water quality data are available for barium. It is unlikely that the hazard quotient for barium would exceed 1.0 because inhalation is the predominant pathway for this contaminant (Tetra-Tech, 1996). Barium would have to be greater than 8.3 milligrams per liter (mg/L) in water to cause the hazard quotient to exceed 1.0. The hazard quotient for arsenic exceeds the soil ingestion/dust inhalation HQ. Historic arsenic data for surface water are all less then laboratory practical quantitation limits, but a conservative estimate of arsenic concentrations (1.0 micrograms/liter) increase the hazard quotient for arsenic to 1.33.

The total hazard quotient for zinc is 3.0, which is completely due to the water component of the calculation. This suggests that zinc is a human health concern based on the risk assessment performed by Tetra Tech (1996). In this risk assessment, almost the entire risk of zinc in surface water is posed by ingestion of fish taken from the stream by recreationists. Because there are currently no fish in Daisy Creek and Fisher Creek, this risk of exposure to 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. The Spalding and Tredennic dumps are the dumps that contribute arsenic concentrations higher than the human health standard (Table 3-3).

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 Site* (EPA, 1989b). Because there are no site-specific ecological risk data available, this evaluation, although executed in a quantitative manner, is only intended to be qualitative.

Because this 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, barium, cadmium, chromium, copper, iron, lead, and zinc. All of these contaminants have the potential to pose ecological risks. Barium is not expected to affect aquatic organisms because of its low solubility in water (EPA, 1986).

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, Miller Creek, and Fisher Creek located downgradient of the source areas. These receptors are of concern because these tributaries provide habitat for aquatic organisms, possibly including spawning areas for fish migrating from Soda Butte Creek, the Stillwater River, and the Clarks Fork of the Yellowstone. 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 quasi-quantitatively assessed by comparing site-specific surface water, sediment, and soil data to toxicity-based criteria and standards for the respective media. No standards are currently available to evaluate exposures in wetlands.

Exposure pathways for aquatic life include: 1) direct exposure of aquatic organisms to metals in surface water that exceed toxicity thresholds; 2) exposure of aquatic organisms (e.g. insect larvae, fish embryos) to sediment pore water that is toxic due to contaminants in the sediments; and 3) ingestion of aquatic species (e.g. insects) that have bioaccumulated 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
Selective Source Response Action

Contaminant	Surface Water (1) (micrograms/liter)	Sediment (2) (milligrams/kilogram)	Phytotoxic Soil (3) (milligrams/kilogram)
Aluminum	87	--	--
Arsenic	150	85	15-50
Barium	--	--	--
Chromium (as III)	86(4)	--	--
Copper	9.3(4)	390	60-125
Iron	1,000	--	--
Lead	0.0032	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

The surface water criteria are the Chronic Aquatic Life Standards promulgated by the State of Montana (MDEQ, 1998). Criteria for chromium (III), copper, and zinc are calculated as a function of water hardness while aluminum, arsenic, and iron criteria are fixed numerical standards. No surface water criterion is determined for barium. 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, barium, 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 noncarcinogens. 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 station SW-3 in Fisher Creek (Table 3-5) by the chronic water quality criteria (Table 4-4). For soils, EQs are generated by dividing the average values from Table 3-3 by the soil phytotoxicity values in Table 4-4. Adverse ecological impacts may occur if an EQ value is 1.0 or greater. Results of the EQ calculations are presented 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 Fisher Creek. In addition, toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The calculated EQ values indicate the potential for aquatic life impacts (EQs greater than 1.0) for aluminum, copper, iron, and lead in surface water (Table 4-5).

TABLE 4-5
Ecological – Impact Quotients (EQ)
New World Mining District- Response and Restoration Project
Selective Source Response Action

Contaminant	Surface Water	Sediment	Phytotoxic Soil	Total EQ
Aluminum	29	NC	NC	29
Arsenic	NC	0.24	5.5	5.74
Barium	NC	NC	NC	NC
Chromium	0.01	NC	NC	0.01
Copper	73.5	5	29	107.5
Iron	4.5	NC	NC	4.5
Lead	1.25	1.0	2.75	5.0
Zinc	0.8	1.3	2.3	4.4

Note: NC – Not calculated, toxicity data unavailable.

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 and Fisher Creeks, and toxicity to 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, lead, 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, copper, lead, and zinc 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 and copper. Arsenic, copper, lead, and zinc appear to be phytotoxic in waste rock if the lower phytotoxicity guidelines are used.

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 Selective Source Response Action. Environmental risks associated with mine dumps appear in surface water and groundwater due to migration of contaminants from the mine dumps. These contaminants (aluminum, copper, iron, lead, and zinc) present ecological risks to aquatic life. Phytotoxicity is a concern in mine waste due to excessive copper, lead, and zinc concentrations and low pH values.

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

5.1 SCOPE OF THE SELECTIVE SOURCE RESPONSE ACTION

The scope of the Selective Source Response Action is limited to reducing or eliminating uncontrolled releases of metals from selected mine waste dumps that are in direct contact with surface water or groundwater. The scope of this initial response action was purposefully limited for several reasons as described in Section 3.1 of this EE/CA. Because this is the first removal action proposed in this multi-year project, future response actions will address impacts to human health and the environment that result from other high priority source areas in the District. Notable among these priority sites are the McLaren Pit and Glengarry Adit.

Addressing environmental impacts associated with solid wastes presumes that some reduction in contaminant concentrations will occur in surface water, groundwater, and stream sediment as a result of removing or controlling the primary sources of contamination present in solid mine wastes. More comprehensive analysis of response technologies applicable to adit discharges that are present at several of the selective source removal sites will be completed in conjunction with the on-going assessment of the Glengarry Adit discharge. Response actions associated with the Glengarry assessment work will likely be evaluated in a separate EE/CA.

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 Selective Source 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. Since the Selective Source Response Action focuses on removing select waste rock dumps in the District that have been prioritized using AIMSS, the project specific RAOs are:

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

- Prevent soluble contaminants or contaminated solid materials from migrating into adjacent drainages 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 tailing materials 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 overall, the primary contaminant-specific ARARs apply to groundwater and surface water. There are no contaminant-specific ARARs for soil media. A preliminary list of ARARs is presented in Appendix E. The preliminary list of ARARs presented in Appendix E generally identifies ARARs for the *Overall Project Work Plan.* The USDA-FS will issue final ARARs for the Selective Source Response Action in the Action Memorandum, which documents the decision involved with the selection of the preferred response alternative.

5.3.1 GROUNDWATER

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 dissolved concentrations of aluminum, copper, iron, and zinc exceed the standards. However, cleanup of potential contamination in groundwater is not being considered for the initial Selective Source Response Action primarily because

TABLE 5-1
ARAR-Based Reclamation Goals for Groundwater
New World Mining District – Response and Restoration Project
Selective Source Response Action

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

Notes: (1) HHS = Human Health Standard (MDEQ, 1988); MCL = Maximum Contaminant Level (EPA, 1996b)
(2) Secondary standard for taste, odor, color.
µg/L = micrograms per liter

removal actions are intended to address a small area and volume of material. Locally, groundwater quality should improve at the individual sites addressed in each response action. Future response work will address the larger known groundwater concerns in the McLaren Pit and Como Basin areas. Removing local sources of the contaminants should provide a beneficial effect on the quality of groundwater, thus acting as an indirect method of meeting these ARARs to the extent practicable.

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. Because the aquatic life standards are more stringent than the human health standards for the COCs, and ecological risks predominate at this site, aquatic standards represent the surface water ARARs for this site. These goals are presented in Table 5-2. 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 in which case the cleanup standard for the hardness dependent contaminants should be calculated based on the hardness at those specific stations.

TABLE 5-2
ARAR-Based Reclamation Goals for Surface Water
New World Mining District – Response and Restoration Project
Selective Source Response Action

	Total Recoverable Metals (micrograms/liter)[(1)]					
	Al	Ba	Cr	Cu	Fe	Zn
Goal	87	4,200	89	9.3	1,000	120

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

CBMI, with the support of the USDA-FS, petitioned the State of Montana Board of Environmental Review (Board) for temporary modification of water quality standards for certain stream segments in the District. The temporary standards are necessary so that improvements to water quality may be achieved by implementation of the response and restoration project. A rule allowing temporary standards on specific reaches of Fisher Creek, Daisy Creek, and the headwaters of the Stillwater River was approved by the Board on June 4, 1999.

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 presented in Section 4.1, arsenic is the only contaminant that presents a human health risk at the waste rock dumps being considered for the Selective Source Response Action. Recreational cleanup goals for solid mine wastes have been adopted by MDEQ in the form of cleanup guidelines. Cleanup guidelines for COCs in the District are listed in Table 5-3.

TABLE 5-3
Cleanup Guidelines for Mine Waste
New World Mining District – Response and Restoration Project
Selective Source Response Action

	Total Metals (milligrams/kilogram)(1)				
	As	**Cd**	**Cu**	**Pb**	**Zn**
Human Health Guideline(1)	70	1,950	54,200	2,200	440,000
Reclamation Criteria(2)	<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 1.0 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).

Ecological risk from waste dumps included in the Selective Source Response Action is likely due to copper, lead, and zinc phytotoxicity. Because 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. These soil cleanup guidelines should be balanced with the goals for the response project rather than used as absolute numerical criteria.

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 specified 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. The waste rock dumps identified for evaluation in this phase of the project were selected from the priority list of mine waste sites using AIMSS.

This section of the report presents the scope of the Selective Source Response Action and potential response technologies, screens the technologies, and develops the remaining technologies into alternatives. The alternatives are then evaluated in detail against three primary criteria in Section 7.0.

6.1 RESPONSE TECHNOLOGY AND PROCESS OPTION SCREENING

Because the scope of the Selective Source Response Action was limited to removal of selective mine waste dumps, potential response technologies and process options that apply to the selective source removal were also limited. No evaluation was conducted for technologies that directly address adit discharges, surface water, groundwater, or stream sediments, as these environmental media will be addressed in future response actions. However, addressing environmental impacts associated with solid wastes presumes that some reduction in contaminant concentrations will occur in surface water, groundwater, and stream sediment as a result of removing or controlling the primary sources of contamination present in waste rock.

More comprehensive analysis of response technologies applicable to adit discharges will be completed in conjunction with the on-going assessment of the Glengarry Adit discharge. Evaluation of response action technologies applicable to adit discharges will likely be done in 2002.

The purpose of identifying and screening technology types and process options is to eliminate those technologies that are obviously unfeasible, while retaining potentially effective options. General response actions and process options are applied to the mitigation of contaminants in specified waste rock dumps.

General response actions potentially capable of achieving RAOs and goals at the selected waste rock dumps are screened for applicability in Table 6-1. Response actions include no action, institutional controls, engineering controls, excavation and treatment, and in-situ treatment. The general response actions, technology types, and process options are discussed in text following the table. Screening comments are found in Table 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 the Table 6-1.

TABLE 6-1
Response Technology Screening Summary
New World Mining District – Response and Restoration
Selective Source Response Action

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	Install fences around contaminated areas to limit access.	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 soil used to cover waste; soil vegetated; covers contaminant source to prevent direct contact.	Reduces surface infiltration by evapotranspiration; not effective in early spring or late fall when plants are dormant; acid wastes may contaminate soil cover; readily implementable.
		Multi-layered RCRA Cap	Compacted clay layer covered with soil 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; long-term maintenance required.
	Surface Controls	Consolidation	Consolidate mine waste into single area.	Consolidation of mine dumps at higher elevations eliminated due to harsh environment and site suitability; readily implementable.
		Grading	Level waste dumps 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; 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
Selective Source Response Action

General Response Action	Response Technology	Process Option	Description	Screening Comment
ENGINEERING CONTROLS (continued)	Surface Controls (Continued)	Erosion Protection/Run-on Control	Erosion resistant materials and/or commercial fabrics placed over mine wastes; stormwater diversion structures constructed to channel water away from mine wastes.	Potentially effective at reducing lateral contaminant migration; does not reduce contaminant mobility; potentially effective if combined with other process options; readily implementable.
	On-site Disposal	Soil Cap Repository	Excavate mine waste and dispose in on-site repository with soil cap.	Potentially effective. Readily implementable.
		Composite Cover Repository	Excavate mine waste and dispose in on-site repository with composite cover; liner included in cover system design.	Potentially effective. Readily implementable.
		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
Selective Source Response Action

General Response Action	Response Technology	Process Option	Description	Screening Comment
EXCAVATION & TREATMENT	Reprocessing	Milling and Smelting	Excavate and 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; not readily implementable due to small volume of waste and lack of nearby processing facility; high cost.
	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
Selective Source Response Action

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.
	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.

6.1.1 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.

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/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 prevent contaminant exposure and migration. Engineering controls typically include containment, capping, runon/runoff controls, revegetation and/or disposal. Engineering controls generally do not reduce the volume or toxicity of hazardous materials.

<u>Containment</u>

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.

Capping is an appropriate alternative when contaminated materials are left on-site. An on-site capping design is dependent on the relative toxicity and mobility of the contaminants and 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 ***not retained*** for several reasons. First, the larger dumps considered for the Selective Source Response Action are situated in locations that directly impact surface water, requiring removal to a near-by location if containment were to be considered viable. Because there are numerous small-volume dumps, it would be highly inefficient to move and contain dumps in-place. Several other factors that limit the application of containment options include the location of the dumps at relatively high elevation, on steep slopes, and in high avalanche hazard areas. These factors would likely compromise the effectiveness of in-situ containment technologies.

<u>Surface Controls</u>

Surface controls are used to minimize contaminant 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 impacts on 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 is important in areas where multiple smaller waste sources are present and wastes are in sensitive areas (e.g. floodplains).

Grading is 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. In addition, neutralizing agents and/or additives to improve pH conditions and/or the water storage capacity of the waste may be appropriate. 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.

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 ***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. ***Consolidation is not retained*** due to the lack of a suitable site near the selected waste dumps.

<u>On-Site Disposal</u>

On-site disposal can be used as a permanent source control measure. On-site disposal may require solid waste or hazardous waste repository design or a modification of these designs. The design of a containment facility would depend on the toxicity, mobility and type of material requiring disposal.

This reclamation technology involves placing the untreated or treated contaminated materials in an engineered repository located on-site. Design specifications could range from a simple, unlined, covered waste facility to a capped and lined facility with a leachate collection system. 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).

Several ***on-site disposal technologies are retained*** for further analysis. However, the RCRA level design is eliminated because it is not substantially more effective than the composite cap option that includes a leachate collection system. The RCRA level design is also more costly.

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 retained*** for further analysis. 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.

Reprocessing

Reprocessing involves excavation and transportation of contaminated materials to an existing mill or smelter for processing and recovery of valuable metals. 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. 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. ***Reprocessing is not retained*** for further evaluation.

Fixation/Stabilization

Fixation/stabilization technologies employ treatment processes that chemically alter the contaminant to reduce its mobility or toxicity (fixation) or physically treat the contaminant by encapsulating it with an inert material (stabilization). The technology involves mixing materials with binding agents under specific conditions to form a stable matrix. For inorganic contaminants, fixation/stabilization employs a reagent or combination of reagents to promote a chemical and/or physical change in order to reduce the mobility. Fixation of mine wastes with additives that raise the pH of the waste have been used widely in the last 15 years to reduce the mobility of metals. These additives include lime (calcium oxide), limestone (calcium carbonate), and calcium hydroxide. The in-situ process uses both surface and deep mixing techniques to achieve the best integration of the fixation agents with contaminated media. Stabilization processes commonly use pozzolan/cement as additives.

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 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.

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.

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. Treating mine wastes with additives that raise the pH of the waste have been used widely in the last 15 years to reduce the mobility of metals. These additives include lime (calcium oxide), limestone (calcium carbonate), 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 the pilot scale. This process option is ***not retained*** for further consideration because of the difficulty of implementation of 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. This process option is ***not retained*** for further consideration because of the difficulty of implementation of this technology at disperse sites that are situated in less than ideal environmental settings. The cost of this technology is expected to be high.

6.2 RESPONSE ALTERNATIVE DEVELOPMENT

The most promising technologies and process options that were retained through the screening process are summarized in Table 6-2. These options appear to be effective and readily implementable for a reasonable cost and will be used to develop response action alternatives for further consideration. 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, the response action alternatives for this initial 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 done 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 6-2
Process Options Retained From Technology Screening
New World Mining District – Response and Restoration
Selective Source Response Action

General Response Action	Reclamation Technology	Process Option
No Action	None	Not Applicable
Institutional Controls	Access Restrictions	Fencing/Signage
		Land Use Controls
Engineering Controls	Surface Controls	Grading
		Revegetation
		Erosion Protection/Run-on Control
	On-Site Disposal	Soil Cap Repository
		Composite Cap Repository
		Composite Cap Repository with Leachate Collection System
	Off-Site Disposal	Disposal in RCRA-C Permitted Facility
Excavation and Treatment	Fixation/Stabilization	Lime Fixation
In-Situ Treatment	Physical/Chemical Treatment	Lime Fixation

Table 6-3 lists the six 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. For Alternative 2, the repository cap designs were modified from those presented in the 1999 EE/CA.

1. *No Action* - No action requires no removal, treatment, or containment of waste. Site conditions remain unaltered and risks to human health and the environment persist.

2. *Disposal in On-Site Repository* - There are three sub-alternatives included with this alternative. For each of the three, this alternative combines engineering controls of on-site disposal with access restrictions. One of the three sub-alternatives utilizes lime fixation of the wastes disposed in the repository. Implementation of the three on-site repository alternatives assumes additional wastes will be hauled to the repository in future years.

TABLE 6-3
Response Action Alternatives
New World Mining District – Response and Restoration
Selective Source Response Action

Alternative	Response Technology/Process Options
1. No Action	None
2A. Disposal in On-Site Repository with Soil Cap	On-site disposal in a repository with a soil cover. Mine waste amended with lime.
2B. Disposal in On-Site Repository with Composite Cap	On-site disposal in a repository with a composite cover consisting of a geosynthetic clay liner, geomembrane liner, and revegetated soil layer
2C. Disposal in On-Site Repository with Composite Cap and Leachate Collection System	On-site disposal in a repository with a composite cover, a bottom liner, and a leachate collection system.
3. Disposal in Off-Site Repository	Off-site disposal at a RCRA permitted hazardous waste landfill.
4. In-Situ Treatment	Regrading waste in-situ, amendment of upper 15 to 20 cm with lime, revegetated.

- *Modified Alternative 2A –Disposal in On-Site Repository with Soil Cover and Amended Waste:* Mine waste placed in the repository will be amended with a neutralizing agent, compacted, and graded. A soil cap using native materials will be used to cover the wastes and the soil cap will be revegetated.

- *Modified Alternative 2B –Disposal in On-Site Repository with Composite Cover:* After the mine waste is compacted and graded, a composite cover system consisting of a geomembrane liner and geocomposite clay liner (GCL) would be constructed above the waste. The two synthetic liners in the cover system will be covered with a drainage layer and a revegetated soil layer.

- *Modified Alternative 2C –Disposal in On-Site Repository with Composite Cover and Leachate Collection System* - This alternative requires placement of a bottom liner and leachate collection system under the waste. The composite cover system would consist of the same cover system used in Alternative 2B.

3. *Disposal in Off-Site Repository* – Selective mine wastes would be excavated, transported, and disposed in an off-site repository. This alternative would require approximately 1,400 round trip truck trips on public highways to a RCRA-C permitted facility located in Idaho.

4. *In-Situ Treatment* - In-situ treatment combines the three surface control process options with in-situ lime fixation. This alternative involves regrading the waste to a stable configuration, amending the top 15 to 20 cm (six to eight inches) with a lime amendment, and then revegetating the amended waste. In-situ treatment has been used in the past by CBMI in the District to reclaim the McLaren pit and the Como basin. The USDA-FS has also been studying revegetation of amended waste dumps in the District since the late 1970s.

7.0 ANALYSIS AND COMPARISON 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 the EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA/540-R-93-057, 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 during 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.

Evaluation of alternative costs consists of developing conservative cost estimates based on the description of work items developed for each alternative. These costs do not necessarily represent the cost that may 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 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 contingency.

