RESTORATION ALTERNATIVES REPORT FOR THE UPPER ARKANSAS RIVER BASIN

December 31, 2003

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LIST OF ACRONYMS

ATV	All Terrain Vehicle
BMPs	Best Management Practices
CDOW	Colorado Division of Wildlife
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COCs	Constituents of Concern
CT	Consulting Team
DOI	Department of Interior
EE/CA	Engineering Evaluation/Cost Analysis
ERA	Ecological Risk Assessment
GIS	Geographical Information System
HQ	Hazard Quotient
LMDT	Leadville Mine Drainage Tunnel
MOUP	Memorandum of Understanding Parties
NPL	National Priority List
NRDA	Natural Resource Damage Assessment
OU	Operable Unit
PRP	Potentially Responsible Parties
RAR	Restoration Alternatives Report
SCR	Site Characterization Report
TVS	Table Value Standard
UARB	Upper Arkansas River Basin
USDA	United States Department of Agricultural
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

This Restoration Alternatives Report (RAR) presents and evaluates a range of alternatives to restore impaired natural resources within an 11-mile reach of the Upper Arkansas River Basin (UARB). The 11-Mile Reach is comprised of the 500-year floodplain and adjacent irrigated lands of the Upper Arkansas River (UAR), extending from California Gulch to the valley constriction just downstream of Kobe (Figure 1-1).

This RAR builds upon the information in the Site Characterization Report (SCR) (Memorandum of Understanding Parties Consulting Team [MOUP CT 2002]). The SCR presents existing information on the condition of the UARB natural resources; the nature and extent of contamination linked to historic mining and smelting in and around Leadville, Colorado; a determination of related injuries; and an identification of corresponding restoration needs. The SCR also includes a characterization of conditions within the UAR 500-year floodplain downstream of the 11-Mile Reach and the Airshed surrounding Leadville, Colorado. The RAR, however, is limited to the 11-Mile Reach.

The SCR and this report have been prepared by the CT (Mr. Andrew Archuleta, United States Forest Service, Boulder, Colorado; Dr. William Clements, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado; Dr. Edward Redente, Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University, Fort Collins, Colorado; Dr. Stanley Schumm, Mussetter Engineering, Fort Collins, Colorado; and Mr. Steven Werner, MFG, Inc., Boulder, Colorado).

Members of the CT are in agreement on the findings presented in this report. There are no dissenting or minority opinions regarding the alternatives analysis effort. The opinions presented in this report are those of the CT unless otherwise referenced.

1.1 OVERVIEW OF RAR PROJECT ELEMENTS

The "Work Plan for Upper Arkansas River Basin Consulting Team: 11-Mile Reach, Downstream Survey, and Airshed Survey" (Work Plan) (MOUP 1999) tasks the CT to:

- Develop a range of restoration alternatives, which will effectively restore injured resources within the 11-Mile Reach;

- Evaluate the restoration alternatives based on the following considerations:
  - Technical feasibility;
  - The relationship of the expected costs of the proposed actions to the expected benefits from the restoration;
  - Cost effectiveness (as defined in 43 CFR 11);
  - Potential for additional injury resulting from the proposed actions;
  - The results of any proposed or planned response actions;
  - The natural recovery period; and
  - The ability of the resources to recover with or without alternative actions.

- Develop alternatives for the coordination and sequencing of the implementation of potential restoration actions.

Following submittal of the SCR (October 31, 2002), and after consultation with the MOUP (January 17, 2003), the CT was tasked to develop and evaluate alternatives for restoration measures within the 11-Mile Reach, including the identification of specific restoration projects or actions. Subsequent to the meeting, the MOUP provided the CT with public comments on the SCR. These comments were considered during development of the RAR.

1.2 SCR/RAR RELATIONSHIP

The SCR effort was conducted to describe the cause, nature, and extent of injuries to natural resources of the UARB. All relevant information was organized and evaluated to generally correspond to the pertinent portions of the natural resource damage assessment (NRDA) regulations, consistent with the objectives of the Work Plan. For the 11-Mile Reach, the SCR presented:

- An identification of sources and pathways providing further focus on the fundamental resources (soil, water, sediment) that may cause injuries to biological resources;

- A determination of injury by resource and by geographic area;

- An understanding of the extent and magnitude of the injuries and analysis of the relationship of those injuries to a reduction in the baseline level of services;

- An understanding of the role of non-mining impacts to the UARB resources; and

- An identification of restoration needs.

The restoration needs identified in the SCR provide the basis for development of restoration alternatives. Restoration needs within the 11-Mile Reach were identified for the categories of:

- Fluvial Mine-Waste Deposits;
- Surficial Floodplain Soils Peripheral to the Mine-Waste Deposits;
- Channel Morphology/In-Stream Habitat; and
- Riparian Areas.

Specific needs within these categories were identified for Reaches 1-4. Where appropriate, restoration needs were identified at a subreach level (e.g., subreaches 1A-1C). These restoration needs categories have been utilized for the restoration technology identification and screening. The specific restoration needs within a reach are used as the basis for alternative development and evaluation.

1.3 REPORT STRUCTURE AND CONTENT

According to the objectives of the Work Plan, this report has been structured to present the development and evaluation of restoration alternatives for the injured natural resources identified in the SCR. The focus of alternative development is the primary restoration of conditions within the UARB. Correspondingly, the range of actions appropriate for addressing restoration needs within the UARB could be viewed as remediating and/or restorative. For the purposes of this report, the term restoration alternative is used to collectively represent the combinations of Technologies and Process Options being considered. The following bullets provide a brief description of the structure and content for the remaining report sections.

- <u>Section 2</u> summarizes the findings reported in the SCR. This section includes details on the geographic setting and summarizes site conditions. This section also identifies any relevant new information since the release of the SCR and includes an updated summary of SCR findings of injury.

- <u>Section 3</u> describes the restoration action objectives. An explanation of the CT's approach for identifying restoration needs and a description of how information on injuries was translated to a need for restoration are included in this section. New information since the release of the SCR, identified in Section 2, is considered in terms of restoration needs.

- <u>Section 4</u> identifies and screens a range of Technologies that may be appropriate for use in the development of comprehensive restoration alternatives. Screening of Technologies was based on the criteria of: applicability to site conditions and restoration objectives; implementability; and cost effectiveness.

- Section 5 details the comprehensive restoration alternatives developed for Reaches 1-4 of the 11-Mile Reach, from the range of Technologies identified in Section 4. The rational for each restoration alternative is explained. Due to the differences between reaches in terms of settings, conditions, access, and travel distance, the categories of restoration needs were used as the basis to develop several comprehensive alternatives for each reach. A No Action/Natural Recovery alternative is included for each reach, as a point of comparison.

- Section 6 is a practical analysis of the appropriateness/feasibility of each restoration alternative considering the United States Environmental Protection Agency's (USEPA) guidance on conducting Engineering Evaluation/Cost Analysis (EE/CA) and the U.S. Department of Interior's (DOIs) Restoration Planning Process. The analysis qualitatively explains the expected performance of an alternative (i.e., the extent to which an alternative will likely achieve baseline conditions) as part of the discussion of effectiveness. Additional considerations of feasibility are also discussed in this section.

- Section 7 is a comparative analysis of the alternatives, highlighting the differences between the alternatives for the criteria of implementability, effectiveness, and cost. The summary in this section brings together all of the analyses presented for each set of alternatives across all reaches.

1.3.1 ISSUES BEYOND THE SCOPE OF THE RAR

A reduction in the concentrations of dissolved zinc and other metals in surface water is identified as a primary restoration need within the 11-Mile Reach of the UARB. The elevated metals concentrations are attributable in large part to ongoing releases from sources within the California Gulch National Priority List (NPL) Site and are beyond the scope of the RAR. The USEPA and participating Potentially Responsible Parties (PRPs) are currently addressing sources of metals loading from California Gulch through a series of response actions meant to control releases from the remaining source areas. It is expected that full implementation of response actions for the remaining sources will occur over the next several years and that additional time will be required before the metals-load reductions associated with these actions will be fully realized. For the purposes of the RAR, it is expected that water quality within California Gulch, and correspondingly the UAR, will continue to improve as the previously implemented response actions mature and additional response actions occur within the California Gulch NPL Site.

Although not as significant, additional metals loading from mining sources upstream of the 11-Mile Reach and within the Lake Fork drainage also contribute to elevated metals concentrations within the UARB. As with the California Gulch NPL Site, these sources are beyond the scope of the RAR. No remediation is planned for these areas and it is not expected that the metals loading from these source areas will diminish in the near term.

Management of stream-flow augmentations is a restoration need that is not linked to mining impacts. Although beneficial from a water quality perspective because of greater metals dilution, periods of highly increased flows due to augmentation, coupled with historic deposition of hydraulic mining spoils, has resulted in a change in channel morphology, primarily a broadening of the active channel. Rapid flow increases and unseasonal peak flows, associated with flow augmentation, can contribute to accelerated bank erosion and result in a loss of irrigation head gates. For the purposes of the RAR, it is assumed that flow augmentation management will be similar to what has occurred over the last decade.

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UPPER ARKANSAS RIVER BASIN
RESTORATION ALTERNATIVES REPORT

FIGURE 1-1

DRAINAGE BASIN, LEADVILLE TO PUEBLO RESERVOIR, 500-YEAR FLOODPLAIN, SUPERFUND SITE, AIRSHED, 11-MILE REACH, AND MINING ACTIVITY

PROJECT: 010004.4	DATE: JANUARY 08, 2004
REV: 0	BY: MCP CHECKED: SAW

MFG, Inc.
consulting scientists and engineers

2.0 SUMMARY OF RELEVANT SCR FINDINGS

The SCR details the sources of hazardous substances, identifies pathways for exposure, and defines injuries to natural resources. The results of the characterization effort were used as a basis for identifying areas that would benefit from restoration measures.

2.1 BACKGROUND

The SCR presents a characterization of conditions within the 11-Mile Reach, the Downstream Area, and the Airshed. The Downstream Area includes the 500-year floodplain from the downstream end of the 11-Mile Reach to the tailwaters of Pueblo Reservoir. The Airshed is comprised of those UARB upland areas surrounding Leadville and Stringtown that were subject to deposition of historic smelter emissions. Restoration needs were not identified for the Downstream Area and the Airshed. Restoration needs were identified for the 11-Mile Reach.

In order to provide the appropriate framework for the restoration alternatives analysis, the SCR was structured based on the geography of the UARB. The history and geographic setting of the 11-Mile Reach are important factors in identifying restoration needs and developing the applicable restoration alternatives. The 11-Mile Reach of the Arkansas River is defined as the 500-year floodplain from the confluence of California Gulch (River Mile 0) with the Arkansas River, to a point approximately 11 miles downstream at its confluence with Two-Bit Gulch (Figure 2-1). Within the 11-Mile Reach, the Arkansas River is a relatively steep, wandering gravel-bed flowing in a wide valley, until it enters a canyon downstream of river mile 11. The 11-Mile Reach was divided into Reaches 1-4 and further divided into subreaches within a reach, based upon the physical characteristics of the floodplain (Figure 2-1). The primary factors considered in creating the reaches and subreaches were geomorphology and hydrology. The following bullets briefly describe the reach boundaries and detail some specific characteristics.

- Reach 1 – California Gulch confluence downstream to Lake Fork confluence (approximately 1.81 river miles)
  - Subreach 1A – Extends from junction of California Gulch to approximately 2,200 feet downstream. This subreach is a steep relatively active channel.
  - Subreach 1B – Approximately 3,300 feet long with a steep gradient that is sufficient to allow transport of mine waste to subreach 1C.
  - Subreach 1C – Approximately 4,100 feet long, above the junction of Lake Fork. This subreach contains a gentler gradient than subreach 1B, but is a very active channel.

- Reach 2 – Lake Fork confluence to Highway 24 Bridge (approximately 3.79 river miles)
  - Subreach 2A – Approximately 11,350 feet long and extends from confluence of Lake Fork to just upstream of the railroad bridge at river mile 4 near Iowa Gulch. Subreach 2A is less active than Reach 1, although there is evidence of cutoff and avulsion.
  - Subreach 2B – Approximately 8,650 feet long and extends upstream of the railroad bridge at river mile 4 to the Highway 24 bridge. Channel braiding is evident in this subreach.

- Reach 3 – Downstream of Highway 24 Bridge to narrows below Kobe (approximately 3.88 river miles)
  - Subreach 3A – Approximately 12,350 feet long and extends from the Highway 24 Bridge to mile 8 where the narrows constrict the alluvial valley. Channel braiding is evident in this subreach.
  - Subreach 3B – Approximately 8,150 feet long and extends from the confluence of Big Union Creek to the Narrows, 1,500 feet downstream of County Road 55. This subreach is steep and active.

- Reach 4 – Downstream of the narrows near Kobe to Two Bit Gulch (approximately 1.76 river miles)

Further rationale for the division of the 11-Mile Reach into reaches, and subdivision within a reach (i.e., subreaches), is presented in the SCR.

Historic and ongoing releases from up-gradient sources within the California Gulch NPL Site and historic releases of mine waste now deposited within the 11-Mile Reach have resulted in past and present injuries to surface water and sediments, soils, and terrestrial and aquatic biological resources. These injuries were defined based on a comparison of conditions with the relevant regulatory criteria/standards and a comparison of the Arkansas River and its floodplain with conditions upstream of California Gulch inflow (Reach 0).

The UAR and its floodplain above the confluence with California Gulch were determined to provide an appropriate reference for evaluating the impacts of mining. Reach 0 was used as a “control” area for establishing baseline conditions within the 11-Mile Reach and for the establishment of specific benchmarks for sediments, benthic macroinvertebrates, fish, vegetation, mammals, and birds. It is important to note that injury to surface and groundwater is defined by comparisons to the State of Colorado water quality standards and it is recognized that metal levels in the UAR in Reach 0 have historically exceeded chronic toxicity levels. Correspondingly, the ecological conditions in Reach 0 are not pristine. However, today, a healthy and productive aquatic community exists in spite of exceedences of water quality criteria.

Metal levels in Reach 0 have declined significantly since remediation of the Leadville Mine Drainage Tunnel (LMDT) began in 1992. Despite historic levels of elevated metals from the LMDT and Tennessee Creek and infrequent unexplained excursions of zinc, biological conditions in Reach 0 have shown dramatic improvement. As metal levels have declined, metal-sensitive organisms such as mayflies (Ephemeropta: Heptageniidae) have recovered significantly (Nelson and Roline 1999), and brown trout populations are relatively healthy and productive (Nehring and Policky 2002). Based on results of a large-scale monitoring program conducted by USEPA (Clements et al. 2002), and more recent unpublished data (Personal Communication with Dr. William Clements 2003), benthic communities and overall water quality within Reach 0 are similar to other Colorado streams.

2.2 SUMMARY OF CONDITIONS WITHIN THE 11-MILE REACH

Review of the historical record indicates that current injuries within the 11-Mile Reach can be traced to the original hydraulic placer mining activity of the late 1800s, with increasing levels of impact as hard-rock mining occurred over the first half of the 20th century. Examination of recent data indicates that response actions within the California Gulch NPL Site have reduced the magnitude of injury to surface water. There is corresponding evidence of recovery for components of the aquatic community. However, a number of injuries are still evident within the 11-Mile Reach.

<u>Surface Water</u>

By far, the largest ongoing impacts are to the surface waters of the Arkansas River. Although improved, current water quality immediately below the confluence with California Gulch (Reach 1) substantially exceeds the relevant Colorado Table Value Standards (TVSs). The degradation of surface water quality for the 11-Mile Reach of the Arkansas River is primarily due to the metals load emanating from California Gulch.

Further downstream from California Gulch, the water quality of the Arkansas River improves due to dilution from tributary inflows. Approximately two miles downstream, Lake Fork joins the Arkansas River. Lake Fork carries significant natural flow, as well as large volumes of water diverted from the Western Slope for downstream use. The dilution effects of the augmented flow are significant, resulting in substantial reductions of metal concentrations in the Arkansas River. Water quality and, correspondingly, the condition of the aquatic communities continue to improve downstream as more tributaries bring additional clean flows to the Arkansas River. However, at times, the concentrations in the lower portions of the 11-Mile Reach still exceed the TVSs used to define injury.

Although beneficial from a water quality perspective, historically the highly increased flows due to augmentation, coupled with prior deposition of hydraulic mining spoils, have resulted in a change in channel morphology, primarily a broadening of the active channel. The rapid flow increases and unseasonal peak flows associated with flow augmentation contribute to accelerated bank erosion and loss of irrigation head gates. This is most apparent below the confluence with Lake Fork, which receives west slope water through Turquoise Lake. Grazing of the riparian area may also be contributing to this condition. Flow augmentation within the 11-Mile Reach has been reduced with the development of the Mt. Elbert Tunnel in 1981, which transfers water further downstream to Lake Creek. However, flow augmentation of the Arkansas River continues both above California Gulch and through Lake Fork.

Sediments

In-stream deposits of fine-grained sediments/mine wastes occur infrequently within the 11-Mile Reach. Although elevated metals concentrations in in-stream sediments were measured and exceed typical threshold values for toxicity, the coarse gravel cobble riverbed limits the potential for this exposure pathway. Because of the limited number of fine-grained, in-stream sediment samples for the 11-Mile Reach, it is difficult to discern any spatial trends within this relatively short span. However, a pattern of decreasing average metals concentrations can be observed along the 11-Mile Reach.

Floodplain Soils/Vegetation

Deposits of mine waste in the floodplain are prevalent within the upper nine miles of the 11-Mile Reach. On average, the deposits extend approximately two feet below the current ground surface and are mostly isolated from contact with surface water and groundwater. Additionally, some portions of the irrigated meadows within the 11-Mile Reach have been contaminated by the historic use of Arkansas River water.

The fluvial mine-waste deposits (and to a much lesser degree, portions of the irrigated meadows) have impacted soil function, inhibited or precluded riparian vegetation, and present a pathway for metals exposure to terrestrial biota. Evidence of erosion of these deposits during periods of bankfull and overbank flow was observed. However, studies examining the influence of these deposits on surface water and groundwater quality demonstrated that the deposits do not measurably influence Arkansas

River surface water concentrations. Metals loading from leaching of the fluvial mine-waste deposits, resulting in exceedence of groundwater criteria, is limited to groundwater within and immediately adjacent to the deposits. Exceedences of the groundwater criteria appear to be limited to shallow locally perched systems and impacts to domestic water supplies were not observed. The lack of impact is due to the small size of the fluvial mine-waste deposits relative to the large volume of surface water and groundwater flow during bankfull conditions. Also, in general, the majority of the fluvial mine-waste deposits are not in contact with surface water and groundwater during most flow regimes.

Deposits in the first few miles below California Gulch appear to be older, coarser mine wastes, with higher concentrations of metals on average than deposits in the more downstream portions of the 11-Mile Reach. For the next several miles downstream of Lake Fork (Reach 2), the average metals concentration of floodplain fluvial mine-waste deposits drops and the floodplain broadens. The volume of tailings deposits per stream length is also less than upstream of Lake Fork. This is most likely due to the increased flow capacity of the channel in this area, which would reduce the frequency of overbank flow conditions. Lower average concentrations of metals in floodplain deposits are also evident in Reach 3 (approximately river miles 7, 8, and 9); however, the number of deposits increases as the wide, shallow channel through this area is more prone to overbank flow. Over the remaining length of the 11-Mile Reach, the floodplain generally narrows. Only a few small deposits of mine waste are present in Reach 4, due to the flushing effect of the more efficient channel.

Aquatic Resources

The condition of the aquatic biological resources tends to correspond to improvements in water quality. Although water quality improves substantially over the 11-Mile Reach, and fish and macroinvertebrates are present, metals concentrations, toxicity testing and field studies indicate that dissolved metals concentrations (primarily due to loading from California Gulch) are still having a strong negative effect on macroinvertebrates and fish. These effects are linked to direct toxicity from elevated concentrations of metals in the water column, and also due to food chain pathways where periphyton accumulate water column metals, in turn serving as a food source for grazing benthic macroinvertebrates. Elevated metals in grazing macroinvertebrates are then available to predatory macroinvertebrate species, as well as for larger predators, such as fish.

Flow augmentation and ongoing flushing effects of amplified and extended peak flows and fluctuations in flow levels can also directly impact stream biological productivity. It is difficult to separately quantify the effects on stream productivity due to metals from those due to stream augmentation; however, the impacts on the density and diversity of benthic macroinvertebrates and the numbers and health of brown trout are primarily due to the effects of elevated metals concentrations.

Terrestrial Resources

Although the primary injuries within the 11-Mile Reach appear to be to the aquatic resources, injuries to terrestrial resources have been identified as well. Elevated metals concentrations in fluvial mine-waste deposits have impacted soil function and exceed concentrations that cause phytotoxicity. In turn, the lack of vegetation on these near-stream deposits reduces the productivity of riparian food sources to the stream. Where present, these deposits also generally reduce riparian-habitat suitability through loss of shade and possible bank erosion. Although similar impacts can occur from grazing or road building, the loss of habitat directly due to fluvial mine-waste deposits can be roughly quantified through mapping efforts.

Food chain exposure pathways for injury were documented for two avian species within the 11-Mile Reach. Studies conducted by the U.S. Fish and Wildlife Service and U.S. Geological Survey show that benthic macroinvertebrates and their adult emergent forms have elevated metals-body burden and are a food source for dippers and swallows, respectively. Ingestion of the terrestrial form of the aquatic insects has resulted in injury due to elevated blood lead and decreased enzyme production in swallows. As with the aquatic species, it appears that the general trend is a decrease in injury with the dilution effects downstream.

Direct exposure to mine-waste deposits may be a concern for small mammals (e.g., mice or voles) or other species that have a home range small enough that they would spend a majority of their time in direct contact with a mine-waste deposit. However, no conclusive information was found describing this type of injury. Based on exposure analyses conducted for the SCR and the more recent risk assessment by USEPA (USEPA 2003b), it is estimated that given the large range of movement for larger species of predators (e.g., fox, coyote, etc.) and grazers (e.g., deer, elk, etc.), the small amount of time spent in contact with the deposits limits the potential for injury. An exception could occur for domestic livestock if grazing was confined to a small area. However, it was not possible with existing information to distinguish impacts, such as osteochondrosis, due to elevated metals in soils and vegetation, from possible non-mining related nutrient imbalances. The potential for impacts to livestock is limited to exposure at the discrete fluvial mine-waste deposits and identified localized areas of the irrigated meadows.

The following matrix provides a summary of SCR findings regarding injury sorted by resource category and by reach. The matrix has been updated based on new data/information received since the release of the SCR. The resource categories identified in the matrix are utilized for the identification of restoration needs.

MATRIX SUMMARIZING UPDATED FINDINGS REGARDING INJURY
SORTED BY RESOURCE CATEGORY AND BY REACH
FOR THE 11-MILE REACH OF THE
UPPER ARKANSAS RIVER BASIN

	Reach 1	Reach 2	Reach 3	Reach 4
SURFACE WATER RESOURCES				
Surface Water	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs[1] for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3[2] are 4 and 5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Runoff from historic mine sites contributes metals in Reach 0[3]. On average, water quality upstream of Reach 1 is typically near the TVSs. Inflow from California Gulch at the top of Reach 1 is responsible for large increases in in-stream metals concentrations measured throughout Reach 1. 4. Extent of Injury: Surface water is injured throughout Reach 1. Although substantial exceedences of the TVSs continue to occur, water quality has improved compared to pre-1992 conditions. Improvements are due to treatment of discharges from the Leadville Mine Drainage Tunnel on the East Fork of the Arkansas River, the Yak Tunnel on upper California Gulch, and ongoing remediation at the California Gulch Superfund Site.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3 are 4 and 1.5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Ongoing metals releases from California Gulch. 4. Extent of Injury: Surface water is injured throughout Reach 2. Exceedences of the TVSs occur and the frequency and magnitude of those exceedences are a function of upstream sources. Some dilution of metals concentrations occurs in this reach due to the influence of flows from Lake Fork.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3 are 3and 1.5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Ongoing metals release from California Gulch. 4. Extent of Injury: Surface water is injured throughout Reach 3. Exceedences of the TVSs occur and the frequency and magnitude of those exceedences are a function of upstream sources.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3 are 3and 1.5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Ongoing metals release from California Gulch. 4. Extent of Injury: Surface water is injured throughout Reach 4. Exceedences of the TVSs occur and the frequency and magnitude of those exceedences are a function of upstream sources.

[1] TVS: Table Value Standards for State of Colorado surface water quality

[2] Period 3: Composite data record for 1992 to present

[3] Reach 0: Segment of Arkansas River upstream of California Gulch

	Reach 1	Reach 2	Reach 3	Reach 4
Sediments	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of cadmium, copper, lead, and zinc in sediments are found when compared to sediments in Reach 0. See benthic organisms for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. The 11-Mile Reach of the Arkansas River is considered to be a sediment-poor system. Fine sediments have a relatively short residence time in the 11-Mile Reach and only tend to be deposited in areas of reduced water velocities. Recent data indicate a reduction in sediment metals concentrations compared to prior periods. However, metals concentrations in fine-grained sediments continue to be elevated throughout Reach 1.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of copper and lead in Reach 2 sediments are found when compared to sediments in Reach 0. See benthic invertebrates for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. However, fine-grained sediments throughout the reach are expected to have elevated metals concentrations.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of lead in Reach 3 sediments are found when compared to sediments in Reach 0. See benthic invertebrates for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. However, fine-grained sediments throughout the reach are expected to have elevated metals concentrations.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of lead in Reach 4 sediments when compared to sediments in Reach 0. See benthic invertebrates for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. However, fine-grained sediments throughout the reach are expected to have elevated metals concentrations.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR) (MOUP CT 2002). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

	Reach 1	Reach 2	Reach 3	Reach 4
Groundwater Resources				
Groundwater	1. Has the Resource Been Injured: No 2. Description of Injury: Although concentrations of cadmium exceed the drinking water MCL and zinc exceeds the secondary MCL, the exceedences are not influencing drinking water supplies. Elevated metals concentrations in shallow groundwater are not causing injury to surface water. 3. Source of Injury: Contaminated surface water exchange between surface and subsurface flows. Leaching of metals has increased concentrations in groundwater adjacent to fluvial mine-waste deposits. 4. Extent of Injury: Elevated metals concentrations in shallow groundwater (<10 feet depth) decrease rapidly with depth and horizontal distance from a given mine-waste deposit. Discharge of shallow groundwater with elevated metals concentrations to the Upper Arkansas River has no measurable effect on in-stream concentrations.	1. Has the Resource Been Injured: No 2. Description of Injury: Although concentrations of cadmium exceed the drinking water MCL and zinc exceeds the secondary MCL, the exceedences are not influencing drinking water supplies. Elevated metals concentrations in shallow groundwater are not causing injury to surface water. 3. Source of Injury: Contaminated surface water exchange between surface and subsurface flows. Localized contamination adjacent to fluvial mine-waste deposits. 4. Extent of Injury: Elevated metals concentrations in shallow groundwater decrease rapidly with depth and horizontal distance from a given mine-waste deposit. Additional information on metals levels in groundwater below 10 feet in depth should be obtained to confirm extent of injury.	1. Has the Resource Been Injured: No 2. Description of Injury: Although concentrations of cadmium exceed the drinking water MCL and zinc exceeds the secondary MCL, the exceedences are not influencing drinking water supplies. Elevated metals concentrations in shallow groundwater are not causing injury to surface water. 3. Source of Injury: Contaminated surface water exchange between surface and subsurface flows. Localized contamination adjacent to fluvial mine-waste deposits. 4. Extent of Injury: Elevated metals concentrations in shallow groundwater decrease rapidly with depth and horizontal distance from a given mine-waste deposit. Additional information on metals levels in groundwater below 10 feet in depth should be obtained to confirm extent of injury.	1. Has the Resource Been Injured: No 2. Description of Injury: There are no significant fluvial mine-waste deposits within Reach 4. Only a few very small deposits have been identified within this reach. The volume of material is small and direct impact to the groundwater pathway is not a concern. 3. Source of Injury: No injury. 4. Extent of Injury: Not determined.