In addition to the capital costs discussed above, post-removal site control (PRSC) costs are estimated for each alternative. These PRSC costs were estimated using reasonable assumptions for potential maintenance of each of the alternatives. Because it is difficult to determine the actual maintenance that will be needed to ensure that an alternative is successful (due to the fact that the reclamation alternatives considered for this project depend to a large extent on the success of revegetation), PRSC requirements tend to be based on the relative difference in perceived maintenance between alternatives. This is a subjective decision that relies on professional judgement rather than a predictable event. The assumptions that were used to determine the average annual cost of PRSC are discussed for each alternative. 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 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.

Costs presented in this section are based on waste volumes determined from Maxim's 1999 field investigation and areas 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 RECLAMATION CONSTRUCTION ACTIVITIES

Except for the no action alternative, ancillary reclamation construction activities will be done in addition to the primary removal action components associated with each alternative. These ancillary activities are described separately in this section. For Alternatives 2, 3, and 4, clearing and grubbing, road improvements, and bridge construction will be completed. For Alternative 2, a new connect road will be constructed to move wastes from the Daisy Creek road to the proposed repository site.

A separate fixed cost for the ancillary activities is included as a line item to the alternative cost estimates. Although several of the ancillary activities (road improvements, connect road construction, repository construction, and bridge construction) will be utilized in future years as response and restoration project work proceeds, the entire cost for these items is included in the Selective Source Response Action cost analysis for each alternative rather than apportioning this cost over the life of the project.

- *Clearing and Grubbing* – All waste dumps will be cleared and grubbed.

- *Road Improvements* - Considerable road improvements were made in 1999 on the Daisy Pass and Lulu Pass roads. Remaining improvements will be made to improve access to selected dump sites. Road improvement work includes regrading existing roads, improving drainage, increasing the width of the road to the Tredennic, Rommel tailings, and Soda Butte tailings sites, and constructing new access roads to the Upper and Lower Tredennic sites and the Lower Spalding Dump. New and upgraded access road construction is shown on Figures 4a and 4b. For 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. No turnouts would be required. The road to the Upper Tredennic dumps will involve the most disturbance. The new haul road will depart from the existing road near the Middle Tredennic Dump One and will follow the east side of Polar Star Creek for a distance of about 365 meters (1,200 feet). Total new disturbance associated with this road is expected to be 0.25 hectares (0.67 acres). New access roads needed to the Lower Spalding and Lower Tredennic will require much less disturbance that the Upper Tredennic road, with estimated length of 30 meters and 100 meters, respectively. All new access roads will be fully reclaimed after the removal is completed.

- *Bridges* - Two permanent, pre-cast concrete bridges will be installed on the Lulu Pass Road. At the current location of the low water crossing on Fisher Creek, a 12 to 15 m long (40 to 50 feet) bridge will be constructed. The construction of a permanent bridge on this county-owned road was preferred to a temporary bridge by Park County, which is responsible for maintaining the road. A second bridge will be constructed over Polar Star Creek, located about 450 m below the Glengarry Mine. This second bridge will be about 6 m long.

Figure 4a. Alternative 2- On-Site Disposal Site Map, North Half-

Figure 4b- On-Site Disposal Site Map, South Half-

- *Connect Road Construction* - The County Connect Road 3227 could be used to haul waste rock from the Miller Creek and Daisy Creek drainages if removal to an on-site repository is selected as the preferred alternative. The existing road extends from Daisy Pass Road at MP 0.75 to the Lulu Pass Road at MP 1.10, a distance of 1.2 kilometers (km). The road is 2.5 to 4 meters (m) wide with few turnouts, and has three washouts. About 400 m of the road traverses a steep (40%+) side hill within the view shed of US 212. About 600 m of the road has adverse (uphill haul) grades of 10% to 12%. To efficiently accommodate haul traffic, the road would need to be widened to 4 m, have additional turnouts constructed, have 8 or 9 culverts installed, and perform heavy reconditioning to the roadbed. A difficult creek crossing would need to be constructed at the beginning of the road. The road widening would create road cuts 6 to 10 m high in the side hill section in view of the US Highway 212. Cost of reconstruction would be about $35,000.

  An alternative to reconstructing the County Connect Road would be to construct a new road (Upper Connect) between Daisy Pass Road and Lulu Pass about 0.5 km north of the County Connect Road. This new road would extend from MP 1.41 of the Daisy Pass Road (near the Alice E turnoff) for 1.2 km easterly, where it would tie into the County Connect Road and Lulu Pass Road at MP 1.10. The proposed road would be constructed to a 4 m width with ditches and culverts as needed, and turnouts would be constructed at intervals that allow clear sight distances. The location traverses a bench outside the viewshed of US 212, with no side slopes exceeding 30%. The route is completely within the 1988 burn area, minimizing clearing costs. Road grades would be favorable (downhill) to flat. Haul distance to the SB-4B area would be 0.6 km shorter than the County Connect route. Cost of construction is estimated at about $35,000. Approximate location of the road is shown on Figure 4b.

  There are several advantages to building a new road on the Upper Connect location. Waste rock haul costs would be reduced by about $\$1/m^3$ because of the shorter distance and elimination of adverse grades. The road cuts would be minimal and would not be visible from US 212. Public safety could be improved by closing the road to public traffic during haul, allowing the public to continue to use the County Connect Road. There are no risky or difficult creek crossings. The construction costs are about the same for both routes.

  Final closure of both cut-off roads will be determined after conclusion of response and restoration activities in the District. When the road is no longer needed for waste hauling, long term travel management planning for the area will determine whether to reclaim either the Upper Connect Road, the County Connect Road, or both.

- *Adit Discharges* - As described in Section 5.1, which presents the scope of the removal action, response technologies will not be applied to the adit discharges present at the Upper, Middle, and Lower Tredennic dumps and at the Lower Spalding dump. At a later timeframe in the overall process for the New World site, all adit discharges will be evaluated and further actions will be determined. However, each of the alternatives in this EE/CA will involve closing any open adits and regrading the surface around the closed or collapsed adits to blend with the surrounding topography. To facilitate regrading, the seasonal drainage emanating from the adits 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 reclaimed or treated. 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 discharges 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.

7.3 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of alternatives that are listed in Table 6-3.

7.3.1 NO ACTION - ALTERNATIVE NO. 1

The no action alternative involves leaving the mine sites in the existing condition of unvegetated mine dumps. No reclamation would be accomplished at the site to control contaminant migration or to reduce toxicity or volume. No further investigation or monitoring activities would be conducted. However, periodic maintenance may be required if erosion of mine waste dumps increases to unacceptable levels or threatens other resources.

Effectiveness

The no action alternative does not address surface water impacts, nor would 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. Protection of the environment would not be achieved under this alternative. Only one of the RAOs would be met for the site -- preserving the existing undeveloped character of the District and surrounding area. A No action alternative is currently in compliance with temporary water quality standards for portions of Daisy Creek, Fisher Creek, and the Stillwater River. However, as these standards expire in 15 years, a no action alternative 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, long term costs associated with no action are unknown since there is an on-going risk that unstable mine dumps may fail, resulting in damage to other resources and requiring action. In addition, there are external costs associated with no action, including the loss of certain ecological functions such as a healthy, viable fishery and aquatic community.

7.3.2 ON-SITE DISPOSAL - ALTERNATIVE NO. 2

Alternative 2 involves removal of waste rock from the dumps listed in Table 3-2 to an on-site repository. All dumps identified for removal will be fully removed. Figures 4a and 4b show the dumps that will be removed and the haul routes to the repository site.

On-Site Repository Siting

The main considerations in evaluating on-site disposal are selecting suitable sites within the District that meet minimum environmental and engineering criteria, and selecting a suitable repository design that takes into consideration site-specific environmental and engineering factors. The location of the District at a relatively high elevation, in an area that receives a large amount of snowfall, and in a relatively remote mountainous region presents certain difficulties in finding the most suitable location for an on-site repository. The notion of finding a site that is 'high and dry' does not necessarily apply in the New World Mining District because the entire District is blanketed with two to six meters of snow (six to 20 feet) for five to six months of the year. When the snow melts in the spring, runoff is a major occurrence in the District and flowing water is evident over most of the land area.

To determine the feasibility of on-site disposal, 27 potential repository sites situated within the District were initially evaluated in the spring of 1999. Twenty-eight criteria were used to rank the 27 sites considering everything from general site features to proximity to faults and avalanche potential. Also considered in this siting evaluation were disturbed areas on District Property, which included the McLaren Pit and Como Basin. This evaluation resulted in the selection of a single site, designated SB-4B, that possessed the most favorable characteristics for a mine waste repository (Maxim, 1999d). This site was further investigated in 1999 and 2000 by gathering additional geophysical data, excavating test pits, analyzing subsurface materials, drilling and sampling numerous borings, installing monitoring wells, analyzing groundwater quality, completing hydrogeologic tests, conducting a dye tracer study, and monitoring groundwater levels in the wells.

The results of the detailed repository site investigation (Phase II) were published in a separate report in December 1999 (Maxim, 1999e) along with two subsequent addenda. This repository siting information has been consolidated in Appendix G. Water level and dye monitoring conducted to date and reported in the previously mentioned addenda support the general tenants that were described in the Phase II report.

Results of the Phase II investigation (including addenda) indicate that the SB-4B site is suitable for mine waste disposal in an engineered repository. The emphasis on an engineered repository is necessary because protecting the waste from the severe climate, large amount of snow, and mountainous topography cannot be done on-site without careful planning and engineering. The most important aspect of the engineered design, regardless of the site selected, is the capping system used to cover the waste. The cap is the essential element in limiting the amount of snowmelt and other forms of precipitation from contacting the waste. Bottom liner systems are the other engineered element of an on-site repository design that provide further protection to the environment.

Both lined and unlined systems can be designed to prevent contact with the waste from below. Subsurface drainage is controlled using gravel blankets or other suitable drainage materials and diversions of groundwater and surface water can be used to prevent off-site water from entering the waste. In a lined system, leachate is collected and disposed in a controlled manner. Liners cannot completely eliminate seepage through the liner but the quantity of leachate is substantially reduced through a combination of cap and liner construction.

With these considerations in mind, the SB-4B site ranked the highest in many of the key criteria evaluated. The SB-4B site is underlain by glacial till, which is preferred to bedrock or alluvial geologic units because of its lower permeability. The site slopes to the southeast at a moderate gradient of about

16% to 23% and is bisected by a perennial drainage that flows to the east (also referred to as the swale).

Depth to groundwater varies widely across the site and throughout the year. On the hillsides, depth to groundwater in the late summer and through the winter is as great as 60 feet. At the upper end of the site where three of the four till wells were dry through the fall and winter, water rapidly recharged the till during the spring snowmelt period, which began in late April 2000. Water levels rose in all wells during this period. As local snowmelt recharges the till at the site, depth to groundwater becomes shallower and groundwater levels rise to within 0.3 meters (one foot) of the surface (Appendix G). Groundwater levels fall rapidly following spring snowmelt, dropping as much as 32 feet in bedrock and 23 feet in till over the course of a month between late May and late June (Appendix G).

Groundwater flow direction generally follows the slope of the land to the south-southeast. Dye monitoring indicates that groundwater discharges into surface drainages that surround the SB-4B site. Groundwater flow in bedrock is generally upward into till except during times when the till is dry (this only occurred at the upper end of the SB-4B site). This characteristic was affirmed by both water level data in dual bedrock and till completions at ten monitoring well nests and by recovery of fluorescent dye injected into one of the bedrock wells.

Runoff from the site and surrounding area drains into Soda Butte Creek from several small ephemeral and perennial drainages. Slope palustrine and upper perennial riverine wetlands are present in the perennial drainage bottom, covering a total of about 3.8 hectares (9.2 acres) within the area considered suitable as a repository. These wetlands are classified as Category II with a functional rating of 6.9. Perennial and intermittent streams that flow through the site are first order streams that carry a maximum of about 2 to 3 cfs during the runoff period. Late summer and fall flows are on the order of 0.5 cfs.

Except for the shallow depth to groundwater during the spring and the presence of Category II wetlands in portions of the site, repository site SB-4B has suitable geologic and hydrogeologic conditions condusive to disposing mine waste. Within the area studied, geology is characterized by glacial till overlying granite gneiss bedrock. Major faults were absent from the area. Two small areas with bedrock outcrops are present within the site. Glacial till is a desirable geologic material because it can be used as a source of coversoil for cap construction and has a lower permeability to water movement than bedrock. Till thickness ranges from 2.5 to up to 25 meters (8 to 83 feet) with the till consisting of a heterogeneous mixture of coarse fragments, sand, silt, and clay. The percentage of fine-grained silt and clay in till ranges from 25 to 29%.

The heterogeneous nature and amount of fine-grained material in the till result in relatively low horizontal and vertical hydraulic conductivity. Horizontal hydraulic conductivity of glacial till ranges from 10^{-3} to 10^{-6} centimeters per second (cm/sec), with an average of about $1x10^{-4}$ cm/sec. Vertical hydraulic conductivity of glacial till ranges from 10^{-6} to 10^{-8} cm/sec, with an average of approximately $1x10^{-7}$ cm/sec. Horizontal hydraulic conductivity of bedrock ranges from 10^{-3} to 10^{-7} cm/sec as determined by slug and pump testing. The average hydraulic conductivity is low, about $3x10^{-5}$ cm/sec. The low hydraulic conductivity of bedrock tested at this site would likely result in sub-optimal performance as an aquifer for domestic well use.

As the repository siting study indicates that the SB-4B site is suitable for disposal of mine wastes in the District, the SB-4B site will be used for disposal of District Property wastes in this initial year as well as in future years.

Appendix H presents a discussion of repository design and construction issues that are relevant to the Selective Source Response Action. Also included in Appendix H are drawings showing the phased construction of the repository to a full build-out capacity. Appendix I presents an analysis of the effects of a repository in Soda Butte Creek on the water rights compact between the National Park Service and the State of Montana.

<u>Alternative Description</u>

In addition to the common items described in Section 7.2, the following work activities are included in the construction of Alternative 2:

- *Site Preparation:* Clearing and grubbing repository site; separating combustible and non-combustible debris; and, debris disposal.

- *Construct Repository:* Common design items for all three repository alternatives include:
  - Salvaging soil from the disturbed area;
  - Excavating the area to a design depth of 1 m (3 feet) and stockpiling excavated materials;
  - Preparing the subgrade of the repository by compacting to a specified density;
  - Constructing runon and runoff control ditches around the perimeter of the repository;
  - Constructing a perimeter drainage trench to intercept subsurface flow;
  - Blasting rock from a nearby source to provide material for the rock toe;
  - Crushing rock from a nearby source to provide drainage gravel and sand or importing this material from an off-site source;
  - Revegetating the repository cap with an appropriate seed mix and mulch; and,
  - Covering the cap with an erosion control blanket.

- *Excavate/Load Waste:* Excavate and load all waste from selected dumps. About 24,600 cubic meters (32,300 cy) of mine waste would be loaded onto haul trucks. This repository size is based on assumed side slopes of 4H:1V. The area of disturbance would cover approximately 1.5 hectares (3.7 acres).

- *Haul Waste to Repository:* Truck wastes to on-site repository and place and compact waste.

- *Regrade and Revegetate Mine Waste Dump Sites:* Regrade excavated areas; truck and place 15 cm (0.5 feet) of coversoil from SB-4B repository site; amend coversoil with lime and fertilizer, and seed, mulch, and cover with an erosion control blanket.

- *PRSC*: Monitoring and maintenance of vegetation on removal areas and at the repository; Monitoring of surface water and groundwater quality at the repository.

<u>Repository Alternative Options</u>

Three different conceptual repository alternatives are included in the detailed analysis and described below. Figure 5 shows a graphical representation of the repository alternatives. The repository alternatives have been designated as "modified" to reflect changes made from the designs presented in the draft 1999 EE/CA.

- *Modified Alternative 2A – Disposal in On-Site Repository with Soil Cover and Amended Waste:* Mine waste placed in the repository will be amended with a neutralizing amendment (such as agricultural limestone, lime kiln dust, or calcium oxide), compacted, and graded. The neutralizing amendment will be added to the waste to increase the waste pH, which produces an effective decrease in copper and zinc mobility. Total lime required (calcium carbonate equivalent) is 3,000 metric tons (Table 7-1). The cap for this alternative would be constructed with 60 centimeters of soil salvaged on-site (Figure 5). Filter fabric would be placed over the waste to prevent loss of fines from the coversoil into the waste.

TABLE 7-1
Lime Requirement for Modified Alternative 2a
New World Mining District – Response and Restoration Project
Selective Source Response Action

Waste Dump Name And Designation	Volume[1] cubic meters (cubic yards)	Lime Req[2] (t/1000t)	Lime[3] mtons (tons)
Rommel Tailings	13,730 (17,990)	0	0
Lower Spalding Dump	2,000 (2,630)	314	1,355 (1,490)
Lower Tredennic Dump One	2,610 (3,430)	21	120 (130)
Upper and Middle Spalding Dump	560 (740)	1,109	1,340 (1,480)
Upper Tredennic - Five Dumps	375 (495)	159	130 (140)
Soda Butte Tailings Dump	330(440)	0	0
Middle Tredennic - Dumps One to Three	620 (845)	48	65 (70)
Small Como Dump	310 (410)	0	0
ADJUSTED TOTALS:	**24,642 (32,281)**	**--**	**3,010 (3,310)**

Notes: 1 - Adjusted totals are the sum of the volumes multiplied by 1.2 to allow over-excavation.
2 - Lime requirement in tons of calcium carbonate equivalent amendment per 1000 tons waste.
3 - Total lime for each waste dump in metric tons (mtons) and tons; tons of lime calculated using an average density of 1.5 tons/cubic yard of mine waste multiplied by the adjusted quantity and lime rate and dividing by 1000.

- *Modified Alternative 2B – Disposal in On-Site Repository with Composite Cover (Cover System and Soil):* This alternative would use a double synthetic liner in the cover system, consisting of a geomembrane liner over a geosynthetic clay liner (GCL), as a barrier layer (Figure 5). A coarse sand or gravel drainage layer would be placed between the coversoil and barrier layer. Coversoil thickness would be increased to 1.2 meters to prevent the drainage layer from freezing.

- *Modified Alternative 2C – Disposal in On-Site Repository with Composite Cover and Leachate Collection System:* A bottom liner and leachate collection system (LCS) would be used in addition to a composite cover system constructed in the same manner as Alternative 2B (Figure 5). The LCS would include a barrier layer (geomembrane) overlying a GCL, a drainage layer with leachate collection pipes, and a storage tank. Since the District is a net precipitation area, a collection tank is needed instead of an evaporation pond to collect the leachate. PRSC for the tank would require periodic pumping and the leachate would then have to be treated or disposed at a licensed facility (depending on its chemical characteristics).

Figure 5

Figure 5 - back page

- *Modified Alternative 2C (continued)* – Several design changes to the modified alternative 2C design were identified following the issuance of the draft EE/CA. These changes were made to account for the placement of a bottom liner on the hillside location at the SB-4B site and to allow for potential shallow groundwater levels during the spring snowmelt period. To account for shallow groundwater, a geocomposite drainage layer was added at the base of the liner. This drainage layer will intercept any shallow groundwater that may be present beneath the liner. Shallow groundwater would flow into a rock toe constructed at the base of the hill, allowing the flows to disperse by both percolation and seepage within the rock toe structure. The bottom liner design was modified slightly to improve constructability and to increase stability of the repository. The modification was to place the HDPE and GCL on the level grade created by the rock toe where the leachate collection system terminates. On the hillside where stability of the waste is more critical, the bottom liner will consist of textured HDPE without a GCL. This change in the bottom liner design does not affect performance of the liner.

<u>HELP Modeling</u>

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to compare the effectiveness of the three repository alternatives using average annual leachate generated as the measure of effectiveness. 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." Modeling results are included in Appendix J.

Default material textures were used in the HELP model to model the different soil and geosynthetic layers in the repository. Selection of default material textures was made based on similar physical characteristics to native materials present at the repository site. Texture of mine waste placed in the repository was assumed to be coarse sand and texture of coversoil was assumed to be loam.

Precipitation data were synthetically generated using coefficients derived using the rainfall distribution for Billings, Montana, and monthly averages from Cooke City multiplied by 2.5. The 2.5 factor raises the average annual precipitation for the site to 1,596 mm (62.82 inches) per year, which corresponds with 1,524-1,778 mm (60-70 inches) of annual precipitation shown in the *Average Annual Precipitation Montana* report published by the Soil Conservation Service (USDA, 1975). Temperature data were also generated synthetically using coefficients derived for Billings Montana. This data set was supplemented with average temperatures obtained for Cooke City.

The length of the growing season used in the model was 45 days, from June 24 to August 13 (Brown, 1999). The evaporative zone depth was modeled at 460 mm (18 inches). The modeling was completed with the premise that mine waste will not be saturated when placed in the repository, and only minimal precipitation will be allowed to be in contact with the waste during construction. This second premise requires that the waste be temporarily tarped when precipitation is received during construction. The model was run to simulate a 100-year period. Summary modeling results are displayed in Table 7-2.

TABLE 7-2
HELP Modeling Summary - Alternative 2
New World Mining District – Response and Restoration Project
Selective Source Response Action

	Percolation Through Bottom mm/yr (in/yr)	Percolation Through Bottom per Hectare m^3/yr (cf/yr)	Leachate Collected m^3/yr (cf/yr)
Modified Alternative 2A	231 (9.1)	2,310 (81,700)	None
Modified Alternative 2B	0.0002 (0.00001)	0.002 (0.067)	None
Modified Alternative 2C	<0.0001 (<0.00001)	0.0015 (0.052)	0.00083 (0.029)

Notes: mm/yr = millimeters per year; in/yr = inches per year
m^3/yr = cubic meters per year; cf/yr = cubic feet per year

As expected, percolation through the repository decreases considerably from unlined modified Alternative 2A (2.3 million liters per year per hectare) to modified Alternatives 2B (2 liters per year per hectare) and 2C (1.5 liters per year per hectare). For modified Alternative 2C, the HELP model was adjusted for this final EE/CA to include only an HDPE in the bottom liner.

Using the double liner in the composite cover system of modified Alternatives 2B and 2C, the HELP model shows a virtual elimination of percolation into the waste and, consequently, into the substrate below the repository. Output from the HELP model shows that an extremely small amount of leachate would be collected in the leachate collection system of modified Alternative 2C (0.8 liters per year per hectare).

Appendix I presents data used to predict leachate quality. Concentrations of arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, and zinc in leachate generated by a mine waste repository were estimated from EPA Method 1312 synthetic precipitation leachate procedure (SPLP) tests. The SPLP analytical method was performed on 30 waste material samples collected from the New World Mining District in 1996 and 1999. The 30 samples were selected to represent mine wastes in the entire District.

Leachate concentrations were estimated using a weighted average of waste materials expected to be placed in the repository. This calculation was made by multiplying the SPLP concentration times the waste volume for each waste source and then divided by the total volume of mine waste that could be placed at the SB-4B site. For mine waste sources that were not sampled, an average SPLP concentration was calculated using the SPLP values from wastes with similar geologic and material characteristics. Because aluminum was not analyzed in the SPLP leachate, concentrations of aluminum were estimated using data collected by DNRC in 1974 and 1975 from a seep (Station 321) located below the McLaren Mill tailings dam.

Concentrations of arsenic, cadmium, and silver were all below the analytical detection limit. Of the 30 samples analyzed, mercury was detected in only two, chromium was detected in only three, and lead was detected in only six of the samples. Weighted average concentrations of copper, iron, and zinc are 0.44, 3.37, and 0.07 mg/L. Aluminum in the McLaren tailings spring was measured at 0.32 mg/L. Results of the SPLP tests are included in Attachment F of Appendix I.

Metal loads generated by leachate from the repository were estimated by multiplying the SPLP data by the anticipated volume of leachate predicted from HELP modeling. Loads for the three modified alternative repository designs were calculated. Table 6 in Appendix I presents the results of these calculations. As is apparent from the table, metal loads from any of the three repository designs are very small. Both the modified Alternative 2B and modified Alternative 2C repository designs result in virtually non-detectable metal loads to Soda Butte Creek. Metal loads for the modified Alternative 2A design are also very low, although potentially significant for copper if the effects of amendment are not accounted for. Actual metals concentrations in leachate from the modified Alternative 2A design would likely be lower than the SPLP concentrations used in the loading calculations because the mine waste in this design would be amended. Data available for other mine wastes indicate that metals mobility is greatly reduced when the waste is amended with lime (Appendix H reference, Maxim, 1998, pp.16,17).

The SPLP analysis does not take into account the effects of attenuation, co-precipitation, or precipitation that is likely to occur when the waste disposed in the repository is mixed with the Rommel Tailings, which has excess neutralization capacity, or as the leachate contacts the underlying till. As a result of the high percentage of till that is fine grained (33% smaller than #200 sieve), alkaline pH (8.3 su), and excess buffering capacity of the till (i.e. high neutralization potential), metals in leachate are expected to be lower in concentration than that estimated using the conservative SPLP weighted average approach as leachate moves through the till.

Appendix K presents a nondegradation analysis of metals loading to groundwater at the repository site under the case of leachate percolating through the bottom of the modified Alternative 2C design. This calculation showed that calculated discharges would result in a non-significant change in water quality beneath the repository. Under modified Alternative 2B, approximately only slightly more leachate will be produced than modified Alternative 2C. Factoring this into the nondegradation calculation, a non-significant change in water quality is also the case for modified Alternative 2B.

<u>Effectiveness</u>

Under this alternative, mine wastes are removed and disposed in an engineered on-site repository. Because wastes are isolated from the environment, this alternative is highly effective in controlling future migration of contaminants. The repository cap included in each of the three design alternatives is the key design element that isolates the wastes from the environment. While the effectiveness of the three cap designs varies, as discussed in detail in this section, the cap provides the break between direct percolation of precipitation into the waste. By minimizing percolation into the waste, leachate generated within the waste is minimized, resulting in relatively low quantities of leachate that can percolate through the bottom of the repository (Table 7-2).

❖ *<u>REMOVAL ACTION OBJECTIVES</u>*

Removal to an on-site repository would meet RAOs to the maximum extent because all wastes would be removed to an engineered repository.

❖ *<u>OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT</u>*

Removal to an on-site repository would provide protection of human health and the environment because contaminants would no longer be exposed at uncontrolled sites. Some risk will remain to the environment for modified Alternative 2A because leachate will percolate through the base of the repository. Leachate produced under Alternative 2A, however, will contain lower concentrations of copper and zinc as a result of the precipitation of these compounds as low solubility oxides and hydroxides in the amended waste. As discussed in Appendix I, there is no measurable impact on surface water quality in the tributary immediately below the repository or in Soda Butte Creek as a result of leachate percolating into the till beneath the repository. An extremely small volume of leachate is generated under either modified Alternatives 2B or 2C. Nondegradation analysis indicates non-significant changes in water quality would be measured under either modified Alternatives 2B or 2C (Appendix K).

❖ *COMPLIANCE WITH ARARS*

Some improvement in water quality in Fisher Creek and Soda Butte Creek is expected under this alternative. Surface water quality at station FCT-2, a tributary to Fisher Creek, should improve with the removal of the Tredennic dumps. As estimated by Amacher (1998), the mean copper load to Fisher Creek could be reduced by one percent, with reductions of aluminum and manganese of four percent. With the removal of the Rommel Tailings, a source of contaminants to Soda Butte Creek will be eliminated.

Compliance with contaminant-specific ARARs should be achieved for any discharges released to surface water after removals are complete. Removing the selected waste dumps is not expected to result in full compliance with contaminant-specific ARARs on Fisher Creek because the dumps to be removed contain only a small quantity of the total volume of contaminants present in the District. However, it is expected that the Selective Source Response Action will have a larger and more significant impact on meeting surface water contaminant-specific ARARs when combined in the long run with future response actions in the District.

Because groundwater has not been investigated in the vicinity of any of the dumps included in the Selective Source Response Action, it is not known whether groundwater quality is impacted. Removal of these source areas, however, should not degrade groundwater quality and may improve it in specific areas. The removal of the small volume of waste in this initial response action is not anticipated to significantly affect overall groundwater quality.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because the wastes will be capped in an engineered repository and the repository and removal areas 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 removed.

Location-specific ARARs at the dump removal sites are expected to be met to a substantial degree. Certain cultural and historic features may be affected if this alternative is implemented (see Appendix C). Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed adits; and, removing 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 are not expected to be impacted for several reasons. First, new disturbances are limited to upgrading existing roads and constructing new roads to the Upper Tredennic dumps, the Lower Spalding Dump, and the new connect road. Second, the response action will be completed in a relatively short period of time, reclaiming any new disturbances, and maintenance of permanent facilities (the repository) will not require a level of activity that is greater than that existing under current conditions.

Other location-specific ARARs at the dump removal sites will be protected through substantive compliance with the requirements of laws related to streambeds, floodplains, and wetlands. The Floodplain and Floodway Management Act will be complied with because no response activities will be conducted in a designated 100-year floodplain. The Natural Streambed and Land Preservation Act will be complied with at those sites where wastes are in contact with surface water. These include removals at the upper, middle, and lower Tredennic sites, and at the Rommel tailings site. Removals will be done in a surgical manner at each of the Tredennic sites to minimize any disturbance to the bed or banks of the associated stream. Affected areas will be reconstructed with earth and natural materials and sufficiently protected with erosion control techniques so that the bed and banks are protected from flood erosion. At the Rommel tailings, the stream buried by tailings will be reconstructed with earth and native materials following removal. The reconstructed stream will be designed to provide hydraulic stability. All disturbed areas will be managed during construction to minimize erosion. Location-specific ARARs derived from the Montana Solid Waste Management Act and regulations will be complied with at the repository site. The repository site investigation and proposed repository design alternatives meet the substantive requirements of this act.

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 removal areas and at the repository. 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. Modified Alternatives 2B and 2C will meet the requirements of the Montana Water Quality Act and nondegradation by minimizing the quantity of leachate percolating to state water (Appendix I and Appendix K). Alternative 2A may not comply with nondegradation, although leachate quality from amended tailings may contain sufficiently low concentrations of copper and zinc such that compliance with nondegradation is possible as degradation may be considered nonsignificant in light of the hydrogeologic conditions present at the repository site.

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 et seq.

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

Hydrological regulations contained in the Montana Strip and Underground Mine Reclamation Act would be met by minimizing any changes to the hydrologic balance. Appendix I presents the results of such an analysis substantiating this statement. 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 (BAT).

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 wastes from current locations should be a permanent solution requiring little maintenance and providing long-term effectiveness at the 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.

There are some concerns associated with each of the repository alternatives. Modified alternative 2A should provide long-term effectiveness by adding enough neutralizing amendment to fully eliminate future acid production. However, quality control during mixing operations will be needed to insure the wastes are mixed properly with the amendment.

For Alternatives 2B and 2C, GCL and geomembrane liners require proper installation and sequencing for the alternatives to be considered effective in the long-term. The LCS in Alternative 2C is a proven technology with long-term effectiveness and permanence; however, for the geomembrane liner to be effective in the long-term it must be properly installed. While GCLs have become widely accepted in the waste containment industry, long-term performance of these materials has not been proven to date.

The multi-layer caps in all three 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 repository alternatives. Alternative 2A will be affected the least by these factors. Continued PRSC monitoring and maintenance will be a factor in the effectiveness of the repository alternatives to insure long-term effectiveness. PRSC for the LCS tank in Alternative 2C will require periodic inspection and pumping if leachate collects in the LCS. Any leachate will require treatment or disposal at a licensed facility, and leachate will have to be managed in perpetuity.

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

There will be some 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 wastes to a repository. Reduction in mobility through treatment, however, only occurs under modified Alternative 2A through the treatment of the wastes with a neutralizing amendment.

❖ *SHORT-TERM EFFECTIVENESS*

The Selective Source Response Action should be completed 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.

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 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 (6), transports (4), and miscellaneous light duty trucks (15). For construction of the permanent bridges on Fisher Creek, a crane and several more transports will be used. Materials will be supplied by transports and trucks that will periodically travel to the site. An estimate of five truck or transport trips per day is anticipated for the construction season. To construct Alternative 2A, 3,000 metric tons of neutralizing amendment will be hauled to the repository site by truck over the course of the project. About 150 additional truck trips will be needed for this function over a period of 30 days. To construct modified Alternative 2C, drainage sands and gravels will be needed for repository construction. This will require trucking the materials from a variety of sources in the surrounding communities of Cody, Wyoming and Red Lodge, Gardiner, and Livingston, Montana.

Short-term road closures in the project area may be necessary, limiting access to the forest. To haul the waste to the repository, about 600 round-trip truck trips will be made on the Daisy Pass and Lulu pass roads. An additional 800 round-trip truck trips will be needed to haul the Rommel Tailings to the repository, although this will not require travel on public roads. 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 exposed widened roads and deeper and wider borrow ditches. These impacts will be mitigated by implementing best management practices for stormwater runoff.

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.

Most activities associated with repository cap construction can be implemented with conventional construction techniques and equipment that are readily available in the region. GCLs are available within Montana and do not require specialized labor for installation. Geomembrane liner installation for modified Alternative 2B and 2C 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.

Installation of the LCS may prove to be difficult at the hillside location, primarily resulting from placing the liner and drainage layers on a moderate slope. It will also be more difficult to construct a bottom liner and leachate collection system that has to be built in phases (Appendix H). Design changes incorporated into the final bottom liner design have addressed several of the major concerns associated with liner placement on a moderate slope, allowing modified Alternative 2C to be only slightly more difficult to construct that modified Alternative 2B. The same construction phasing difficulties are not expected for cap construction in modified Alternatives 2B and 2C because the cover system liners can be more easily integrated into the next phase of work.

Administrative issues may involve permanent land use restrictions to prohibit grazing and recreation activities at the repository. Institutional controls such as fencing will be used to protect the repository from inappropriate uses.

Cost

A summary of the total estimated costs for Alternatives 2A, 2B, and 2C are shown on Table 7-3. The difference in costs between Alternatives 2A and 2B is about $150,000. Alternative 2C would cost nearly $500,000 more than Alternatives 2B. The detailed cost analysis is contained in Appendix F.

The costs associated with the ancillary activities, removal of the wastes to the repository, and reclamation of the waste dump sites is identical for all three repository alternatives, and accounts for approximately $380,000. Due to the extreme terrain, the cost of hauling the wastes to the repository is estimated at about $111,000. Cost of the lime amendment in modified Alternative 2A is about half the cost of constructing the composite cap in modified Alternative 2B. The increased cost of modified Alternative 2C is associated with the LCS and a higher PRSC.

Monitoring and maintenance for the reclaimed waste dump sites and the repository cap were assumed the same for all three alternatives. Qualitative monitoring would occur annually at a cost of $2,000 per year, and maintenance would be required twice in the 30 years after construction. Maintenance would amount to an annual cost of $1,000. The total estimated annual cost for PRSC is $3,000 for monitoring and maintaining the reclaimed waste dump sites and the repository cap. This would be the only PRSC cost for Alternatives 2A and 2B and would require a present worth investment of $46,648. It was estimated that Alternative 2C would require an additional $3,000 per year to maintain the LCS and manage leachate. The annual PRSC for Alternative 2C, $6,000, translates into a present worth value of $93,295.

TABLE 7-3
Summary of Total Estimated Costs for Modified Alternative 2
New World Mining District – Response and Restoration Project
Selective Source Response Action

Item	Alt. 2A	Alt. 2B	Alt. 2C
Ancillary Activities	$150,188	$150,188	$150,188
Excavate/Load Waste	$51,478	$51,478	$51,478
Haul Waste	$111,253	$111,253	$111,253
Reclaim Waste Dump Sites	$68,301	$68,301	$68,301
Repository- Site Preparation/Rock Toe Construction	$400,400	$416,240	$416,240
Lime Amendment	$152,419		
Spread and Compact Waste		$41,642	$41,642
Construct Cap	$91,376	$271,866	$342,606
Construct Leachate Collection System			$203,620
SUBTOTAL FOR ALL ITEMS:	$1,025,415	$1,110,968	$1,385,323
Mobilization, Bonding, and Insurance (12%):	$123,050	$133,316	$166,239
Overhead and Profit (15%):	$172,270	$186,643	$232,735
Contingency (10%):	$132,073	$143,093	$178,430
TOTAL CONSTRUCTION ESTIMATE:	$1,452,808	$1,574,020	$1,962,733
Engineering Evaluation and Design (12%):	$174,337	$188,882	$235,528
Construction Oversight (10%):	$145,281	$157,402	$196,273
Present Worth Post-Removal Site Control Estimate:	$46,648	$46,648	$93,295
TOTAL ESTIMATED COST:	**$1,819,073**	**$1,966,952**	**$2,487,830**

7.3.3 OFF-SITE DISPOSAL - ALTERNATIVE NO. 3

This alternative involves removal of all mine waste from selective waste dumps to an off-site repository. It is assumed that mine waste will be hauled to a transfer station near US 212 for reloading onto highway haul trucks. The highway trucks would transport the waste to an off-site repository located in Idaho.

<u>Alternative Description</u>

- *Site Preparation:* Clearing and grubbing; separating combustible and non-combustible debris; and, debris disposal.
- *Excavate/Load Waste:* Excavate and load mine waste from selected dumps. About 24,600 cubic meters (32,300 cy) of waste would be loaded onto haul trucks.
- *Haul Waste to Off-Site Repository:* Haul mine wastes to a transfer area near US Highway 212. Load mine wastes onto highway haul trucks that would haul the waste to the off-site repository in Idaho.

- *Regrade and Revegetate Mine Waste Dump Sites:* Regrade excavated areas; truck and place 15 cm (0.5 feet) of coversoil from SB-4B repository site; amend coversoil with organic matter and fertilizer, and seed, mulch, and cover with an erosion control blanket.

- *PRSC*: Monitoring and maintenance of vegetation on removal areas.

Effectiveness

Off-site disposal would be the most effective alternative for reducing contaminants in the District. The off-site repository is a RCRA permitted facility.

❖ *REMOVAL ACTION OBJECTIVES*

Removal to an off-site repository would meet RAOs to the maximum extent.

❖ *OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT*

Removal to an off-site repository would provide the maximum amount of protection to human health and the environment at the removal sites because all the waste rock dumps would be moved to an off-site repository. However, short-term risks to human health are associated with this alternative due to potential traffic accidents resulting from highway transport of 1,400 round-trip truck trips to the off-site repository.

❖ *COMPLIANCE WITH ARARS*

Compliance with ARARs would be similar to the on-site disposal alternative. Some improvement in water quality in Fisher Creek and Soda Butte Creek is expected under this alternative. Surface water quality at station FCT-2, a tributary to Fisher Creek, should improve with the removal of the Tredennic dumps. As estimated by Amacher (1998), the mean copper load to Fisher Creek could be reduced by one percent, with reductions of aluminum and manganese of four percent. With the removal of the Rommel Tailings, a source of contaminants to Soda Butte Creek will be eliminated.

Compliance with contaminant-specific ARARs should be achieved for any discharges released to surface water after removals are complete. Removing the selected waste dumps is not expected to result in compliance with contaminant-specific ARARs on Fisher Creek because the dumps removed represent only a small quantity of the total volume of contaminants present in the District. However, it is expected that the Selective Source Response Action will have a larger and more significant impact on meeting surface water contaminant-specific ARARs when combined in the long run with future response actions in the District.

Because groundwater has not been investigated in the vicinity of any of the dumps included in the Selective Source Response Action, it is not known whether groundwater quality is impacted. Removal of these source areas, however, should not detract from groundwater quality and may improve it in specific areas. The removal of the small volume of waste selected for the initial response action is not anticipated to significantly affect overall groundwater quality.

Contaminant-specific ARARs for ambient air are expected to be met under this alternative because the wastes will be capped in an engineered off-site repository and the removal areas 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 removed.

Location-specific ARARs are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented (see Appendix C). Impacts to historic features may include removing timbers, metal debris, and trash; backfilling collapsed adits; and, removing 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 are not expected to be impacted, primarily because new disturbances are limited to upgrading existing roads and constructing new roads to the Upper Tredennic dumps and the Lower Spalding Dump. The response action will be completed in a relatively short period of time and new disturbances will be reclaimed. No permanent facilities require maintenance under this alternative. Maintenance at the removal sites will not require a level of activity that is greater than that existing under current conditions.