MCL – Maximum Contaminant Level

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR) (MOUP CT 2002). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

	Reach 1	Reach 2	Reach 3	Reach 4
GEOLOGIC RESOURCES: SOILS				
Floodplain Soils	1. Has the Resource Been Injured: No. However, the potential for unacceptable exposure risks to wildlife and/or phytotoxicity were identified by EPA for localized areas of irrigated meadows. 2. Description of Injury: Total metal concentrations in floodplain (riparian) soils are substantially higher than concentrations found in Reach 0. However, plant-available concentrations are in a similar range to concentrations in Reach 0 and lower than concentrations considered to be toxic to plants (see vegetation). However, some localized areas of elevated soil metals concentrations in irrigated areas were identified by USEPA as potentially posing increased risks to wildlife and/or phytotoxicity. 3. Source of Injury: No injury, although metal concentrations are elevated in floodplain (riparian) soils and these metals are most likely from historic flooding and irrigation activities. 4. Extent of Injury: Soil metal concentrations are elevated throughout Reach 1, but generally below concentrations considered to be toxic to plants. 34.4 floodplain and non-floodplain acres were identified as posing the greatest potential risks.	1. Has the Resource Been Injured: No. However, the potential for unacceptable exposure risks to wildlife and/or phytotoxicity were identified by EPA for localized areas of irrigated meadows. 2. Description of Injury: Total metal concentrations in floodplain (riparian) soils are substantially higher than concentrations found in Reach 0. However, plant-available concentrations are in a similar range to concentrations in Reach 0 and lower than concentrations considered to be toxic to plants (see vegetation). However, some localized areas of elevated soil metals concentrations in irrigated areas were identified by USEPA as potentially posing increased risks to wildlife and/or phytotoxicity. 3. Source of Injury: No injury, although metal concentrations are elevated in floodplain (riparian) soils and these metals are most likely from historic flooding and irrigation activities. 4. Extent of Injury: Soil metal concentrations are elevated throughout Reach 2, but generally below concentrations considered to be toxic to plants. 66.1 floodplain and non-floodplain acres were identified as posing the greatest potential risks.	1. Has the Resource Been Injured: No. However, the potential for unacceptable exposure risks to wildlife and/or phytotoxicity were identified by EPA for localized areas of irrigated meadows. 2. Description of Injury: Total metal concentrations in floodplain (riparian) soils are substantially higher than concentrations found in Reach 0. However, plant-available concentrations are in a similar range to concentrations in Reach 0 and lower than concentrations considered to be toxic to plants (see vegetation). However, some localized areas of elevated soil metals concentrations in irrigated areas were identified by USEPA as potentially posing increased risks to wildlife and/or phytotoxicity. 3. Source of Injury: No injury, although metal concentrations are elevated in floodplain (riparian) soils and these metals are most likely from historic flooding and irrigation activities. 4. Extent of Injury: Soil metal concentrations are elevated throughout Reach 3, but generally below concentrations considered to be toxic to plants. 70.2 floodplain and non-floodplain acres were identified as posing the greatest potential risks.	1. Has the Resource Been Injured: No 2. Description of Injury: There is no evidence to indicate injury to floodplain (riparian) soils in Reach 4. It is assumed that soil metal concentrations in Reach 4 are lower than in Reach 3. 3. Source of Injury: No injury, although if soil metal concentrations are elevated, it is assumed that these metals came from flooding. 4. Extent of Injury: No data available to define the extent of metals in floodplain (riparian) soils.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR) (MOUP CT 2002). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

	Reach 1	Reach 2	Reach 3	Reach 4
Soils where Floodplain Fluvial Mine-Waste Deposits Exist	1. Has the Resource Been Injured: Yes 2. Description of Injury: Metal concentrations in fluvial mine-waste deposits exceed toxicity thresholds for plants and plant growth has been substantially reduced on most sites where fluvial mine-waste deposits occur. Of 24 deposits along Reach 1, 14 have poor vegetation cover (10% cover), 9 deposits have fair vegetation cover (10-50% cover), and 1 deposit has good vegetation cover (>50% cover). 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Fluvial mine-waste deposits cover a surface area of approximately 18 acres, with a volume of approximately 887,000 cu. ft. Of the 24 deposit groups in this reach, 11 are ranked as a high priority for restoration, 11 are ranked as moderate priority, and 2 are ranked as low priority. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential relative to the large volume of surface and groundwater moving through the valley.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Metal concentrations in fluvial mine-waste deposits exceed toxicity thresholds for plants and plant growth has been substantially reduced on most sites where fluvial mine-waste deposits occur. Of 35 deposits along Reach 2, 2 have poor vegetation cover (10% cover), 19 deposits have fair vegetation cover (10-50% cover), and 14 deposits have good vegetation cover (>50% cover). 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Fluvial mine-waste deposits cover a surface area of approximately 9 acres, with a volume of approximately 233,000 cu. ft. Of the 35 deposit groups in this reach, 3 are ranked as a high priority for restoration, 27 are ranked as moderate priority, and 5 are ranked as low priority. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential relative to the large volume of surface and groundwater moving through the valley.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Metal concentrations in fluvial mine-waste deposits exceed toxicity thresholds for plants and plant growth has been substantially reduced on most sites where fluvial mine-waste deposits occur. Of 94 deposits along Reach 3, 26 have poor vegetation cover (10% cover), 56 deposits have fair vegetation cover (10-50% cover), and 12 deposits have good vegetation cover (>50% cover). 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Fluvial mine-waste deposits cover a surface area of approximately 38 acres, with a volume of approximately 1,578,300 cu. ft. Of the 94 deposit groups in this reach, 13 are ranked as a high priority for restoration, 69 are ranked as moderate priority, and 12 are ranked as low priority. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential relative to the large volume of surface and groundwater moving through the valley.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Some small fluvial mine-waste deposits exist in Reach 4, but they have not been quantified with respect to chemical properties and plant cover. 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Not enough information exists to draw conclusions about injury to vegetation at locations where deposits occur. However, only several small accumulations of mine waste were observed in Reach 4.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR) (MOUP CT 2002). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

	Reach 1	Reach 2	Reach 3	Reach 4
BIOLOGICAL RESOURCES				
Vegetation	1. Has the Resource Been Injured: Yes 2. Description of Injury: Cover, biomass, and number of species of plants growing on floodplain (riparian) soils in Reach 1 are equal to or greater than Reach 0. All tissue metal concentrations are below thresholds considered to be toxic to perennial species. However, vegetation has been injured where most fluvial mine-waste deposits occur (see fluvial mine-waste deposits). 3. Source of Injury: Available data does not indicate injury to vegetation growing on floodplain (riparian) soils. Source of injury is limited to elevated metals in fluvial mine-waste deposits. 4. Extent of Injury: Injury to vegetation is limited to fluvial mine-waste deposits where vegetation cover is less than 50%.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Cover, biomass, and number of species of plants growing on floodplain (riparian) soils in Reach 2 are equal to or greater than Reach 0. Tissue metal concentrations of zinc are in the toxic range for grasses and forbs. Vegetation has been injured where most fluvial mine-waste deposits occur (see fluvial mine-waste deposits). 3. Source of Injury: Metal deposition on floodplain (riparian) soils from flooding and irrigation activities and elevated metals in fluvial mine-waste deposits. 4. Extent of Injury: Available data indicates that zinc concentrations in plant tissue are high enough to cause injury to plants growing on floodplain (riparian) soils. However, with existing data, it is not possible to determine the geographic extent or degree of injury. Injury also exists on fluvial mine-waste deposits where vegetation cover is less than 50%.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Cover, biomass, and number of species of plants growing on floodplain (riparian) soils in Reach 3 are equal to or greater than Reach 0. All tissue metal concentrations are below thresholds considered to be toxic to perennial species. However, vegetation has been injured where most fluvial mine-waste deposits occur (see fluvial mine-waste deposits). 3. Source of Injury: Available data does not indicate injury to vegetation growing on floodplain (riparian) soils. 4. Extent of Injury: Injury to vegetation is limited to fluvial mine-waste deposits where vegetation cover is less than 50%.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Field observations confirm that vegetation is productive and shows no signs of injury associated with elevated metal concentrations in floodplain (riparian) soils. 3. Source of Injury: Source of injury is limited to elevated metals in fluvial mine-waste deposits. However, there are several small fluvial mine-waste deposits that lack adequate vegetation indicating injury to vegetation in these locations. 4. Extent of Injury: Injury to vegetation is limited to a few small fluvial mine-waste deposits where vegetation cover is less than 50%.

	Reach 1	Reach 2	Reach 3	Reach 4
Benthic Organisms	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and species richness of benthic macroinvertebrates; elevated metal levels in periphyton. 3. Source of Injury: Elevated metal levels in water and periphyton from California Gulch. 4. Extent of Injury: Benthic macroinvertebrate communities are severely degraded in Reach 1. Greatest effects are observed during spring runoff.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and species richness of benthic macroinvertebrates; elevated metal levels in periphyton. 3. Source of Injury: Elevated metal levels in water and periphyton from California Gulch. 4. Extent of Injury: Benthic macroinvertebrate communities are moderately degraded in Reach 2. In particular, the reach is characterized by reduced abundance of metal-sensitive organisms. Greatest effects are observed during spring runoff.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and species richness of benthic macroinvertebrates; elevated metal levels in periphyton. 3. Source of Injury: Elevated metal levels in water and periphyton from California Gulch. 4. Extent of Injury: Benthic macroinvertebrate communities are slightly degraded in Reach 3. Greatest effects are observed during spring runoff. Improvement in community composition and abundance of metal-sensitive taxa has been observed since 1992.	1. Has the Resource Been Injured: Uncertain 2. Description of Injury: Insufficient data to determine injury. 3. Source of Injury: n/a 4. Extent of Injury: n/a

	Reach 1	Reach 2	Reach 3	Reach 4
Brown Trout	1. Has the Resource Been Injured: Yes 2. Description of Injury: Greatly reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in Reach 1 are characterized by reduced abundance, biomass and very poor recruitment. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in Reach 2 are characterized by reduced abundance, biomass and poor recruitment. However, there is some improvement in conditions compared to Reach 1. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in Reach 3 are characterized by reduced abundance, biomass and poor recruitment. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Brown trout sampling in Reach 4 after 1992 is limited, and the extent of injury is difficult to determine. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.

	Reach 1	Reach 2	Reach 3	Reach 4
Small Mammals	1. Has the Resource Been Injured: No 2. Description of Injury: Based on comparisons of exposure data (vegetation & soils) from Reaches 0, 2 and the NPL Site; potential exposure in Reach 1 would not result in injury to small mammals. Tissue concentrations and pathology data from the NPL Site and Reach 2 (representing higher areas of exposure) did not show indications of injury. 3. Source of Injury: There are no specific data for Reach 1. Exposure would occur primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.	1. Has the Resource Been Injured: No 2. Description of Injury: Metals concentrations do not exceed benchmark values. Histopathology shows no signs of injury. 3. Source of Injury: Exposure occurs primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.	1. Has the Resource Been Injured: No 2. Description of Injury: Based on comparisons of exposure data (vegetation & soils) from Reaches 0-2 and the NPL Site; potential exposure in Reach 3 would not result in injury to small mammals. 3. Source of Injury: There are no specific data for Reach 3. Exposure would occur primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.	1. Has the Resource Been Injured: No 2. Description of Injury: Based on comparisons of exposure data (vegetation and soils) from Reaches 0-3, potential exposure in Reach 4 would not result in injury to small mammals. 3. Source of Injury: There are no specific data for Reach 4. Exposure would occur primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR) (MOUP CT 2002). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

	Reach 1	Reach 2	Reach 3	Reach 4
Migratory Birds	1. Has the Resource Been Injured: Yes 2. Description of Injury: Possible elevated lead tissue concentrations and suppressed ALAD. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: Because birds move between reaches it is assumed that metals exposure in Reaches 2 and 3 is representative of the typical metals exposure throughout the 11-Mile Reach.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Lead concentrations in tissues are significantly higher than the Control Site and study Reference Area. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: All birds foraging on aquatic invertebrates in the 11-Mile Reach are potentially exposed to elevated metals concentrations and may experience ALAD inhibition.	1. Has the Resource Been Injured: Yes 2. Description of Injury: ALAD levels are significantly different than the study Reference Area and suppression is > 50%, lead tissue concentrations are significantly higher than the Control Site and study Reference Area. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: All birds foraging on aquatic invertebrates in the 11-Mile Reach are potentially exposed to elevated metals concentrations and may experience ALAD inhibition.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Possible elevated lead tissue concentrations and suppressed ALAD. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: Because birds move between reaches it is assumed that metals exposure in Reaches 2 and 3 is representative of the typical metals exposure throughout the 11-Mile Reach.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR) (MOUP CT 2002). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

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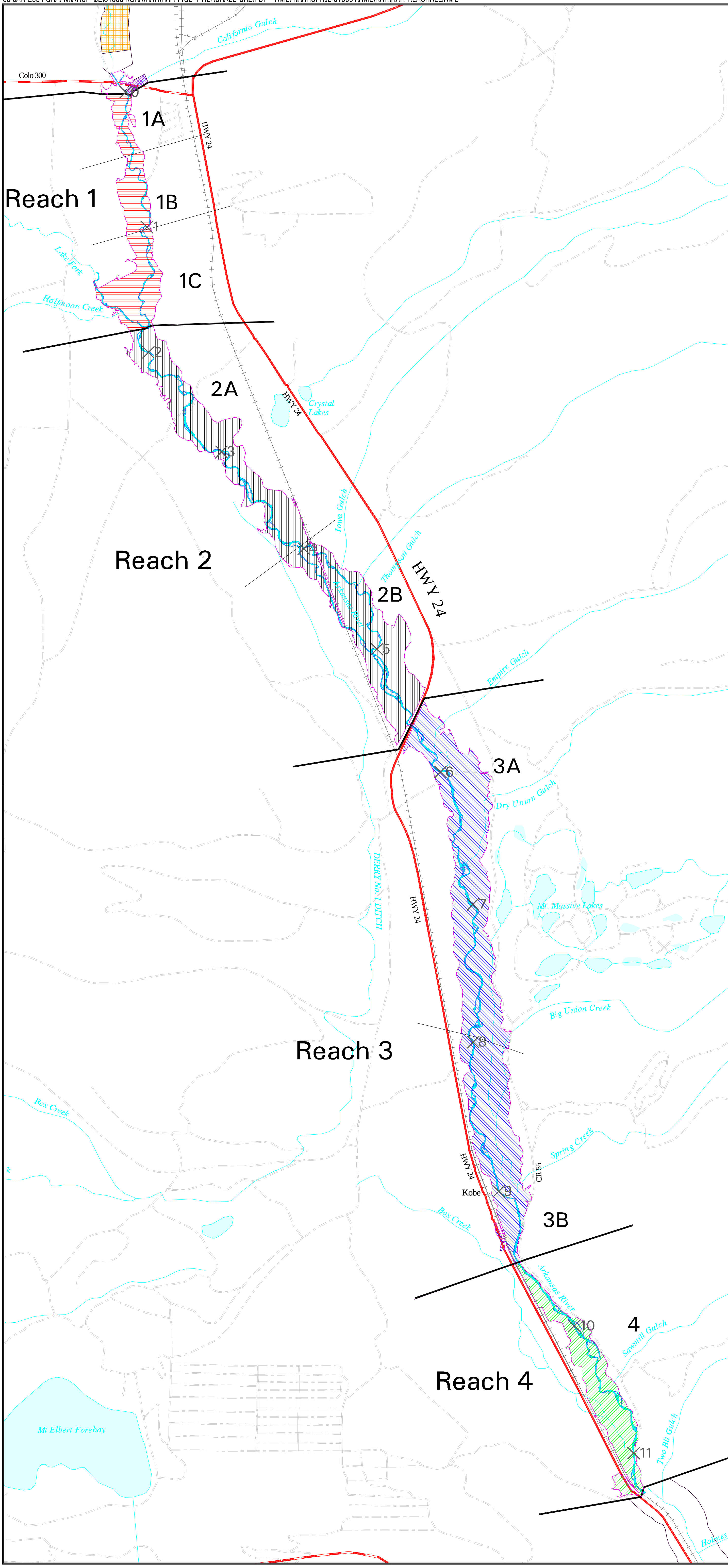


EXPLANATION

Hydrology

River or Stream
Lake or Open Water
11- Mile Reach 500- Year Floodplain
Reach 0
Reach 1
Reach 2
Reach 3
Reach 4
California Gulch at Arkansas River
1 River Mile (from confluence with California Gulch)

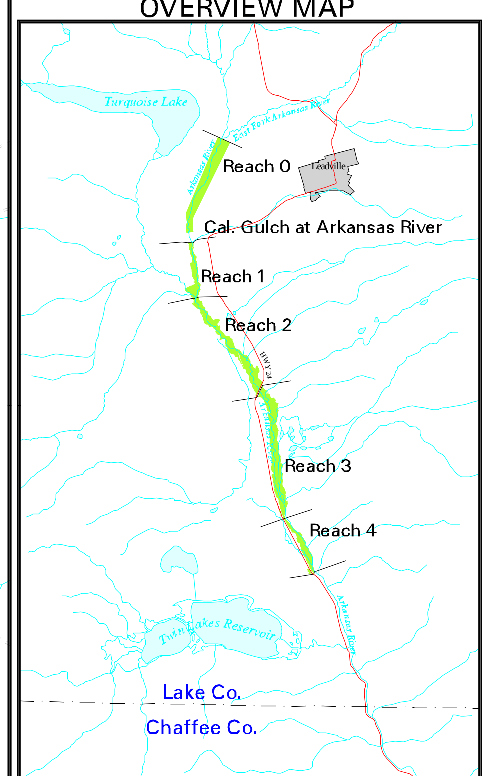
Transportation

Minor Road
Medium Duty Road
Highway
Railroad

Other Features

Reach Boundary
Subreach Boundary

OVERVIEW MAP



Reach Definitions:
1 - California Gulch to Lake Fork
2 - Lake Fork to HWY 24 Bridge
3 - HWY 24 Bridge to Narrows below Kobe
4 - Narrows below Kobe to above Two-Bit Gulch

0 - From EF Arkansas River to California Gulch

N

SCALE IN FEET
3000 0 3000

UPPER ARKANSAS RIVER BASIN
RESTORATION ALTERNATIVES REPORT

FIGURE 2-1

SUBREACH MAP SHOWING MAIN REACHES 1-4 AND REACH 0

PROJECT: 010004.4	DATE: JAN 08, 2004
REV: 0	BY: MCP / CHK: SAW

MFG, Inc.
consulting scientists and engineers

3.0 RESTORATION NEEDS

The restoration needs are presented as a basis for the development of restoration alternatives. Restoration needs were initially identified in the SCR (MOUP CT 2002). Additional information describing the identification of restoration needs can be found in the SCR. Where appropriate, the SCR restoration needs have been updated, based on a review of newly available information.

3.1 RESTORATION OBJECTIVES

The general restoration objectives presented below were provided by the MOUP. Restoration alternatives are evaluated, in large part, in terms of their relative abilities to achieve the following restoration objectives:

- Restore, replace or acquire the equivalent of injured resources with lost services within the 11-Mile Reach to levels consistent with applicable baseline conditions; and

- Provide for restoration actions that are protective of human health and the environment.

An additional objective is to improve the physical conditions within the floodplain. Examples of this objective include: improving the quality of in-stream and riparian habitat within the 11-Mile Reach. Although in most areas the diminished quality of the physical habitat is not linked to the presence of hazardous substances, improvements in habitat quality will reduce physical stressors to brown trout and potentially reduce the negative effects associated with surface water quality.

It should be noted that, although included in the MOUP general objectives, the RAR does not consider acquisition or replacement. Consistent with the DOI NRD regulations, acquisition or replacement can be considered along with primary restoration, as a means to restore lost uses and services. However, evaluation of acquisition or replacement is beyond the scope of the RAR. Per the Work Plan, the RAR is intended to provide a reasonable range of alternatives for restoring impaired resources within the 11-Mile Reach. Given the general nature of these restoration objectives, and the RAR focus on restoration measures to be implemented within the 11-Mile Reach, it is important to clearly define restoration needs.

3.2 APPROACH FOR IDENTIFYING RESTORATION NEEDS

The SCR served as a basis for identifying and evaluating the nature and extent of injuries to natural resources of the UARB based on comparisons to regulatory definitions and expected baseline (Reach 0) conditions. This injury determination step was the first step in the approach for identifying restoration needs.

The SCR provides an understanding of the cause of mining related injuries to natural resources within the UARB by identifying the current sources of hazardous substances and the pathways for exposure. On-going releases from the California Gulch NPL Site were identified to be the largest contributor of metals responsible for injuries to the aquatic resources. The sources identified to be contributing metals to the surface and groundwaters of the California Gulch drainage, are being addressed through Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Response Actions, and are beyond the scope of the RAR. Mine sites in the UAR headwaters upstream of Leadville (e.g., St. Kevin's Gulch) and on Lake Fork (e.g., Dinero Tunnel) also contribute measurable metals loads to the 11-Mile Reach. Additional reduction in metals loading from these upstream sources would have a beneficial effect on water quality and the aquatic biota of the 11-Mile Reach.

It is recognized that without additional metals-loading control measures, restoration measures within the 11-Mile Reach will not restore surface water quality and will provide limited benefit to the aquatic biological resources. At this time, the exact schedule for completion of all California Gulch NPL Site Response Actions, and the time frame to achieve full effectiveness, are unknown. However, based on the types of source control measures implemented, it is expected that water quality in the UARB will continue to improve. A lessening of maximum concentrations of dissolved metals in California Gulch during spring runoff should occur over the next few years, as source-area engineering controls and associated revegetation efforts mature. Low-flow metals concentrations should also continue to decline over a somewhat longer time frame. With time, it is expected that these source control measures should also be effective in reducing dissolved metals concentrations in the shallow alluvial groundwater within California Gulch. Consideration of additional restoration actions for improving 11-Mile Reach water quality would not be sensible until the planned Response Actions for the California Gulch NPL Site have been fully implemented and have achieved maximum effectiveness. Restoration measures to control the ongoing releases from the Dinero Tunnel and St. Kevin's Gulch Mine Sites, as well as other potential mine-site sources outside the current NPL boundaries, should also be implemented. The ongoing metals contributions from upstream sources were considered when identifying restoration needs.

Understanding the relationship between an identified resource injury and any reduction in the baseline of services provided by the resource was the second step of the approach to determining restoration needs. For example, based on the SCR, injury to surface water was initially determined relative to the frequency and extent of exceedences of the relevant water-quality criteria for the period of record. The impacts of water-quality exceedences on resource conditions were ultimately considered in terms of a potential for reduction in services provided by surface water, both in terms of limitations of the uses of the surface water (e.g., agricultural waters and/or drinking water) and the impacts on dependent resource components (e.g., fish). Although an injury was defined for surface water, it may not result in a quantifiable reduction in all resource services.

Although it is possible to understand the relationship between mining impacts and a diminished resource, quantification of a reduction in the past or current level of resource services attributable solely to an identified injury is beyond the scope of the SCR. This is due in large part to the complexities of sorting the cumulative effects of mining impacts from non-mining impacts. In the UARB, there are several baseline factors related to land use and water management (e.g., trans-mountain water diversions) that have modified the UARB ecosystem over the past 130 years. Although the relative role of non-mining impacts could not be quantified, impacts were identified and considered.

Also considered was whether a resource is recovering. The evaluation of recovery considered temporal changes in the nature and extent of injury, as well as whether or not uses and services are recovering and will achieve the expected baseline. Evidence of, or expectations for, resource recovery were important to evaluating the need for and extent of future restoration activities. The RAR considers information pertinent to the ability of the UARB resources to recover from the effects of the 100+ year history of mining impacts (43 CFR § 11.82[d]). Changes in water quality due to recent upstream source control activities, the long period of time since initial release, and ongoing Response Actions are factors that contribute to resource recovery and are apparent in an evaluation of spatial and temporal trends. Conversely, short-term impacts from restoration activities or long-term changes in land use may adversely affect recovery trends. Although the natural resources of the UARB are recovering in certain areas, it is important to identify where mining impacts in the 11-Mile Reach will negatively affect or preclude resource recovery.

USEPA has been conducting remediation work on selected fluvial mine-waste deposits in the 11-Mile Reach (USEPA 2003a) and has recently investigated the concentration and toxicity of metals in irrigated lands, within and adjacent to the 11-Mile Reach (USEPA 2003b). New information on these

USEPA activities within the 11-Mile Reach has become available since the time of the SCR development (USEPA 2003b). USEPA's remediation to date includes the addition of amendments, revegetation efforts, and some limited bank stabilization measures. The effectiveness of USEPA's remediation in terms of improving environmental conditions within specific portions of the 11-Mile Reach, as well as new data regarding risks to wildlife and livestock from irrigated lands, have been evaluated and were fully considered in this RAR.

Overall, USEPA's study (USEPA 2003b) is consistent with the analysis conducted in support of the SCR (See SCR Appendix J - Characterization of the Potential for Injury to Mammalian Wildlife), which identified a limited potential for unacceptable risks to livestock associated with discrete areas of elevated soil/vegetation. Further study would be required to assess the role of elevated metals concentrations on livestock in these localized areas. Such studies would involve an evaluation of the ranching practices utilized by landowners (e.g., irrigation practices, feeding, and use of nutritional supplements) in conjunction with additional livestock health and environmental data. Conducting the appropriate studies would require several years. Also, it is not clear if the potential effects to livestock would be assessed as an injury to natural resources. Setting these issues aside, the RAR considers restoration alternatives that may be beneficial to those portions of the floodplain identified by USEPA as potentially problematic. However, it should be noted that the primary benefit from both a terrestrial natural resource and agricultural-use perspective would come from the restoration measures proposed for the discrete fluvial mine-waste deposits.

As noted above, accurate quantification of any reduction in services attributable solely to one specific cause of injury is difficult under many circumstances. It is particularly difficult for the UARB when considering the long duration since the initial release of mine waste and the concurrent shifts in land-use patterns and resource management. In order to accurately measure a reduction in services attributable solely to mining impacts, it would be necessary to sort and quantify the role of all of the overlapping natural and anthropogenic influences on the UARB. Such an effort goes beyond the level of understanding that could be garnered from existing information and may not be possible given the dynamic nature of the system, even with years of study. Instead, resources that would benefit from restoration are identified and addressed from a practical level of understanding. This understanding is based on knowledge of the sources and pathways for exposure, comparison of the 11-Mile Reach conditions with control areas, and the experience of the authors. Although a reduction in services was not quantified through this process, it was identified. Correspondingly, the need for restoration of a resource was identified and, based on an understanding of the causes of the reduced service(s), specific geographic areas were targeted for restoration measures.