Other location-specific ARARs will be protected through substantive compliance with the requirements of laws related to streambeds, floodplains, and wetlands. The Floodplain and Floodway Management Act will be complied with because no response activities will be conducted in a designated 100-year floodplain. The Natural Streambed and Land Preservation Act will be complied with at those sites where wastes are in contact with surface water. These include removals at the upper, middle, and lower Tredennic sites, and at the Rommel tailings site. Removals will be done in a surgical manner at each of the Tredennic sites to minimize any disturbance to the bed or banks of the associated stream. Affected areas will be reconstructed with earth and natural materials and sufficiently protected with erosion control techniques so that the bed and banks are protected from flood erosion. At the Rommel tailings, the stream buried by tailings will be reconstructed with earth and native materials following removal. The reconstructed stream will be designed to provide hydraulic stability. All disturbed areas will be managed during construction to minimize erosion.

Location-specific ARARs derived from the Montana Solid Waste Management Act and regulations do not apply to this alternative since all the wastes will be hauled to an off-site, permitted facility.

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 removal areas. 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 and nondegradation will be complied with at the removal areas.

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 substantively met by grading, backfilling, and topsoiling removal areas, and using primarily native species and matching species to surrounding habitat types. BMPs for seeding, planting, mulching, soil amendments, control of noxious weeds, and erosion control will also be followed under this alternative.

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 (BAT).

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.

❖ *<u>LONG-TERM EFFECTIVENESS AND PERMANENCE</u>*

Removing the wastes from current locations should be a permanent solution requiring little maintenance and providing long-term effectiveness at the 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.

❖ *<u>REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT</u>*

There will be some reduction in mobility but no reduction of toxicity or volume with this alternative. Reduction in the mobility of the contaminants would be achieved by removing wastes to an off-site repository, although this effect will not be achieved through treatment of the wastes.

❖ *<u>SHORT-TERM EFFECTIVENESS</u>*

The Selective Source Response Action should be completed 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.

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, and during transport of wastes to the off-site repository. It is estimated that about 33 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 (6), transports (4), and miscellaneous light duty trucks (15). For construction of the permanent bridge on Fisher Creek, a crane and several more transports will be used. Materials will be supplied by transports and trucks that will periodically travel to the site. An estimate of two truck or transport trips per day is anticipated for the construction season. 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 road closures in the project area may be necessary, limiting access to the forest. To haul the estimated 24,600 cubic meters of waste to the transfer station, about 2,690 round-trip truck trips will be made on the Daisy Pass and Lulu Pass roads. About 1,400 round-trip truck trips will be needed for the highway transport portion of the project. It is assumed that haul truck traffic would not be allowed in Yellowstone Park. Because of this, Alternative 3 places more impacts on the local community and roads as the 1,400 truck trips will be made on Highway 212 through numerous small communities in Montana, Wyoming, and Idaho. In addition, the highway route from the site to Cody, Wyoming follows steep and winding roads. This amount of traffic and road conditions increase the risk of possible accidents and fatalities associated with highway transport.

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 exposed widened roads and deeper and wider borrow ditches. These impacts will be mitigated by implementing best management practices for stormwater runoff.

Implementability

Removal of wastes to an off-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 will allow the timely implementation and successful execution of the alternative. There may be administrative concerns of long-term liability for wastes transported to a site not under USDA-FS control.

Cost

Estimated costs for removal and haul of waste to the off-site repository are shown on Table 7-4. The detailed cost analysis can be found in Appendix F. The total estimated cost for this alternative is about $10.5 million. Hauling costs and disposal fees account for approximately 67% of the total estimated cost. Two licensed RCRA repositories, one in Utah and the other in Idaho, were evaluated as potential RCRA disposal facilities. Envirosafe Services of Idaho near Grand View, Idaho was used in the cost estimate because the quoted tipping fees were substantially lower. A tipping fee of $100 per ton was assumed and haul costs were estimated at $80 per ton. This results in a total cost of $180 per ton for hauling and disposal.

TABLE 7-4
Summary of Total Estimated Costs for Alternative 3
New World Mining District – Response and Restoration Project
Selective Source Response Action

Item	Off-Site Removal
Ancillary Activities	$115,188
Excavate/Load Waste	$51,478
Haul Waste to Reloading Area	$111,253
Reclaim Waste Dump Sites	$68,301
Haul Waste to Off-site Repository	$3,137,713
Tipping Fee	$3,922,142
SUBTOTAL FOR ALL ITEMS:	$7,406,075
Mobilization, Bonding, and Insurance (10%):	$740,607
Overhead and Profit (15%):	$1,222,002
Contingency (10%):	$936,868
TOTAL CONSTRUCTION ESTIMATE:	$10,305,553
Engineering Evaluation and Design:	$100,000
Construction Oversight:	$80,000
Present Worth Post-Removal Site Control Estimate:	$31,098
TOTAL ESTIMATED COST:	**$10,516,651**

The estimate for removal and haul to the off-site repository is based on the use of a transfer station to transfer waste from off-highway to highway trucks. Costs for the ancillary activities do not include the cost to construct the Upper Connect Road since this road will not be needed. PRSC costs associated with maintaining the removal areas amount to $31,098 in present worth.

7.3.4 IN-SITU TREATMENT - ALTERNATIVE NO. 4

This alternative involves treating the wastes in place with a neutralizing amendment. Figure 6 shows a schematic of the alternative components using the Lower Tredennic Dump One as an example. A description of the alternative is presented below, followed by the detailed analysis.

<u>Alternative Description</u>

- *Site Preparation:* Clearing and grubbing; separating combustible and non-combustible debris; and, debris disposal.

- *Regrade Waste Dumps:* Mine waste dumps 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. Regrading would be done to blend with the surrounding topography.

Figure 6 - Schematic of Alternative No. 4

Figure 6 - Back Page

- *Treat Waste with Neutralizing Amendment:* A neutralizing amendment, such as agricultural limestone, lime kiln dust, or calcium oxide, would be mixed into the top 30 cm (1 foot) of the waste according to the rate calculated for each dump shown in Table 7-5.

TABLE 7-5
Lime Requirement for Alternative 4
New World Mining District – Response and Restoration Project
Selective Source Response Action

Waste Dump Name And Designation	Area hectares (acres)	Lime Req[(1)] (t/1000t)	Lime[(2)] mtons (tons)
Rommel Tailings	0.90 (2.22)	0	0
Lower Spalding Dump	0.13 (0.32)	314	330 (364)
Lower Tredennic Dump One	0.16 (0.40)	21	27 (30)
Upper and Middle Spalding Dump	0.11 (0.28)	1,109	1,024 (1,127)
Upper Tredennic - Five Dumps	0.11 (0.28)	159	147 (162)
Soda Butte Tailings Dump	0.06 (0.14)	0	0
Middle Tredennic - Dumps One to Three	0.11 (0.28)	48	44 (48)
Small Como Dump	0.10 (0.25)	0	0
TOTALS:	**1.87 (4.62)**	**--**	**1,572 (1,731)**

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) and tons; total lime calculated according to the following formula: ([{area (acres) x 1.5 (to allow for spreading out wastes) x 1 foot (mixed waste) / 27 cubic feet per cubic yard} x 1.5 tons per cubic yard] / 1000 tons soil per ton of lime] x lime rate).

- *Revegetate Waste Dump Sites:* Following neutralization, 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.

Effectiveness

Overall, in-situ treatment would be only somewhat effective. Because site conditions limit the amount of waste that would be treated, untreated wastes will remain. Under certain conditions during moderate to extreme weather, untreated wastes could become saturated and release contaminants to the environment.

❖ *REMOVAL ACTION OBJECTIVES*

In-situ treatment meets most of the RAOs to some extent. By neutralizing the upper 30 cm of waste to a pH of greater than 6.0 s.u., phytotoxicity of the waste will be reduced to the extent that plants will grow directly in the amended waste. Revegetating the waste dumps will greatly reduce soluble metals that can migrate from the dumps to surface water. Soluble metals will not be eliminated because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation. The RAO of reducing or eliminating concentrated runoff and sediment discharges will be met through the establishment of a viable vegetative cover. Potential exposure to the food chain to metal contaminants 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. Some risk remains to those dumps located proximal to surface water drainages (Tredennic dumps and Rommel tailings) because the dumps will either be exposed to flooding, high intensity precipitation events, freeze-thaw, avalanches (Tredennic dumps only), and other environmental hazards that could compromise the stability of the reclaimed dumps. In addition, some waste material may remain saturated by groundwater originating from adits or other sources. While maintenance of the dumps will reduce this risk to some extent, maintenance will not prevent failure under extreme conditions that occur in a relatively short period of time (hours or days).

A moderate protection to human health would be achieved under this alternative. Because people visiting the reclaimed areas will still be exposed to the same concentrations of metals present under existing conditions, human health exposure will not be eliminated.

❖ *COMPLIANCE WITH ARARS*

Compliance with ARARs will not be fully achieved under Alternative 4. Some improvement in water quality in Fisher Creek and Soda Butte Creek is expected because soluble concentrations of copper and zinc would be reduced and erosion from the revegetated waste dumps would be greatly reduced. Surface water quality at station FCT-2, a tributary to Fisher Creek, should improve with the treatment of the Tredennic dumps.

Compliance with contaminant-specific ARARs for surface water should be achieved during base flow conditions at the dump sites. For dumps located near-stream (Tredennic and Rommel tailings), wastes will be pulled back so that the dumps no longer toe into the tributary drainage. Under higher flow conditions, some load from the dumps is likely to be released due to saturation of unamended wastes, particularly at the Middle and Lower Tredennic dumps. Contaminant-specific ARARs may not be met in these tributaries under high flow conditions. Treating the selected waste dumps in place is not expected to result in compliance with contaminant-specific ARARs because the dumps removed represent only a small quantity of the total volume of contaminants present in the District. However, it is expected that the Selective Source Response Action will have a larger and more significant impact on meeting surface water contaminant-specific ARARs when combined in the long run with future response actions in the District.

Because groundwater has not been investigated in the vicinity of any of the dumps included in the Selective Source Response Action, it is not known whether groundwater quality is impacted. In-situ treatment will likely have a positive effect on groundwater except for those times when unamended wastes become saturated. Treatment of the small volume of waste in this initial response action is not anticipated to significantly affect overall groundwater quality.

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.

Location-specific ARARs are expected to be met. Certain cultural and historic features may be affected if this alternative is implemented (see Appendix C). 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.

Endangered species (primarily the grizzly bear) should not be affected since the response action will be completed in a relatively short period of time.

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 are not expected to be impacted for several reasons. First, new disturbances are limited to upgrading existing roads and constructing new roads to the Upper Tredennic dumps and the Lower Spalding Dump. Second, the response action will be completed in a relatively short period of time, reclaiming any new disturbances. There are no permanent facilities under this alternative. Maintenance at the amended waste dumps will not require a level of activity that is greater than that existing under current conditions.

Other location-specific ARARs will be protected through substantive compliance with the requirements of laws related to streambeds and wetlands. The Floodplain and Floodway Management Act does not directly apply because the tributaries next to the selected waste dumps are not in a designated 100-year floodplain. However, wastes from the Lower Tredennic, and Rommel tailings will be left in the floodplain of the nearby tributaries. The Natural Streambed and Land Preservation Act (§§ 75-7-101 et seq., MCA) will be complied with at those sites where wastes are in contact with surface water such that the streambanks affected by waste will be moved away from the stream, and the affected areas will be reconstructed with earth and natural materials and sufficiently protected with erosion control techniques so that the bed and banks are protected from flood erosion. Reconstructed streambed and banks will be designed to provide hydraulic stability. All disturbed areas will be managed during construction to minimize erosion.

Location-specific ARARs derived from the Montana Solid Waste Management Act and regulations will not be complied with as wastes will be left in the floodplain of several tributaries. Groundwater may be impacted at several of the dump sites because unamended wastes will likely be in contact with shallow groundwater.

Action-specific ARARs are expected to be met by this alternative. Action-specific ARARs for storm water runoff will be complied with using best management practices (BMPs) at the treated dump sites. 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 and nondegradation will not be fully complied with under this alternative. Unamended wastes will likely be in contact with groundwater from adit seeps and during periods of high water tables.

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

Revegetation requirements contained in the Surface Mining Control and Reclamation Act, Montana Strip and Underground Mine Reclamation Act and Metal Mining Act would be substantively met by regrading and amending treated sites. 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 (BAT).

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*

Because the entire package of waste materials at each dump site cannot be fully amended under this alternative, on-site treatment may not be a permanent solution. Acidity from unamended wastes lying below the amended zone has the potential to move upward into the treated zone through capillary action. If this condition occurs, retreatment of the wastes may be necessary if vegetation impacted through a reduction in cover or vigor. Amended wastes are also subject to erosion and unamended wastes may eventually resurface. PRSC monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term.

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

There will be some reduction in mobility but no reduction of toxicity or volume under this alternative. Reduction in the mobility of contaminants will be achieved through treatment with a neutralizing amendment.

❖ <u>*SHORT-TERM EFFECTIVENESS*</u>

This alternative should allow completion of the Selective Source 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.

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). For construction of the permanent bridge on Fisher Creek, a crane and several more transports will be used. Materials will be supplied by transports and trucks that will periodically travel to the site. An estimate of two truck or transport trips per day is anticipated for the construction season. To construct Alternative 4, 1,570 metric tons of neutralizing amendment will be hauled to the various waste dumps by truck over the course of the project. About 75 additional truck trips will be needed for this function over a period of 30 days.

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 exposed widened roads and deeper and wider borrow ditches. These impacts will be mitigated by implementing best management practices for stormwater runoff.

<u>Implementability</u>

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.

<u>Cost</u>

Estimated costs for Alternative No. 4 are shown in Table 7-6. The detailed cost analysis can be found in Appendix F. Total cost for this alternative is about $410,000. About 25% of that cost is associated with regrading and amending the dumps with a neutralizing amendment. Another 25% is attributed to construction of the common items. For the common items, the Upper Connect Road would not have to be constructed.

TABLE 7-6
Summary of Total Estimated Costs for Alternative 4
New World Mining District – Response and Restoration Project
Selective Source Response Action

Item	In-Situ Treatment
Ancillary Activities	$115,188
Regrade and Amend Dumps with Lime	$109,903
SUBTOTAL FOR ALL ITEMS:	$225,091
Mobilization, Bonding, and Insurance (10%):	$22,509
Overhead and Profit (15%):	$37,140
Contingency (10%):	$28,474
TOTAL CONSTRUCTION ESTIMATE:	$313,214
Engineering Evaluation and Design:	$37,586
Construction Oversight:	$31,321
Present Worth Post-Removal Site Control Estimate:	$31,098
TOTAL ESTIMATED COST:	**$413,220**

8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the four 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 Selective Source Response Action present a range of effectiveness. Alternative 3, off-site disposal, is the most effective of the alternatives evaluated. The overall effectiveness of Alternative 2, on-site disposal, is comparable to Alternative 3 except for modified Alternative 2A, which is less effective because leachate will percolate through the base of the repository into the underlying till. However, because the waste is amended, leachate will likely have a negligible effect on groundwater quality in the near-surface. Alternative No. 4, in-situ treatment, is less effective than Alternatives 2 and 3 because unamended wastes may still release contaminants to the environment under certain conditions. Overall effectiveness of the no action alternative is poor.

8.1.1 REMOVAL ACTION OBJECTIVES

Alternatives 2 and 3 achieve RAOs to a similar degree. Removal to either an on-site or off-site repository meets RAOs to the maximum extent because all wastes would be controlled in an engineered facility. The three on-site repository alternatives are equivalent with respect to RAOs.

On-site treatment meets most of the RAOs to some extent but does not completely meet RAOs with respect to surface water. Soluble metals will not be eliminated because some portion of the wastes in the dump will remain untreated and in contact with infiltrating precipitation. 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

Alternative 3 provides the highest degree of protection to human health and the environment. Alternative 2 should fully protect human health because wastes will be isolated from human contact in an engineered repository.

A very small risk remains to the environment for each of the repository alternatives. Modified Alternative 2A allows some leachate (2.3 million liters per year per hectare) to percolate through the base of the repository. Because the wastes are amended, concentrations of metals in leachate should be very low and have a minimal effect on the environment. Using the double liner in the composite cover systems of modified Alternatives 2B and 2C, percolation into the waste is virtually eliminated. An extremely small amount of leachate would be collected in the leachate collection system of modified Alternative 2C (0.8 liters per year per hectare).

8.1.3 COMPLIANCE WITH ARARS

The no action alternative does not fully comply with ARARs and in fact is the alternative that is least compliant with ARARs. Alternatives 2 and 3 largely comply with ARARs. Under Alternatives 2 and 3, some improvement in water quality in Fisher Creek and Soda Butte Creek is expected to occur.

Reduction in copper, aluminum, and manganese loads to Fisher Creek and Soda Butte Creek should occur, although the measurable impact of these reductions will be small. Removing the selected waste dumps under either Alternative 2 or 3 is not by itself expected to result in full compliance with contaminant-specific ARARs for Fisher Creek because the dumps to be removed contain only a small quantity of the total volume of contaminants present in the District. Other location-specific and action-specific ARARs will be met under Alternative 3.

Compliance with ARARs will not be fully achieved under Alternative 4. Some improvement in water quality in Fisher Creek and Soda Butte Creek is expected because soluble concentrations of copper and zinc would be reduced and erosion from the revegetated waste dumps would be greatly reduced. Achievement of surface water ARARs will likely only occur during base flow conditions if Alternative 4 is implemented. Under higher flow conditions, some load from the dumps will likely be released due to saturation of unamended wastes. Groundwater ARARs may not be met in areas with adit seeps or seasonally high groundwater. Location-specific ARARs associated with the Montana Solid Waste Management Act will not likely be met since uncontrolled wastes will remain in the floodplain of the small tributaries flowing past the regraded dump sites. Other location-specific and action-specific ARARs will be met under Alternative 4.

8.1.4 Long-Term Effectiveness and Permanence

Alternatives 2 and 3 are equally effective in the long-term at the removal sites. Removing the wastes from current locations should be a permanent solution requiring little maintenance. Because Alternative 3 removes the wastes off-site, this alternative is more effective and permanent than the other alternatives. The no action alternative is neither effective in the long-term nor permanent.

For Alternative 2, there are some concerns associated with each of the repository alternatives. Modified alternative 2A should provide long-term effectiveness by adding enough neutralizing amendment to fully eliminate future acid production. However, quality control during mixing operations will be needed to insure the wastes are mixed properly with the amendment. For Alternatives 2B and 2C, GCL and geomembrane liners require proper installation and sequencing for the alternatives to be considered effective in the long-term. While GCLs have become widely accepted in the waste containment industry, long-term performance of these materials has not been proven to date. The multi-layer caps in all three alternatives could also 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 the repository alternatives. For Alternative 2C, leachate will have to be managed in perpetuity.

For Alternative 4, on-site treatment may not be a permanent solution because the wastes will not be fully amended. Monitoring and maintenance will be essential to maintaining the effectiveness of this alternative in the long-term.

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, although only modified Alternative 2A and Alternative 4 reduce mobility through treatment with a neutralizing amendment. The greatest reduction in mobility through treatment is achieved by modified Alternative 2A since all the wastes are amended with a neutralizing amendment. Reduction in plant toxicity through treatment is achieved by Alternative 4, although none of the alternatives reduce toxicity to humans by treatment.

8.1.6 SHORT-TERM EFFECTIVENESS

Short-term effectiveness of all the alternatives considered for in the selective source removal, except for no action, is similar in that construction will be completed in a period of no more than 90 days. Alternative 4 has the least impacts to the community because it can be constructed in 30 days less time and does not require construction of the Upper Connect road. It also requires fewer pieces of equipment and much less travel on off-highway roads than either Alternatives 2 or 3. There are no impacts in the short-term from the no action alternative.

Short-term impacts associated with Alternatives 2 and 3 are similar. Both alternatives place more impacts on the local community and roads due to the large number of truck trips that will be made hauling materials to the repository site or hauling waste materials offsite. Alternative 3 requires about 1,400 round-trip truck trips hauling mine wastes along state highways through communities in Montana, Wyoming, and Idaho. Because of this, Alternative 3 and modified Alternatives 2B and 2C pose the greatest risk of fatalities to people and wildlife from vehicle accidents. Much less materials are needed to implement modified Alternative 2A so the short-term impacts associated with this repository design are less than the other two repository 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 3 is the most implementable of the alternatives because wastes are hauled off-site. Long-term liability of wastes transported to a site not under USDA-FS control may cause some administrative concerns for Alternative 3 that are not a factor in the other alternatives.

Alternative 2 requires some specialized construction techniques, but these techniques are proven and can be implemented at the site. GCLs are available within Montana and do not require specialized labor for installation. Geomembrane liner installation for modified Alternatives 2B and 2C 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.

Installation of the LCS for Alternative 2C may prove to be difficult at SB-4B, primarily resulting from placing the liner and drainage layer on a moderate slope. It will also be more difficult to construct a bottom liner and leachate collection system that has to be built in phases. The same construction phasing difficulties are not expected for cap construction in modified Alternatives 2B and 2C because the cover system liners can be more easily integrated into the next phase of work.

8.3 COST

Alternative 3, off-site removal, is by far the most expensive of the alternatives evaluated. The total cost to implement this alternative is about $10.5 million. The no action alternative is the least expensive of the alternatives as there are no capital costs that will be expended for cleanup. However, there are external costs associated with no action, including the loss of certain ecological functions such as a healthy, viable fishery and aquatic community.

Alternative 4 is the least expensive of the alternatives where an action is taken, as no waste hauling is involved. About $410,000 is the estimated cost for Alternative 4. Of the three repository alternatives, modified Alternative 2A is the least expensive (about $1.8 million) and modified Alternative 2C is the most expensive (about $2.5 million). The cost to implement modified Alternative 2B is about $2.0 million.

8.4 PREFERRED ALTERNATIVE

On March 24, 2000, a draft of this document was released to the public for comment. The preferred alternative selected in the draft was modified Alternative 2B. The USDA-FS preferred this alternative, removal to an on-site repository with a composite cap, because it best met the objectives of the project as well as effectiveness and cost criteria. The Draft EE/CA originally selected the repository location within the SB-4B area on the hillslope located near the upper (north) end of the site.

Written comments were received on the draft from several parties including the EPA, Montana DEQ, Department of Interior National Park Service, Environmental Materials Inc., Greater Yellowstone Coalition, Ralph Glidden, and Park County Environmental Council. These comments are attached in Appendix L. While numerous comments were directed at procedural issues, technical issues were primarily related to the preferred design alternative selected in the draft, which was perceived to be less protective of the environment than modified Alternative 2C, and the limited capacity available in the SB-4B site as initially located. One major theme of many of the comments was the need to find a repository site that could accommodate the McLaren Tailings. Because the USDA-FS was limited by the Consent Decree in considering the McLaren Tailings at this juncture in the project, the original repository location selected in the draft did not have the capacity to contain the McLaren Tailings.

In light of the comments received, and in light of new groundwater data that became available after the Draft EE/CA was released, the USDA-FS proposed amending its preferred alternative to modified Alternative 2C. With this change, the USDA-FS also proposed moving the location of the repository to a swale within the SB-4B. This site would have provided the necessary capacity to contain all mine wastes within the District including the McLaren Tailings. By moving to the swale, the total capacity of the repository would have increased to 1,000,000 cubic yards, and difficulties previously associated with the construction of the lined repository on a hillslope would have been alleviated. However, there were several disadvantages to the proposed repository location in the swale, including the disturbance of about 0.4 hectares of Category II wetland and about 90 meters of perennial stream channel that would be affected by the Selective Source Response Action repository build-out.

A technical meeting was held in Mammoth, Wyoming on June 29, 2000, to discuss these proposed changes with the technical team, agency coordinators, and representatives of several environmental groups. The proposed changes in the preferred repository design and the change in repository location to the swale were supported by most of the participants at the meeting.

After numerous discussions with MDEQ representatives between July and December 2000, it became clear that filling a portion of the Category II wetland in the swale was unacceptable to the State of Montana. MDEQ also indicated that the State of Montana would take responsibility for final disposition of the McLaren Tailings, thereby eliminating the need to provide sufficient capacity to contain all the mine wastes within the District. Moreover, MDEQ made clear that it would not allow disposal of the McLaren Tailings in the swale. In view of these positions, the USDA-FS decided to return to the hillside location and eliminate from further consideration the building of a central repository with the capacity to dispose of all District wastes.

For these reasons, the hillside location within the SB-4B site will be used for disposal of District Property wastes selected in this EE/CA as well as in future years. The remaining determinations (and their rationales) that were presented in the draft EE/CA on the selection of the preferred alternative remain intact. This information is reiterated in the following discussion.

On-site disposal is preferred to off-site disposal and in-situ treatment of the selected mine waste dumps for the following reasons:

- Effectiveness of on-site disposal is comparable to off-site disposal. Although some risk remains for recontamination of the environment under on-site disposal, this risk is managed through engineering controls employed at the on-site repository. Evaluation and field investigations of potential repository sites in the District led to the selection of a site that has suitable characteristics for mine waste disposal. These characteristics include an appropriate geologic setting, presence of an adequate thickness of low permeable glacial till beneath the repository, suitable hydrogeologic conditions, adequate size, suitable materials for repository construction, and limited visibility from adjacent land.

- Effectiveness of on-site disposal is superior to in-situ treatment for the dumps included in the Selective Source Response Action. 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 in-situ treatment. In-situ treatment also does not comply with ARARs to the extent that on-site disposal does.

- Although all the alternatives are technically implementable, administrative concerns remain with off-site disposal. A policy decision by the USDA allows disposal of mining wastes located on federal property only in a hazardous waste managed facility. The primary administrative issue for off-site disposal is the USDA-FS will maintain liability for waste that it will no longer physically control.

- The cost of off-site disposal is about four times higher than the cost of on-site disposal.

Of the three on-site repository alternatives evaluated, modified Alternative 2A, which relies on a soil cap to reduce infiltration of water into waste, is not considered sufficiently protective of the environment because the high precipitation in the District setting results in excessive moisture in the waste. This is balanced to some extent because the wastes are amended with a neutralizing agent, effectively reducing the mobility of copper and zinc.

Modified Alternative 2B was preferred to 2A because this design reduces infiltration through the cap and migration of leachate through the base of the repository to very small quantities. While, the bottom liner system of modified Alternative 2C provides an additional level of protection than modified Alternative 2B, site conditions will make construction difficult. Considering that very small quantities of leachate are expected to be generated and adding in the protection afforded to groundwater and surface water quality from where these waste dumps currently are present at the site, modified Alternative 2B was thought to be very effective at protecting the environment. This alternative is less costly and requires less maintenance than modified Alternative 2C. For modified Alternative 2C, leachate will have to be managed in perpetuity.

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Selective Source Response Action EE/CA

New World Mining District Response and Restoration Project

Final

REPOSITORY SITE EVALUATION REPORT NEW WORLD MINING DISTRICT RESPONSE AND RESTORATION PROJECT

Prepared for:

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1.0 INTRODUCTION

Maxim Technologies, Inc. (Maxim) prepared this report for the United States Department of Agriculture, Forest Service (USDA-FS), Region 1 as part of an on-going Response and Restoration Project that is being conducted by the USDA-FS in the New World Mining District (District). The purpose of this report is to summarize the findings of a repository siting evaluation and investigation conducted in the District between March 1999 and October 2000. Results of the siting evaluation are being used to select a repository site in the District with sufficient capacity to dispose of historic hard rock mining waste.

A central repository site is being considered to isolate approximately 120,000 cubic yards (90,000 cubic meters) of waste rock and tailings currently located at various abandoned mine and mill sites present on USDA-FS controlled lands in the District. Initially, the repository siting evaluation targeted sites with a total excess capacity that would ideally contain other District wastes including the McLaren Mine waste rock or McLaren Tailings. With this in mind, the repository siting evaluation examined locations able to contain a minimum of 500,000 cubic yards (400,000 cubic meters) of waste material, or approximately 810,000 tons. Depending on design requirements, an area of approximately 15 to 25 acres will be required for the repository.

The location of the District at a relatively high elevation, in an area that receives a large amount of snowfall, and in a relatively remote mountainous region presents certain difficulties in finding the most suitable location for an on-site repository, in addition to difficulties involved with repository construction. The notion of finding a site that is 'high and dry' does not necessarily apply in the District because the entire District is blanketed with two to six meters of snow (six to 20 feet) for five to six months of the year. When the snow melts in the spring, runoff is a major occurrence in the District and flowing water is evident over most of the land area.

The repository siting evaluation consisted of two phases. Phase 1, conducted in March through July 1999, evaluated technical information available from previous investigations conducted in the District to identify sites with physical and environmental characteristics that would be suitable for disposal of mining wastes. The data evaluated included groundwater, surface water, geology, soil, geotechnical, vegetation, and other environmental information. Phase II was conducted from July 1999 through September 2000, and involved collecting site specific data at the highest ranked sites determined in the Phase I evaluation.

The following sections summarize results of the Phase I and Phase II studies. Results of the Phase I repository siting study were published in a report in June 1999 (Maxim, 1999a). Results of the Phase II investigation were published in December 1999 (Maxim, 1999b) and two technical memoranda issued in November 1999 and June 2000 (Maxim, 1999c; 2000). More detailed information is contained in the earlier reports and will not be repeated herein. The referenced documents contain raw data, recommendations, field investigation notes, summary tables, and other pertinent information.

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2.0 PHASE I INVESTIGATION

The Phase I repository siting evaluation was initiated in the spring of 1999 by convening a meeting of a interdisciplinary team of scientists and engineers familiar with the District and with the data available from previous sources. The meeting was held on April 21, 1999 with USDA-FS, Environmental Protection Agency (EPA), Montana Department of Environmental Quality (MDEQ), Maxim, and Maxim subcontractors in attendance.

One of the major sources of information considered by the technical group was an initial tailings siting study prepared for Crown Butte Mines, Inc (CBMI) by Knight Piesold (1992). This regional screening and fatal flaw analysis included an evaluation of 28 potential tailings impoundment sites within a 10-mile radius of CBMI's proposed mine. Sites considered in the Knight Piesold report included several sites in each of the four principal watersheds in the District (Soda Butte Creek, Daisy Creek, Fisher Creek, and Miller Creek), and sites in disturbed areas at the top of Lulu and Daisy passes. Following a detailed site selection process, Knight Piesold engineers reduced the number of suitable sites to 13 and performed a qualitative evaluation of each of the 13 sites. Three sites were selected from the 13 sites after a second level of site ranking was completed.

CBMI collected additional environmental data from each of these three sites identified in the 1992 siting study. Additional data were reported in several pertinent reports including Bechtel (1992), Knight Piesold (1994), and Knight Piesold (1995).

The USDA-FS technical team recommended that these three sites be further pursued with respect to repository siting. Technical information reviewed to evaluate the three sites recommended by the technical group was obtained from the USDA-FS Response and Restoration Project administrative record file located in the Gallatin National Forest Supervisor's Office in Bozeman, Montana. The data were collected during field investigations completed by various engineering and environmental consulting firms from 1990 to 1996 for CBMI. Additional information sources that were used in this evaluation included data collected by the (EPA), Montana Department of Natural Resources and Conservation (DNRC), Montana Bureau of Mines and Geology (MBMG), and published geologic and hydrogeologic information.

The three sites evaluated in detail in Phase I included two areas in the Fisher Creek drainage, a tributary to the Clark Fork of the Yellowstone River, (FC-4 and FC-6), and one area in the headwaters area of Soda Butte Creek, a tributary of the Lamar River (SB-4). These sites are shown in Figure 1. Two individual subareas at the SB-4 location were identified and evaluated. Objectives of the Phase I evaluation were to collect and review existing information on the three candidate repository areas and to summarize the advantages and disadvantages of each area based on that information.

Criteria used for the Phase I evaluation of the three candidate sites are shown in Table 1. Evaluation criteria were heavily weighted toward numerous environmental factors. Wetlands were included as one of the 28 criteria used to rank potential sites, as were several critical geologic, climatic, and topographic factors.

The two subareas within the SB-4 site (SB-4A and SB-4B) were the highest ranked, and recommendations were forwarded for additional field investigation. Table 2 presents a summary of the SB-4 subarea ranking relative to the other two sites in Fisher Creek.

Table 1
Repository Site Evaluation Criteria
New World Mining District
Response and Restoration Project

GENERAL SITE FEATURES
- Size of Site (acres)
- Estimated Capacity
- Elevation of Site
- Slope
- Visual Compatibility
- Access to Site
- Operations and Maintenance

GEOLOGY
- Surficial Material
- Type of Bedrock
- Depth to Bedrock
- Repository Base Characteristics
- Proximity to Faults, Unstable Slopes
- Sulfide Mineralization/Acid Potential
- Non-sulfate Sulfur
- Acid/Base Potential

HYDROGEOLOGY
- Depth to Groundwater
- Hydraulic Conductivity
- Run-on/Run-off Characteristics
- Land Application Area

MATERIALS
- Embankment Materials Availability
- Permeable Backfill Availability
- Coversoil Availability and Quality
- Soil Properties
  - Shear Strength
  - Consolidation
  - Slope Stability
  - Chemical Properties

ENVIRONMENTAL
- Avalanche Potential
- Disturbance Area/New Roads
- Wildlife
- Aspect
- Vegetation Type
- Wetlands Area/Occurrence

Figure 1

Figure 1 - back page

TABLE 2
Summary of Repository Site Characteristics
New World Mining District - Response and Restoration Project

Site Attribute		Repository Site Name			
		FC-4	FC-6	SB-4 A	SB-4 B
GENERAL SITE FEATURES					
Size of Site (acres)		35	49	23	71
Elevation of Site (feet)		9500	9600	8400	8400
Slope (%)		12	7-10	7-10	13
Visual Compatibility		Fair	Fair	Fair-Good	Fair-Good
Access to Site		Fair/Poor	Fair-Poor	Good	Good
Operations and Maintenance		Fair	Fair	Good	Good
GEOLOGY					
Surficial Material		Qc	Qc	Qg	Qg
Type of Bedrock		Rhyodacite Porphyry	Gray granitic gneiss to schistose gneiss and granite	Gray granitic gneiss to schistose gneiss and granite	Gray granitic gneiss to schistose gneiss and granite
Depth to Bedrock (feet)		5	5	10-30 est.	20-50
Repository Base Quality		Bedrock - Fair	Qc/Bedrock – Fair	Qg – Good	Qg – Good
Proximity to Faults\ Unstable Slopes		Good	Good	Good	Good
Sulfide Mineralization (Acid Potential, meq/100g)		NA	NA	<1	<1
Non-Sulfate Sulfur (%)		NA	NA	<0.01	<0.01
Acid/Base Potential (Parts CaCO3/1000)		NA	NA	3-6	3-6
HYDROGEOLOGY					
Depth to Groundwater	Surficial Material	NA	NA	NA	NA
	Bedrock	NA	NA	4 to +2	4 to +2
Hydraulic Conductivity	Surficial Material	NA	NA	NA	NA
	Bedrock	NA	NA	$3x10^{-5}$ to $2x10^{-7}$	$3x10^{-5}$ to $2x10^{-7}$
Suitable Run-on/Run-off		Good	Fair	Fair	Good
Land Application Area		Fair-Poor	Fair	Good	Good

Note: NA indicates information not available

TABLE 2 (continued)
Summary of Repository Site Characteristics
Response and Restoration Project
New World Mining District

Site Attribute		Repository Site Name: FC-4	FC-6	SB-4 A	SB-4 B
MATERIALS					
Embankment Materials Availability		Qc/Bedrock	Qc/Bedrock	Bedrock or glacial till. Rock could be crushed, glacial till may need mixing with other materials to be suitable.	Qg/Bedrock
Permeable Backfill Availability		Good	Good	?	?
Coversoil	Availability	Poor/Fair	Qc - Fair/Good	Qg - Good	Qg – Good
	Quality	Qal B Fair	Qc – Fair	Qg - Good	Qg – Good
Soil Properties	Shear Strength	Bedrock B Good	NA	NA	NA
	Consolidation	Bedrock	Qc/Bedrock	Qg	Qg
	Slope Stability	Good	Good	Good	Good
	Acid/Base Potential (Parts CaCO3/100)	NA	NA	11-33	11-33
	Acid Potential (meq/100g)	NA	NA	3-8	3-8
	Non-sulfate Sulfur (%)	NA	NA	0.04-0.13	0.04-0.13
ENVIRONMENTAL					
Avalanche Potential		yes	yes	no	no
Aspect		East	Southeast	Southeast	Southeast
Wetlands Area (acres)		6.7	2.0	2.4	9.2
Vegetation Type		Above timberline to some alpine coniferous forest	Open meadow	Alpine coniferous forest (burned)	Alpine coniferous forest (burned)

Note: NA indicates information not available

Reasons for the high ranking of the SB-4 subareas include the following:

- *Access* – Locations in the SB-4 area will require only minimal road construction for access. The locations are near the Fisher Creek road, and hauls from the majority of waste rock sources in the district will be downhill.

- *Materials* - Materials availability in the area is good, with both glacial till and granitic gneiss bedrock available for repository construction. Glacial till extends to a depth of 20 to 50 feet in the area and granite bedrock could be quarried nearby to the north or east.

- *Hydrogeology* - Repository base material at both Site SB-4A and Site SB-4B and other locations in the SB-4 area would be glacial till. Glacial till typically has a relatively low permeability, and does not have joints or prevalent fractures that would facilitate rapid groundwater movement. An upward hydrologic gradient from bedrock to till is present in the area, effectively inhibiting potential migration of leachate from the repository to the bedrock hydrogeologic system.

- *Elevation* - The SB-4 area is the lowest of the potential sites evaluated and would be the easiest to revegetate.

- *Environment* - Vegetation type in the area is lodgepole pine and the area has been burned. Wetlands in the area are relatively contiguous and impacts could be mitigated.

- *Slope Stability/Avalanche Potential* – The SB-4 area has stable slopes and is not affected by avalanches.

Due to several concerns raised by MDEQ about repository siting in July 2000 (Smith, 2000), the USDA-FS met with its technical advisors and reopened the initial repository site evaluation decision to be sure that no sites were better suited for on-site disposal. Of all the sites evaluated, reexamination of the issue by Maxim and other technical advisors to the project resulted in the same conclusion -- that the SB-4B area was the best place in the District to dispose of mine waste.

In their July comments on the project (Smith, 2000), MDEQ also raised the issue of using the relatively large and previously disturbed areas at the McLaren Pit and Como Basin. The technical team revisited this issue as well, and summarized the characteristics of the two disturbed sites in Table 3.

In 1994, CBMI (1994) evaluated the McLaren Pit and Como Basin as potential tailings disposal sites. They rejected these sites primarily because of faults that run through the prospective areas, and winter operating hazards. The USDA-FS technical team reached this same conclusion based on both technical and administrative concerns. The primary considerations associated with the USDA-FS determination are the relatively more severe climate present in the higher elevations of the District, the considerable amount of additional snow and precipitation at these sites than those at lower elevations, the nature of the geology in the area, including proximity to fault zones, and the shorter construction season and higher operating costs that would be incurred at these two sites.

The Phase I site evaluation resulted in the selection of the SB-4 site because it possessed the most favorable characteristics for a mine waste repository. Recommendations for further work were make in the Repository Site Evaluation Report that included the following:

- ***Geophysical Exploration*** - Completion of seismic refraction investigations are recommended at the sites to allow preliminary determinations of unconsolidated material thickness, stratigraphy, and bedrock topography. This information would be used to delineate a specific repository location and determine geotechnical borehole and monitoring well locations.

- ***Geotechnical Borehole Drilling*** - Additional geotechnical drilling is needed to establish the thickness of colluvial and glacial till overburden, characterize engineering and chemical properties of glacial till and bedrock, and identify potential sources of borrow materials.

- ***Groundwater Monitoring Wells*** - Groundwater monitoring wells should be installed on the perimeter of the area to verify groundwater elevation and flow characteristics. Groundwater samples should be analyzed for standard chemical parameters to establish background conditions for the site. Of particular importance is the investigation of the groundwater interaction between the colluvium/glacial till overburden and the bedrock groundwater system. Identification of an upward gradient in the bedrock system, if present, by completion of multi-depth wells will be necessary to characterize three-dimensional groundwater movement and support repository design.

- ***Test Pits*** - Backhoe test pits should be excavated at the site to collect material samples for engineering tests and materials suitability determination.

- ***Topographic Contour Map*** - A one-meter topographic contour map of the site should be prepared to support engineering design.

The USDA-FS accepted these recommendations and approved the Phase II investigation of the SB-4B repository site. A summary of activities conducted for the Phase II investigation is presented in the following section.