3.3 RESTORATION NEEDS

The following restoration needs were initially identified in the SCR. Where identified, they have been updated based on information available since the release of the SCR in 2002.

3.3.1 FLUVIAL MINE-WASTE DEPOSITS

Aside from the impacts of poor water quality due to upstream metals loading, the primary source of injury within the 11-Mile Reach is the numerous discrete floodplain deposits of mine waste. These deposits have resulted in direct injury to the underlying soil and floodplain vegetation, and pose a pathway for exposure of terrestrial wildlife. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential, relative to the large volume of surface and groundwater moving through the valley. Furthermore, SCR analyses indicate that even large-scale erosion of the deposits would not have a measurable effect on water quality. However, even though not measurably influencing water quality, pathways for floodplain fluvial mine-waste deposits to contribute metals to the surface and shallow groundwater systems exist. Key factors in evaluating the current and future potential for individual fluvial mine-waste deposits to contribute metals to the surface and shallow groundwater systems are the potential for erosion and the metals concentration of each deposit. These factors were considered, along with the defined injuries to soils and plants and the potential for direct exposure of wildlife, when identifying target restoration areas.

Based on the findings of the SCR, it is evident that the different characteristics of the individual fluvial mine-waste deposits should be considered when developing restoration alternatives. An understanding of these characteristics was important when prioritizing the need for restoration and developing and evaluating restoration alternatives. For these reasons, a methodology to classify the fluvial mine-waste deposits was developed. USEPA has conducted physical and chemical analyses of the fluvial mine-waste deposits within the 11-Mile Reach (URS Operating Services, Inc. 1997, 1998). This information served as a starting point for prioritizing the individual deposits. The primary criteria for the prioritization were:

- Erosion Potential - As defined by distance from or contact with the active channel based on a review of recent aerial photographs and available reports.

- Vegetation Cover – Based on review of recent aerial photography and limited site reconnaissance.

- Volume of Material – Based on recent work by USEPA to map the surface area and average depth of the individual deposits.

- Average Zinc Concentration – Based on a compilation of various USEPA sampling efforts. Categories of average zinc concentrations were developed as an indication of the potential metals toxicity to plants and wildlife, and to generally characterize the potential for a deposit to contribute metals loads to the water resources. The ranges are not meant to define any specific aspect of metals loading potential or toxicity, but to serve as a general tool for prioritization when coupled with other information.

Information related to the above criteria was analyzed using a Geographic Information System (GIS), and the results were quantified using the following scoring system:

- **Vegetation Class Score:** 1: > 50 percent cover
  2: 10-50 percent cover
  3: < 10 percent cover

- **Erosion Potential Score:** 1: Isolated from river
  2: In 500-year floodplain
  3: In contact with Arkansas River channel

- **Deposit Volume:** 1: < 10,000 cu. ft.
  2: 10,000-50,000 cu. ft.
  3: > 50,000 cu. ft.

- **Average Zinc Concentration:** 1: < 1,000 mg/Kg Zinc
  2: 1,000-5,000 mg/Kg Zinc
  3: > 5,000 mg/Kg Zinc

A priority ranking of the deposits for restoration was then conducted by dividing the range of possible scores (4 to 12) into three equal categories. These categories were then identified as a high (10-12), moderate (7-9), or low (4-6) priority. Figure 3-1 details the mine-waste deposit prioritization by Reach. A detailed tabulation of the GIS analysis and additional information on the methodology was presented as Appendix H of the SCR.

Since 1998, USEPA has conducted treatment on 47 of the 153 fluvial mine-waste deposits within the 11-Mile Reach. USEPA released the 2002 Interim Monitoring Report in October 2002 (USEPA 2002a). This report contains the Final Assessment Report on the Effectiveness of Biosolids and Lime Treatment as Soil Amendments for Fluvial Tailings Along the Upper Arkansas River (USEPA 2002b). The Final Assessment Report evaluated the effectiveness of biosolids cake and lime amendments one year after treatment. The success of the treatments to reduce the availability of metals, increase deposit pH and promote growth of vegetation was evaluated. The results of the evaluation concluded that the amendments were successful in improving soil quality, allowing growth of vegetation and the recovery of the microbial community. Soil toxicity was also reduced. However, results indicated that treating the deposits with biosolids cake and agricultural grade lime did not dilute total concentrations of metals and effects such as reductions in the production of plant root biomass and bioaccumulation of constituents of concern (COCs) in the food chain may still occur.

USEPA's work is still in progress and detailed information as to the performance of any given treatment approach on long-term effectiveness, plant community effects and dietary exposure risk is not yet available. However, USEPA continues to modify and re-amend the deposits based on field observations, and additional amendments were added to many of the deposits in the summer of 2003. Specific treatment summaries for individual deposits were provided to the CT on behalf of USEPA. This information is detailed below by reach and priority.

Reach 1

Reach 1 metal concentrations in fluvial mine-waste deposits exceed toxicity thresholds for plants, and plant growth has substantially been reduced on most sites where fluvial mine-waste deposits occur. Of the 24 deposits along Reach 1, 14 had poor vegetation cover, 9 deposits had fair vegetation cover, and 1 deposit had good vegetation cover. Fluvial mine-waste deposits cover a surface area of approximately 18 acres, with a volume of approximately 32,845 cu. yds. Of the 24 deposit groups in this reach, 11 are ranked as high priority for restoration, 11 are ranked as moderate priority and 2 are ranked as low priority. Figure 3-2 details the locations and priorities of the mine-waste deposits within Reach 1.

USEPA has conducted treatments on 16 of the 24 deposits within Reach 1, including all of the high priority deposits (13.46 acres), and 1.84 acres of moderate priority deposits (Tables 3-1 and 3-2). Treatments in Reach 1 generally involved the integration of a variety of combinations of organic matter (biosolids, wood chips, fish pond sediments) and lime (agricultural grade limestone, kiln dust, dolomite chips) with the fluvial deposits. The treatments also included reseeding.

TABLE 3-1
REACH 1 HIGH PRIORITY
USEPA MINE-WASTE DEPOSIT TREATMENT SUMMARY[1]

High Priority Deposit	Treatment	Year(s)	Acreage
AB	100 dt/a biosolids compost + cow manure compost + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added to portions of AC during 2003.	1999 2003	0.38
AC	100 dt/a biosolids compost + cow manure compost + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added to portions of AC during 2003.	1999 2003	0.71
AD	100 dt/a biosolids + cow manure compost + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator.	1999	0.80
AE	100 dt/a biosolids + cow manure compost + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator.	1999	2.37
CA	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	0.88
CD	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	1.64
CJ	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	0.48
CE	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. Incorporated to approximately 8 inches using an excavator.	1999	0.55
CL	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. Incorporated to approximately 1 foot with Metrogrow disc. Sugar beet lime added and raked in (shallow) during Summer 2001. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998 2003	2.43
CO	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. Incorporated to approximately 1 foot with Metrogrow disc. Sugar beet lime added and raked in (shallow) during Summer 2001. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998 2003	2.34
CS	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	0.88
		Total Acres of Reach 1 High Priority Treated Deposits	**13.46**

[1]Treatment information provided to CT by Jan Christner, URS Greiner on behalf of USEPA.

TABLE 3-2
REACH 1 MODERATE PRIORITY
USEPA MINE-WASTE DEPOSIT TREATMENT SUMMARY[1]

Moderate Priority Deposit	Treatment	Year(s)	Acreage
AA	100 dt/a biosolids compost + cow manure compost + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added to portions of AC during 2003.	1999 2003	0.10
CK	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. Incorporated to approximately 1 foot using an excavator. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	0.31
CN	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. Incorporated to approximately one foot with Metrogrow disc. Sugar beet lime added and raked in (shallow) during Summer 2001. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998 2003	0.40
CP	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	0.13
CR	100 dt/a biosolids pellets + 100 t/a agricultural grade limestone. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1999 2003	0.90
Total Acres of Reach 1 Moderate Priority Treated Deposits			**1.84**

[1]Treatment information provided to CT by Jan Christner, URS Greiner on behalf of USEPA.

Reach 2

In Reach 2, metal concentrations in fluvial mine-waste deposits exceed toxicity thresholds for plants, and plant growth has been substantially reduced on most sites where fluvial mine-waste deposits occur. Of the 35 deposits along Reach 2, 2 have poor vegetation cover, 19 deposits have fair vegetation cover, and 14 deposits have good vegetation cover. Fluvial mine-waste deposits cover a surface area of approximately 9.3 acres, with a volume of approximately 8,644 cu. yds. Of the 35 deposit groups in Reach 2, 3 are ranked as high priority for restoration, 27 are ranked as moderate priority, and 5 are ranked as low priority. Figure 3-3 details the locations and priorities of the mine-waste deposits within Reach 2.

USEPA has not conducted any treatment of the mine-waste deposits within Reach 2. However, test plot studies were conducted by the United States Department of Agricultural (USDA) in 1998 on the high priority deposit FA (1.17 acres) and by Colorado State University/ASARCO in 1997-1999 on the high priority deposit FB (2.47 acres).

Reach 3

In Reach 3, metal concentrations in fluvial mine-waste deposits exceed toxicity thresholds for plants, and plant growth has been substantially reduced on most sites where fluvial mine-waste deposits occur. Of the 94 deposits along Reach 3, 26 have poor vegetation cover, 56 have fair vegetation cover, and 11 have good vegetation cover (vegetation cover of deposit RF was not evaluated). Fluvial mine-waste deposits cover a surface area of approximately 37.6 acres, with a volume of approximately 58,456 cu. yds. Of the 94 deposit groups in this reach, 13 are ranked as high priority for restoration, 69 are ranked as moderate priority, and 12 are ranked as low priority. Figure 3-4 details the locations and priorities of the mine-waste deposits within Reach 3.

USEPA has conducted treatments on 31 of the 94 deposits within Reach 3, including 5.74 acres of high priority deposits, 10 acres of moderate priority deposits and 1.06 acres of low priority deposits. Treatments generally involving the integration of a variety of combinations of organic matter (biosolids, wood chips, fish pond sediments) and lime (agricultural grade limestone, kiln dust, dolomite chips) with the fluvial deposits have been utilized for approximately 17 of the 38 acres within Reach 3. The treatments also included reseeding (Tables 3-3-3-5).

TABLE 3-3
REACH 3 HIGH PRIORITY
USEPA MINE-WASTE DEPOSIT TREATMENT SUMMARY[1]

High Priority Deposit	Treatment	Year(s)	Acreage
LB	115 dt/a biosolids pellets + 105 t/a fine grained agricultural grade limestone. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.29
LI	20 dt/a biosolids pellets + 40 dt/a compost + 80 t/a fine grained lime kiln dust. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.26
LN	30 dt/a biosolids pellets + 50 dt/a compost + 105 t/a fine grained lime kiln dust. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added to the very south end of LN during 2003.	2000 2003	1.06
LV	30 dt/a biosolids pellets + 50 dt/a compost + 105 t/a fine grained lime kiln dust. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.25
MB	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998 2003	0.73
MQ	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime	1998	0.93
NI	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	1.60
RB	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998 2003	0.62
Total Acres of Reach 3 High Priority Treated Deposits			**5.74**

[1]Treatment information provided to CT by Jan Christner, URS Greiner on behalf of USEPA.

TABLE 3-4
REACH 3 MODERATE PRIORITY
USEPA MINE-WASTE DEPOSIT TREATMENT SUMMARY[1]

Moderate Priority Deposit	Treatment	Year(s)	Acreage
LA	115 dt/a biosolids pellets + 105 t/a fine grained agricultural grade limestone. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.14
LC	46 dt/a biosolids pellets + 40 dt/a compost + 90 t/a fine grained lime kiln dust. 20 lb/a native seed[2]. 600 lb/a phosphate on east half only. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	1.02
LD	46 dt/a biosolids pellets + 40 dt/a compost + 30 t/a fine grained lime kiln dust. Half plot 20 lb/a native seed[2]. Half plot 20 lb/a perennial rye seed. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.50
LH	30 dt/a biosolids pellets + 60 dt/a compost + 120 t/a fine grained lime kiln dust.	2000	0.37
LK	46 dt/a biosolids pellets + 40 dt/a compost + 30 t/a fine grained lime kiln dust. 5 t/a native hay with seed. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.41
LM	30 dt/a biosolids pellets + 55 dt/a compost + 115 t/a fine grained lime kiln dust.	2000	0.38
LO	60 dt/a biosolids pellets + 25 dt/a compost + 105 t/a fine grained lime kiln dust. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.47
LP	70 dt/a biosolids pellets + 30 dt/a compost + 125 t/a fine grained lime kiln dust. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.36
LQ	30 dt/a biosolids pellets + 50 dt/a compost + 100 t/a fine grained lime kiln dust. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	2000 2003	0.14
LS	35 dt/a biosolids pellets + 60 dt/a compost + 120 t/a fine grained lime kiln dust.	2000	0.99
ME	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998	0.88
MI	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.23
MP	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime	1998	0.11
NB	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.81
NG	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	1.01
NH	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.82
NL	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.32
RA	100 dt/a biosolids cake + 100 t/a 3/8 inch- agricultural grade lime. 10 t/a wood chips, 35 t/a fish pond sediments, and 20 t/a dolomite added during 2003.	1998 2003	1.04
Total Acres of Reach 3 Moderate Priority Treated Deposits			**10**

[1]Treatment information provided to CT by Jan Christner, URS Greiner on behalf of USEPA.

TABLE 3-5
REACH 3 LOW PRIORITY
USEPA MINE-WASTE DEPOSIT TREATMENT SUMMARY[1]

Low Priority Deposit	Treatment	Year(s)	Acreage
LL	46 dt/a biosolids pellets + 40 dt/a compost + 30 t/a fine grained lime kiln dust. No seed.	2000	0.12
LR	30 dt/a biosolids pellets + 50 dt/a compost + 100 t/a fine grained lime kiln dust.	2000	0.03
MG	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.52
MH	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.16
MK	100 dt/a compost + 100 t/a 3/8 inch- agricultural grade lime	1999	0.23
Total Acres of Reach 3 Low Priority Treated Deposits			**1.06**

[1]Treatment information provided to CT by Jan Christner on behalf of USEPA.

Reach 4

In Reach 4, some small fluvial mine-waste deposits exist, but they have not been quantified with respect to chemical properties and plant cover. Not enough information exists to draw conclusions about injury to vegetation at locations where deposits occur. However, only several small accumulations of mine waste were observed in Reach 4 and they all have some degree of vegetation. Observation indicates that these areas cover substantially less than 2 acres. However, for the purpose of alternatives development, a total area of 2 acres is conservatively assumed.

USEPA has not conducted any treatment of the mine-waste deposits within Reach 4.

3.3.2 AGRICULTURAL LANDS

The SCR identified elevated metals concentrations in surficial floodplain soils peripheral to the fluvial mine-waste deposits and in irrigated meadows as a mining impact (See SCR Appendix J - Characterization of the Potential for Injury to Mammalian Wildlife). Irrigation and drainage ditches in the 11-Mile Reach and vicinity are shown in Figure 3-5. One of the resources utilized in the SCR was the Ecological Risk Assessment for the Terrestrial Ecosystem of the California Gulch NPL Site (ERA) (Weston and Terra 1997). This ERA contained only limited data, and risks to herbivores did not include an estimation of the risk from plant ingestion. Although defined injuries to terrestrial natural resources (i.e., soils, vegetation and terrestrial wildlife) could not be directly linked to the presence of metals in these soils, in certain settings they may have the potential to impact vegetation and/or the health of wildlife and livestock. Elevated metals concentrations in floodplain soils are of potential concern for the following reasons:

- Soils with elevated metal concentrations may be phytotoxic to plants which reduces habitat quality and/or the availability of forage for herbivores;

- Herbivores foraging in areas of elevated metal concentrations may be exposed both by ingestion of plant tissue and by direct ingestion of soil; and

- Metals in plant tissue can be ingested by terrestrial insects and can become a source of exposure for insectivorous birds.

Since the release of the SCR in 2002, USEPA published an addendum to the ERA: Evaluation of Risks to Plants and Herbivores in the Upper Arkansas River Flood Plain (USEPA 2003b). This addendum provides an evaluation of the potential for mine-waste related phytotoxicity and risks to herbivorous mammals (wildlife and livestock) that may forage in the area. The addendum presents new data collected to evaluate surficial soil and vegetation within the 500-year floodplain and in irrigated meadows.

In the addendum, USEPA identified three categories of potential phytotoxicity:

- ≤ 0.5 Non-Phytotoxic to Mildly Phytotoxic
- 0.5 to ≤ 1 Moderately Phytotoxic
- >1 Highly Phytotoxic

The summary statistics for exposure and risk to herbivores revealed that risks were limited to very localized areas and usually dominated by ingestion of soil, with plant ingestion contributing significant risk at only two sampling stations. Zinc was the primary chemical at the two stations where plant intake was above a level of concern. Lead was the chemical in soil that had the highest predicted risk, with contributions from zinc and mercury at some locations. In all instances, the contribution of plant ingestion to the total Hazard Quotient (HQ) was negligible compared to that of soil ingestion. In their assessment, USEPA identified only marginal risks to herbivores associated with some limited areas. Unacceptable risks were generally not identified at a scale more consistent with the grazing range of the species evaluated. When risks were evaluated in terms of total exposure within a reach, none of the reaches were identified as resulting in an HQ of >1.

The sample locations identified as posing unacceptable risks to herbivores (i.e., HQ > 1) were compared with USEPA's analysis of potential phytotoxic effects due to surficial soil metals concentrations. The number of locations of potentially high phytotoxicity is greater than the number of locations with a HQ > 1. When locations of potentially high phytotoxicity were compared with locations of risks to herbivores, the areas of herbivore risk were most often included in the areas of potentially high phytotoxicity. Although no obvious signs of phytotoxicity were observed in the field for these areas, and cover was similar to that in Reach 0, the areas exhibiting potentially high phytotoxicity and/or HQs > 1 for deer and elk were conservatively adopted for the purpose of identifying restoration needs.

In order to quantify the acreages of agricultural lands predicted by USEPA to have potentially high phytotoxicity and/or HQ > 1 by subreach, information from several figures in the USEPA Risk Assessment Addendum (USEPA 2003b) were digitized. Areas of predicted high phytotoxicity were captured as polygons from Figure 6-1, and HQ point locations were digitized from Figure 7-1 (USEPA 2003b). Most of the points with HQ > 1 were located within the predicted high phytotoxicity areas. Two of the points with HQs > 1 were located outside of the predicted high phytotoxicity areas. These two sample locations were converted to polygons by using the average distance to the nearest neighboring sample locations. Using the UARB GIS, the spatial intersection of the predicted photoxicity areas, areas with HQ's > 1, the 500-year floodplain, the subreach zones, and the mine-waste deposit areas was produced. The result of the spatial intersection is a set of polygons that contain information about predicted phytotoxicity, HQ's, floodplain type, mine-waste deposit identifier, and subreach zone. The location of predicted high phytotoxicity in relation to mine-waste deposits is shown in Figure 3-6. The mapped fluvial mine-waste deposits were not included in the irrigated area calculations because specific restoration alternatives are being developed for the deposits. Summary statistics for the areas of high phytotoxicity and/or areas with HQ > 1 are presented for each reach in Tables 3-6 through 3-8.

<u>Reach 1</u>

In Reach 1 the areas of the 500-year floodplain irrigated agricultural lands identified as having the greatest potential for phytoxicity are in subreach 1A (2.7 acres). Subreach 1A also contains 1.4 acres within the non-floodplain area characterized as potentially highly phytotoxic. The areas of the non-floodplain irrigated agricultural lands identified as having the greatest potential for phytotoxicity and as posing unacceptable risks to grazing animals are in subreach 1C (26 acres). Subreach 1B contains 2.4 acres within the 500-year floodplain area characterized as potentially highly phytotoxic and/or as posing unacceptable risks to grazing animals and 1.9 acres within the non-floodplain area characterized as potentially highly phytotoxic and as posing unacceptable risks to grazing animals (Table 3-6). Areas USEPA has identified as having an HQ of greater than 1 for deer and elk are combined with areas exhibiting the greatest potential for phytotoxicity (Figure 3-6). These acreages are exclusive of the mapped fluvial deposits.

Table 3-6
Summary of USEPA Predicted High Phytotoxicity and/or HQ >1 Areas in Reach 1

Subreach	Type	Acres
1A	Floodplain	2.7
	Non-floodplain	1.4
1B	Floodplain	2.4
	Non-floodplain	1.9
1C	Floodplain	--
	Non-floodplain	26
	Total	**34.4**

Reach 2

In Reach 2, the areas of the floodplain and non-floodplain irrigated agricultural lands identified as having the greatest potential for phytotoxicity and/or as posing unacceptable risks to grazing animals are almost evenly split between subreaches 2A and 2B. Subreach 2A contains 4.7 acres of potentially high phytotoxic soils within the 500-year floodplain and 6.2 acres of potentially high phytotoxic soils in the non-floodplain. Subreach 2B contains 7.6 acres of potentially high phytotoxic soils within the 500-year floodplain and 3.6 acres of potentially high phytotoxic soils in the non-floodplain (Figure 3-6).

Two areas identified by USEPA within Reach 2 as having an HQ of greater than 1 for deer and elk are located outside of the areas of potentially high phytotoxicity (Figure 3-6). Subreach 2A contains 20.8 acres with a HQ > 1 in the non-floodplain. Subreach 2B contains 21.2 acres with a HQ > 1 within the 500-year floodplain and 2 acres in the non-floodplain.

Table 3-7 summarizes the acreages of potentially high phytotoxicity and/or HQ >1 in Reach 2. These acreages are exclusive of the mapped fluvial deposits.

Table 3-7
Summary of USEPA Predicted High Phytotoxicity and/or HQ >1 Areas in Reach 2

Subreach	Type	Acres
2A	Floodplain	4.7
	Non-floodplain	27
2B	Floodplain	28.8
	Non-floodplain	5.6
	Total	**66.1**

Reach 3

In Reach 3 the areas of the 500-year floodplain irrigated agricultural lands identified as having the greatest potential for phytoxicity and/or as posing unacceptable risks to grazing animals are in subreach 3A (19.9 acres). In addition, subreach 3A contains 3.5 acres of potentially phytotoxic non-floodplain soils. Subreach 3B contains 8.9 acres within the 500-year floodplain and 37.9 acres of non-floodplain soils having the greatest potential for phytotoxicity and/or posing unacceptable risks to grazing animals (Figure 3-6). Table 3-8 summarizes the acreages of potentially high phytotoxicity and/or HQ >1 in Reach 2. These acreages are exclusive of the mapped fluvial deposits.

Table 3-8
Summary of USEPA Predicted High Phytotoxicity and/or HQ >1 Areas in Reach 3

Subreach	Type	Acres
3A	Floodplain	19.9
	Non-floodplain	3.5
3B	Floodplain	8.9
	Non-floodplain	37.9
	Total	**70.2**

Reach 4

Floodplain vegetation appears to be in good condition within Reach 4. USEPA phytotoxicity analyses were not conducted for Reach 4.

3.3.3 CHANNEL MORPHOLOGY, IN-STREAM HABITAT AND RIPARIAN AREAS

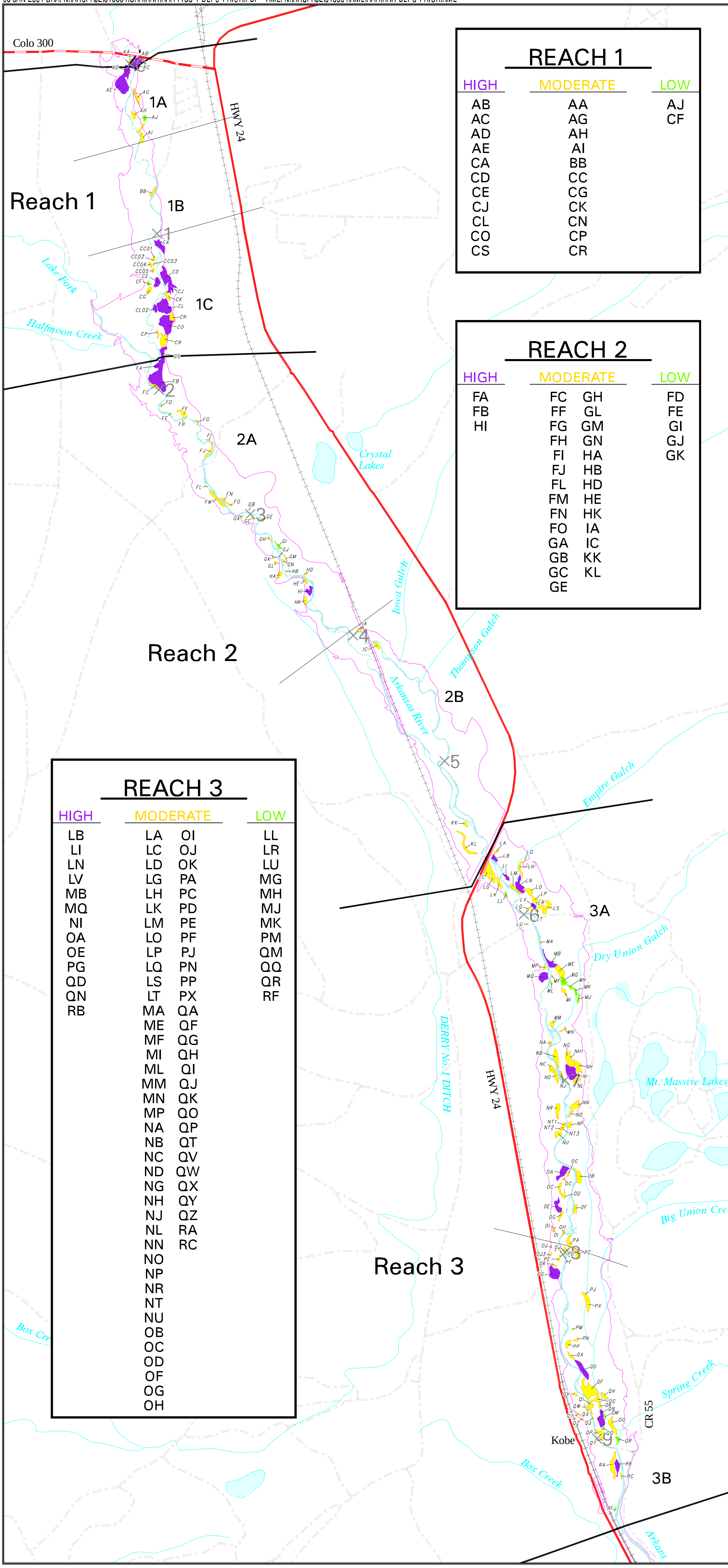
At the direction of the parties overseeing the execution of the Work Plan, natural resource areas and agricultural lands that would benefit from restoration measures due to impacts other than from mining have also been identified. As discussed in the SCR, specifically for Reach 3, flow augmentation and grazing appear to have had the largest negative impacts on the conditions of the riverbanks and riparian habitat. Residual mining impacts appear to be limited to riparian vegetation and bank stability at the location of the mine-waste deposits. Areas that would benefit from improvements in the riparian area vegetation were initially identified based on review of data, aerial photographs, site reconnaissance, and land-use patterns. These areas appear to be predominately within Reach 3 and the most downstream portions of Reach 2, although portions of Reach 1 should also be considered.

Portions of the stream channel within the 11-Mile Reach downstream of Lake Fork appear to have been altered, possibly by the deposition of coarse sediments from hydraulic mining, and more recently by augmented flows. In these areas (predominantly Reach 3), the channel appears to be broad, shallow, and therefore mainly riffle habitat. A lack of pool habitat was also identified in subreaches 1A and 1C. Homogeneous habitat is a concern because it offers little cover for larger fish and does not provide holding areas for fingerling fish during runoff or periods of augmented flow. Improvements in in-stream habitat and riparian vegetation in these areas may provide direct benefits to the fishery and may also reduce physical stressors that can compound the effects of metals toxicity. As improvements in water quality occur, such restoration measures would mitigate the potential for physical habitat to serve as a limiting factor for further recovery of the fishery.

Although the relationship to stream productivity cannot be quantified, restoration measures aimed at improving the quality of in-stream habitat and riparian vegetation would be beneficial to the fishery and other aquatic biota and would enhance ongoing restoration of the fishery associated with any improvements in the water quality of the Arkansas River.

Finally, although not a restoration measure, the need to better control flow augmentation has been a common theme in reports and conversations with various stakeholders. Even though progress has been made, additional measures to return and maintain the system closer to natural flow patterns could enhance any restoration measures ultimately implemented. Flow augmentation could be managed to enhance bank stability measures and the brown trout fishery. It is also recognized that, at times, flow augmentation can have a positive benefit in the form of dilution of in-stream metal concentrations.

08-JAN-2004 GRA: N:\ARCPRJ2\010004\GRA\RAR\RAR-FIG3-1-DEPO-PRIOR.PDF * AML: N:\ARCPRJ2\010004\AML\RAR\RAR-DEPO-PRIOR.AML



REACH 1

HIGH	MODERATE	LOW
AB	AA	AJ
AC	AG	CF
AD	AH	
AE	AI	
CA	BB	
CD	CC	
CE	CG	
CJ	CK	
CL	CN	
CO	CP	
CS	CR	

REACH 2

HIGH	MODERATE		LOW
FA	FC	GH	FD
FB	FF	GL	FE
HI	FG	GM	GI
	FH	GN	GJ
	FI	HA	GK
	FJ	HB	
	FL	HD	
	FM	HE	
	FN	HK	
	FO	IA	
	GA	IC	
	GB	KK	
	GC	KL	
	GE		

REACH 3

HIGH	MODERATE		LOW
LB	LA	OI	LL
LI	LC	OJ	LR
LN	LD	OK	LU
LV	LG	PA	MG
MB	LH	PC	MH
MQ	LK	PD	MJ
NI	LM	PE	MK
OA	LO	PF	PM
OE	LP	PJ	QM
PG	LQ	PN	QQ
QD	LS	PP	QR
QN	LT	PX	RF
RB	MA	QA	
	ME	QF	
	MF	QG	
	MI	QH	
	ML	QI	
	MM	QJ	
	MN	QK	
	MP	QO	
	NA	QP	
	NB	QT	
	NC	QV	
	ND	QW	
	NG	QX	
	NH	QY	
	NJ	QZ	
	NL	RA	
	NN	RC	
	NO		
	NP		
	NR		
	NT		
	NU		
	OB		
	OC		
	OD		
	OF		
	OG		
	OH		

EXPLANATION

Hydrology

- River or Stream
- Lake or Open Water
- 500- Year Floodplain
- × 1 River Mile (from confluence with California Gulch)

Transportation

- Minor Road
- Medium Duty Road
- Highway
- Railroad

Deposit Action Priority

- High Priority
- Moderate Priority
- Low Priority

Other Features

- Reach Boundary
- Subreach Boundary

N

SCALE IN FEET

2400 0 2400

UPPER ARKANSAS RIVER BASIN

RESTORATION ALTERNATIVES REPORT

FIGURE 3-1

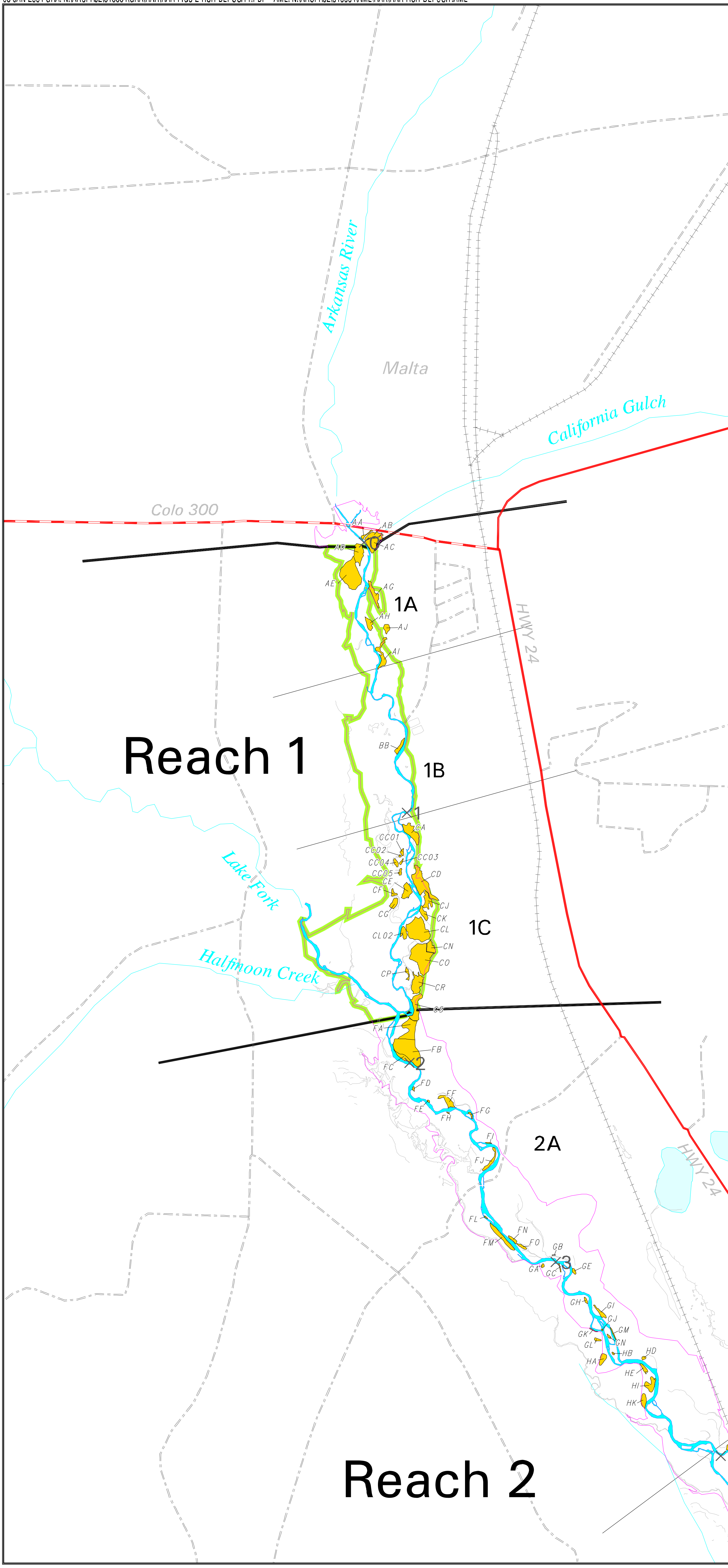
MINE-WASTE DEPOSIT PRIORITY

PROJECT: 010004.4	DATE: JAN 08, 2004	
REV: 0	BY: MCP	CHK: SAW

MFG, Inc.

consulting scientists and engineers

08-JAN-2004 GRA: N:\ARCPRJ2\010004\GRA\RAR\RAR-FIG3-2-RCH-DEPOSIT1.PDF * AML: N:\ARCPRJ2\010004\AML\RAR\RAR-RCH-DEPOSIT.AML



EXPLANATION

Hydrology

- River or Stream
- Lake or Open Water
- 500- Year Floodplain
- Reach 1
- × 1 River Mile (from confluence with California Gulch)

Transportation

- Minor Road
- Medium Duty Road
- Highway
- Railroad

Other Features

- Mine- Waste Deposit
- Reach Boundary
- Subreach Boundary

N

SCALE IN FEET

1500 0 1500

UPPER ARKANSAS RIVER BASIN

RESTORATION ALTERNATIVES REPORT

FIGURE 3-2
MINE-WASTE DEPOSIT LOCATIONS
CALIFORNIA GULCH TO LAKE FORK
(REACH 1)

PROJECT: 010004.4	DATE: JAN 08, 2004	
REV: 0	BY: MCP	CHK: SAW

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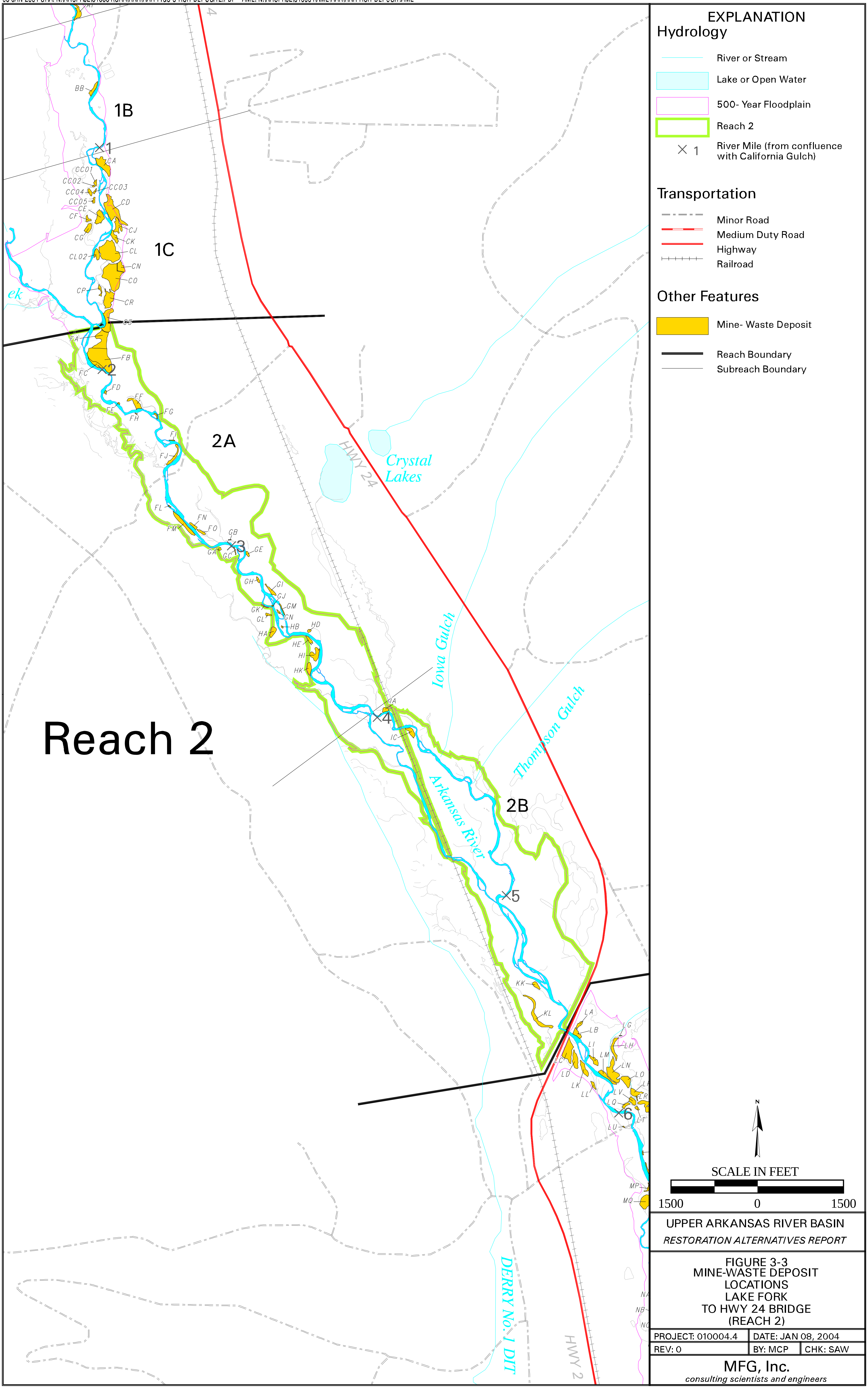
08-JAN-2004 GRA: N:\ARCPRJ2\010004\GRA\RAR\RAR-FIG3-3-RCH-DEPOSIT2.PDF * AML: N:\ARCPRJ2\010004\AML\RAR\RAR-RCH-DEPOSIT.AML



UPPER ARKANSAS RIVER BASIN

RESTORATION ALTERNATIVES REPORT

FIGURE 3-3
MINE-WASTE DEPOSIT
LOCATIONS
LAKE FORK
TO HWY 24 BRIDGE
(REACH 2)

PROJECT: 010004.4	DATE: JAN 08, 2004	
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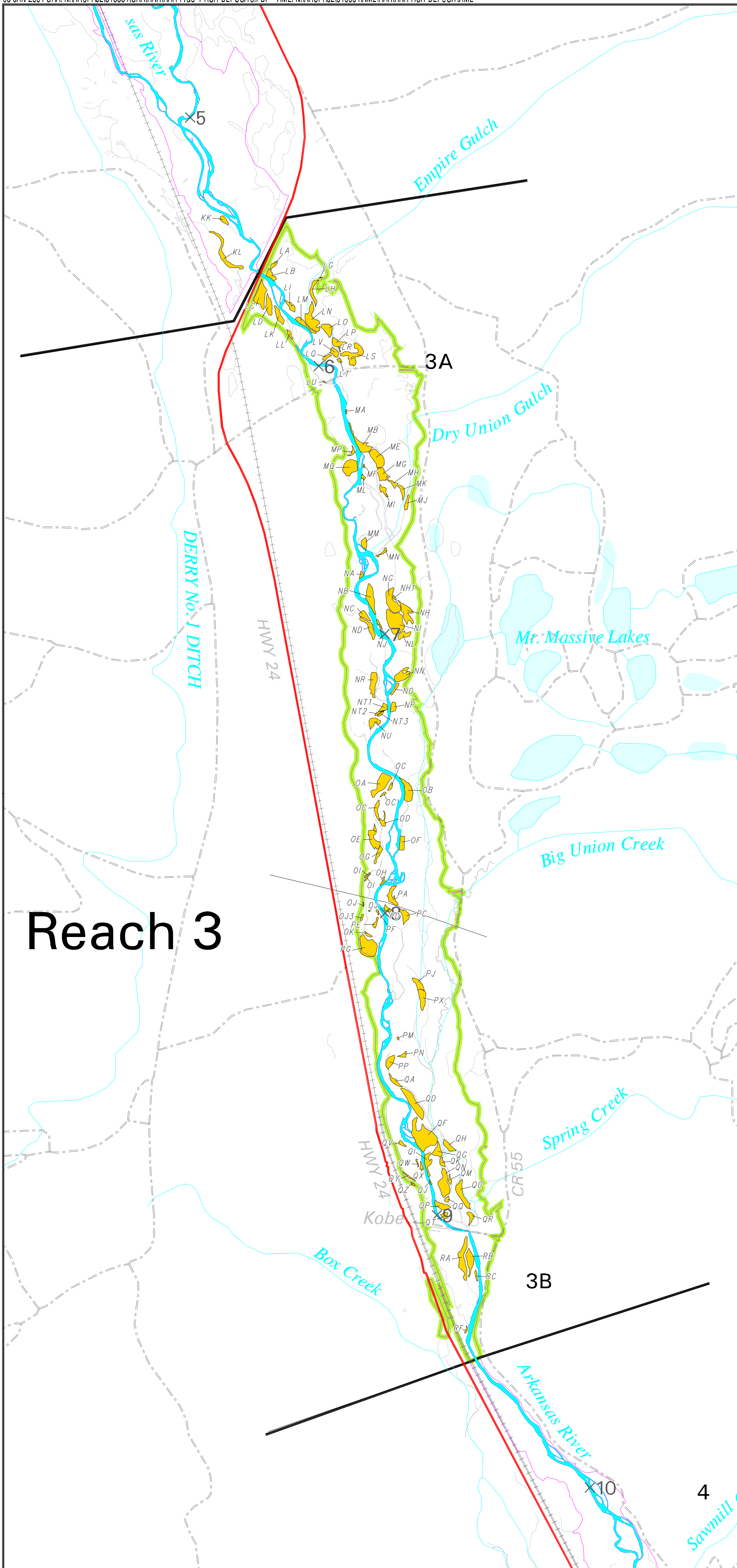
08-JAN-2004 GRA: N:\ARCPRJ2\010004\GRA\RAR\RAR-FIG3-4-RCH-DEPOSIT3.PDF * AML: N:\ARCPRJ2\010004\AML\RAR\RAR-RCH-DEPOSIT.AML



EXPLANATION

Hydrology

River or Stream

Lake or Open Water

500- Year Floodplain

Reach 3

× 1 River Mile (from confluence with California Gulch)

Transportation

Minor Road

Medium Duty Road

Highway

Railroad

Other Features

Mine- Waste Deposit

Reach Boundary

Subreach Boundary

SCALE IN FEET

1500 0 1500

UPPER ARKANSAS RIVER BASIN

RESTORATION ALTERNATIVES REPORT

FIGURE 3-4
MINE-WASTE DEPOSIT LOCATIONS
HWY 24 BRIDGE TO NARROWS BELOW KOBE
(REACH 3)

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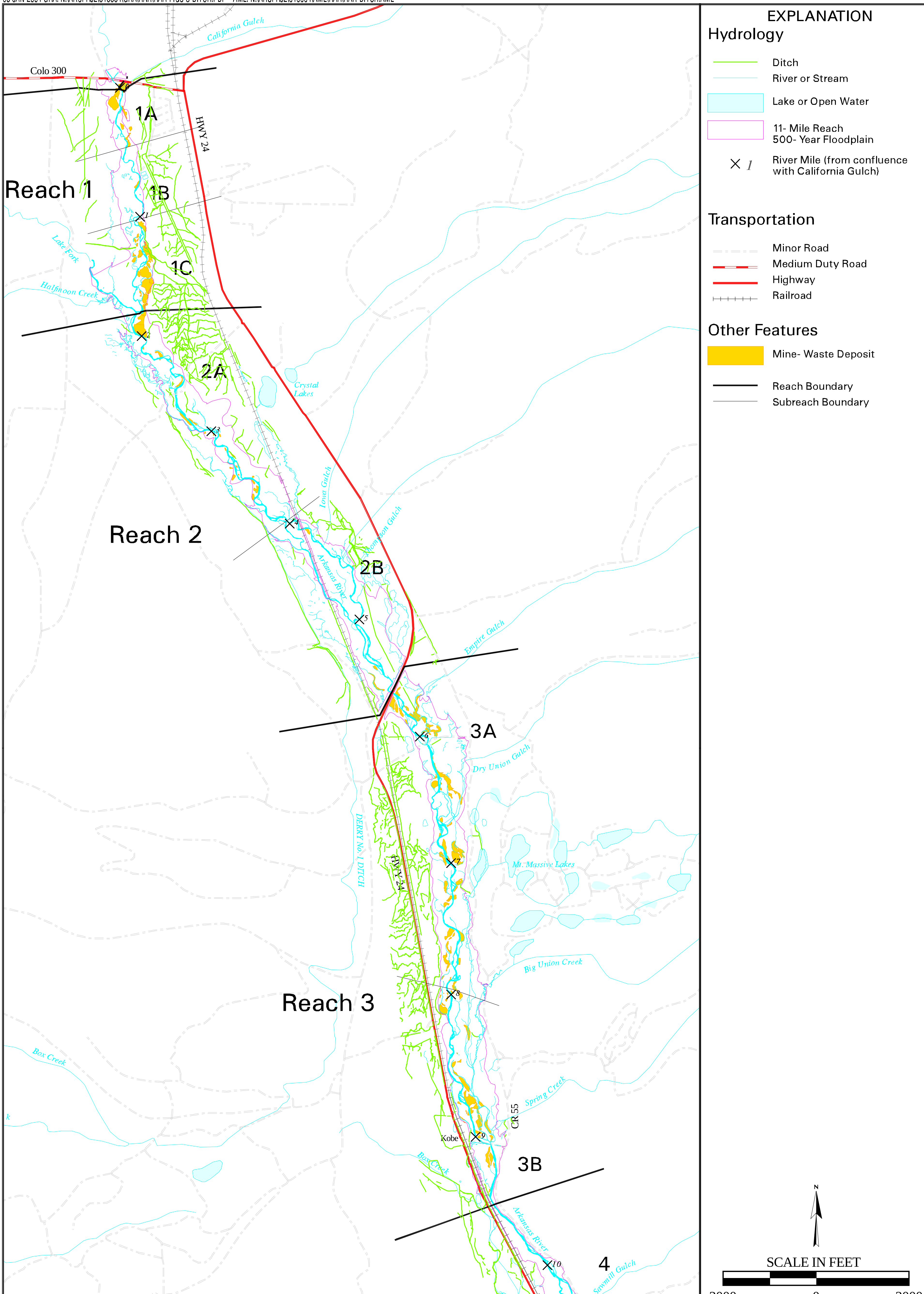
08-JAN-2004 GRA: N:\ARCPRJ2\010004\GRA\RAR\RAR-FIG3-5-DITCH.PDF * AML: N:\ARCPRJ2\010004\AML\RAR\RAR-DITCH.AML



UPPER ARKANSAS RIVER BASIN

RESTORATION ALTERNATIVES REPORT

FIGURE 3-5
IRRIGATION AND DRAINAGE DITCHES IN THE 11-MILE REACH AND VICINITY

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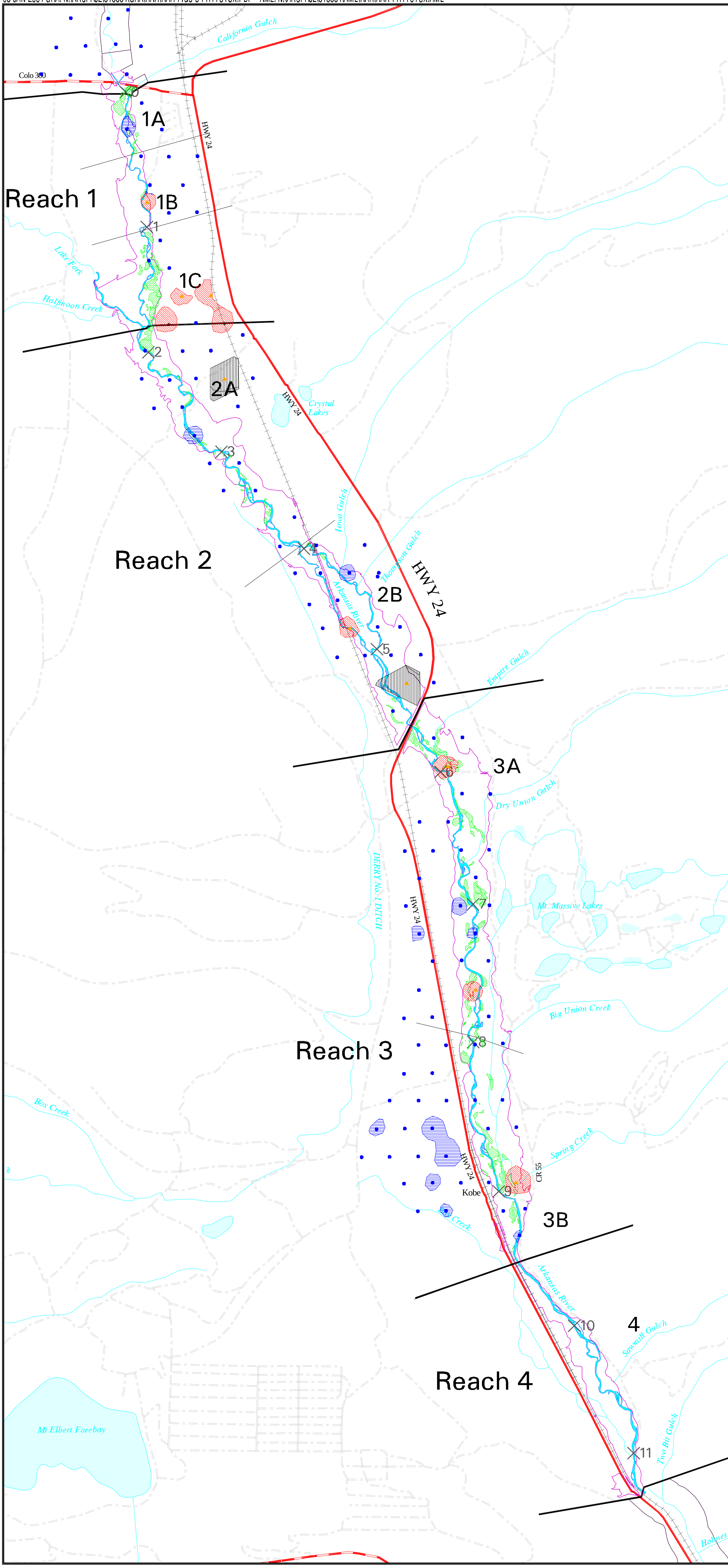
08-JAN-2004 GRA: N:\ARCPRJ2\010004\GRA\RAR\RAR-FIG3-6-PHYTOTOX.PDF * AML: N:\ARCPRJ2\010004\AML\RAR\RAR-PHYTOTOX.AML



EXPLANATION

Hydrology

- River or Stream
- Lake or Open Water
- 11- Mile Reach 500- Year Floodplain
- River Mile (from confluence with California Gulch)

Transportation

- Minor Road
- Medium Duty Road
- Highway
- Railroad

Other Features

- Predicted area of high phytotoxicity and HQ>1 (67.6 Ac)
- Predicted area of high phytotoxicity and HQ<=1 (59.4 Ac)
- Predicted area of HQ>1 and not high phytotoxicity (44.0 Ac)
- HQ <= 1
- HQ 2 to 4
- HQ > 5
- Mine-Waste Deposit
- Reach Boundary
- Subreach Boundary

NOTES:
Predicted phytotoxicity and HQ data from: "Ecological Risk Assessment for the Terrestrial Ecosystem, California Gulch NPL Site, Leadville, Colorado. July 2003

Acreages are exclusive of Mine Waste Deposits

N

SCALE IN FEET
3000 0 3000

UPPER ARKANSAS RIVER BASIN
RESTORATION ALTERNATIVES REPORT

FIGURE 3-6

MAP OF PREDICTED PATTERN OF PHYTOTOXICITY (ADAPTED FROM USEPA, 2003b)

PROJECT: 010004.4	DATE: JAN 08, 2004
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4.0 IDENTIFICATION AND SCREENING OF RESTORATION APPROACHES

The identification of restoration approaches is intentionally limited to primary restoration of the impaired resources of the 11-Mile Reach (i.e., physical actions to improve conditions within the boundaries of the 11-Mile Reach). Approaches that potentially involve actions outside of the 11-Mile Reach, such as acquisition or replacement, have not been considered. The information on primary restoration alternatives, including relative costs, presented in the RAR could be used as a basis for evaluating those alternative approaches. However, acquisition or replacement alternatives are best considered jointly by the MOUP and various stakeholders of the UARB. Approaches for restoration of resources within the 11-Mile Reach have been identified by the Resource Categories presented in Section 3. The Resource Catagories with identified restoration needs include:

- Fluvial Mine-Waste Deposits;
- Agricultural/Floodplain Lands;
- Channel Morphology/In-Stream Habitat; and
- Riparian Areas.