TABLE 3
Summary of Repository Site Characteristics
New World Mining District - Response and Restoration Project

Site Attribute		Repository Site Name: McLaren Pit	Repository Site Name: Como Basin	Repository Site Name: SB-4B
GENERAL SITE FEATURES				
Size of Site (acres)		7.7	10.4	71
Elevation of Site (feet)		9700	9800	8400
Slope (%)		23	11-33	13
Visual Compatibility		Fair	Fair	Fair-Good
Access to Site		Fair-Poor	Fair-Poor	Good
Operations and Maintenance		Poor	Poor	Good
Capacity (cubic yards)		215,000	200,000 - 300,000	1,000,000
GEOLOGY				
Surficial Material		Waste Rock	Cw	Qg
Type of Bedrock		Limestone	Limestone	Gray granitic gneiss to schistose gneiss and granite
Depth to Bedrock (feet)		0-30	0-5	20-50
Repository Base Quality		Cm Bedrock - Fair	Cw /Bedrock – Fair	Qg – Good
Proximity to Faults\ Unstable Slopes		Poor	Fair	Good
Sulfide Mineralization (Acid Potential, meq/100g)		High	High	<1
Non-Sulfate Sulfur (%)		NA	NA	<0.01
Acid/Base Potential (Parts CaCO3/1000)		NA	NA	3-6
HYDROGEOLOGY				
Depth to	Surficial Material	0-20	NA	0-50
	Bedrock	5-40	5-150	4 to +2
Hydraulic Conductivity	Surficial Material	$3x10^{-3}$	NA	$3x10^{-5}$
	Bedrock	$3x10^{-4}$ to $2x10^{-5}$	$3x10^{-4}$ to $2x10^{-5}$	$3x10^{-3}$ to $2x10^{-7}$
Suitable Run-on/Run-off		Poor/Fair	Good	Good
Land Application Area		Poor	Poor	Good

Note: NA indicates information not available

TABLE 3 (continued)
Summary of Repository Site Characteristics
New World Mining District - Response and Restoration Project

Site Attribute		Repository Site Name		
		McLaren Pit	**Como Basin**	**SB-4B**
MATERIALS				
Embankment Materials Availability		Bedrock/Poor	Bedrock/Poor	Qg/Good
Permeable Backfill Availability		Good	Good	Good
Coversoil	Availability	(?) Poor	(?) Poor	Qg – Good
	Quality	Poor	Poor	Qg – Good
Soil Properties	Shear Strength	Bedrock B Good	Bedrock – Good	Qg – Moderate
	Consolidation	Bedrock	Bedrock	Qg
	Slope Stability	Poor Above, Good below	Good	Good
	Acid/Base Potential (Parts CaCO3/100)	High	High	11-33
	Acid Potential (meq/100g)	High	High	3-8
	Non-sulfate Sulfur (%)	High	High	0.04-0.13
211 ENVIRONMENTAL				
Avalanche Potential		Yes	yes	No
Aspect		East	Southeast	Southeast
Wetlands Area (acres)		0	0	9.2
Vegetation Type		Above timberline, revegetated to some extent	Above timberline, minimal vegetation	Alpine coniferous forest (burned)

Note: NA indicates information not available

3.0 PHASE II INVESTIGATION

Further investigation of the SB-4 area was conducted in 1999 and 2000. Results of this Phase II repository site investigation were published in a report (Maxim, 1999b) and two addendum (Maxim, 1999c; Maxim, 2000). Investigative activities performed at the site were designed to evaluate physical and chemical properties of the glacial till and bedrock as well as the hydrogeologic interaction between the underlying bedrock and overlying glacial till.

Because ongoing groundwater monitoring activities continued to be conducted beyond the publishing of the Phase II report and the June 2000 addendum, pertinent figures and data resulting from this monitoring are attached to this final report. Supplemental figures are contained in Attachment A; water level data are contained in Attachment B; and the final groundwater tracing study report is presented in Attachment C.

3.1 INITIAL FIELD ASSESSMENT

For purposes of the Phase II report, the SB-4 area was defined as glacial deposits lying on either side of the Lulu Pass road between the low water crossing at Fisher Creek and the intersection of the Lulu Pass road with Highway 212. An initial field evaluation of the SB-4 area was performed during May and June 1999. Nine potential areas from 10 to 20 acres in size were delineated in the general SB-4 area based on till thickness, bedrock geology, vegetation/wetlands, and other existing information. The letters A through I were used to designate the nine potential repository sites. Figure 2 in the body of this report shows the site locations. Table 4 summarizes general site characteristics for the nine sites.

TABLE 4
GENERAL REPOSITORY SITE CHARACTERISTICS - SB-4 AREA
New World Mining District - Response and Restoration Project

Site Attribute	Repository Site Name							
	SB-4A	SB-4B	SB-4C	SB-4D	SB-4F	SB-4G	SB-4H	SB-4I
Size (acres)	20	8	30	20	9	9	9	11
Drainage Basin (1)	SB/FC	SB	SB	SB	SB	SB/FC	SB	SB
Elevation (feet)	8400	8360	8400	8440	8800	8760	8760	8240
Slope (%)	0-15	7-30	7-30	7-15	15-30	<7	7-30	7->30
Visual Compatibility	Good	Good	Fair	Fair	Good	Good	Good	Good
Estimated Till Thickness	5-10	10-25	0-5	0-5	0-5	0-15	1-10	20-50
Surficial Material (2)	Qg	Qg	Qg/Gn	Qg/Pz	Qg/Gn	Qg/Gn	Qg	Qg
Type of Bedrock (2)	Gn	Gn	Gn	Pz	Gn	Gn	Gn	Gn

Notes: 1 - Drainage Basin - SB = Soda Butte, FC = Fisher Creek
2 - Surficial Material/Bedrock – Qg = glacial till, Gn = Granite/gneiss, Pz = Paleozoic

Each of the nine sites was evaluated with respect to the siting criteria listed in Table 1. During this evaluation, an emphasis was placed on selecting a site that contained relatively thick deposits of glacial till, was relatively dry, and where surface water drainage would not be a concern. Based on the results of the field evaluation, sites SB-4A, SB-4B, and SB-4I (Figure 2) were identified as having the most favorable characteristics for a potential repository in the SB-4 area. Additional investigation activities were performed at these sites to further characterize geologic and hydrogeologic properties.

3.2 GEOPHYSICAL INVESTIGATION

A seismic refraction survey was performed at each of the three potential mine waste repository sites selected for additional investigation to determine the thickness of glacial till. The geophysical survey indicated the depth to bedrock generally ranged from four to eight feet at the SB-4A site. At the SB-4B site, till thickness was greatest near the west side of the site at about 24 feet and thinned toward the east to about eight feet. At the SB-4I site till thickness ranged from 30 to 50 feet over most of the area surveyed.

Evaluation of the geophysics data indicated that the SB-4B and SB-4I sites exhibited an adequate thickness of glacial till to be suitable for a mine waste repository. The SB-4A site contained relatively thin deposits of glacial till and was the wettest of the three sites. For these reasons, no further Phase II investigation activities were conducted at the SB-4A site. In further references, the subarea designations were dropped, and the two sites are considered part of SB-4B.

3.3 SUBSURFACE INVESTIGATION

Geotechnical boreholes were drilled and backhoe test pits were excavated to establish the thickness of colluvial and glacial till overburden, characterize engineering and chemical properties of glacial till and bedrock, and to identify potential sources of borrow materials. Results of the subsurface investigation were published in the Phase II report. Figure 1 in Attachment A shows the test pit and well locations, and Figure 3 in Attachment A shows a cross-section through the SB-4B site. Pertinent findings of the subsurface investigation include the following:

- The SB-4B site is located on glacial till overlying granite bedrock (Figure 3, Attachment A). The northern portion of the site is located on a generally southeastern facing slope; a lateral moraine is located on the southern portion of the site. A groundwater discharge area and surface water drainage flows from west to east north of this lateral moraine.

- Unconsolidated glacial till ranges from 83 feet thick at well SB-101 to 15 feet thick at well SB-107. Bedrock outcrops in a small area in the north central portion of the site. Test pits excavated in the drainage that bisects the site encountered 8 to 10 feet of till.

- The percentage of fine-grained silt and clay in till ranges from 25 to 29%. The heterogeneous nature and amount of fine-grained material in the till result in relatively low horizontal and vertical hydraulic conductivity. Horizontal hydraulic conductivity of glacial till ranges from 10-3 to 10-6 cm/sec, with an average of about 1x10-4 cm/sec. Vertical hydraulic conductivity of glacial till ranges from 10-6 to 10-8 cm/sec.

Figure 2

Figure 2 - Back Page

3.4 GROUNDWATER MONITORING

Groundwater monitoring wells were installed in eight clusters at the SB-4B site to document groundwater conditions, groundwater levels, and groundwater flow characteristics. Groundwater samples were collected and analyzed for standard water quality parameters to establish background groundwater conditions at the two sites. Of particular importance for this activity was to investigate groundwater interaction between glacial till and bedrock. Completion of multi-depth monitoring wells in the till was done to characterize three-dimensional groundwater movement. Aquifer and slug tests were performed to measure the hydraulic conductivity of glacial till and bedrock, and to monitor groundwater interaction between the two water-bearing units.

Figure 2, Attachment A, shows the potentiometric surface developed from water level elevations in bedrock wells. Water level data is presented in Attachment B.

3.4.1 General Hydrogeologic Features – SB-4B Site

The following general hydrogeologic features are present at the SB-4B site:

- Glacial till confines groundwater in the underlying granite bedrock, resulting in artesian conditions in all bedrock wells installed at the site (Figure 3, Attachment A).

- Water levels in bedrock wells SB-102 and SB-103 (Figure 4, Attachment A; Attachment B) and glacial till well SB-22TD required several weeks to several months to stabilize following completion and/or sampling. Water levels in other wells stabilized relatively quickly. This indicates there are portions of till and bedrock which are very tight, with minimal interconnectedness with permeable zones, while the majority of the subsurface is moderately to well connected to more permeable zones or features.

3.4.2 Water Levels: Winter 1999-2000

Water levels in site monitoring wells were relatively stable over the majority of the site during the winter. Water levels were the lowest in all wells during the March 15 to April 15 measuring events. A summary of hydrologic data collected at the site is provided below:

- Groundwater levels in most bedrock and glacial till monitoring wells declined slightly (0.4 to 1.5 feet) from November 1999 to April 2000.

- Paired bedrock and glacial till piezometers (Figures 4 and 5) indicate there is an upward hydraulic gradient from bedrock to glacial till over most of the site during the winter (Table 1). A slight downward gradient from the deep till well to bedrock was recorded at well SB-23TD along the east side of the site.

- Water levels in glacial till wells SB-106T, SB-107T, and SB-108T were below the screened intervals in these wells during the winter, so no vertical gradients could be determined at these paired well locations.

- Potentiometric heads in bedrock monitoring wells are near or slightly higher than the bedrock-till interface over the northern portion of the site and range from 13 to 85 feet above the bedrock-till contact in the southern portion of the site.

- Groundwater flow in bedrock is toward the southeast within the Soda Butte drainage at a gradient ranging from 20% in the north and south to 4% in the central portion of the site.

3.4.3 Water Levels: Spring 2000

Water level data for the period April 15 to April 26, 2000 show a relatively quick rise of the hydraulic head in both bedrock and till monitoring wells. Water levels in till wells rose two to eight feet from April 15 to May 3, 2000. Water levels in bedrock wells increased four to eight feet during that same period. Following the rise in water levels in the till, water elevations in several paired wells show a downward hydraulic gradient (Table 5) from the till to the bedrock system. Water levels in near surface piezometers indicate the upper two to three feet of till is saturated during the spring snowmelt period.

The rapid rise of the potentiometric surface in both bedrock and till systems indicates that the site rapidly becomes saturated during the spring thaw. The potentiometric surface rise in the bedrock is likely due primarily to recharge up-gradient of the SB-4B site and surface infiltration. Large areas of bedrock are exposed up-gradient of the repository site and, during the spring, relatively rapid recharge to bedrock would be expected. Higher heads in bedrock were accompanied by higher heads in the majority of the till wells. The relatively rapid rise of water levels in till wells to elevations near or higher than those in paired bedrock wells indicates that the majority of the recharge water in the till is infiltrating from the surface. The influence of snowmelt recharge on water levels in the till is also shown by the decline in water levels in till wells due to colder temperatures which occurred in mid-May, 2000 (Figures 4 and 5, Attachment A). This effect was slightly less in most bedrock wells.

Table 5
Variations in Upward and Downward Gradients
Shallow Glacial Till Wells and Bedrock Wells

Season	Upward Gradient	Downward Gradient
Winter	22, 23, 24, 101, 102, 103, 105	None
Spring	22, 24, 101, 102, 105, 108	23, 103, 106, 107
Summer/Fall	22, 24, 101, 102, 103, 105, 108	23, 106, 107

Note: Static water levels in bedrock are all above the bedrock/till contact. Static water levels in till wells SB-106, SB-108, and SB-109 were below the screened interval of the wells during the winter so gradient direction could not be determined.

Some component of recharge to bedrock is likely occurring through downward leakage of infiltrating surface water through the till during the spring when the elevation of water levels in till is higher than the potentiometric surface in bedrock. Water levels in till wells indicate that recharge to the till occurs quickly during spring thaw, and that the till will likely drain relatively quickly after the snow pack has melted. Spring snowmelt data allow the following conclusions:

- Potentiometric heads in bedrock monitoring wells are located higher than the bedrock-till interface over the entire site, indicating the bedrock aquifer is confined under the site.

- Most bedrock and glacial till wells experienced a relatively rapid rise in water levels during spring runoff, with several wells exhibiting water levels above ground surface.

- Infiltration of surface water into glacial till during spring snowmelt causes saturation of the till and a rapid increase in water levels in glacial till wells to near the ground surface. Water levels in some till wells rise to elevations above the potentiometric surface in the bedrock, which may temporally reverse the upward hydrologic gradient found over the site during the majority of year (Table 5).

- The near surface till from 0 to 3 feet below ground surface was saturated during spring runoff

- Some bedrock and till wells appear well-connected to groundwater recharge sources, while other wells appear to be completed in relatively tight zones with little interconnectedness to either surface recharge or permeable bedrock zones.

3.4.4 Water Levels: Summer/Fall 2000

Peak water levels were reached during the period between May 23 and June 6, 2000. After peak water levels were reached, water levels dropped in all wells except for the bedrock well at the SB-22 well cluster. At the upper end of the site, water levels declined rapidly and, except for the till well at the SB-105 cluster, all till wells were dry by the late September sampling date. Water levels in bedrock wells at the upper end of the site fell as much as 20 feet, with water level declines in bedrock wells ranging from 5 to 20 feet. Bedrock wells at the SB-104 and SB-106 cluster were dry in July and September, respectively.

At the lower end of the site, water level declines were not as dramatic but ranged from 4 to 11 feet lower than peak water levels in till wells by the end of September. Bedrock wells SB-101, SB-102, and SB-103 maintained relatively constant heads through the summer and early fall, dropping as little as 2 feet from the peak levels reached at the end of May. Following the decline in water levels in the till, water elevations in several paired wells show a downward hydraulic gradient (Table 5) from the till to the bedrock system.

The rapid fall of the potentiometric surface in both bedrock and till systems indicates that groundwater recharge is predominantly a function of the amount of melting snow percolating through till, supporting earlier observations made in the spring.

3.5 GROUNDWATER DYE TRACER INVESTIGATION

Fluorescent dyes were injected at the upper and lower ends of the SB-4B area to provide additional information to support the conceptual model of groundwater movement at the site. A complete report of the dye study results is presented in Attachment C.

Eosin OJ (CI Acid Red 87) dye was injected in bedrock monitoring well SB-101 (Figure 1, Attachment A) at 1640 hrs on October 7, 1999. The dye was injected approximately 5.6 hours after well SB-101 was pumped at a constant discharge rate for 72 hours. Well SB-101 is screened in granite bedrock with the well screen extending from 92 to 102 feet below ground surface. The dye was driven into the bedrock formation by chasing the dye with approximately 300 gallons of water. The chase water consisted of formation water pumped from well SB-101 during an aquifer test.

On the same day at approximately 1700 hrs, uranine (CI Acid Yellow 73) was injected in a shallow backhoe pit at the lower end of the site (Figure 1, Attachment A). The backhoe pit was excavated about three feet deep into glacial till approximately 200 feet upgradient from monitoring well SB-103. A third fluorescent dye, phloxine B (CI Acid Red 92), was injected in a backhoe pit excavated at the northern end of the site (Figure 1, Attachment A) at about 1800 hrs on October 7, 1999. Both dyes injected into the backhoe pits were chased with water obtained from well SB-101.

Water samples were collected from 12 surface water stations and 30 groundwater locations (wells) to monitor the movement of dye. Dye monitoring stations are shown on Figure 1, Attachment A. Data summary sheets and graphs are contained in Attachment C. Dye was recovered at numerous wells and surface water sampling sites. A complete summary of dye detections is presented in Figure 7, Attachment C.

Eosin OJ (CI Acid Red 87), which was injected into well SB-101, was recovered in the three till monitoring wells at the SB-101 cluster, the bedrock well and the two deeper till wells at the SB-23 cluster, and the bedrock well and till wells at the SB-24, SB-102, and SB-103 sites. The dye was detected in well SB-101TDD 13 days following the injection into adjacent bedrock well SB-101. The total depth of the filter pack in well SB-101TDD is approximately 78 feet below ground surface, and the depth of the bedrock/till contact in SB-101 is 83 feet below ground surface. Concentration of the dye increased steadily for four weeks, leveled off, and began increasing again on May 10, 2000 coincident with spring snowmelt.

Eosin was also detected in bedrock wells SB-22 and SB-24, located approximately 750 feet and 1100 feet downgradient from SB-101, respectively. The first recovery in well SB-22 was on November 17, 1999, 35 days following dye injection and the first recovery in well SB-24 was on November 23, 1999, 41 days after injection. Dye recoveries in wells SB-22 and SB-24 have been sporadic (Attachment C). The concentration of dye in well SB-22 increased from November 17 to November 23, was absent on December 10 and 28, then was detected again on January 15, and then detected at much lower concentrations on February 11 and May 5, 2000. Concentrations in well SB-24 were relatively high when first detected, decreased rapidly, and have been less than detection on numerous sampling events. Eosin was first detected in till well SB-103TD on May 17, 2000, 223 days following injection.

Phloxine B (CI Acid Red 92) was detected in bedrock wells SB-104, SB-107, and SB-108. This dye was infiltrated into a test pit at the north edge of the site. The dye was first detected in well SB-108 on January 15, 2000, 101 days following dye injection. During the spring snowmelt, water levels increased in the bedrock and the dye was detected in well SB-104 on April 26, 2000, when water first was present in this well (203 days following injection). This well was dry during the fall of 1999, and the winter and summer of 2000.

On June 6 or 16, uranine (CI Acid Yellow 73) from the lower injection pit was first recovered at surface water locations SBT-6 and SBT-8. The SBT-6 location is near a groundwater discharge area. SBT-8 is downstream from SBT-6 (Figure 1). This dye was also detected in the till well at SB-24T.

3.6 PHASE II GROUNDWATER MONITORING CONCLUSIONS

Groundwater flow directions interpreted from the dye tracer investigation support the conceptual model describing groundwater movement at the site and confirm flow directions derived from potentiometric head data. Groundwater flows to the southeast, discharging to the surface drainages to the east and south of the site. A component of flow also is to the east and slightly northeast in both the till and the bedrock.

There is no evidence to suggest that groundwater flow crosses the topographic divide to the east of the SB-4B repository site. Groundwater flow beneath the site remains in the Soda Butte Creek watershed, and sampling stations in the SB-4B tributary drainage appear to be the local discharge points for groundwater in both the till and bedrock water-bearing units. No dye was detected in any domestic wells to the south or to the east in the Clarks Fork drainage.

4.0 SUMMARY

Results of the Phase II investigation indicate that the SB-4B site is suitable for mine waste disposal in an engineered repository. The site has suitable geologic and hydrogeologic conditions that are conducive to siting a repository. The emphasis on an engineered repository is necessary because protecting the waste from the severe climate, large amount of snow, and mountainous topography cannot be done on-site without careful planning and engineering.

With these considerations in mind, the SB-4B site ranked the highest of the 28 sites evaluated in many of the key siting criteria. These include the following: major faults are absent from the area; slopes are shallow to moderate; the potential for avalanche is very low; precipitation and snowfall at the site is at the low end compared to the sites considered; and, the site is easily accessed using existing roads. One of the key factors for site ranking is the SB-4B site is underlain by glacial till, which is preferred to bedrock or alluvium because of its lower permeability and because it can be salvaged and used in repository construction. The heterogeneous nature and amount of fine-grained material in the till result in relatively low horizontal and vertical hydraulic conductivity, two characteristics important in limiting the movement of leachate that could potentially migrate below a repository facility.