A hierarchical approach was utilized for the identification of specific types of actions to be considered for restoration alternatives development. For each Resource Category identified as needing restoration, General Response Actions were selected for consideration. General Response Actions reflect a broad category of restoration measures that should be considered (e.g., Institutional Controls). For a given General Response Action, Restoration Technology options were identified for consideration. Restoration Technologies identify the types of technical approaches available for a given Response Action Category. For example, for the Riparian Areas, General Response Action of Streambank Restoration, the Restoration Technology of Bioengineering/Soft Treatments was identified. For each Restoration Technology, a list of specific Process Options was then identified for screening. Process Options are the specific restoration actions that apply to a Restoration Technology (e.g., fencing is a Process Option for the Grazing Control Restoration Technology).

The restoration needs categories of Riparian Areas and Channel Morphology/In-Stream Habitat are closely related and thus contain Technologies that are applicable to both categories. In particular, Streambank Stabilization Technologies provide benefits specific to Riparian Areas as well as Channel Morphology/In-Stream Habitat. However, this overlap is appropriate at the screening level to assure that an acceptable set of actions is identified, to address the varying conditions along the 11-Mile Reach.

The range of Process Options for each Resource Category has been identified utilizing the following sources:

- Feasibility Studies or comparable reports for individual OUs within the California Gulch Superfund Site: OU4-Upper California Gulch (Shepard Miller, Inc. [SMI]/Terra Matrix 1998); OU5-Smelter Sites (MFG 2000b); OU6-Stray Horse Gulch (HDR 2002); OU7-Apache Tailings Impoundments (MFG 2000a); OU8-Lower California Gulch (SMI/Terra Matrix 1997b); and OU-10 Oregon Gulch Tailing Impoundment (SMI/Terra Matrix 1997a);

- Final Screening Feasibility Study for Remediation Alternatives at the California Gulch Superfund Site (USEPA 1993b);

- EPA START, Draft Alternatives Analysis for the Year 2000 UAR Fluvial Tailings TDD No 9702-0025 (URS 1999);

- Effects of Remediation on Geochemistry and Hydrology of the Unsaturated Area of Fluvial Tailings Deposits in the Floodplain of the Upper Arkansas River, Colorado (Walton-Day et al. 2000);

- Identifying sites for riparian wetland restoration: Application of a Model to the Upper Arkansas River Basin (O'Neill et al. 1997);

- December 13, 2001 Memo [including Attachments A through E] to the CT from Colorado Division of Natural Resources re: Restoration Alternatives;

- Memos from Resurrection and ASARCO re: Restoration Alternatives; and

- Experience of the CT at numerous other mining sites including:

  - The Bunker Hill Superfund Site in Kellogg, ID;
  - The Clark Fork Superfund Site in Butte/Anaconda, MT;
  - The Eagle Mine Superfund Site in Minturn, CO;
  - The Summitville Mine Superfund Site in Sumittville, CO;
  - The Jasper County Superfund Site in Jasper, MI;
  - The Idarado Mine Site in Telluride and Ouray, CO;
  - The Coeur d' Alene Basin Superfund Site in northern ID; and
  - The Las Animas Basin in Silverton, CO.

4.1 OTHER CONSIDERATIONS

Although not identified as a General Response Action for screening, improved management of flows in the Arkansas River was identified as an applicable action that on its own could improve bank stability and the quality of in-stream fish habitat. Certain augmented flow conditions (i.e., above optimal bankfull conditions, rapid drawdown) have led to significant changes in bank stability and channel morphology and have seasonally reduced the quality and availability of in-stream habitat. It is beyond the scope of the RAR to develop an array of flow management options for screening and inclusion in restoration alternatives. Broad analyses of flow management have been conducted in the past (Smith & Hill 1999) that shed some light on the complexities of this issue. However, it has been noted by the CT and others (InterFluve 1999) that the success of many of the identified Technologies for improving the riparian area, channel stability and in-stream habitat are also dependent upon future management of flows.

Implementation of a flow management plan that strives to achieve optimal flows based on attaining a stable channel form will effectively improve in-stream habitat. A stable channel will lead to increased overhanging vegetation and shade, improved riffle and pool habitat through more effective scouring and active sediment transport, and improved survival and recruitment by providing optimal flows during critical life-stages. The effectiveness of flow management is dependent upon the flexibility that is available to water regulators to consistently meet optimal flows necessary to facilitate natural channel recovery. This will require the identification of optimal channel bankfull discharge and sufficient frequency and duration of channel forming flows. In addition, although recently improved, optimal increases and decreases in flow (i.e. ramping rates) need to be identified and implemented to maintain channel stability.

Legal and political concerns and physical capabilities may preclude full implementation of a flow management plan. There are multiple up- and downstream water users and regulators that influence river flow along the 11-Mile Reach. The needs and desires for water may or may not coincide with flows that are optimal for a stable channel form and the brown trout fishery. The current primary source of flow augmentation that affects the 11-Mile Reach is from Turquoise Reservoir through Lake Fork. Because of physical limitations that affect storage capacity, a flow-management plan that is optimal for the fishery may not be possible. However, over the long-term, strategic flow management could provide a substantial benefit to channel stability and riparian area recovery, as well as influencing the success of any constructed improvements.

General Response Actions have not been included for improving water quality in the UARB. As discussed in Chapter 3, the primary impacts to water quality originate within the California Gulch

Superfund Site. Substantial improvements in water quality would currently provide the largest benefit to the aquatic biota within the 11-Mile Reach, including the brown trout fishery. A variety of source control measures are currently being implemented to reduce surface water metals loading within California Gulch. It is expected that, over time, these actions will result in further improvements in water quality in the UARB. It would not be appropriate to consider surface water quality restoration measures until the California Gulch remedies have been fully implemented and adequate time has been allowed for those remedies to be fully effective.

4.2 SCREENING

Drawing upon the identification of Resource Categories for restoration, and the development of corresponding General Response Actions, the list of Restoration Technologies was broken down into specific Process Options that were then identified for screening.

A qualitative screening of the appropriateness of each restoration alternative was based upon a blend of USEPAs EECA and the DOIs Restoration Planning Process. The following criteria were considered for screening of each Process Option:

- Implementability/Applicability to Site Conditions;
- Effectiveness/Applicability to Restoration Objectives; and
- Cost.

The implementability of a Process Option was considered to encompass both the technical and administrative feasibility of implementing an action, the ability to handle the estimated areas and volumes of media, and how proven and reliable the action is with respect to conditions at the site.

The effectiveness of a process option was evaluated based upon the ability to meet the goals and objectives of the restoration alternative, potential impacts to human health and the environment during construction, and how proven and reliable the action is over the long-term with respect to the site conditions.

The cost of a Process Option was based on actual costs in other areas, standard estimating references and engineering judgment. Costs are evaluated as to whether costs for a specific Process Option are high, medium or low relative to other Process Options in that Restoration Technology category. During the initial screening, cost was considered to be relative capital cost and operation and maintenance costs. When two or more Process Options provided the same or similar levels of expected benefits, cost effectiveness was considered to be a distinguishing factor and the least costly alternative noted.

4.2.1 FLUVIAL MINE-WASTE DEPOSITS

Several General Response Actions, Restoration Technologies and Process Options were identified for screening-level evaluation (Table 4-1) for fluvial mine-waste deposits. The implementability, effectiveness and cost of these Process Options varied depending upon location, setting and priority of a given deposit. The following discussion provides a summary of the relevant screening considerations. Where appropriate, the Technologies/Process Options relationship to the different priorities (high, moderate and low) of fluvial mine-waste deposits is discussed.

4.2.1.1 INSTITUTIONAL CONTROLS

Institutional controls are measures that limit exposure by restricting access to, usage of, or activity in areas with residual contamination. The institutional control considered as a Restoration Technology for fluvial mine-waste deposits is Access Control. Fencing to restrict cattle access to fluvial mine-waste deposits is the screened Process Option.

Access Control

Fences to Restrict Cattle Access - Fences are an easily implementable and low cost restoration measure, if access from the property owner can be obtained. Fences could be multi-strand barbed wire or electric. However, land access and long-term maintenance requirements limit the implementability of small segments of fencing to restrict cattle access to the individual fluvial mine-waste deposits as a remedy.

Using small segments of fencing as an institutional control to restrict cattle access to the fluvial mine-waste deposits does not effectively provide long-term protection of deposits from the potentially erosive effects of intensive grazing, protection of vegetation or a reduction in direct exposure to cattle. The durability of fences in this environment without maintenance is an important consideration. Fences for fluvial mine-waste deposits would be most effective as a temporary measure following restoration activities.

Fencing fluvial mine-waste deposits to restrict cattle access is not retained as a Process Option, except as a temporary measure. Continuous fencing may be appropriate for other settings, such as riparian areas. However, fencing of fluvial mine-waste deposits offers no benefits as a stand-alone action and is not applicable to situations where causes other than cattle are limiting vegetative cover.

4.2.1.2 CONTAINMENT/ENGINEERING CONTROLS

Containment/Engineering Controls are measures that limit exposure by preventing direct contact. The types of controls considered as Restoration Technologies to be screened for fluvial mine-waste deposits are Cover/Barrier Placement and Surface Water Controls.

Cover/Barrier Placement

The cover/barrier placement Process Options considered during the screening analysis are a Simple Soil Cover and a Multi-Layer Cover.

Simple Soil Cover and Revegetation - A simple soil cover was identified as being an applicable Process Option for fluvial mine-waste deposits. Soil covers have been used as a remedy for mine-wastes at many sites around the country, including California Gulch. The primary implementability concern for soil covers relates to the availability of local suitable capping material (e.g., topsoil), because availability of topsoil in the UARB is limited. Import of topsoil greatly reduces the cost effectiveness. However, local alternative sources, such as pond sediment from Mt. Massive Lakes (Mt. Massive Lakes Community Development is located approximately 6 miles south of Leadville, along Highway 24), would greatly increase implementability, especially in Reach 3 where transport distances are minimal. Access should pose limited implementability concerns, as most deposits could be accessed with conventional construction equipment.

Soil covers are effective at eliminating direct exposure and with grading and vegetation they can reduce infiltration and subsequent leaching. At thicknesses of 6 inches or greater, the barriers prove to be adequate for most shallow rooted vegetation. Limitations on effectiveness are related to the types of vegetation to be restored and future land use. If deep-rooted vegetation is to be restored, a thicker soil cover may be required to address the potential for phytotoxicity and metals transfer to vegetation. This effectiveness issue could in part be addressed with the addition of metals-stabilizing amendments (e.g., lime) to the fluvial mine-waste deposits, prior to placement of a soil cover. This would be especially important for deposits containing the highest metal concentrations and lower pH values, such as the high priority deposits.

Durability of soil covers is also an effectiveness concern. Most fluvial mine-waste deposits are located in settings where grazing or other agricultural activities could occur. A thicker soil cover (e.g., 12 inches) may be required to provide long-term durability in these areas. Soil covers alone generally would not be as effective for fluvial mine-waste deposits potentially subject to erosion (i.e., stream-side deposits); however, establishment of woody vegetation would reduce this concern.

Overall, simple soil covers are retained for consideration during restoration alternative development. Direct application would be most effective for low and moderate priority deposits. Amendment of low pH (high priority) deposits may be required in conjunction with soil covers to improve effectiveness.

Multi-Layer Cover - A multi-layer cover was identified as being an applicable Process Option for fluvial mine-waste deposits. Multi-layer covers consist of layers of material with different properties. Typically, at mining sites, a low permeability material, such as a geotextile or geofabric or clay, is covered directly with topsoil or a suitable growth medium and revegetated. Depending upon conditions, designs may also include intermediate layers, such as a gravel blanket for drainage. Using multi-layer covers is technically implementable, however, ease of implementation decreases as the number of small isolated deposits increases. Additionally, multi-layer covers may not be applicable to site conditions, as additional infiltration control is not necessary and the relative cost is high. Multi-layer covers would be most appropriate for consolidated fluvial mine-waste deposits/repositories.

Multi-layer covers have been used as a remedy for mine-waste repositories at many sites around the country (e.g., Bunker Hill Superfund Site). Multi-layer covers can be effective in preventing erosion of and direct contact to mine wastes and are also effective in reducing infiltration. The root depth of vegetation used for multi-layer covers should not exceed the growth medium depth of the multi-layer cover.

As a Process Option, the multi-layer cover will not be retained because in this setting the effectiveness would be similar to the simple soil cover Process Option, but at a higher cost. The multi-layer cover may be considered for repository design.

Surface Water Controls

Surface water controls are a Restoration Technology identified to reduce the potential for erosion of and infiltration through fluvial mine-waste deposits. As the fluvial mine-waste deposits are within the relatively flat UARB floodplain between valley terraces, the primary concerns for erosion are related to overbank flows. Overbank flows within the UAR are usually associated with spring runoff during years of well above average snowpack. Flow in overbank areas is of limited velocity and does not present significant erosion potential. The surface water control Process Option considered during the screening analysis is diversion ditches (run-on control).

Diversion Ditches (Run-On Control) - Diversion ditches are readily constructed with conventional equipment and are relatively low cost. However, the flat grades and the lateral extent of some of the deposits may limit the applicability of diversion ditches to the site. The large number of small individual deposits further limits implementability.

Diversion ditches are potentially effective in reducing direct contact with stormwater from upgradient areas. However, the actual effectiveness of diversion ditches at the site is likely to be low, due to the relatively flat grades of the deposits. Run-on is not a significant exposure pathway.

Diversion ditches to provide run-on control for fluvial mine-waste deposits is not a Process Option that will be retained for this site. Surface water management technologies are most appropriately considered in conjunction with the design process for other engineering options (e.g., soil covers).

4.2.1.3 IN-SITU STABILIZATION

Long-term in-situ or “in place” physical stabilization of fluvial mine-waste deposits is best achieved through the development of a healthy, low maintenance vegetation that meets the objectives for acceptable habitat/forage. Because the discrete fluvial mine-waste deposits cover a relatively small portion of the floodplain, exposure related to plant consumption by deer and elk is not a primary concern.

Vegetation

Direct Revegetation with Metals Tolerant Species - Direct revegetation is technically implementable for all priorities of deposits. The process of direct revegetation would include light tilling of the soil and the addition of a planting mixture and mulch. The planting mixture used would correspond to the intended land use and surrounding areas.

An important effectiveness consideration for direct revegetation is plant-available moisture. USEPA has identified plant-available moisture as a controlling factor in revegetation efforts (Personal Communication with Jan Christner, URS Greiner). Mulch would be added to help retain moisture.

Direct revegetation of the fluvial mine-waste deposits is a Process Option that has limited effectiveness for high metals and low pH deposits, because of the limited tolerance of vegetation to those soil conditions, and because of exposure concerns for livestock from metals transferred to vegetation.

The cost of direct revegetation is low. Direct revegetation as a stand-alone Process Option is retained only for the low priority mine-waste deposits.

Lime Addition, Deep Tilling and Direct Revegetation –The combination of lime addition, deep tilling and direct revegetation is technically implementable for all priorities of fluvial mine-waste deposits. Lime would be added to the deposits and tilled to a depth of 18-inches and the direct revegetation process would include the addition of a planting mixture and mulch. The planting mixture used would correspond to the intended land use and surrounding areas. Mulch would be added to help retain moisture.

The combination of lime addition, deep tilling and direct revegetation would be most effective for low priority deposits. The lack of organic matter may limit the effectiveness for moderate and high priority deposits, however it would be more effective in conjunction with a soil cover and/or organic amendments. Because the average depth of most deposits is less than 12-inches, deep tilling to a depth of 18-inches is expected to result in a reduction of the surficial metals concentration.

The cost of this combination is low to medium. Lime addition, deep tilling and direct revegetation will be retained as a Process Option for the low priority deposits.

Revegetation with Organic (biosolids) and Lime Amendments - Revegetation with the addition of organic matter and lime amendments is technically implementable for all priorities of deposits. The rate of biosolids and lime application can be matched with the conditions of a specific fluvial mine-waste deposit, based on its priority (i.e., high, moderate or low priority). However, the implementability of this combination for near bank deposits is reduced because non-composted biosolids cannot be used within 10 feet of the river channel.

Revegetation with organic and lime amendments offers restoration of vegetation and potential for reduction of metals transfer. Although listed under stabilization technologies, USEPA (2002b) has noted some treatment benefits related to reduced bioavailability of metals. In addition, because the average depth of most deposits is 12-inches or less, deep tilling to a depth of 18-inches is expected to result in reduced surficial metals concentrations.

The cost of this combination can be high depending upon the source of biosolids. Revegetation with organics and lime amendments will be retained as a Process Option.

Lime Addition, Deep Tilling, Soil Cover and Revegetation - The combination of lime addition, deep tilling, soil cover and revegetation has a high level of implementability where a soil source is readily available, and offers the greatest flexibility for restoration of vegetation and potential for reduction of metals transfer. The haul distance required will most likely be the most significant cost influence. For this site, the availability of stockpiled pond sediment from Mt. Massive Lakes may provide a high implementability for Reach 3.

The effectiveness of this proven option is achieved through neutralization of low pH deposits and a corresponding reduction in metals availability. Liming of the riparian mine-waste deposits and integration of the lime through the deposit profile by deep tilling, addresses metals mobility/pH concerns for high priority deposits. The soil cover provides the organic matter and rooting zone needed for most plant species. Placement of the soil cover provides long-term durability and allows for a wide range of vegetation/habitat to be developed. Vegetation can be matched to adjacent areas, restoring full use of the area.

The cost of this combination is medium to high depending upon the source of cover soil. The combination of lime addition, deep tilling, soil cover and revegetation will be retained as a Process Option.

4.2.1.4 REMOVAL/REPLACEMENT

This General Response Action involves the removal of mine waste and replacement to grade with soil, or suitable growth medium. The primary distinction for Removal/Replacement Process Options is the fate of the excavated material.

Excavate & Truck Hauling with Replacement of Soils and Vegetation

<u>Consolidate with Other Deposits Within a Reach (Multiple Small Repositories)</u> - Consolidated removal is technically implementable, however, if a repository cannot be located outside the floodplain, floodplain considerations of final grade of consolidated deposits may limit applicability. For each reach, a suitable location for a repository would have to be identified. The repository location would ideally be outside the 500-year floodplain and away from any tributary drainage. The ability to acquire private lands for this purpose may limit implementability. In addition, consolidated materials may require some level of amendments, such as a simple soil cover with revegetation, to provide an adequate reduction in infiltration and the necessary durability for long-term protection. Multiple repositories also increase maintenance efforts.

Removal of fluvial mine-waste deposits with nearby consolidation outside of the floodplain adjacent to a reach is effective at limiting potential exposure routes, and with soil backfill as necessary, it offers the ability to restore appropriate vegetation/habitat. Removal with nearby consolidation greatly reduces the footprint of mine waste and correspondingly the potential for future transport/erosion of metals from the fluvial mine-waste deposits. The effectiveness of this Process Option is greatest for high priority deposits with diminishing applicability for deposits that have both lower metals concentrations and lower potential for erosion in the future.

The relative cost for removal of fluvial mine-waste deposits with nearby consolidation within each reach is medium to high. This Process Option will be retained for further consideration.

<u>On-Site Single Repository (within the 11-Mile Reach) -</u> The ability to acquire suitable property for a single on-site repository within the 11-Mile Reach greatly influences the implementability of this Process Option. The cost for hauling mine waste to a single repository would be substantially larger than for multiple repositories. Long-term operation and maintenance (O&M), however, would be more straightforward than for multiple repositories.

Removal and consolidation of fluvial mine-waste deposits with transport to an on-site (within the 11-Mile Reach) repository is effective at eliminating all potential exposure routes, and with soil backfill it offers the ability to restore appropriate vegetation/habitat. Removal and consolidation of individual fluvial mine-waste deposits with transport to a single on-site repository eliminates the potential for future transport/erosion of metals within the fluvial mine-waste deposits. The applicability of this Process Option is highest for high priority deposits with diminishing applicability for deposits that have lower metals concentrations and lower potential for erosion.

The relative cost for removal of consolidated fluvial mine-waste deposits with transport to an on-site (within the 11-Mile Reach) repository is medium to high. This Process Option will be retained for further consideration.

California Gulch NPL Site Repository - A site-wide repository location is being established for the Superfund site at the Black Cloud Mine tailings impoundment, and is assumed to be of adequate capacity. Using this repository is technically implementable and applicable to site conditions.

Removal of consolidated fluvial mine-waste deposits with transport to a repository within the California Gulch NPL Site is effective at eliminating all potential exposure routes, and with soil backfill it offers the ability to restore appropriate vegetation/habitat. Consolidated removal eliminates the potential for future transport/erosion of metals within the fluvial mine-waste deposits. The applicability of this Process Option is highest for high priority deposits with diminishing relative applicability for deposits that have lower metals concentrations and lower potential for erosion.

Closure and O&M costs would be proportional to the total volume of material and would therefore be less than a single repository or multiple new repositories. This Process Option is most cost effective for deposits within the upper reaches, as increasing haul distance increases costs.

The relative cost for removal of consolidated fluvial mine-waste deposits with transport to a repository within the California Gulch NPL Site is low to medium. This Process Option will be retained for further consideration.

Distant Off-Site Repository - Removal of consolidated fluvial mine-waste deposits with transport to a distant off-site repository is technically implementable and applicable to site conditions.

The applicability of this process option is highest for high priority deposits with diminishing applicability for deposits that have lower metals concentrations and lower potential for erosion.

Removal of consolidated fluvial mine-waste deposits with transport to a distant off-site repository is effective at eliminating all potential exposure routes, and with soil backfill, it offers the ability to restore appropriate vegetation/habitat. Consolidated removal eliminates the potential for future transport/erosion of metals within the fluvial mine-waste deposits.

The relative cost for removal of consolidated fluvial mine-waste deposits with transport to a distant off-site repository is very high. The haul costs are prohibitive and therefore, this process option will not be retained.

4.2.1.5 TREATMENT

Chemical and biological treatment technologies have been considered for numerous mining sites across the country. Other than the addition of lime, these technologies have not proven to be both effective and implementable. Also, there are several limitations for these technologies when considered for in-situ application in a floodplain setting.

Chemical

Alkali Addition (lime) - Alkali addition is readily implementable depending upon the depth of deposits and the required depth of incorporation.

One-time application of relatively large quantities of lime may be required to produce long-term effectiveness for the most acidic deposits. The chemical treatment of alkali addition (lime) may be effective at raising soil pH and reducing metals availability, but this alone may not meet restoration objectives. Addition of lime may reduce the formation of highly soluble metal-rich salts and buffer acid generation resulting from water contact with the deposits. Alkali addition is effective and appropriate as a soil amendment for vegetation restoration activities.

The relative cost of alkali addition is medium. Alkali addition is not retained as a stand-alone treatment Process Option for the fluvial mine-waste deposits.

Passivation/Micro-Encapsulation - The long-term effectiveness of coating the surface of deposits with reactive minerals (e.g., phosphate) is questionable for highly mineralized low pH mine-waste deposits. Depending upon the depth of the mine-waste deposit, the thorough degree of mixing necessary to promote encapsulation may be difficult to achieve. The relative cost of this Process Option is high.

The passivation/micro-encapsulation process option is not being retained for in-situ application to fluvial mine-waste deposits.

Chemical Addition to Enhance Precipitation/Adsorption - There is no proven effectiveness of using chemical addition to enhance precipitation/adsorption for conditions consistent with the environmental setting of the fluvial deposits within the 11-Mile Reach (e.g., wet dry cycles in conjunction with extreme temperature swings). The implementability and relative cost of this Process Option for a floodplain setting is unknown. Chemical addition to enhance precipitation/adsorption is not retained as a Process Option.

Biological

Bio-Mineralization (in-situ sulfate reduction; insoluable sulfide precipitation) - There is no proven effectiveness of using bio-mineralization for conditions consistent with the setting of the fluvial deposits. This technology has only been proven in relatively stable environments (e.g., wet closure of tailings impoundments) and/or where an organic carbon source is readily and consistently available. The implementability and relative cost of this option for a floodplain setting is unknown. Bio-mineralization is not retained as a Process Option.

Bactericides (sodium laurel sulfate) - There is no proven effectiveness of using bactericides for restoration of conditions consistent with the environmental setting of the fluvial deposits. Examples of successful large-scale in-situ application were not identified. Therefore, the implementability and relative cost is unknown. Use of bactericides is not retained as a Process Option.

Phytoremediation - There is no proven effectiveness of using phytoremediation for restoration of tailings deposits. Also, it is likely that this technology would meet restoration objectives in a timeframe similar to natural recovery. This Process Option would require the harvest and disposal of high metal content vegetation and land-use would have to be restricted for grazing until replanting with low metals uptake species occurs. Overall, the implementability of this Process Option is low and the relative cost is unknown. Phytoremediation is not retained as a Process Option.

4.2.2 AGRICULTURAL/FLOODPLAIN LANDS

Several General Response Actions, Restoration Technologies and Process Options were identified for screening-level evaluation for Agricultural/Floodplain Lands (Table 4-2). The applicability, implementability and effectiveness of these Technologies vary depending upon location, setting and land ownership.

4.2.2.1 INSTITUTIONAL CONTROLS

Institutional controls are measures that limit exposure by restricting activity, use and access to areas with residual contamination. This institutional control considered as a Restoration Technology for fluvial mine-waste deposits is Agricultural Best Management Practices (BMPs). Seeding with metal tolerant/low uptake species, nutritional supplements, grazing rotation and irrigation management are the screened Process Options.

Agricultural BMPs

Seed with Metals Tolerant/Low Uptake Species - This Process Option entails seeding agricultural lands with metals tolerant species that would also have the characteristic of low accumulation of metals in above ground plant parts. These species may be effective in increasing plant cover and making these sites more productive. The implementation of this Process Option would require some tillage to prepare a seedbed and reduce the abundance of existing species that may not be productive under current soil conditions or may accumulate metals at concentrations that could be problematic for livestock.

However, the species that would be used for this Process Option may not have high forage value and therefore may not meet the restoration objectives for these lands. The effectiveness of this Process Option is questionable depending upon the landowner's preference and planned land use. This Process Option may be more implementable on non-private land where livestock use is not a designated land use or may not be a high priority. Seeding with metals tolerant/low uptake species is retained for site-specific consideration.

Nutritional Supplements - The logic behind this Process Option is to supplement livestock with minerals, such as Zn, with salt blocks. The increase in dietary Zn could offset the potential toxicity effects associated with elevated cadmium in forage (Church 1988). This approach is commonly used on rangelands where mineral deficiencies occur among cattle or horses when forages are low in certain elements (Holechek et al. 1998).

This is an effective Process Option in areas where mineral deficiencies occur or where the problem is limited to one element. However, its effectiveness in this setting is unknown. The probability of effectively implementing this strategy in an area where the problem is an excess of certain elements (e.g. Cd and Zn) is low. The agricultural lands have elevated Zn and Cd. Elevated Zn can bring about a Cu deficiency in some livestock. Zn can also work in a positive way by reducing the toxicity effect of Cd. Because of these complex interactions this Process Option is not retained for further consideration.

Grazing Rotation - The implementation of a grazing management plan that will rotate livestock through pastures at stocking rates that will not over utilize the forage and will be timed in a way to allow adequate regrowth will increase forage production and plant cover. Proper grazing management limits the amount of forage that is used at any one point in time, uses forage during times when adequate carbohydrate reserves are available for regrowth, and uses forage at the end of the growing season when plants are ready to senesce. Properly grazed vegetation will be more productive and the higher production may lead to lower metal concentrations. In addition, if livestock can be rotated among pastures with different metal concentrations in the soil and vegetation, it may be possible to reduce the overall uptake of metals by livestock and reduce the potential for any toxicity problems. This option is easily implementable provided the landowner agrees, and has the potential to be effective with the long-term commitment of the land manager.

The short and long-term effectiveness of this option will be dependent upon landowners and their willingness to implement and maintain a system of rotating animals through a series of pastures. There would be cost associated with fencing and with moving animals at designated times of the year. Properly implemented grazing systems are highly effective in improving and maintaining healthy plant communities and have good potential to reduce metal concentrations in forage and therefore in the animal's diet.

Because of the uncertainty of voluntary implementation by the landowner, this Process Option is not retained for further consideration.

Irrigation Management - Once an option is implemented to improve forage quality and production, it will be important that any future irrigation be done with water of adequate quality such that substantial metals loads are not re-introduced into the system. Water quality has improved in the UAR and this should continue over time, thus making this management practice readily implementable. Management would involve the rate and timing of irrigation water application. This process is currently managed by landowners and would require some additional effort. Head gates would need to be closed during exceptional periods of runoff from the California Gulch Superfund Site (e.g., when restoration activities are occurring upstream that could result in an increase of metals bearing sediment). Correspondingly, this Process Option is retained for consideration for downstream areas during the periods of active upstream restoration construction.

4.2.2.2 SOIL MIXING

Plowing

Deep Tilling - This option would require plowing to a depth of about 12 inches to remove the existing vegetation and mixing the soil to reduce metal concentrations in those areas where surface soils have elevated metal concentrations. Seeding with native and/or introduced species that would meet the land use objectives of livestock grazing would then follow plowing. This approach of soil mixing to reduce metal concentrations through the process of dilution has been used at other Superfund sites (e.g. Anaconda) and is highly effective where the concentration of metals is in the upper 6 inches. It will be effective in sites dominated by herbaceous vegetation, but is less effective in areas dominated by woody vegetation.

This option is more implementable on grassland sites. Sites that are dominated by shrubs (for example in riparian corridors) would be difficult to plow. However, it is possible to treat these areas with an implement that would mulch the vegetation in place and then plow the site after the shrubs have been turned to mulch. This Process Option is retained for further consideration.

4.2.2.3 IN-SITU STABILIZATION

Soil Amendments

Application of Lime - The addition of lime to agricultural lands would be used to raise soil pH and immobilize the COCs. The result will be a more productive soil that will support greater plant cover and forage with metal concentrations in normal ranges. This option could be used on soils with a pH below 5.5 and the objective would be to raise the soil pH to 6.5 or 7.0. Within this pH range the metals of concern would become complexed and unavailable for plant uptake. This option would require soil tillage to incorporate the lime into the root area and then reseeding to establish new species that will meet the desired land use.

The option would be highly effective in reducing the bioavailability of metals and re-establishing vegetation that would support livestock use. This option is more implementable on grassland sites. Sites that are dominated by shrubs (for example in riparian corridors) would be difficult to till. It is possible to treat these areas with an implement that would mulch the vegetation in place and then till the site after the shrubs have been turned to mulch to incorporate the lime amendment. This Process Option is retained for further consideration.

Application of Phosphate Rich Amendment (Organic Matter) - Phosphate rich material can be utilized within the agricultural lands to reduce the availability of certain metals in a circumneutral soil pH environment. This option is physically similar to the addition of lime, in that the source of phosphate is applied at a set rate and tilled in. However, the effectiveness of this approach for the COCs is unknown. There is limited information on the long-term effectiveness of this Process Option, and in particular, for a floodplain/irrigated meadows setting. This Process Option is not retained for further consideration.

4.2.3 RIPARIAN AREAS

Several General Response Actions, Restoration Technologies and Process Options were identified for screening-level evaluation of Riparian Areas (Table 4-3). The applicability, implementability and effectiveness of these Technologies vary depending upon location, accessibility, land ownership and engineering controls.

4.2.3.1 INSTITUTIONAL CONTROLS

Institutional controls are measures that limit exposure by restricting activity, use and access to areas with residual contamination. The institutional control considered as a restoration technology for riparian areas is land-use management. Fencing to restrict livestock access, grazing management and conservation leases are the screened Process Options.

Land-Use Management

Fencing to Restrict Livestock Access - The use of fencing (e.g., barbed wire or electric) to restrict livestock access would be an institutional control to keep cattle out of riparian areas where historical grazing has been a primary cause of streambank instability. The implementability of fencing will depend upon cooperation of landowners. Fencing will be more implementable on public lands subject to grazing than on private land.

Fencing to restrict livestock access is a common and effective management practice in riparian areas that are subject to overgrazing. Riparian systems are relatively resilient and recovery will occur once animals are excluded.

The cost of fencing is low. This Process Option is retained for further consideration.

Grazing Management - Rotation and agricultural BMPs would not be effective for limited acreage without physical restrictions. Grazing management for riparian areas is only implementable through fencing. Grazing management is not retained as a stand-alone Process Option for riparian areas.

Conservation Leases - Conservation leases would not be effective as a stand-alone option for riparian areas and are not as effective as fencing. Conservation leases are highly implementable if landowners are willing. The cost of conservation leases on private land is uncertain. Conservation leases are retained as a Process Option for further consideration.

4.2.3.2 STREAMBANK RESTORATION

Streambank restoration involves repairing and stabilizing bank segments that have been, or are being, impacted by erosion, livestock, vehicle crossings or other disturbances. Process Options typically include repair of the bank structure and protection of that bank segment. Protection may range from soft treatments (e.g., root wads) to hardened structures (e.g., rip-rap). Vegetation is typically enhanced in these areas, in conjunction with bank protection, to restore habitat.

Bioengineering/Soft Treatments

There are several Process Options within the Restoration Technology category of bioengineering/soft treatments. Each should have similar applicability, effectiveness and implementability. Costs for portions of a stream segment can range from $15 to $150 per linear foot of channel. The most unpredictable variables influencing costs are a large rock source and hauling costs. The average cost of $35 per linear foot of channel used in developing restoration alternatives was based on experience at other sites and CT confirmation with a local stream restoration contractor (Rick Dornfeld-Intermountain Habitat Restoration, LLC). Screening of the following Process Options will be performed at the Technology level. Design activities will determine the most appropriate Process Option for a specific area and a more specific cost.

Revegetation - Revegetation within the riparian corridor is a common practice to reestablish vegetation in areas that are either void of vegetation or where the plant community needs to be improved. Streambanks must be physically stable before plant establishment from seed will occur. Therefore, revegetation would be most effective when done in combination with soft or hard engineering treatments. Engineering treatments would provide the bank stability necessary for plant establishment to occur. Once vegetation does become established, it will effectively control erosion. Revegetation can occur through reseeding or from willow cuttings. Reseeding would include light tilling of the soil and the addition of mulch. Willow cuttings can be easily obtained from willows native to the area. Establishment success from cuttings is normally effective. The ultimate effectiveness of these treatments will depend on suitable soil conditions for planting, which includes adequate moisture for root development.

Revegetation would be readily implementable on public or private land and should not vary with location along the 11-Mile Reach. Revegetation is retained as a Process Option for further consideration.

Willow Waddling, Anchored logs, Root Wads - Bioengineering soft treatment approaches like willow waddling, anchored logs, and root wads are commonly used to stabilize steep, eroding banks. The Colorado Division of Wildlife (CDOW) lists soft treatment approaches in their River Channel and Trout Habitat Treatments table. According to their table, the expected benefits of soft treatment approaches include reduced bank erosion, increased trout habitat and increased pool and run river habitat (CDOW 2002). Examples of soft treatment approaches include using a single log (cover log), at least 16 inches in diameter, anchored parallel to the base of the eroding streambank at water level. An alternative to this technique is to drive two or three abutment logs at least 4 to 6 feet into the unstable soil of the streambank, and then anchor the cover log parallel. This process can also be repeated with multiple overlapping layers (cribbing). The specific approach selected would be based on the availability of materials.

Implementablility of soft treatments will require access and engineering controls during construction to avoid impacts to the river. This Process Option is retained for further consideration.

Hard Treatments

There are several Process Options within the Restoration Technology category of hard or pure engineering treatments. Each should have similar applicability, effectiveness and implementability. Screening of the following Process Options will be performed at the Technology level. Design activities will determine the most appropriate Process Option for a specific area.

Rock Structures (Vanes, J-Hook, Cross Vanes, Deflector) –There are several rock structure techniques that have successfully been used to reduce channel widening. The CDOW lists rock structures treatment in their River Channel and Trout Habitat Treatments table. According to their table, the expected benefits of rock structure treatments include improvements in the river channel, reduced bank erosion, increased trout habitat and improved river habitat in the upper end of the pools (CDOW 2002). Strategic placement of rock structures (Vanes, J-Hook, Cross Vanes, Deflector) within a reach is a proven effective technique for reducing the development of over-width channels by slowing the bank erosion process by concentrating flow in the middle of the stream, narrowing the flow path and reducing stress to the banks. The appropriate technique or combination of techniques to use depends upon the specific characteristics of the river reach and the desired restoration effects. The implementability of rock structures depends on various factors such as the channel size of the reaches, the vicinity of a quarry or rock supply, the accessibility of the reaches for heavy equipment to place boulders and the seasonal timing of construction (i.e., to avoid impacts to spawning fish and high flow conditions). Rock structures also are an effective technology for enhancing fish habitat (See Section 4.2.4.2).

The cost of rock structures is greatly impacted by the distance of the rock supply. Engineering controls would also be required during construction to avoid impacts to the river. Design and installation must be carefully considered because inappropriate placement of rock structures can drastically alter streamflow and cause bank failure. The Process Option of rock structures is retained for further consideration.

Gabion Riprap and Retaining Walls - Hard treatments like rock gabions and riprap are commonly used for bank stabilization. The specific technique selected would be based on the availability of materials. These approaches should be done in combination with plant establishment to provide a more natural functioning streambank system and to improve the aesthetics of the river. This approach is more expensive than soft treatments but could be appropriate in areas where erosion is active and bank instability is high.

Implementablility of hard treatments will require access and engineering controls during construction to avoid impacts to the river. Using gabion riprap and retaining walls as a Process Option for bank stabilization is retained for further consideration.

4.2.4 CHANNEL MORPHOLOGY/IN-STREAM HABITAT

General Response Actions addressing Channel Morphology and In-Stream Habitat Improvements can be closely related. For this reason, these Restoration Technology categories are combined during the screening process (Table 4-4). It should also be noted that these categories of General Response Actions overlap with certain Process Options being considered for Riparian Areas. These relationships/overlaps will be further considered in the development of alternatives.

4.2.4.1 RIVER CHANNEL ALTERATION

There are several Process Options within the Restoration Technology category of river channel alteration. River channel alteration treatments are considered as a means to restore natural river functions, improve channel and bank stability and enhance aquatic habitat. Each should have similar applicability, effectiveness and implementability. Screening of the following Process Options will be performed at the technology level. Design activities will determine the most appropriate Process Option for a specific area.

River channel alterations involve significant modification of the current channel. These actions range from movement of the existing channel, to channel modification and channel movement constraints.

Restore Flow to Abandoned Channel - Restoration of flow to an abandoned channel is an option where the current active main channel is unstable (e.g., "perched"), or is unacceptably threatening a feature (e.g., fluvial mine-waste deposits) in its current configuration. This alternative can be effective if properly applied. However, even with substantial studies, it is difficult to evaluate the potential for long-term success. Changes in flow regime may result in failure of the channel relocation and creation of unanticipated channel morphology. It is also extremely difficult to accurately predict upstream and downstream impacts on channel stability, and extensive studies may be required to understand the potential for long-term effectiveness.

The implementability of this option is limited by many factors including: access; engineering controls; and short construction seasons. The cost of such an option is considered to be very high. Channel relocation is not retained as a Process Option because the applicability is very limited.

Reduce Channel Braiding by Confining River to a Single Channel - This option involves consolidation of existing braided channel segments to a single channel and eliminating or utilizing existing channels for overbank flow. The new consolidated main channel would either be an expansion of an existing channel or a newly created channel. The channel would, at a minimum, have capacity for base flows. This option has the same group of effectiveness and applicability/implementability considerations as described above. The long-term effectiveness of channel constraints over short reaches is uncertain. Braided reaches are not uncommon for high mountain valley streams and reduced braiding may therefore not be considered restoration. The Process Option of reducing channel braiding by confining the river to a single channel is not retained because the applicability is limited.

Create Channel Migration Corridor - Creation of a channel migration corridor involves the placement of hardened structures at a set dimension within the floodplain. The hardened structures limit migration of the channel. This option can be used to constrain channel migration away from areas of concern (e.g., structures and/or tailings deposits). Without tailings removal within the original migration corridor, this option is not fully effective and flood effects could be more focused and/or channel migration could intercept deposits.

In general, the same effectiveness and implementability considerations apply. The applicability of this alternative is limited when considering both the setting and the potential benefits. The cost is very high. This Process Option is not retained for further consideration.

Reduce Channel Width - The river channel through portions of the 11-Mile Reach (especially below the confluence of Lake Fork) has widened compared to the historic channel. However, the channel width appears to be stabilizing in response to better management of augmented flows in recent years.

If flows are managed appropriately, reducing channel width could be effective in facilitating natural recovery of a stable channel form. The CDOW lists treatments reducing channel width in their River Channel and Trout Habitat Treatments table. According to their table, the expected benefits of reducing channel width include improvements in the river channel, increased trout habitat and improved pool, run and riffle river habitat (CDOW 2002). Reducing channel width will also lead to reduced sediment deposition, increased bank stability, reduced lateral movement, and as noted by CDOW, improved in-stream habitat. The long-term effectiveness of a constructed narrow channel is not known, nor the upstream and downstream impacts on bank stability. Construction of a narrow channel may require armoring to improve effectiveness.

Reducing channel width to handle optimal bankfull discharge is applicable to the 11-Mile Reach, where a width/depth ration of between 20 and 30 can be achieved. Reducing channel width is physically implementable where the river is accessible to an excavator. This Process Option is not retained given other similar options have fewer effectiveness and implementability concerns.

Channel Relocation - The channel relocation option involves the creation of a new channel and elimination of the existing channel. This option is typically considered when the current channel morphology unacceptably threatens a structure or feature (e.g., mine-waste deposits). The effectiveness and implementability concerns raised for other river channel alteration Process Options can be magnified for this option.

The channel relocation Process Option is not applicable to the conditions of the UARB and the restoration objectives, and is not retained for further consideration.

4.2.4.2 In-Stream Habitat Enhancement

There are several Process Options within the Restoration Technology category of in-stream habitat enhancement. Each should have similar applicability, effectiveness and implementability. Screening of the following Process Options will be performed at the technology level. Design activities will determine the most appropriate Process Option for a specific area.

Habitat Enhancement

<u>**Enhance Riffles (gravel & cobble placement)**</u> - Enhancement of riffle habitat through the placement of imported gravel and cobble is a common in-stream habitat improvement technique; however, it is not applicable to the 11-Mile Reach. Currently the 11-Mile Reach has a less than optimal pool to riffle ratio due to the lack of pools, yet abundant riffle habitat.

Enhancing riffle habitat would not be effective at improving the overall quality of in-stream habitat in the 11-Mile Reach due to the abundance of riffle habitat already present. Enhancement of riffles is not applicable to the conditions of the UARB and the restoration objectives, and therefore is not retained as a Process Option for further consideration.

<u>**Boulder Placement (e.g., random boulders, boulder clusters)**</u> - Placement of random boulders and boulder clusters is an applicable treatment for improving mid-stream habitat by dissipating energy and deflecting flow which leads to increased overhead cover, shelter from high-flows, and increased in-stream habitat through long runs of riffles. This treatment is readily implementable in locations where an excavator can access the river. The CDOW lists boulder placement treatments in their River Channel and Trout Habitat Treatments table. According to their table, the expected benefits of boulder placement include reduced bank erosion, increased trout habitat (boulder clusters only) and improved pool, run and riffle (random boulders) or run and riffle (boulder clusters) river habitat (CDOW 2002).

Boulder placement would be an effective treatment for the 11-Mile Reach especially in areas of monotonous riffle habitat and where the river is entrenched or confined by physical barriers (i.e. railroad, highway). Boulder placement would provide several in-stream habitat types that are currently limited in many sections of the 11-Mile Reach (i.e. shelter from high-flows, mid-channel habitat, overhead cover).

The cost of boulder placement is medium based on the distance of a boulder supply. Large boulders are available in most sections of the 11-Mile Reach. Boulder placement is retained as a Process Option for further consideration.

Mid-Channel Root Wads, Stumps - Placement of root wads and stumps is applicable for improving mid-stream habitat such as overhead and resting cover, both of which are somewhat limited in sections of the 11-Mile Reach.

Root wads and stumps would be effective in the11-Mile Reach and would increase the quantity and diversity of in-stream habitat. This treatment would create habitat similar to the placement of boulders. The CDOW lists root wad and stump treatments in their River Channel and Trout Habitat Treatments table. According to their table, the expected benefits of root wad and stump placement includes reduced bank erosion, increased trout habitat and improved pool and run (root wads) or riffle and run (stumps) river habitat (CDOW 2002).

Placing root wads and stumps in the stream may not be implementable due to the lack of readily available root wads and stumps of sufficient size. In addition, anchoring root wads and stumps in the stream bottom may be difficult to complete. The cost of root wad and stump placement is medium, dependent upon the availability of materials. Root wad and stump placement is retained as a Process Option for further consideration.

Log Placement (log spurs, horizontal logs) – Placement of logs is applicable for improving in-stream habitat such as overhead and resting cover, both of which are somewhat limited in sections of the 11-Mile Reach (Riley and Fausch 1995; Gowan and Fausch 1996).

Log placement techniques, such as log spurs and horizontal log placement, would be effective in the 11-Mile Reach and would increase the quantity and diversity of in-stream habitat. This treatment would create habitat similar to the placement of boulders and mid-channel root wads and stumps. The CDOW lists log placement treatments in their River Channel and Trout Habitat Treatments table. According to their table, the expected benefits of log placement include reduced bank erosion, increased trout habitat and improved pool, run and riffle (log spurs) or riffle (horizontal logs) river habitat (CDOW

2002). This treatment would create habitat similar to the placement of boulders and mid-channel root wads and stumps. The cost of log placement is medium and dependent upon the availability of logs and river access. Log placement is retained as a Process Option for further consideration.

Excavation of Pools - Excavation of pools is applicable for improving in-stream habitat where the pool to riffle ratio is very low. Pools provide over-wintering habitat and help to reduce flow velocity.

Given the low ratio of pools to riffles, pool excavation would be an effective treatment in some portions of the 11-Mile Reach, especially in conjunction with boulder placement to achieve increased in-stream habitat diversity.

Pool excavation is readily implementable where the river can be accessed by an excavator and where engineering controls can be implemented to reduce negative impacts to the river. Costs of pool excavation are medium. Pool excavation is retained as a Process Option for further consideration.

Drop Structures/Weirs - Drop structures/weirs are commonly used for stream improvement and are designed to dissipate energy and increase pool habitat. They are an applicable treatment for improving in-stream habitat in the 11-Mile Reach.

Drop structures and weirs are effective at dissipating energy and creating pool and riffle habitat. In some instances, drop structures and weirs can have a negative effect on bank stability and channel form.

Drop structures and weirs are readily implementable where the river can be accessed by an excavator for construction, and where engineering controls can be implemented to reduce negative impacts to the river. The cost of drop structures/weirs is high and they will not be retained as a Process Option for further consideration.

Table 4-1

Technology Identification and Screening for
Fluvial Mine-Waste Deposits

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
No Action (no restoration actions, but considers any ongoing or planned response actions)	Natural Recovery			Required alternative	$0	
Institutional Controls	Access Control	Fences to restrict cattle access	Low – easily implemented as a temporary measure provided access from property owner is obtained, but land access and long term maintenance requirements limit use as a remedy. Not applicable to situations where causes other than cattle are limiting vegetative cover.	Not effective long term in protecting deposits from potentially erosive effects of intensive grazing, protecting vegetation, and reducing direct exposure to cattle. Most effective as a temporary measure following restoration activities.	Low	No-offers no benefits as a stand-alone action
Containment/Engineering Controls	Cover/Barrier Placement	Simple Soil Cover (E-T barrier) and revegetation	Availability of local soil borrow area is a limiting factor. Higher implementability where a soil source is available. Availability of stockpiled pond sediment from Mt. Massive Lakes may provide high implementability for Reach 3.	Effective at eliminating direct exposure and reducing infiltration. Soil cover alone would not be effective for deposits potentially subject to erosion. Appropriate vegetation can be established. Plant metals uptake may occur depending upon soil depth and nature of underlying deposits. Deep-rooted vegetation needs a thicker soil cover to effective. Most effective for low to moderate priority deposits that are not streamside.	Medium-dependent upon transport distance.	Yes
		Multi-layer Cover (e.g., CCL, gravel, soil composite)	Technically implementable, however may not be applicable to site conditions (additional infiltration control not necessary). Most appropriate for consolidated deposits/repositories.	Effective in preventing erosion of and direct contact to mine wastes, and reducing infiltration. The root depth of vegetation used for multi-layer covers should not exceed the soil cover depth.	High	No-redundant with simple soil cover process option but higher cost. Consider for repository design.
	Surface Water Controls	Diversion Ditches (run-on control)	Medium – readily constructed with conventional equipment. Not applicable to site conditions.	Potentially effective in reducing direct contact with stormwater from upgradient areas. However, actual effectiveness is likely to be low, due to relatively flat grades of deposits (run-on not a significant pathway)	Low	No
In-Situ Stabilization	Vegetation	Direct revegetation with metals tolerant species	Technically implementable, but may only be applicable at deposits with moderate pH and relatively low metals availability.	Limited effectiveness based on previous work. Vegetation type/habitat restoration may be limited. Metals transfer to vegetation may present exposure concerns for deer and elk.	Low	Yes-for low priority deposits with small surfaces.
		Lime addition, deep tilling and direct revegetation	Technically implementable, but may only be applicable at deposits with moderate pH and relatively low metals availability.	Most effective for low priority deposits. Lack of organic matter may limit effectiveness for moderate and high priority deposits. Would be effective in conjunction with soil cover.	Low/Med	Yes-for low priority deposits.
		Organic (biosolids) and lime amendments, deep tilling and Revegetation	Non-composted biosolids cannot be used within 10 feet of the river channel, which reduces the implementability of this treatment option for near bank deposits.	Offers restoration of vegetation and potential for reduction of metals transfer.	High	Yes
		Lime addition, deep tilling, soil cover and revegetation	Higher implementability where soil source is available. Availability of stockpiled pond sediment from Mt. Massive Lakes may provide high implementability for Reach 3.	Offers restoration of vegetation and potential for reduction of metals transfer.	Med/High-dependent upon source of soil cover	Yes
Removal/replacement	Excavate & Truck Hauling with replacement of soils and vegetation	Consolidate with other deposits within a reach (multiple small repositories)	Technically implementable. However, floodplain considerations of final grade of consolidated deposits and land acquisition within a reach may limit applicability. Multiple repositories increase maintenance efforts.	Removal effective at eliminating all potential exposure routes and with soil backfill it offers the ability to restore appropriate vegetation/habitat. Eliminates the potential for future transport/erosion of metals within deposits. Applicability highest for high priority deposits with diminishing applicability for deposits that have lower metals	Med/High	Yes

Table 4-1

Technology Identification and Screening for
Fluvial Mine-Waste Deposits

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
				concentrations and lower potential for erosion.		
		On-site single repository (within 11-mile reach)	Implementability affected by the ability to acquire suitable property for a repository within the 11-Mile Reach. Long-term O & M required.	Removal effective at eliminating all potential exposure routes and with soil backfill it offers the ability to restore appropriate vegetation/habitat. Eliminates the potential for future transport/erosion of metals within deposits. Applicability highest for high priority deposits with diminishing applicability for deposits that have lower metals concentrations and lower potential for erosion.	Med/High	Yes
		Cal Gulch NPL Site repository	A site-wide repository location is being established for the Superfund Site at the Black Cloud Mine tailings impoundment. Process Option is technically implementable and applicable to site conditions. Most implementable for deposits within upper reaches as increasing haul distance increases cost effectiveness. Capacity of site wide repository is assumed to be adequate.	Removal effective at eliminating all potential exposure routes and with soil backfill it offers the ability to restore appropriate vegetation/habitat. Eliminates the potential for future transport/erosion of metals within deposits. Effectiveness highest for high priority deposits with diminishing relative effectiveness for deposits that have lower metals concentrations and lower potential for erosion.	Low/Med	Yes
		Distant off-site repository	Technically implementable and applicable to site conditions. Highest applicability for high priority deposits.	Removal effective at eliminating all potential exposure routes and with soil backfill it offers the ability to restore appropriate vegetation/habitat. Eliminates the potential for future transport/erosion of metals within deposits. Effectiveness highest for high priority deposits with diminishing relative effectiveness for deposits that have lower metals concentrations and lower potential for erosion.	High	No
Treatment	Chemical	Alkali Addition (lime)	Technically implementable depending on depth of deposit and desired depth of incorporation. May require large quantities of lime to produce long-term effectiveness.	May be effective at raising soil pH and reducing metals availability, but this alone may not meet the restoration objectives. May reduce the formation of highly soluble metal-rich salts and buffer acid generation resulting from water contact with the deposits. Effective and appropriate as a soil amendment for vegetation activities.	Med	No-not as a stand-alone treatment
		Passivation / Micro-encapsulation	Depending on depth of waste deposit, effective mixing may be difficult.	Long-term effectiveness is questionable for highly mineralized low pH deposits	High	No-not proven to be effective
		Chemical addition to enhance precipitation/adsorption	Unknown	No proven effectiveness for site conditions	Unknown	No-not proven to be effective
	Biological	Bio-mineralization (in-situ sulfate reduction; insoluble sulfide precipitation)	Unknown	No proven effectiveness for site conditions	Unknown	No-not proven to be effective
		Bactericides (sodium laurel sulfate)	Unknown	No proven effectiveness for site conditions	Unknown	No-not proven to be effective
		Phytoremediation	Low - would have to harvest and dispose of high metals content vegetation. Land-use would be restricted for grazing until replanting with low metals uptake species occurs. Overall implementability would be low.	No proven effectiveness for site conditions	Unknown	No-not proven to be effective