Depth to groundwater varies widely across the site and throughout the year. On the hillsides, depth to groundwater in the late summer and through the winter is as great as 60 feet. At the upper end of the site, where three of the four till wells were dry through the fall and winter, water rapidly recharges the till during the spring snowmelt period. Depth to groundwater during this period rises to within a foot the surface. Groundwater levels decline rapidly following spring snowmelt.

Groundwater flow direction generally follows the slope of the land to the south-southeast. Dye tracer monitoring indicates that groundwater discharges into surface drainages that surround the SB-4B site. Groundwater flow in bedrock is generally upward into till except during times when the till is dry, which only occurred at the upper end of the SB-4B site. The dye tracer results indicate that early detection of any impacts to groundwater and surface water quality resulting from repository construction and maintenance will be detected in surface water stations immediately below the site.

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ATTACHMENT A

SUPPLEMENTAL FIGURES
Final Repository Site Evaluation Report
New World Mining District Response and Restoration Project

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

ATTACHMENT B

WATER LEVEL DATA

Final Repository Site Evaluation Report

New World Mining District Response and Restoration Project

ATTACHMENT C

GROUNDWATER TRACING INVESTIGATION REPORT

Final Repository Site Evaluation Report

New World Mining District Response and Restoration Project

APPENDIX H

REPOSITORY DESIGN DETAILS
Selective Source Response Action EE/CA
New World Mining District Response and Restoration Project

TECHNICAL MEMORANDUM
CONSTRUCTION AND DESIGN DETAILS - PRELIMINARY

INTRODUCTION

This memorandum presents construction and design details associated with the construction of a mine waste repository at a hillside location within the larger SB-4B site. Characteristics of the site's environment, such as geology and hydrogeology, are described in the *Phase II Repository Site Investigation Report* (Maxim, 1999). As a design of a repository is finalized for this site, additional information and details will be developed beyond that described by this memorandum. Figures and tables referenced in the memorandum are contained in Attachment A.

CONSTRUCTION DESCRIPTION

The overall layout for repository SB-4B is shown on Figure G-1 and a cross-section through the repository is shown on Figure G-2. The repository will be constructed in phases over a period of several years with a maximum capacity of about 88,000 cubic meters of mine waste. The footprint of the full buildout will cover approximately 4.0 hectares. Maxim thickness of waste rock and cap is estimated to be 8 meters. Details for modified Alternatives 2B and 2C are shown on Figure G-3.

The repository will be constructed in a sequential fashion. Figure G-4 shows the initial phase buildout. The area needed for construction during each phase will be cleared and grubbed of vegetation; soil needed for cap and coversoil construction will be stripped to a required depth. The maximum depth of soil salvage is estimated to be 1.2 meters. Access roads will be constructed as needed each year to access the waste placement area. A rock base material will be placed in Phase 1 and Phase 3 to allow placement of the waste at the toe of the repository footprint. Mine waste will be placed in horizontal lifts into the phased cells (Figure G-4). Each phase may take one to two years to construct, depending on the quantity of mine waste moved to the site.

Construction of the repository includes a rock base composed of angular cobbles and boulders. The rock base allows placement of the 88,000 cubic meters of waste within the preferred footprint area while maintaining a maximum 4:1 cover slope. The rock base also serves several other functions: 1) it provides a stable foundation at the toe of the repository where waste material can begin to be placed in horizontal lifts; 2) it will provide an access route to the toe of the repository to allow for maintenance work to be completed on the lower south face of the repository, and; 3) it provides a diffuse pathway for directing surface water runoff away from the toe of the repository.

At the end of each construction season, a permanent cover will be placed on slopes that are constructed to the final buildout configuration. Temporary covers will be installed over exposed mine waste that lie at the upper end of each phase (flat areas shown in Figures G-4) and interior slopes that will be incorporated into succeeding phases. Temporary covers may also be deployed over the exposed waste rock during construction to shed precipitation that would otherwise enter the waste. Temporary erosion control measures will be implemented and maintained as construction progresses. For a repository constructed using the modified Alternative 2A design (earthen soil cover only), the temporary cover would consist of 6-inches of clean soil to minimize erosion of the mine waste. For a repository constructed with modified design B or C, the temporary cover would consist of a 20 mil PVC geomembrane (or a 10 mil reinforced polyethylene product) that will be held in place using sandbags or similar anchoring device to secure the geomembrane edges.

The repository design includes the flexibility to construct a combination of the repository design alternatives. Such a design change may be warranted by the type of waste placed during a particular phase of repository construction. For instance, if the repository is constructed initially using modified Alternative 2B (composite cap without a bottom liner), the design could be changed to modified Alternative 2C (composite cap with leachate collection system) in a subsequent phase. Such a change may be necessary if mine waste designated for disposal in the repository contains higher concentrations of contaminants than currently found in the majority of waste rock present in the District. While there are some difficulties that could be experienced in implementing such a change, solutions such as stockpiling wastes that need to be handled differently until a substantial quantity is obtained, or delaying removal of these wastes until the final buildout phase may simplify this issue.

The final buildout topography will generally consist of 4:1 slopes that have a maximum slope length of 40 meters between benches. Surface water will be controlled at the repository in several ways. Potential run-on from uphill slopes north of the repository will be diverted around and away from the edge of the repository margins. Runoff from the northern portion of the repository will be captured at the 2562.5-meter bench and conveyed by ditches to outfalls at the repository's east or west edge. Runoff from the repository's southern portion, above the lower access road at elevation 2552.5, will filter through the rock base material and then drain through the toe of the rock base.

At the end of construction, long term access to the repository will be provided by maintenance roads remaining along the north and east margins of the repository (Figure G-1). The construction access roads along the west side of the repository will be reclaimed.

MATERIAL ENGINEERING PROPERTIES

Materials used in repository construction include blasted rock material for the rock base, mine waste removed from dumps and tailings sites, and salvaged native soil that will be used for the earthen cover. Depending on the design alternative selected, other materials may include geosynthetic materials that would be incorporated into the cover and base liners, and drainage sand and gravel. Waste rock is expected to contain less than 10 to 30% fines. Geosynthetics may include nonwoven geotextiles and low permeable liners such as geomembranes and geosynthetic clay liners. To effectively drain water from above the low permeable liners, drainage gravel and sand will have a hydraulic conductivity in the range of 0.1 to 1 cm/sec.

Table G-1 presents engineering properties for materials described which could be used in repository construction. The information presented in this table is from testing completed for this project, published data, or is in-house data Maxim has gained from similar projects. For the base liner system (Alternative 2C), conservative shear strength values were selected.

SLOPE STABILITY EVALUATION

A slope stability evaluation was completed to determine whether the repository design alternative(s) provides an adequate factor of safety (FS) against failure due to mass sliding. The stability evaluation was performed in large part using the STABL 6H computer program (USDOT, 1986). This program uses the method of slices technique and the limit equilibrium method along with a searching routine to identify failure surfaces which produce a low FS. Static and seismic analyses were included in the evaluation. The seismic analysis was completed using a pseudostatic method wherein the seismic forces generated by an earthquake are generalized in the STABL model using a seismic coefficient. Data and calculations used to complete the analysis are contained in Attachment B.

Material weights and conservative shear strength values were incorporated into the analysis. For the base liner, a friction angle (ϕ) of 20° and a cohesion (c) of 0 pounds per square foot were used. Both static and seismic analyses were performed. A look-up program maintained by the United States Geological Survey, National Hazard Mapping Project (USGS, 2000) shows a peak bedrock acceleration at the site location of 0.16g for an earthquake event with a 90% probability of not being exceeded in 250 years. This same seismic event criteria is used for landfill design in the United States (USEPA, 1993).

The slope stability analyses were computed with the following considerations incorporated:

- The bottom-most 1.5 meters of the waste is saturated.

- The failure surfaces do not pass through the underlying subgrade or the rock base due to the relatively high shear strength associated with these materials.

- For the pseudostatic analyses, the seismic coefficient, k_s, was selected as ½ the peak bedrock acceleration following the recomendation of Hynes and Franklin (1984). Computations performed with the seismic coefficient calculated in this manner which result in an FS>1 are considered to indicate that displacements of less than two feet will occur for the given peak bedrock acceleration. Displacements of two feet or less for the type of designs proposed for repository SB-4B are considered acceptable.

Two types of slope failure surfaces were evaluated. The first type considered a circular failure through waste material. This analysis is applicable to all three modified alternative designs considered (modified 2A, 2B and 2C). The second analysis type considered a block failure where a portion of the slide surface passes along the base liner interface (e.g. the surface contact between HDPE liner and GCL) that may have a lower shear strength than other materials incorporated into the repository. This analysis is applicable to Design 2C.

FSs computed for the repository are summarized in Table G-2. FSs greater than 1.5 were computed for the static analyses and FSs greater than 1.0 were computed for the pseudostatic analyses. The FSs are considered acceptable (Richardson, 1999) and indicate that all three modified repository design alternatives achieve a satisfactory slope stability.

One additional slope stability issue that was not examined at this time is the stability of the various cover systems. The cover system for modified alternative 2A should be stable. The cover systems for modified alternatives 2B and 2C are potentially less stable as compared to design 2A due to the geosynthetic materials incorporated into the covers. Instability for designs using these cover types would likely be a result of poor drainage within critical areas of the drainage layer immediately above the low permeable liner. We expect that instability will not occur in the cover systems which incorporate a low permeable liner because: 1) the drainage gravel and sand will exhibit a relatively high hydraulic conductivity; 2) a thick coversoil will be used to protect the drainage layer from freezing, and; 3) drainage water reaching the bench at elevation 2562.5 m will be transmitted to the edges of the repository for discharge.

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ATTACHMENT A

FIGURES AND TABLES

TABLE G-1
SOIL AND LINER ENGINEERING PROPERTIES

Material/Liner Interface	Peak Strength		Residual Strength		Used in Analysis		Source
	c (psf)	ϕ (deg)	c (psf)	ϕ (deg)	c (psf)	ϕ (deg)	
Waste Rock	0	35	0	35	0	35	Maxim, conservative estimate
Subgrade, Glacial Till	110-3000	40 -55	0	40 –55	0	35	Testing results for till material obtained from project site
Rock Base	0	35	0	35	0	35	Maxim, conservative estimate
Base Liner	0	30	0	30	0	20	Maxim, conservative estimate

TABLE G-2
SLOPE STABILITY ANALYSES – FACTORS OF SAFETY
REPOSITORY SITE SB-4B

Case	**Factor of Safety**
Static Analysis	
Circular Failure	1.85
Block Failure	1.69
Pseudostatic Analysis	
Circular Failure	1.04
Block Failure	1.25

Figure G-1

Figure G-2

Figure G-3

Figure G-4

ATTACHMENT B

SLOPE STABILITY ANALYSIS RESULTS

APPENDIX I

WATER RIGHTS COMPACT ANALYSIS
Selective Source Response Action EE/CA
New World Mining District Response and Restoration Project

TECHNICAL MEMORANDUM
ANALYSIS OF POTENTIAL EFFECTS OF AN ON-SITE REPOSITORY ON THE WATER RIGHTS COMPACT
STATE OF MONTANA AND UNITED STATES OF AMERICA, NATIONAL PARK SERVICE
New World Mining District Response and Restoration Project

The U.S. Department of Agriculture Forest Service (USDA-FS) is proposing to construct a repository in the headwaters of Soda Butte Creek to encapsulate mine waste materials removed from abandoned mines in the New World Mining District (District). The mine waste removals are being performed as part of the New World Response and Restoration Project (Maxim, 1999a). Because Soda Butte Creek flows into Yellowstone National Park (YNP), this technical memorandum was prepared to evaluate potential effects of a mine waste repository constructed in the District on the quantity and quality of water entering the park. The Water Rights Compact between the State of Montana and the United States National Park Service (Water Rights Compact, 1994) addresses water rights reserved by the US government for the park. The compact regulates alterations in the quantity of water flowing through the park and has implications for users of water that may degrade water quality flowing into the park.

This technical analysis was performed using existing data collected in the Soda Butte drainage basin as well as data developed during the design of the proposed repository. Tasks addressed in this memorandum include the following:

- Estimate average monthly flows of Soda Butte Creek at the Park boundary and two other points on Soda Butte Creek downgradient of the proposed repository site.

- Quantify water intercepted by the proposed repository -- including precipitation, surface water diversion, and groundwater interception -- and compare pre-construction and post-construction scenarios.

- Summarize water quality data on Soda Butte Creek upstream of YNP for contaminants of concern identified in the District. Contaminants of concern in surface water are aluminum, barium, chromium, copper, iron, and zinc (Maxim, 2000a). Combine these data with flow data to determine estimated annual loads in Soda Butte Creek.

- Evaluate impacts of repository leachate on the watershed by estimating the chemical quality of leachate and calculating loads using three alternative repository designs. Compare repository metals contributions to existing loads in Soda Butte Creek.

This memorandum is organized into several sections. These sections describe average monthly flows, water intercepted by the repository, Soda Butte Creek water quality, and repository effects. A summary and references are provided at the end of the document. Figures and tables referenced in the text are included in Attachment A. Numerous other attachments to this memorandum contain other supporting data to the water rights compact evaluation.

AVERAGE MONTHLY FLOWS

Average monthly flows for Soda Butte Creek were determined from information contained in the New World database prepared by Maxim for the USDA-FS. This database contains the results of numerous investigations performed in the District. The data used for this water rights compact analysis includes data collected in 1974-1975 by the Montana Department of Natural Resources and Conservation (DNRC) during an evaluation of mine drainage control in the New World area (DNRC, 1977), information collected during the period 1990 to 1995 by Crown Butte Mines for a mine permit application, and 1999 monitoring data collected by Maxim for the response and restoration project (Maxim, 2000b). Data collected from three locations on Soda Butte Creek were evaluated. These locations are shown on Figure 1 and are described as follows:

- SBC-1 – This sampling site is located just upstream of the McLaren Tailings deposit on Soda Butte Creek. Previous investigators including EPA and Crown Butte Mines have used this site. Sixty-one discharge measurements are available for this site, with the most complete data available for the period from June 1974 through September 1975. The drainage area above this station is 7.0 square kilometers (2.7 square miles). This is the furthest upstream station on Soda Butte Creek that has been sampled on any continuous basis.

- SBC-4 –This sampling station is located on Soda Butte Creek at the east boundary of YNP. DNRC, Crown Butte Mines, and Maxim have used the station. There is currently a continuous gauge maintained by the National Park Service (NPS) at this location. Seasonal (May-October) flow and water quality data (specific conductivity and temperature) for this station that were available from the NPS for the period 1996 through 1998 were used in this evaluation. The drainage area above this station is 80.8 square kilometers (31.2 square miles). A total of 11 instantaneous discharge measurements that were obtained in 1975, 1992, 1993, and 1999 are also available for this station.

- SB4-4 – This sampling site is located immediately below the potential repository sites. Three discharge measurements obtained by Crown Butte Mines in 1992 are available for this station. The drainage area above this station is 1.0 square mile.

Figure 2 shows instantaneous flow measurements obtained for station SBC-1 from 1974 and 1975. These data were collected during the Montana DNRC evaluation of the District (DNRC, 1977). Monthly flows for this station were calculated from the data by taking the midpoint of the time period before and after each gauging event and multiplying this time period by the measured flow to yield a calculated monthly flow. Flows obtained within a single month were then added and divided by the number of days represented by the discharge to determine the average daily flow. This average was then multiplied by the number of days in the month to determine monthly flow. Flow measurements and the worksheet used to calculate monthly flows are contained in Attachment B. Table 1 and Figure 3 summarize these monthly flows. As shown by the data, June and July have the largest monthly discharge and April has the lowest discharge for the period of measurement. Total flow for the November 1974 to October 75 period at the SBC-1 location was approximately 5.6 million cubic meters. As Table 1 and Figure 2 indicate, the majority of flow in Soda Butte Creek at station SBC-1 occurs during the period May through October.

Local precipitation data are available from two SNOTEL sites maintained by the U.S. Natural Resources Conservation Service (NRCS) in the Fisher Creek drainage. One station is near the county road crossing of Fisher Creek about two miles north of the repository sites and the other station is near the Glengarry Adit several miles further upstream on Fisher Creek (Figure 1). SNOTEL data (NRCS, 1999, Attachment C) were reviewed for the period 1967 through 1999 to evaluate the representativeness of the 1974 and 1975 water years (Table 2). The 1975 water-year snowpack at both sites was approximately 120 percent above the average for the 33-year period of record. Because an increase in annual precipitation does not directly translate to a proportional increase in runoff, no attempt was made to estimate the average annual runoff at SBC-1. Rather, it should be noted that the annual flow shown in Table 1 is probably greater than the average annual flow.

Due to the limited amount of data, monthly flows for the SB4-4 location could not be calculated from measured flow data. An estimate of flow for the SB4-4 station was calculated by comparing the three flow measurements available for this site with measurements obtained on the same dates at the SBC-1 location. A ratio of 0.21 was determined using this method (Table 3). Comparison of drainage basin areas above the stations yields a ratio of 0.37 for the two stations. The 0.21 ratio is considered the more accurate of the two ratios based on the ratio data presented in Table 3, which included high, moderate, and low flows. Factors, which could cause variable runoff volumes per unit area from the two drainage basins include topography, aspect, and vegetation, among others. Using the average monthly flow data for November, 1974 to October, 1975 from the SBC-1 station and the 0.21 ratio, a flow of 1,186,000 cubic meters is the estimated annual flow for the SB4-4 station (Figure 1).

Flow data published by previous investigations were not sufficient to calculate annual flows for the SBC-4 location. The NPS has operated a gage seasonally at SBC-4 from 1996 through 1999. Flow data for the station were obtained for the years 1996 through 1998 from the NPS (Attachment B). As shown on Table 1, flow data is generally available for the June through September period at this station. Total flow volumes during the four-month period for each year were calculated from the available data. Data for several days in June 1996 were estimated. The average four-month flow for station SBC-4 was approximately 53,000,000 cubic meters over the three-year period (Table 1). Long-term average data calculated for this station using US Geological Survey (USGS) streamflow correlations is 66 cubic feet per second (cfs), which converts to an annual flow of 59,000,000 cubic meters (Metesh, Kendy, and Parrett, 1999). Actual annual flows are likely to be with in the range used to calculate the average annual flow (35 to 85.3 million cubic meters).

INTERCEPTED WATER

The final buildout of the repository will cover 4.0 hectares (10 acres) if the maximum capacity of the repository (88,000 cubic meters) is needed to dispose of high priority wastes present on District Property. Surface water will be diverted around the site to protect the repository cap. Precipitation that falls within the repository footprint will infiltrate into the cap, runoff, or evapotranspire. Groundwater will flow beneath the repository and continue to exchange with surface water at the downgradient end of the repository.

The repository cap will be shaped to promote positive drainage away from the repository in a manner similar to that occurring naturally. The cap will be vegetated with native grass that should provide more surface cover than the forb-dominated cover currently present on the site. Surface water diversions constructed to divert water around the repository site will not result in a consumptive use of water and there will be no consumptive use of water during operation and maintenance of the repository.

An evaluation of the quantities of water that will infiltrate, evapotranspirate, and runoff from the repository were calculated using the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder, et al, 1994). This model was also used to predict percolation through the bottom of three alternative repository designs (Maxim, 2000a). These quantities, in cubic meters/hectare/year (M^3/Ha/year), are:

Modified Alternative 2A	2,310 M^3/Ha/year
Modified Alternative 2B	0.002 M^3/Ha/year
Modified Alternative 2C	0.0006 M^3/Ha/year

Because of the low rate of seepage and lack of a bottom liner, water from modified Alternatives 2A and 2B will infiltrate into the till. A small fraction of leachate from modified Alternative 2C, which includes a bottom liner, will also be released to the underlying till due to small imperfections in the liner material. The maximum buildout of the repository is estimated to be about four hectares, which would result in a total volume of leachate four times the above volumes.

Volumes of evapotranspiration, runoff, and infiltration were calculated for both existing conditions and post-repository construction conditions. Table 4 summarizes these volumes and Attachment C contains the Help Model output for the existing condition. The Engineering Evaluation/Cost Analysis (Appendix I) contains HELP model output sheets for the three modified alternative repository designs.

The HELP model annual runoff volume for the pre-construction condition is estimated at 33,630 cubic meters and an infiltration volume of 7,400 cubic meters per year is estimated. A repository constructed using the modified 2A design would decrease runoff (increase infiltration) at the repository by approximately 2,140 cubic meters per year. The majority of this volume of water would infiltrate into the subsurface and added to baseflow in the drainage basin. Construction of the modified 2B and 2C repository designs would increase runoff from the site by approximately 7,250 cubic meters per year. This increase is due to the presence of a drainage layer within the top liner that would divert infiltration water to surface water via lateral drains. This increase in surface water flow would result in a corresponding decrease in the volume of water added to baseflow in the drainage basin. Evapotranspiration quantities for the pre and post-construction analyses are nearly the same, at 24,000 cubic meters per year.

Water that infiltrates into the modified Alternative 2A repository design will enter the groundwater system and eventually discharge to surface water. Water which infiltrates into the cap system of the modified Alternatives 2B and 2C repository designs will be intercepted by the drainage layer beneath the soil cap, and drain to surface water courses immediately downgradient of the repository sites. Thus, no water will be removed or added to the drainage basin by construction of a repository, although the timing of the water releases may change depending on the cap design. Modified Alternative 2A will reduce surface runoff by about 2,140 cubic meters per year, shifting this amount of water to base flow. Modified Alternatives 2B and 2C will increase surface runoff by 7,250 cubic meters per year, potentially reducing base flow by this amount.

Table 5 summarizes the effects of changes in flow from the repository on the flow of Soda Butte Creek at the three monitoring stations. At SB4-4, the resulting decrease in flow would be 0.18% of the annual flow for the modified Alternative 2A repository design and designs 2B and 2C would result in an increase of 0.61% in the flow. Increases and decreases in flow at the SBC-1 and SBC-4 locations are approximately five and 44 times below these percentages respectively. Again, these increases and decreases represent changes in the timing of the flows; the annual average flows are expected to remain essentially unchanged.

During construction of the repository, it may be necessary to add water to construction materials to reach maximum densities of compacted fill layers. The source of this water could be either Fisher Creek or tributaries to Soda Butte Creek. If Fisher Creek water is used, no impacts to the quantity of water in the Soda Butte Creek drainage will occur. It is estimated that a maximum of 380 cubic meters (100,000 gallons) per year may be necessary for construction during the four to five year construction period.

WATER QUALITY OF SODA BUTTE CREEK

Water quality data for Soda Butte Creek are available from 1973 to the present. These data are contained in Attachment E. Surface water contaminants of concern for the New World Mining District Response and Restoration project are aluminum, barium, chromium, copper, iron and zinc. Variable numbers of water quality sampling events are available for the three stations. Thirty-three sampling events were performed at SBC-1, 10 samples were collected at SBC-4, and three sampling events were conducted at SB4-4 during this 27-year period.

In general, water quality data were collected during three different periods. During 1973-1975, flow measurements and water quality samples were collected from the SBC-1 and SBC-4 stations by the Montana Bureau of Mines and Geology for the Montana DNRC. Results of this investigation were published by the Montana DNRC (DNRC, 1977) and by the Montana Bureau of Mines and Geology (Sonderigger, et al., August 1973-December, 1975). Surface water samples were analyzed for dissolved metals, and some total recoverable iron concentrations were reported. The second data set was from the period 1989 to 1994. Hydrometrics collected these samples for Crown Butte Mines, Inc. Surface water was analyzed for both dissolved and total recoverable metals during this investigation. Maxim collected the third data set during 1999 for the USDA-FS. These samples were analyzed for total recoverable metals.

Dissolved aluminum and iron concentration data from the EPA investigation were collected throughout the 1974-75 period at the SBC-1 location. Total recoverable iron was measured for nine sampling events from June to September 1975. Dissolved copper and zinc were collected during the summers of 1974 and 1975. At the SBC-4 sampling location, dissolved aluminum, copper, zinc, and total recoverable iron were measured in eight samples collected from May through September 1975.

During the period 1989 to 1994, Hydrometrics collected 11 samples from the SBC-1 location and five samples from the SBC-4 location. Samples were collected during May through October, and represent generally moderate to high flows. Three samples were collected by Hydrometrics from the SB4-4 site during May, July, and September 1992. Maxim collected samples during May, July, and September 1999 from both the SBC-1 and SBC-4 locations.

Comparisons of data collected by the various investigations are difficult to make due to differences in sample collection methods, and analytical methods. Surface water samples collected from the 1974-75 investigation were grab samples and not depth integrated. While efforts were made to collect representative samples, suspended sediment may have been introduced into the samples collected by this method (pp. 28 and 29, Sonderigger, et al, 1973-1975). Changes in land use in the drainage basin, changes to McLaren Tailings, or other factors may have occurred between the 1975 sample collection period and later sampling events causing a change in water quality.

With the above limitations being considered, an attempt to evaluate the data and determine the average concentrations of metals in Soda Butte Creek was made. Concentration versus flow graphs were prepared for aluminum, copper, iron, and zinc to evaluate any trends which may be present in the data related to flow as well as time period and analytical method. The result of this analysis did not produce useful relationships for this water rights evaluation so loads were estimated based only on existing data. The majority of concentration data available for barium and chromium were at or below the practical quantitation limit, so no graphs could be prepared for these two parameters.

Figures 4 through 7 show graphs of concentration versus flow collected at the SBC-1 location. Figure 4 shows that the majority of the aluminum concentrations determined were at or below laboratory practical quantitation limits. Total recoverable aluminum was measured at 0.2 mg/l for one sample collected on May 27, 1992. Figure 5 illustrates that dissolved copper concentrations increased at higher flows during 1973-1975. A maximum concentration of 0.1 milligrams per liter (mg/l) dissolved copper was detected on June 17, 1975 at a flow of 920 liters per second (l/s). A maximum total recoverable copper concentration of 0.006 mg/l was detected on May 27, 1992 at a flow of 831 l/s.

Iron concentrations at SBC-1 are shown on Figure 6. Total recoverable iron concentrations varied from less than the quantitation limit of 0.03 mg/l to a maximum of 16.9 mg/l on July 30, 1975 at a flow of 371 l/s. Dissolved iron concentrations varied from less than the practical quantitation limit of 0.03 mg/l to a maximum of 3.26 mg/l on November 18, 1974. The flow for this event was 30 l/s. The latter value appears to be in error based on the normal range of pH and EH at SBC-1. Total recoverable and dissolved iron concentrations were detected at concentrations above 1.0 mg/l at both high and low flows. The majority of zinc concentrations (Figure 7) were near or below quantitation limits. One total recoverable zinc concentration of 0.16 mg/l was detected on July 18, 1992 at a flow of 227 l/s.

The 1974-75 period contains the most complete data set for the SBC-1 location. Data were collected over an entire year and over a wide range of flows. Later data contain total recoverable concentration data, which are more representative of the true metals loads present in Soda Butte Creek. Average concentration data were calculated for dissolved metals during the 1973-75 period, dissolved metals for the 1973-1999 period, and total recoverable data collected from 1989 to 1999 (Table 6). For these calculations, "all" values were used and values reported below the laboratory detection limits were input as zero. Average dissolved concentrations for metals weighted by flow volume were also calculated for the 1974-1975 water-year data. Values below detection limits were not used in these calculations. Average concentrations of barium and chromium were not calculated because the majority of the samples for these parameters are below laboratory quantitation limits.

Average dissolved and total recoverable metals concentrations for the three Soda Butte Creek sample stations are shown on Table 6. The average dissolved aluminum concentrations for the three stations ranged from 0.013 to 0.07 mg/l with the highest values at the SB4-4 and SBC-4 sites. Average dissolved copper concentrations ranged from 0.001 to 0.07 mg/l. The average dissolved iron concentration ranged from 0.1 to 0.32 mg/l and average dissolved zinc concentrations ranged from 0.003 to 0.01 mg/l. Concentrations of dissolved copper, iron, and zinc decreased downstream and with increasing flow. In general, average dissolved concentrations for the 1973 through 1999 period represent the low values at the SBC-1 and SBC-4 sampling locations. Only three samples were available for the SB4-4 site, and no dissolved iron or zinc values were measured.

At station SB4-4, the average total recoverable aluminum concentration was relatively high at 0.4 mg/l, decreased to 0.023 mg/l at SBC-1, and increased to 0.18 at SBC-4. Iron followed the same pattern and was 0.57 mg/l at SB4-4, 0.1 mg/l at SBC-1, and 0.38 mg/l at SBC-4. Total recoverable copper was 0.003 at SB4-4, increased to 0.03 mg/l at SBC-1, and decreased to 0.001 mg/l at SBC-4. Concentrations of total recoverable zinc steadily decreased downstream, with concentrations of 0.08 mg/l at SB4-4, 0.04 mg/l at SBC-1, and 0.006 mg/l at SBC-4. Average concentrations of dissolved iron are expected to be higher compared to total recoverable concentrations due to the many variables affecting the data, including the relatively few data available.

Loading of aluminum, copper, iron, and zinc in Soda Butte Creek at each of the three sampling locations were calculated using the average dissolved metals concentrations obtained from the 1973-1999 period and the average total recoverable concentrations. These data are considered the best estimate of metals concentrations available for the Soda Butte Creek sampling stations. The results of the calculations are shown in Table 6. Metal loadings for the SB4-4 site were calculated using the ratio of flow volumes determined for this station from the SBC-1 sampling site. No loadings were calculated for barium and chromium due to the lack of data above quantitation limits.

Dissolved metal loads generally increased downstream, with the exception of copper from station SBC-1 to SBC-4 and zinc from station SB4-4 to SBC-1. Decreases in downstream loads may be due to the variability of the data available for the stations, or may be due to geochemical reactions in the water as flow increases downstream.

REPOSITORY EFFECTS

Concentrations of aluminum, copper, iron, and zinc in leachate generated by a mine waste repository were estimated from EPA Method 1312 synthetic precipitation leachate procedure (SPLP) tests. This analytical method was performed on 32 waste material samples collected from District waste dumps in 1996 and 1999. Results of these tests were analyzed using a weighted average of the waste materials expected to be placed in the repository. Values for waste groups for which no values were available were calculated using averages of other waste materials with similar geologic and material characteristics. Values that were below detection were input as one-half the laboratory quantitation limit. Anticipated concentrations in leachate are presented in Table 6 and the data used to derive the calculation included in Attachment F.

Concentrations of metals in a seep (Station 321, DNRC, 1977) located below the McLaren Mill tailings deposits were also examined. The concentrations of metals in this seep were averaged for data collected during the 1974-75 water year.

Metal loading of leachate from the repository was estimated by multiplying the SPLP data by the anticipated volume of leachate predicted from HELP modeling. Loadings for the three alternative repository designs were calculated. Table 6 presents the results of these calculations assuming a 4.04 hectare buildout. As is apparent from the table, metal loads contributed by any one of the three repository designs are very small. Both modified Alternatives 2B and 2C repository designs result in virtually non-detectable metal loads to Soda Butte Creek. Metal loads for the modified Alternative 2A design are also very low, although potentially significant for copper if the effects of amendment are not accounted for. Actual metals concentrations in leachate from the modified Alternative 2A design would likely be lower than the SPLP concentrations used in the loading calculations because the mine waste in this design would be amended. Data available for other mine wastes indicate that metals mobility is greatly reduced when mine waste is amended with lime (Maxim, 1998, pp.16, 17).

Table 7 summarizes the relative effects of the change in loading expected at the three Soda Butte Creek stations if the modified Alternative 2B is selected as the preferred design. The existing Soda Butte Creek loads used in these calculations are the dissolved loads based on 1973-1999 average dissolved concentrations. If modified Alternative 2C were selected, the loads summarized in Table 7 would be about ¼ of those shown. As evident in the table, percent increase in metals loading at any of the three stations is negligible.

Additional factors will mitigate the potential of repository leachate contributing measurable loads of metals to Soda Butte Creek. Leachate produced by the repository will infiltrate into till located beneath the repository and migrate to surface water drainages downgradient of the repository. The percentage of till that is fine grained (33% smaller than #200 sieve) and the chemical properties of till (high neutralization potential) will buffer acidic leachate to some extent and precipitate and sorb metals as relatively insoluble oxides and hydroxides (Garrels and Christ, 1965, Stumm and Morgan, 1981). Groundwater discharge areas downgradient of the repository sites contain wetlands with relatively large quantities of organic material. Organics scavenge metals through chelation, tending to further reduce metals concentrations in groundwater discharging at these locations (Thurman, 1986). Calculations presented in Table 6 are conservative in that no attenuation of leachate is assumed.

SUMMARY

No measurable impact to surface water flow is expected in the headwaters of Soda Butte Creek or at the park boundary as a result of the construction of a mine waste repository at the proposed SB-4B site if modified Alternatives 2B or 2C are selected as the preferred design. This result is primarily due to the small size of the repository area of 0.04 square kilometers at full buildout, which constitutes only 0.005% of the 80.8 square kilometer area of Soda Butte Creek above the park boundary. No consumption of water use would occur due to the placement of a mine waste repository at the SB-4B site, as there will be no net loss in the surface source of supply, and substantially all of the diverted water becomes return flow with little or no delay between the time of diversion and the time of return.

Metals loads that potentially could seep from the repository will not be measurable in the drainage immediately downgradient of the repository site if either modified Alternatives 2B or 2C are implemented. Estimated loads of metals from the repository are insignificant with respect to the loads currently present in the headwaters of Soda Butte Creek at the SB4-4 sampling station. Construction of a repository in the drainage will not have a measurable effect on metal loads in Soda Butte Creek and any increase in loads will not be measurable at the park boundary.

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HELP MODEL RESULTS
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New World Mining District Response and Restoration Project

APPENDIX K

NEW WORLD REPOSITORY NONDEGRADATION CALCULATIONS

Selective Source Response Action EE/CA

New World Mining District Response and Restoration Project

TECHNICAL MEMORANDUM

DATE: January 31, 2001

TO: Bob Kirkpatrick, USDA Forest Service, Region 1
Sherm Sollid, On-Scene Coordinator, Gallatin National Forest

FROM: Pat Dunlavy
Todd K. Kuxhaus

SUBJECT: Repository SB-4B - Revised Nondegradation Calculations
New World Mining District Response and Restoration Project

On July 17, 2000, Maxim prepared non-degradation calculations for a proposed repository sited in a swale at the SB-4B repository site. These calculations were made to support the development of a removal design for proposed cleanup activities in the New World Mining District. Due to issues concerning siting a portion of the repository in Class II wetlands present in the swale, the proposed repository was moved to a hillside location within the SB-4B site. This hillside location was previously discussed in the Draft 2000 Engineering Evaluation/Cost Analysis (EE/CA) as the preferred location for disposal of mine wastes within the SB-4B site. The hillside location is situated at the northern end of the site above the swale. This memorandum presents a revised non-degradation calculations for the hillside location.

Metals loading to groundwater at the proposed repository site (SB-4B) were calculated according to procedures described in the Administrative Rules of Montana (ARM) 17.30.517 to determine if the site is eligible for a standard mixing zone. Loading calculations are included as Attachment A. Data and assumptions used to complete the calculations are summarized below.

Existing Groundwater Flux and Load

The volume of water moving beneath the proposed repository site was calculated using Darcy's Law:

$$Q = (K)*(i)*(A)$$

Where: Q = volume of flow per unit time
K = hydraulic conductivity
i = hydraulic gradient
A = aquifer cross section

Hydraulic conductivity values of glacial till at the repository site were obtained from slug tests performed in six till wells (Maxim 1999). Values ranged from 6.5E-03 to 4.3E-05 cm/sec. The median value of 3.1E-05 cm/sec was used for the loading calculation. The measured horizontal hydraulic gradient at the SB-4B site ranges from 18% in the northwest portion to 13.8% in the southwest portion. In order to maintain conservatism, the flatter gradient of 13.8% was used in the calculations. Based on well logs at the proposed repository site, an average aquifer thickness of 5 meters (16.4 feet) deep and assuming the final width of the repository is approximately 228 meters (750 feet) wide, cross-sectional area of the aquifer was assumed to be approximately 1,100 square meters. Based on the aforementioned, groundwater flow in till beneath the repository is about 4.71E-05 cubic meters per second (4.71E-02 liters/sec). Attachment B contains well profile data and a map of the preliminary Phase I buildout.

Water samples were collected from four wells completed in glacial till at the southern end of the site in July 1999 and analyzed for dissolved aluminum, cadmium, copper, iron, lead, manganese, and zinc. With the exception of manganese, concentrations of all metals were below or very near practical quantitation limits. As a result, concentrations of aluminum, copper, iron, lead, and zinc in the receiving water were assumed to be one half the practical quantitation limit. For manganese, the average concentration of 0.17 mg/l was used. Metals loads in the receiving water (glacial till unit) were calculated by multiplying the volume of groundwater flowing beneath the proposed repository site by the concentration of the respective metal.

Leachate Rate and Load

A discharge rate to receiving groundwater of 0.00148 cubic meters per year per hectare (1.42E-07 liters/sec) was based on percolation rates calculated using the Hydrologic Evaluation of Landfill Performance (HELP). These data and supporting information were presented in the Draft and Final EE/CA for the proposed cleanup project (Maxim, February 2001). Assumed metals concentrations in leachate generated within the repository were the weighted average concentration based on Synthetic Precipitation Leaching Procedure (SPLP) test results (Attachment C). Nondegradation calculations were not completed for arsenic or cadmium because no arsenic or cadmium were generated in SPLP tests conducted on 30 samples collected from mine waste dumps present throughout the District (Attachment C). Metals loads in leachate were calculated by multiplying the volume of leachate exiting the repository by the concentration of metal as determined using SPLP tests (Attachment C).

Calculated Rate and Load

Calculated metals concentrations in groundwater after mixing are tabulated below along with lowest applicable groundwater standards.

CALCULATED METALS CONCENTRATIONS IN GROUNDWATER AFTER COMPLETE MIXING NEW WORLD MINING DISTRICT - REPOSITORY SITE SB-4B

Metal	Initial Concentration (mg/l)	Final Concentration (mg/l)	Change in Concentration (mg/l)	Trigger Value (mg/l)	Exceeded (Y or N)
Aluminum	5.00E-02	5.00E-02	8.15E-07	0.03	NO
Copper	5.00E-04	5.01E-04	1.32E-06	0.0005	NO
Iron	5.00E-03	5.01E-03	1.02E-05	NA[(1)]	NO
Lead	5.00E-04	5.00E-04	1.27E-07	0.0001	NO
Manganese	1.70E-01	1.70E-01	2.22E-06	NA[(1)]	NO
Zinc	5.00E-03	5.00E-03	1.78E-07	0.005	NO

(1) Concentrations of iron and manganese must not reach values that interfere with the uses specified in the surface and groundwater standards. Secondary Maximum Contaminant Levels (300 micrograms per liter for iron and 50 micrograms per liter for manganese) which is based on aesthetic properties such as taste, odor, and staining may be considered as guidance to determine the levels that will interfere with the specified uses.

According to ARM 17.30.715, discharges containing toxic parameters or nutrients are “not significant” if the resulting ***change*** in concentration does not exceed the trigger value published in WQB-7. Therefore, from review of data tabulated above, calculated discharges from the proposed repository site will result in “non-significant” changes in water quality. Because the flux of groundwater beneath the repository and the volume of leachate production are both related to area, the nondegradation calculation does not change as the repository expands. That is, if the repository is built out beyond the footprint used for the initial response action cleanup, groundwater flux increases proportionately to leachate generated beneath the liner, resulting in the concentrations in groundwater remaining the same as those calculated in this memorandum.

ATTACHMENT A
NEW WORLD REPOSITORY SB-4B NON DEGRADATION CALCULATIONS
New World Mining District Response and Restoration Project

ATTACHMENT B
REPOSITORY SB-4B WELL PROFILE
AND PLAN SHOWING INITIAL REPOSITORY BUILDOUT
New World Mining District Response and Restoration Project

ATTACHMENT C
LEACHATE CHARACTERISTICS AND SPLP LABORATORY DATA
New World Mining District Response and Restoration Project

APPENDIX L

COMMENTS RECEIVED ON THE DRAFT
Selective Source Response Action EE/CA
New World Mining District Response and Restoration Project