Table 4-2

Technology Identification and Screening for Agricultural/Floodplain Lands

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
No Action (no restoration actions, but considers any ongoing or planned response actions)	Natural Recovery			Required alternative	$0	
Institutional Controls	Agricultural BMPs	Seed with metals tolerant/low uptake species (revegetation)	Readily implementable, provided landowner consents. Most implementable on public lands.	May be effective in increasing vegetative cover, but may not meet restoration objectives for agricultural lands, depending on land owner preferences or planned land use.	Med	Yes
		Nutritional supplements (salt blocks)	Readily implementable, provided landowner consents. Most implementable on public lands.	Complex interactions in areas where the problem is an excess of certain elements (i.e., Cd, Zn and Cu) limit effectiveness.	Low	No
		Grazing rotation	Readily implementable, provided landowner consents. Most implementable on public lands. There is uncertainty associated with voluntary implementation by private landowners.	May be effective in reducing metal uptake by cattle and horses and in increasing forage production and plant cover.	Low	No
		Irrigation management	Readily implementable, provided landowner consents. Most implementable on public lands.	See above, may be considered for post remedy protection depending upon UAR water quality.	Low	Yes
Soil Mixing	Plowing	Deep tilling	Easily implemented in conjunction with standard agricultural practices for preparing land for planting. Not readily implementable for areas of dense woody vegetation (i.e. riparian corridors).	Effective in reducing metals concentrations in areas where only surficial metals concentrations present a problem. May be effective in over soil profile in conjunction with soil amendments.	Med	Yes
In-Situ Stabilization	Soil Amendments	Application of ag-lime	Readily implementable, but will require tilling and reseeding. Not readily implementable for areas of dense woody vegetation.	Effective in reducing the bioavailability of metals and re-establishing vegetation that would support livestock use. Over liming can adversely affect vegetation growth.	High	Yes
		Application of phosphate rich amendment (Organic Matter)	Readily implementable, but will require tilling and reseeding. Not readily implementable for areas of dense woody vegetation.	Limited information on the effectiveness with time in a floodplain/irrigated meadows setting. Can be effective in reducing bioavailability. Particularly effective for lead and not as effective for zinc.	High	No

Table 4-3

Technology Identification and Screening for the Riparian Zone

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
No Action (no restoration actions, but considers any ongoing or planned response actions).	Natural Recovery			Required alternative	$0	Yes
Institutional Controls	Land Use Management	Fencing to restrict cattle access	Readily implementable. Requires cooperation of landowner. Highly implementable on public lands subject to grazing.	Effective and applicable in areas where cattle grazing are the primary cause of bank instability.	Low	Yes
		Grazing management (rotation){Agricultural BMPs}	Readily implementable. Requires cooperation of landowner. Highly implementable on public lands subject to grazing.	Effective and applicable in areas where cattle grazing are the primary cause of bank instability. Difficult to enforce/control. Not as reliable as fencing.	Low	No
		Conservation Leases	Highly implementable if landowner is willing.	Effective in conjunction with fencing, but not as reliable as fencing alone. Not effective as a stand-alone option.	Uncertain-on private land	Yes
Streambank Restoration	Bioengineering/Soft Treatments	Screening performed at technology level. Specific soft treatment options may include those listed below. Design activities will determine most appropriate option for specific areas.	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river. Implementability/ applicability also dependent on having soil conditions suitable for planting.	Effective in reducing bank erosion and the development of over-width channel; and providing overhead trout cover. Effectiveness may be increased in areas where mine waste has been removed and replaced with soil suitable for planting.	Low/Med	Yes
		Revegetation	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river. Implementability/ applicability also dependent on having soil conditions suitable for planting.	Ineffective unless done in combination with hard or soft treatments or some form of bank stabilization. Effective in controlling erosion away from the streambank.	Low	Yes
		Willow waddling	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river.	Effective in reducing bank erosion and the development of over-width channel. May need to be done in combination with hard or additional soft treatments.	Med	Yes
		Anchored logs	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river.	Effective in reducing bank erosion and the development of over-width channel. May need to be done in combination with hard or additional soft treatments.	Med	Yes
		Root wads	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river.	Effective in reducing bank erosion and the development of over-width channel. May need to be done in combination with hard or additional soft treatments.	Med	Yes
	Hard Treatments	Screening performed at technology level. Specific hard treatment options may include those listed below. Design activities will determine most appropriate option for specific areas.	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river.	Effective in reducing bank erosion and the development of over-width channel. Hard treatments may increase flow velocities and create undesirable effects downstream. Unless application is limited to small areas, it can be counter productive to habitat restoration objectives.	Med/High	Yes
		Rock Structures (Vanes, J-Hook, Cross Vanes, Deflector)	Technically implementable, but will require access, and engineering controls during construction to avoid impacts to the river. Dependent on factors such as channel size and vicinity of quarry or rock supply.	Effective in reducing bank erosion and development of over-width channel. Maintains a “natural” look.	Med	Yes
		Gabion retaining walls	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river. Applicable to areas of active erosion &high bank instability.	Effective in reducing bank erosion. Most effective in combination with plant establishment to establish a more natural functioning bank system that is also aesthetically more acceptable.	High	Yes

Table 4-3

Technology Identification and Screening for the
Riparian Zone

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
		Riprap	Technically implementable but will require access, and engineering controls during construction to avoid impacts to the river. Applicable to areas of active erosion &high bank instability.	Effective in reducing bank erosion. Most effective in combination with plant establishment to establish a more natural functioning bank system that is also aesthetically more acceptable.	Med/High	Yes

Table 4-4

Technology Identification and Screening for
Channel Morphology/In-Stream Habitat

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
No Action (no restoration actions, but considers any ongoing or planned response actions).	Natural Recovery			Required Alternative	$0	
Channel Morphology Restoration (See also Riparian Areas)	River Channel Alteration (River channel alteration treatments are considered as a means to restore natural river functions, improve channel and bank stability and enhance aquatic habitat).	Screening performed at technology level. Specific channel alteration options may include those listed below. Design activities will determine most appropriate option for specific segments.	Intensive supporting engineering studies would be required. May not be acceptable to landowners.	Uncertain it would be effective in this environment. May not present long-term effectiveness without a large engineering effort. Effectiveness of individual treatments will be highly dependent on the selection of appropriate locations for implementation and detailed evaluation and design of specific treatments.	High	No
		Restore flow to abandoned channel.	Substantial engineering and construction controls required. Other implementability considerations include water rights, easements, rights-of way, land use, and maintaining/improving trout habitats. Limited applicability.	May be effective in limiting migration of channel(s) through tailings deposits. Restoring flow to abandoned channels can be effective in areas where the abandoned channel offers stable riverbanks and riparian vegetation, and good trout habitat. However, perched channel is considered to be stable so beneficial effects would not be achieved.	High	No
		Reduce channel braiding by confining low river flows to a single channel and utilizing secondary channels as high flow channels.	Substantial engineering and construction controls required. Other implementability considerations include water rights, easements, rights-of way, land use, and maintaining/improving trout habitats. Overall, applicability is limited.	May be effective in limiting migration of channel(s) through tailings deposits. Reducing braided channels could effectively reduce total channel width and possibly increase the river's effectiveness at transporting sediment. The long-term effectiveness of channel constraints over short reaches is uncertain. Furthermore, the need for additional sediment transport has been identified.	Very High	No
		Create hard/armored channel migration corridor bordering within which the channel could migrate.	Requires a large volume of materials to be handled. Tailings within channel migration corridor require removal. Substantial engineering and construction controls required. Other implementability considerations include water rights, easements, rights-of way, land use, and maintaining/improving trout habitats.	May be effective in limiting migration of channel(s) towards tailings deposits. Not fully effective and flood effects could be more focused and/or channel migration could intercept deposits. Depending upon the degree of hard armoring required it could also result in improved fish habitat.	Very High	No
		Reduce channel width	Applicable in areas where a width/depth ratio of between 20 and 30 can be achieved. Physically implementable where the river is accessible to an excavator.	May be effective in limiting migration of channel(s) towards tailings deposits. May be effective in improving lateral channel stability, reducing sediment deposition, and improving fish habitat. However, long-term effectiveness without hardened structures is uncertain.	Medium	No
		Channel relocation	Can be considerable logistical and physical obstacles to relocation. Not applicable to conditions of the UARB.	May be effective in isolation of fluvial tailings deposits. May not be compatible with riparian and in-stream habitat restoration.	Very High	No
In-stream Habitat Restoration	Habitat Enhancement	Screening performed at technology level. Specific fish habitat restoration options may include those listed below. Design activities will determine most appropriate option for specific segments.	Type of actions, and correspondingly costs, are usually based on professional judgment.	Restoration not specific to release of mining wastes, but would improve current condition of fishery.	Medium/High	Yes
		Enhance riffles (gravel & cobble placement)	Readily implementable, but not applicable.	Adequate gravel/cobble substrate present.	Medium	No
		Boulder placement (e.g. random boulders, boulder clusters)	Readily implementable and appropriate for this river system.	Effective at increasing in-stream fish habitat. Applicable to this river system.	Medium	Yes

Table 4-4

Technology Identification and Screening for
Channel Morphology/In-Stream Habitat

General Response Action	Restoration Technology	Process Option	Implementability / Applicability to Site Conditions	Effectiveness / Applicability to Restoration Objectives	Relative Cost	Retain
		Mid-channel root wads, stumps	Applicable to site conditions, but may not be readily implementable due to lack of large rood wads and stumps.	Effective at increasing in-stream fish habitat.	Medium	Yes
		Log placement (log spurs, horizontal logs)	Readily implementable and appropriate for this river system.	Effective at increasing in-stream habitat including overhanging areas.	Medium	Yes
		Excavate pool habitats	Readily implementable in areas with access. Most applicable to Reach 3.	Effective in creating pool to riffle relationships. Providing resting and over-wintering areas.	Medium	Yes
		Drop structures/weirs	Intensive supporting engineering studies would be required. May not be acceptable to landowners. Not as applicable as other habitat improvement options.	Could be effective in creating pool habitat and improving pool to riffle relationships. Provides resting habitat. Uncertain it would be effective in this environment. May not present long-term effectiveness without a large engineering effort.	High	No

5.0 DEVELOPMENT OF RESTORATION ALTERNATIVES

Selecting from the Restoration Technology categories and specific Process Options retained in Section 4, a range of restoration alternatives has been developed. Given the differences in restoration needs between reaches, as well as differences in setting, access, haul distances, etc., alternatives are presented for each reach (1-4). Within each reach, the alternatives developed address the primary restoration need categories of:

- Fluvial Mine-Waste Deposits;
- Agricultural/Floodplain Lands;
- Riparian Areas; and
- Channel Morphology/In-Stream Habitat.

Because of the close relationship between restoration actions addressing riparian areas, channel morphology and in-stream habitat, these categories of restoration needs have been combined for the development of restoration alternatives. This approach simplifies the development of a compatible group of restoration measures addressing the river channel and riparian zone for each alternative.

As noted above, and detailed in Section 3, the need for restoration measures within these categories varies by reach. Correspondingly, the range of alternatives to be considered is somewhat different for each reach. A further distinction occurs for the categories of fluvial mine-waste deposits and riparian areas/channel morphology/in-stream habitat, where alternatives may vary depending upon the volume and prioritization of fluvial mine-waste deposits and the condition of the channel within a given subreach. Where available, details regarding conditions within a given reach or subreach as they relate to implementability, effectiveness and cost are included (e.g., linear feet of bank with exposed mine waste). Expected application rates (e.g., tons of lime per acre), volumes, and quantities of material associated with an alternative are also provided. These parameters are assumed based on currently available information, and are viewed to provide a reasonably accurate cost basis (-30% to +50%) for alternative evaluation. Additional refinement would occur during the design phase for a selected alternative.

In general, the alternatives for a given restoration need category within a reach are arranged from least aggressive to most aggressive in terms of the level of construction activity involved. The potential for Natural Recovery (Alternative 1 for each reach and each restoration need category) is evaluated both as a considered alternative and to provide a consistent basis for comparison. Although some remediation work has been conducted by USEPA within portions of the 11-Mile Reach (see Section 3.3.1) and USEPA plans to continue work in the future, the natural recovery alternative considers changes in resource conditions with time, absent additional measures. Only the remediation already completed by USEPA is considered for the Natural Recovery alternatives. USEPA remediation work completed and in progress is fully considered for alternatives involving restoration actions. Under all alternatives, the baseline environmental conditions (e.g., land use, land-use practices, flow augmentation) currently experienced at the site are expected to continue.

Where appropriate, two or three alternatives prescribing a specific set of restoration measures have been developed for each of the restoration need categories within a reach. The identified range of alternatives has been developed to provide information on the expected relative performance of a spectrum of sensible restoration measures. The performance of the alternative is analyzed relative to specific criteria in Section 6, and a comparison of alternatives is provided in Section 7.

5.1 REACH 1

Reach 1 extends approximately 1.81 river miles from the mouth of California Gulch to just upstream of the confluence with Lake Fork. Reach 1 is comprised of private lands, and the primary land use is agricultural (hay and/or pasture). Access is limited to private driveways and ranch roads. The Seppi Ranch occupies the majority of Reach 1, however, there are several other landowners along this reach (Figure 5-1). Table 5-1 summarizes the alternatives developed for Reach 1.

5.1.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 1 contains a total of 29 discrete fluvial mine-waste deposits (24 deposit groups because deposit CC is composed of 5 parts) and has the highest proportion of high priority deposits of the four reaches. Chemical and observational data indicate that Reach 1 likely contains deposits of mine-waste from the early years of milling; when tailings were coarse and had higher metals concentrations due to less efficient milling technologies. All but one of the deposits have vegetation cover described as poor to fair. The only exception is deposit CF, located west of the Arkansas River, with vegetation cover described as good. This deposit covers an area of approximately 0.1 acres.

The majority of the fluvial deposits within Reach 1 are located at the upstream end of the reach, near the mouth of California Gulch (subreach 1A), and in the lower third of the reach at the confluence with Lake Fork (subreach 1C) (Figure 3-2). Three of the deposits identified for subreach 1A are at the confluence of California Gulch and are within the California Gulch drainage. Characteristics of the Reach 1 deposits are summarized in Table 5-2.

Table 5-2
Reach 1 Fluvial Mine-Waste Deposit Characteristics

Subreach	No. of Deposits	Total Ft of Bank Intercepting Deposits	Priority	No. of Deposits	Acres	Acres Remediated by USEPA	Average Depth of Deposits (ft)	Volume of Deposits (cu. yds.)
1A	9	600	High	4	4.26	4.26	1.33	9,197
			Mod	4	1.52	0.10	0.94	2,303
			Low	1	0.22	0	0.71	251
1B	1	300	Mod	1	0.27	0	0.81	352
1C	14	1,080	High	7	9.2	9.2	1.09	16,242
			Mod	6	2.42	1.74	1.13	4,400
			Low	1	0.12	0	0.50	99
Reach 1 Totals	**24**	**1,980**	**High**	**11**	**13.46**	**13.46**	**1.17**	**25,439**
			Mod	**11**	**4.21**	**1.84**	**1.04**	**7,055**
			Low	**2**	**0.34**	**0**	**0.63**	**350**

USEPA has conducted treatments on 16 of the 24 deposits within Reach 1 (see Section 3.3.1). Treatments generally involving the integration of a variety of combinations of organic matter (biosolids, wood chips, fish pond sediments) and lime (agricultural grade limestone, kiln dust, dolomite chips) with the fluvial deposits have been utilized for approximately 15 of the 18 acres within Reach 1. The treatments also included reseeding. All of the mapped high priority deposits within Reach 1 have been or are being remediated by USEPA. Information is not yet available as to the performance of any given treatment approach, however, USEPA continues to modify and re-amend the deposits based on observations. For the purposes of the RAR, it is assumed that USEPA's activities to date will provide adequate stabilization and allow for establishment of good vegetation cover in the near term, and over the course of several years, have vegetation corresponding to the adjacent areas. Correspondingly, the treated deposits are not included in Reach 1 alternatives calling for in-place stabilization. Removal alternatives, however, consider all of the deposits regardless of prior amendments. Tables 5-3 and 5-4 summarize the alternatives developed for fluvial mine-waste deposits in Reach 1 by reach and by priority, respectively.

5.1.1.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the No Action/Natural Recovery alternative. As noted above, although some remediation work has been conducted by USEPA within Reach 1, this alternative assumes no additional work will occur. This alternative examines the potential for natural recovery and provides a point of reference against which the cost/benefit of action based alternatives can be compared.

Reach 1

No additional restoration actions would occur within Reach 1. As for other alternatives, the baseline of environmental influences (i.e., land use, land-use practices, flow augmentation, etc.) within Reach 1 are assumed to remain constant with time. Changes with regard to the condition of the fluvial mine-waste deposits and the associated natural resources are evaluated in light of the current baseline conditions.

5.1.1.2 ALTERNATIVE 2: LIMING, DEEP TILLING & RESEEDING

Alternative 2 calls for liming, deep tilling and reseeding the 2.71 acres of combined low and moderate priority fluvial mine-waste deposits that have not already been remediated by USEPA. The addition of 75 tons/acre agricultural lime to the deposits could limit the potential for further plant uptake of metals and given the relatively low metals concentration in the top few inches, deep tilling to an average depth of 18 inches should reduce the average concentration of bioavailable metals in surface soils and the root zone to below levels of concern. It is recognized that there may be several seed/planting mixtures that could be successfully used for reseeding. For the purposes of alternatives development and estimating costs, a planting mixture (i.e., species composition) has been developed based on the surrounding land use and setting. The planting mixture developed for reseeding the deposits includes slender wheatgrass (6 lbs/acre), smooth brome (6 lbs/acre), tufted hairgrass (2 lbs/acre), redtop (2 lbs/acre), alpine bluegrass (3 lbs/acre) and western yarrow (4 lbs/acre). Mulch would be used following seeding to improve moisture relationships for germination and establishment.

5.1.1.3 ALTERNATIVE 3: LIMING, BIOSOLIDS, DEEP TILLING & RESEEDING

Alternative 3 is similar to Alternative 2 in that it prescribes liming, deep tilling and reseeding and addresses only those deposits that have not already been remediated by USEPA. In addition to the treatments described in Alternative 2, Alternative 3 includes the application of composted biosolids (40 dry tons/acre) as an amendment to increase organic matter. The lime and biosolids would be tilled to a depth of 18 inches.

5.1.1.4 ALTERNATIVE 4: REMOVAL

Alternative 4 calls for the removal of all low, moderate and high priority mine-waste deposits within Reach 1 (approximately 33,000 cu. yds.). The average depth of fluvial deposits in Reach 1 is approximately one foot. Over-excavation of an additional 6 inches (approximately 14,500 additional cu. yds.) is considered appropriate. Deposits would be removed and transported to the anticipated California Gulch NPL Site central repository to be constructed at the Black Cloud Mine. The high proportion of private land in Reach 1 and the proximity of the Black Cloud Site (approximately 9 miles) makes the possibility of developing a more cost effective repository within Reach 1 unlikely.

After removal, soil underlying the high priority deposits would be amended with an average of 75 tons/acre of agricultural grade lime to address any residual acidity and excavations would be back filled with clean soil (assumed average backfill depth of 18 inches) and graded prior to revegetation. For bank deposits where complete removal increases the potential for bank erosion, appropriate bank stabilization measures will be included. Given the shallow depth of the deposits and the channel characteristics, it is assumed that only approximately 300 feet (15%) of bank associated with fluvial mine-waste deposit removals would require some specific stabilization measures (e.g., root wads and/or placed logs). Alternatives considering further bank stabilization measures within Reach 1 are presented below.

5.1.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

Within Reach 1, subreaches 1A and 1C have been identified as areas with a greater relative potential for channel instability. These subreaches have diminished in-stream habitat quality (fair to good) that can in part be linked to bank instability. Also, the general quality of riparian zone vegetation over most of the reach is not as high as the reference area, which further contributes to bank instability. As discussed above, some specific areas of lower quality riparian cover and bank instability can be attributed to the presence of fluvial mine-waste deposits. These areas are included in the fluvial mine-waste alternatives. Stream flow augmentation patterns and riparian vegetation impacts associated with grazing may contribute to broader areas of bank instability.

USEPA and others have conducted spot treatments (hard armoring of banks and placement of in-stream boulder structures) in Reach 1. These actions appear to have been field designed and specific dimensions are not available. Although there may be some overlap with the actions described in the following alternatives, the estimates of work have not been discounted to allow for USEPA's stream stabilization activities. The discount was not included because of the limited areas involved and the need (cost) of integrating prior work with any future work. Table 5-5 summarizes the Reach 1 restoration alternatives developed for riparian areas/channel morphology/in-stream habitat.

5.1.2.1 Alternative 1: Natural Recovery

Alternative 1 is the No Action/Natural Recovery alternative and assumes no work beyond that already conducted.

5.1.2.2 Alternative 2: Grazing Control

Alternative 2 focuses on the general improvement of streambank/channel stability and riparian vegetation throughout Reach 1 with isolation of the riparian area from grazing. A combination of fencing (18,800 feet of 3-strand solar electric fence) paired with a 20-year conservation lease (a 25 foot offset from the banks for the fenced area), is the primary action for the riparian zone. Access points for stock watering/crossing would be provided. The approximate acreage under lease would be approximately 11 acres (9,400 feet x 50 feet). Alternative 2 can be paired with any of the above restoration alternatives for the fluvial mine-waste deposits.

5.1.2.3 Alternative 3: Soft Treatments

Alternative 3 was developed to be paired with fluvial mine-waste alternatives 2 or 3, involving in-place stabilization of deposits. More aggressive actions are included to reduce the susceptibility of the stabilized deposits to future erosion. Alternative 3 includes grazing control measures from Alternative 2. Additional measures for bank protection/channel stabilization and in-stream habitat improvements are included for subreaches 1A and 1C. Soft treatments including willow waddling, anchored trees, root wads, rock structures and log placement would be used in combination in these subreaches to provide both in-stream habitat and further improve bank/channel stability. The exact location and specific number of these actions per subreach is a design element and beyond the level of study currently available. However, based on field reconnaissance and the total feet of bank intercepting deposits (approximately 1,980 feet), for the purpose of the detailed and comparative analyses, it is assumed that 3,000 feet (approximately 150% of the length of bank intercepting deposits) would receive soft treatments.

5.1.2.4 Alternative 4: Pool Excavation

Alternative 4 was developed in part to pair with fluvial mine-waste deposits Alternative 4, which prescribes removal of the deposits. However, Alternative 4 can also be paired with Alternatives 2 and 3 for the mine-waste deposits (stabilization). Given removal of the deposits, more aggressive streambank/channel stabilization measures, beyond those planned in conjunction with the removal (approximately 300 feet of bank stabilization), are not included. Grazing control to restore riparian areas will contribute to bank/channel stability. Because of the fair to poor condition of in-stream habitat, the habitat improvement Process Option of pool excavation is included for subreaches 1A and 1C within Reach 1. An assumed application rate of 1 pool excavation per subreach has been adopted for the detailed and comparative analyses.

5.1.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

In Reach 1, areas of the floodplain (5.1 acres) and non floodplain (29.3 acres) irrigated agricultural lands have been identified as having soils with the greatest potential for phytotoxicity and/or as posing unacceptable risks to grazing animals. The largest of the Reach 1 areas is within subreach 1C, at the boundary of Reaches 1 and 2 (26 acres of non-floodplain soils). These acreages are exclusive of the mapped fluvial mine-waste deposits and are based on areas that USEPA has identified as having an HQ of greater than 1 for deer and elk and/or areas with the greatest potential for phytotoxicity (see Section 3.3.2). Table 5-6 summarizes the Reach 1 restoration alternatives developed for agricultural lands within the Arkansas River floodplain (irrigated meadows).

5.1.3.1 Alternative 1: Natural Recovery

Alternative 1 considers the scenario of natural recovery and includes no additional actions. Current agricultural activities are assumed to continue.

5.1.3.2 Alternative 2: Deep Tilling & Reseeding

Alternative 2 addresses the surficial concentration of bioavailable metals by deep tilling approximately 35 acres to an average depth of 12 inches, followed by reseeding. Given the relatively low metals concentration in the top few inches, deep tilling should reduce the average concentration of bioavailable metals in surface soils and the root zone to below levels of concern and reseeding will expedite recovery of the vegetation. It is recognized that there may be several seed/planting mixes that could be successfully used for reseeding. For the purposes of alternatives development and estimating costs, a planting mixture (i.e., species composition) has been developed based on the surrounding land-use and setting. The proposed planting mixture includes slender wheatgrass (4 lbs/acre), smooth brome (3 lbs/acre), hard fescue (2 lbs/acre), orchardgrass (3 lbs/acre), alpine Timothy (2 lbs/acre), Idaho fescue (3 lbs/acre) and red clover (3 lbs/acre).

5.1.3.3 ALTERNATIVE 3: LIMING, DEEP TILLING & RESEEDING

Alternative 3 adds soil amendments to Alternative 2. The addition of 10 tons/acre agricultural lime to approximately 35 acres and tilled to 12 inches, could limit the potential for further plant uptake of metals, and reseeding (utilizing the planting mixture from Alternative 2) of the tilled area will expedite recovery of the vegetation.

5.2 REACH 2

Reach 2 extends approximately 3.79 river miles from the confluence of Lake Fork to the Highway 24 bridge. Flow in Lake Fork can, at times, be heavily augmented from "trans-mountain" diversions. Access to the river is limited to driveways and ranch roads. The Smith Ranch occupies the majority of subreach 2A and subreach 2B is primarily comprised of State lands and private property (Figure 5-1). Table 5-7 summarizes the alternatives developed for Reach 2.

5.2.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 2 contains a total of 35 discrete fluvial mine-waste deposits. The majority of the deposits are of moderate priority (27), with few high priority (3) deposits. Twenty-one of the deposits have poor to fair vegetation cover (7.2 acres) with 14 having good cover (2.1 acres). The majority of the fluvial deposits within Reach 2 are near the confluence of Lake Fork and the Upper Arkansas River (subreach 2A). A few deposits are present near the highway 24 bridge (subreach 2B). The parameters of Reach 2 deposits are summarized in Table 5-8.

Table 5-8
Reach 2 Fluvial Mine-Waste Deposit Characteristics

Subreach	No. of Deposits	Total Ft of Bank Intercepting Deposits	Priority	No. of Deposits	Acres	Average Depth of Deposits (ft)	Volume of Deposits (cu.yds.)
2A	31	3,140	High	3	4.13	0.38	2,547
			Mod	23	3.33	0.54	2,895
			Low	5	0.34	0.51	276
2B	4	150	Mod	4	1.52	1.19	2,926
Reach 2 Totals	**35**	**3,290**	**High**	**3**	**4.13**	**0.38**	**2,547**
			Mod	**27**	**4.85**	**0.74**	**5,821**
			Low	**5**	**0.34**	**0.51**	**276**

USEPA has not conducted any significant remediation within Reach 2 (see Section 3.3.1). Tables 5-3 and 5-4 summarize the alternatives developed for fluvial mine-waste deposits in Reach 2 by reach and by priority, respectively.

5.2.1.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the No Action/Natural Recovery alternative. This alternative evaluates the potential for natural recovery and provides a point of reference against which the cost/benefit analyses can be compared.

No restoration actions would occur within Reach 2. The baseline of environmental conditions (i.e., land use, land-use practices, flow augmentation, etc.) within Reach 2 are assumed to remain constant with time. Changes with regard to the disposition of the fluvial mine-waste deposits and the condition of the natural resources are evaluated in light of the current baseline of conditions.

5.2.1.2 ALTERNATIVE 2: LIMING, DEEP TILLING AND RESEEDING

Alternative 2 calls for liming, deep tilling, and reseeding the approximately 5.1 acres of combined low and moderate priority fluvial mine-waste deposits. An average of 75 tons/acre of agricultural grade lime would be applied to raise the pH and lower the bioavailability of metals. The lime would be deep tilled to a depth of 18 inches. Reseeding would match the adjacent areas and mulch would be added following seeding. The seed/planting mixture selected for alternatives development is presented in Section 5.1.1.2.

For the approximately 4.1 acres of high priority deposits, an average of 75 tons/acre of agricultural grade lime would be applied to the to raise the pH and lower the bioavailability of metals. One-time lime addition requirements for the high priority deposits could be substantial, given the acid generating potential of some of the deposits. In addition, 40 dry tons/acre of composted biosolids would be applied to the high priority deposits as an amendment to increase organic matter. The lime and biosolids would be tilled to a depth of 18 inches. Reseeding would match the adjacent areas. The seed/planting mixture selected for alternatives development is presented in Section 5.1.1.2. Mulch would be used following seeding to improve moisture relationships for germination and establishment.

5.2.1.3 ALTERNATIVE 3: SOIL COVER

Alternative 3 is similar to Alternative 2 in that it prescribes liming, deep tilling and reseeding for the low and moderate priority deposits. In addition to the treatments described in Alternative 2, Alternative 3 for the low and moderate priority deposits includes the application of composted biosolids

(40 dry tons/acre) as an amendment to increase organic matter. The lime and biosolids would be tilled to a depth of 18 inches.

High priority deposits would be tilled and amended with lime and a 12-inch deep tapered soil cover would be added prior to reseeding. The 12-inch soil cover will provide additional assurance of successful revegetation, reduce exposure for burrowing animals, and along with liming, will further limit the potential for plant metals uptake. The seed/planting mixture selected for alternatives development is the same as in Alternative 2 and is presented in Section 5.1.1.2.

5.2.1.4 ALTERNATIVE 4: REMOVAL

Alternative 4 calls for the removal of all low, moderate and high priority mine-waste deposits within Reach 2 (8,644 cu. yds.). The average depth of fluvial deposits in Reach 2 is approximately 0.57 feet. Over-excavation of an additional 6 inches (approximately 7,500 additional cu. yds.) is considered appropriate. Deposits would be removed and transported to the anticipated California Gulch NPL Site central repository to be constructed at the Black Cloud Mine (approximately 10 to 12 miles). Although somewhat more distant than Reach 1, the proximity to subreach 2A makes this disposal location feasible. The high proportion of private land in Reaches 1 and 2 makes the possibility of developing a more cost effective repository within these reaches unlikely.

After removal, soil underlying the high priority deposits would be amended with an average of 75 tons/acre of agricultural grade lime to address any residual acidity, and excavations would be backfilled with clean soil (assumed average backfill depth of 12 inches) and graded prior to reseeding. The planting mixture would be the same as identified for Alternative 2. For bank deposits where complete removal increases the potential for bank erosion, appropriate bank stabilization measures will be included. Given the shallow depth of the deposits and the channel characteristics, it is assumed that approximately 15% (500 feet) of bank associated with fluvial mine-waste deposit removals would require some specific stabilization measures (e.g., root wads and/or placed logs).

5.2.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

Overall, the streambanks within Reach 2 are generally stable. Some undercut bank erosion, indicative of channel widening, is evident within subreach 2A. The current areas of bank instability overlap, to some degree, with depositional areas containing mine-waste deposits. For most areas within

Reach 2

Reach 2, the potential for future channel widening will be largely controlled by management of augmented flows and, because of some existing fencing, to a lesser degree cattle access. The general quality of riparian zone vegetation is consistent with the upstream reference reach (Reach 0), except for the most downstream portion (subreach 2B) where woody vegetation is lacking. In-stream habitat at sites within Reach 2 were rated good to optimal, however, additional pool and underbank habitat would be beneficial.

Some limited stream stabilization work (rip-rap weir) appears to have been conducted by the USFS at the junction of reaches 1 and 2. However, the associated length of armored streambank is not substantial enough to be considered in the development of alternatives. Because the quality of in-stream habitat in Reach 2 is generally high, only three restoration alternatives have been developed for this restoration need category. Table 5-5 summarizes the Reach 2 restoration alternatives developed for riparian areas/channel morphology/in-stream habitat.

5.2.2.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the No Action/Natural Recovery alternative and assumes no work beyond that already conducted.

5.2.2.2 ALTERNATIVE 2: GRAZING CONTROL

Alternative 2 focuses on the general improvement of streambank/channel stability and riparian vegetation throughout Reach 2 with isolation of the riparian area from grazing. A combination of fencing (40,400 feet of 3-strand solar electric fence), paired with a 20-year conservation lease (a 25 foot offset from the banks for the fenced area), is the primary action for the riparian zone. Access points for stock watering/crossing would be provided. The approximate acreage under lease would be approximately 23 acres (20,200 feet x 50 feet). Alternative 2 can be paired with any of the above restoration alternatives for the fluvial mine-waste deposits.

5.2.2.3 ALTERNATIVE 3: SOFT TREATMENTS

Alternative 3 was developed to pair with fluvial mine-waste alternatives 2 or 3, involving in-place stabilization of deposits. More aggressive actions are included to reduce the susceptibility of the stabilized deposits to future erosion. Alternative 3 includes grazing control measures from Alternative 2. Additional measures for bank protection/channel stabilization and in-stream habitat improvements are included for subreach 2A. Soft treatments including willow waddling, anchored trees, root wads, rock structures and log placement would be used in combination in this subreach to further improve in-stream habitat and provide bank/channel stability. The exact location and specific number of treatments are a design element and beyond the level of study currently available. However, based on field reconnaissance and the total feet of bank intercepting deposits (approximately 3,290 feet), for the purpose of the detailed and comparative analyses, it is assumed that 5,000 feet of bank (approximately 150% of the length of bank intercepting deposits) would receive soft treatments.

5.2.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

The areas of the floodplain and non-floodplain irrigated agricultural lands identified as having the greatest potential for phytotoxicity and/or posing unacceptable risks to grazing animals are almost evenly split between subreaches 2A (31.7 acres) and 2B (34.4 acres). These acreages are exclusive of the mapped fluvial deposits and are based on areas EPA has identified as having an HQ of greater than 1 for deer and elk and/or areas with the greatest potential for phytotoxicity (see Section 3.3.2). Table 5-6 summarizes the Reach 2 restoration alternatives developed for agricultural lands within the Arkansas River floodplain (irrigated meadows).

5.2.3.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 considers the scenario of natural recovery and includes no additional actions. Current agricultural activities are assumed to continue.

5.2.3.2 ALTERNATIVE 2: DEEP TILLING & RESEEDING

Alternative 2 addresses the surficial concentration of bioavailable metals by deep tilling approximately 66 acres to an average depth of 12 inches and reseeding (see Section 5.1.3.2 for planting mixture). Given the relatively low metals concentration in the top few inches, deep tilling should reduce the concentration of bioavailable metals in surface soils and the root zone to below levels of concern and reseeding will expedite recovery of the vegetation.

5.2.3.3 ALTERNATIVE 3: LIMING, DEEP TILLING & RESEEDING

Alternative 3 adds soil amendments to Alternative 2. The addition of 10 tons/acre of agricultural grade lime to approximately 66 acres and tilled to 12 inches, could limit the potential for further plant uptake of metals, and reseeding (see Section 5.1.3.2 for planting mixture) of the tilled area will expedite recovery of the vegetation.

5.3 REACH 3

Reach 3 extends approximately 3.88 river miles from the Highway 24 bridge to the valley constriction just below Kobe. The majority of Reach 3 is owned by the City of Aurora, Colorado Department of Natural Resources and Lake County, with the exception of a very small portion of private land (Moyer Ranch) near the highway 24 bridge (Figure 5-1). There are a number of former ranch roads that serve as access to Reach 3. Table 5-9 summarizes the alternatives developed for Reach 3.

5.3.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 3 contains the highest volume (58,500 cu. yds.) and largest number of fluvial deposits (94) of all four reaches. The majority of the deposits are ranked moderate priority (69). The deposits are evenly dispersed throughout the reach. Vegetation cover on the deposits is mixed and ranges from poor to good. The reach has been divided into subreaches 3A and 3B primarily based on channel morphology. Characteristics of the Reach 3 deposits are summarized in Table 5-10.

Table 5-10
Reach 3 Fluvial Mine-Waste Deposit Characteristics

Subreach	No of Deposits	Total Ft of Bank Intercepting Deposits	Priority	No. of Deposits	Acres	Acres Remediated by USEPA	Average Depth of Deposits (ft)	Volume of Deposits (cu. yds.)
3A	58	3,480	High	9	6.91	5.12	1.21	13,452
			Mod	42	15.63	8.96	0.98	35,704
			Low	7	1.27	1.06	0.47	969
3B	36	1,300	High	4	4.28	0.62	0.90	6,245
			Mod	27	9.02	1.04	0.83	12,143
			Low	5	0.50	0	1.29	1,049
Reach 3 Totals	**94**	**4,780**	**High**	**13**	**11.19**	**5.74**	**1.09**	**19,697**
			Mod	**69**	**24.65**	**10**	**0.92**	**36,741**
			Low	**12**	**1.78**	**1.06**	**0.70**	**2,018**

USEPA has conducted treatments on 31 of the 94 deposits within Reach 3 (see Section 3.3.1). Treatments generally involving the integration of a variety of combinations of organic matter (biosolids, wood chips, fish pond sediments) and lime (agricultural grade limestone, kiln dust, dolomite chips) with the fluvial deposits have been utilized for approximately 17 of the 38 acres within Reach 3. The treatments also included reseeding. Information is not yet available as to the performance of any given treatment approach, however, USEPA continues to modify and re-amend the deposits based on observations. For the purposes of the RAR, it is assumed that USEPA's activities will provide adequate stabilization and allow for establishment of good vegetation cover. Correspondingly, the treated deposits are not included in Reach 3 alternatives calling for in-place stabilization. Removal alternatives, however, consider all of the deposits regardless of prior amendments. Tables 5-3 and 5-4 summarize the alternatives developed for fluvial mine-waste deposits in Reach 3 by reach and by priority, respectively.

5.3.1.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the No Action/Natural Recovery alternative. As noted above, some work has been conducted by USEPA within Reach 3 and although additional USEPA work may continue in the future, this alternative evaluates the potential for natural recovery and provides a point of reference against which the cost/benefit of action based alternatives can be compared.

No further restoration actions would occur within Reach 3. As for other alternatives, the baseline of environmental conditions (i.e., land use, land-use practices, flow augmentation, etc.) within Reach 3, are assumed to remain constant with time. Changes with regard to the disposition of the fluvial mine-waste deposits and the condition of the natural resources are evaluated in light of the current baseline conditions.

5.3.1.2 ALTERNATIVE 2: BIOSOILDS

Alternative 2 calls for liming, deep tilling and reseeding the approximately 15 acres of low and moderate priority fluvial mine-waste deposits that have not already been remediated by USEPA. The lower metals content and more moderate pH make these deposits suitable for this restoration approach. An average of 75 tons/acre of agricultural grade lime would be deep tilled to raise the pH and lower the bioavailability of metals, prior to reseeding. Reseeding would match the adjacent areas and mulch would be added following seeding. The planting mix used for alternatives development for these deposits is presented in 5.1.1.2.

High priority deposits (5.45 acres) that have not already been remediated by USEPA would also be addressed with liming and deep tilling, and in addition, 40 dry tons/acre of composted biosolids would be applied as an amendment to increase organic matter. The lime and biosolids would be tilled to a depth of 18 inches. One-time lime addition requirements for the high priority deposits could be substantial, given the acid generating potential of some of the deposits. Reseeding would match the adjacent areas. The planting mixture used for alternatives development for these deposits is presented in 5.1.1.2. Mulch would be used following seeding to improve moisture relationships for germination and establishment.

5.3.1.3 ALTERNATIVE 3: SOIL COVER

Alternative 3 is similar to Alternative 2 in that it prescribes liming, deep tilling and reseeding for the low and moderate priority fluvial mine-waste deposits that have not already been remediated by USEPA. In addition to the treatments described in Alternative 2, Alternative 3 includes the application of composted biosolids (40 dry tons/acre) as an amendment to increase organic matter. The lime and biosolids would be tilled to a depth of 18 inches. Reseeding would match the adjacent areas. The planting mixture used for alternatives development for these deposits is presented in 5.1.1.2.

Restoration actions of liming, with deep tilling an average of 18 inches and the addition of a 12-inch deep tapered soil cover prior to reseeding, are prescribed for the high priority fluvial mine-waste deposits. The 12-inch soil cover will provide additional assurance of successful revegetation, reduce exposure for burrowing animals, and along with liming, will further limit the potential for plant metals uptake.

5.3.1.4 ALTERNATIVE 4: REMOVAL

Alternative 4 calls for the removal of all low, moderate and high priority mine-waste deposits within Reach 3 (58,500 cu. yds.). The average depth of fluvial deposits in Reach 3 is approximately 1 foot. Over excavation of an additional 6 inches is considered appropriate (approximately 30,250 cu. yds.). Excavated material would be placed in a centralized repository within Reach 3. The availability of public lands to assure long-term effectiveness, and the longer haul distances for large volumes, make this a cost effective alternative to the Black Cloud Mine site repository. The repository would utilize an 18-inch vegetated earthen cover and would be graded to reduce infiltration. The location would be above the 500-year floodplain. Assuming an average thickness of 10 feet, the repository would require approximately 4 to 5 acres out of the 100-year floodplain.

After removal, soil underlying the high priority deposits would be amended with an average of 75 tons/acre agricultural grade lime to address any residual acidity and excavations would be backfilled with clean soil (assumed average backfill depth of 18 inches) and graded prior to revegetation. The planting mixture would be similar to that identified for Alternative 3. For bank deposits where complete removal increases the potential for bank erosion, appropriate bank stabilization measures will be included. Given the shallow depth of the deposits and the channel characteristics, it is assumed that approximately 15% (750 feet) of bank associated with fluvial mine-waste deposit removals would require some specific stabilization measures (e.g., root wads and/or placed logs).

5.3.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

Within Reach 3 there are some areas of channel instability in the upper portion of subreaches 3A downstream of the highway 24 bridge. In the lower portion of Reach 3B approximately a 3/4 mile portion of the channel is "perched" above the valley floor. Fluvial mine-waste deposits are present between the current "perched" channel and the historic channel**.** The channel has been stable in this "perched" configuration for more than 50 years, however, it could at some point in the future avulse to the slightly lower elevation historic channel. However, based on examination in the field, and further review of prior analysis (Interfluve 1999), it appears that this is unlikely. The potential that the currently active "perched" channel could laterally migrate through the deposits and erode them, is also small.

The condition of floodplain vegetation away from the Reach 3 fluvial deposits is similar to the upstream reference reach (Reach 0). Reconnaissance indicates that cattle have heavily impacted the riparian vegetation and streambanks at certain locations. As discussed above, specific areas of lower quality riparian cover and bank instability can be attributed to the presence of fluvial mine-waste deposits. These specific areas are considered in the fluvial mine-waste deposit alternatives. In-stream habitat is generally fair to good within Reach 3. Lack of bank cover and a monotonous broad flat channel is the setting for most of the reach.

A small amount of bank stabilization work has been conducted by USEPA in conjunction with amendment of certain fluvial deposits (See Section 3.3.1). However, the length of streambank addressed is small and correspondingly is not reflected in the development of Reach 3 alternatives. Table 5-5 summarizes the Reach 3 restoration alternatives developed for riparian areas/channel morphology/in-stream habitat.

5.3.2.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the natural recovery alternative and assumes no work beyond that already conducted by USEPA.

5.3.2.2 ALTERNATIVE 2: GRAZING CONTROL

Alternative 2 focuses on the general improvement of streambank/channel stability and riparian vegetation throughout Reach 3 with isolation of the riparian area from grazing. A combination of fencing (41,000 feet of 3-strand solar electric fence) paired with a 20-year conservation lease (a 25 foot offset from the banks for the fenced area), is the primary action for the riparian zone. Access points for stock watering/crossing would be provided. The approximate acreage under lease would be approximately 24 acres (20,500 feet x 50 feet). Alternative 2 can be paired with any of the above restoration alternatives for the fluvial mine-waste deposits.

5.3.2.3 ALTERNATIVE 3: SOFT TREATMENTS

Alternative 3 was developed to be paired with fluvial mine-waste alternatives 2 and 3 involving in-place stabilization of deposits. More aggressive actions are included to reduce the susceptibility of the stabilized deposits to future erosion. Alternative 3 includes grazing control measures from Alternative 2. Additional measures for bank protection/channel stabilization and in-stream habitat improvements are included for both subreaches (3A and 3B). Soft treatments including willow waddling, anchored trees, root wads, rock structures and log placement would be used in combination to provide both in-stream habitat and further improve bank/channel stability. The exact location and specific number of these actions for Reach 3 are design elements and beyond the level of study currently available. However, based on field reconnaissance and the total feet of bank intercepting deposits (approximately 4,800 feet), for the purpose of the detailed and comparative analyses, it is assumed that 7,200 feet (150% of the exposed bank length) would receive soft treatments.

5.3.2.4 ALTERNATIVE 4: POOL EXCAVATION

Alternative 4 was developed, in part, to pair with the fluvial mine-waste Alternative 4, which prescribes removal of the deposits. However, Alternative 4 can also be paired with mine-waste deposits

Alternatives 2 and 3. Given removal of the deposits, more aggressive streambank/channel stabilization measures, beyond those planned in conjunction with the removal (approximately 750 feet of bank stabilization), are not included. Grazing control to restore riparian areas will contribute to bank/channel stability. Because of the fair to poor condition of in-stream habitat, the habitat improvement Process Option of pool excavation is included for both subreaches in Reach 3. An assumed application rate of 5 pool excavations per subreach has been adopted for the detailed and comparative analysis.

5.3.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

The areas of agricultural lands (irrigated meadows) identified as having the greatest potential for phytotoxicity and/or posing unacceptable risks to grazing animals in subreach 3A are: 3.5 acres of non-floodplain soils and 19.9 acres of 500-year floodplain soils; and in subreach 3B are: 37.9 acres of non-floodplain soils and 8.9 acres of 500-year floodplain soils. These acreages are based on a combination of areas EPA has identified as having an HQ of greater than 1 for deer and elk and/or areas with the greatest potential for phytotoxicity (see Section 3.3.2). Table 5-6 summarizes the Reach 2 restoration alternatives developed for agricultural lands within the Arkansas River floodplain (irrigated meadows).

5.3.3.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 considers the scenario of natural recovery and includes no additional actions. Current agricultural activities are assumed to continue.

5.3.3.2 ALTERNATIVE 2: DEEP TILLING & RESEEDING

Alternative 2 addresses the surficial concentration of bioavailable metals by deep tilling 70 acres to an average depth of 12 inches and reseeding using the planting mixture presented in Section 5.1.3.2. Given the relatively low metals concentration in the top few inches, deep tilling should reduce the concentration of bioavailable metals in the root zone to below levels of concern and reseeding will expedite recovery of the vegetation.

5.3.3.3 ALTERNATIVE 3: LIMING, DEEP TILLING & RESEEDING

Alternative 3 adds soil amendments to Alternative 2. The addition of 10 tons/acre agricultural grade lime to approximately 70 acres and tilled to 12 inches, could limit the potential for further plant uptake of metals, and reseeding of the tilled area using the planting mixture presented in Section 5.1.3.2 will expedite recovery of the vegetation.

5.4 REACH 4

Reach 4 extends approximately 1.76 river miles from the valley constriction just below Kobe to just above the confluence with Two-Bit gulch at the head of the UARB canyon. The reach is bounded on the west by the Hayden Ranch and on the east by BLM properties with some smaller interspersed private parcels. Access is limited to a few private driveways/ranch roads. Reach 4 restoration needs are limited to a few small fluvial mine-waste deposits and long-term habitat protection. Table 5-11 summarizes the alternatives developed for Reach 4.

5.4.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 4 has a relatively gentle slope and should be the repository of large amounts of mine-waste from steep subreach 3B. However, it contains no mapped mine-waste deposits, and apparently acts as a conduit of upstream sediment that is delivered to the canyon downstream. Reach 4 has been able to convey mine-waste downstream, and contains little or no mine-waste. Only a few small areas of potential mine-waste could be observed. For the purposes of alternatives development, an area of 2 acres has been assumed. Tables 5-3 and 5-4 summarize the alternatives developed for fluvial mine-waste deposits in Reach 4 by reach and by priority, respectively.

5.4.1.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the No Action/Natural Recovery alternative. This alternative evaluates the potential for natural recovery and provides a point of reference against which the cost/benefit of action based alternatives can be compared. The baseline of environmental conditions (i.e., land use, land-use practices, flow augmentation, etc.) within Reach 4, are assumed to remain constant with time. Changes with regard to the disposition of the fluvial mine-waste deposits and the condition of the natural resources are evaluated in light of the current baseline conditions.

5.4.1.2 ALTERNATIVE 2: DIRECT REVEGETATION

Alternative 2 calls for direct revegetation of the 2 acres of low priority fluvial mine-waste deposits. Direct revegetation is a proven technology for mine-waste deposits of moderate pH and metals concentrations. The seed/planting mixture selected for alternatives development is presented in Section

5.1.1.2. Revegetation efforts would need to be coordinated with the landowner. Access for this alternative would be on foot or with an All-Terrain Vehicle (ATV). Mulch would be used following seeding to improve moisture relationships for germination and establishment.

5.4.1.3 ALTERNATIVE 3: LIMING, DEEP TILLING & RESEEDING

The small area of suspected fluvial mine-waste deposits would be amended with lime and reseeded. Access would be on foot or with an ATV.

Reseeding would match the adjacent areas. For the purposes of alternatives development, the planting mixture for the deposits is presented in Section 5.1.1.2.

5.4.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

Riparian habitat and floodplain vegetation appear to be in good condition within Reach 4. The channel is stable and fish habitat is good. Management of grazing is included as a long-term habitat protection Process Option. Table 5-5 summarizes the Reach 4 restoration alternatives developed for riparian areas/channel morphology/in-stream habitat.

5.4.2.1 ALTERNATIVE 1: NATURAL RECOVERY

Alternative 1 is the natural recovery alternative and assumes no additional work.

5.4.2.2 ALTERNATIVE 2: GRAZING CONTROL

Alternative 2 focuses on the general improvement of streambank/channel stability and riparian vegetation throughout Reach 4 with isolation of the riparian area from grazing. A combination of fencing (18,600 feet of 3-strand solar electric fence) paired with a 20-year conservation lease (a 25 foot offset from the banks for the fenced area), is the primary action for the riparian zone. Access points for stock watering/crossing would be provided. The approximate acreage under lease would be approximately 11 acres (9,300 feet x 50 feet).

TABLE 5-1
REACH 1 RESTORATION ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
FLUVIAL MINE-WASTE DEPOSITS				
Low Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
Moderate Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
High Priority	No action Natural recovery	N/A[1]	N/A[1]	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT				
Subreach 1A	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Soft treatments for bank protection/channel stabilization/in-stream habitat improvements and riparian area grazing control	Riparian area grazing control (conservation lease/fencing), In-stream habitat enhancement (pool excavation)
Subreach 1B	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)
Subreach 1C	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Soft treatments for bank protection/channel stabilization/in-stream habitat improvements and riparian area grazing control	Riparian area grazing control (conservation lease/fencing), In-stream habitat enhancement (pool excavation)
AGRICULTURAL LANDS				
	No action Natural recovery	Deep tilling and reseeding	Liming, deep tilling and reseeding	------

[1]N/A: Alternatives 2 and 3 for the Reach 1 high priority fluvial mine-waste deposits are not applicable because USEPA has already conducted in-situ treatment on these deposits (see Section 3.3.1).

TABLE 5-3
RESTORATION ALTERNATIVES FOR FLUVIAL MINE-WASTE DEPOSITS BY REACH

	Reach 1	Reach 2	Reach 3	Reach 4
LOW PRIORITY				
Alternative 1	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery
Alternative 2	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	Direct revegetation with mulch addition
Alternative 3	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	Liming and reseeding
Alternative 4	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	N/A
MODERATE PRIORITY				
Alternative 1	No action Natural recovery	No action Natural recovery	No action Natural recovery	N/A
Alternative 2	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	N/A
Alternative 3	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	N/A
Alternative 4	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	N/A
HIGH PRIORITY				
Alternative 1	No action Natural recovery	No action Natural recovery	No action Natural recovery	N/A
Alternative 2	N/A[1]	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	N/A
Alternative 3	N/A[1]	Lime addition with deep tilling, soil cover, grading and reseeding	Lime addition with deep tilling, soil cover, grading and reseeding	N/A
Alternative 4	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	N/A

[1]N/A: Alternatives 2 and 3 for the Reach 1 high priority fluvial mine-waste deposits are not applicable because USEPA has already conducted in-situ treatment on these deposits (see Section 3.3.1).

TABLE 5-4
RESTORATION ALTERNATIVES FOR FLUVIAL MINE-WASTE DEPOSITS BY PRIORITY

Reach	Alternative	Low Priority	Moderate Priority	High Priority
1	1	No action Natural recovery	No action Natural recovery	No action Natural recovery
	2	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	N/A[1]
	3	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	N/A[1]
	4	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
2	1	No action Natural recovery	No action Natural recovery	No action Natural recovery
	2	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding
	3	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	Lime addition with deep tilling, soil cover, grading and reseeding
	4	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
3	1	No action Natural recovery	No action Natural recovery	No action Natural recovery
	2	Liming, deep tilling and reseeding with mulching	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding
	3	Lime and biosolids addition with deep tilling and reseeding	Lime and biosolids addition with deep tilling and reseeding	Lime addition with deep tilling, soil cover, grading and reseeding
	4	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
4	1	No action Natural recovery	N/A	N/A
	2	Direct revegetation with mulch addition	N/A	N/A
	3	Liming and reseeding	N/A	N/A
	4	N/A	N/A	N/A

[1]N/A: Alternatives 2 and 3 for the Reach 1 high priority fluvial mine-waste deposits are not applicable because USEPA has already conducted in-situ treatment on these deposits (see Section 3.3.1).

TABLE 5-5
RESTORATION ALTERNATIVES FOR
RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

Alternative	Reach 1			Reach 2		Reach 3		Reach 4
	1A	1B	1C	2A	2B	3A	3B	
Alternative 1	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery
Alternative 2	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)
Alternative 3	Soft treatments for bank protection/channel stabilization/in-stream habitat improvements, and riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Soft treatments for bank protection/channel stabilization/in-stream habitat improvements, and riparian area grazing control (conservation lease/fencing)	Within upper portion of subreach 2A limited application of soft treatments for bank protection/channel stabilization and riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	Soft treatments for bank protection/channel stabilization/in-stream habitat improvements and riparian area grazing control (conservation lease/fencing)	Soft treatments in the current channel for bank protection/channel stabilization/in-stream habitat improvements and riparian area grazing control (conservation lease/fencing)	N/A
Alternative 4	Riparian area grazing control (conservation lease/fencing) and in-stream habitat enhancement (pool excavation)	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing) and in-stream habitat enhancement (pool excavation)	------	------	Riparian area grazing control (conservation lease/fencing) and in-stream habitat enhancement (pool excavation)	Riparian area grazing control (conservation lease/fencing) and in-stream habitat enhancement (pool excavation)	N/A

TABLE 5-6
RESTORATION ALTERNATIVES FOR AGRICULTURAL LANDS

	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**
Alternative 1	No action Natural recovery	No action Natural recovery	No action Natural recovery	No action Natural recovery
Alternative 2	Deep tilling and reseeding	Deep tilling and reseeding	Deep tilling and reseeding	No action Natural recovery
Alternative 3	Liming, deep tilling and reseeding	Liming, deep tilling and reseeding	Liming, deep tilling and reseeding	No action Natural recovery

TABLE 5-7
REACH 2 RESTORATION ALTERNATIVES

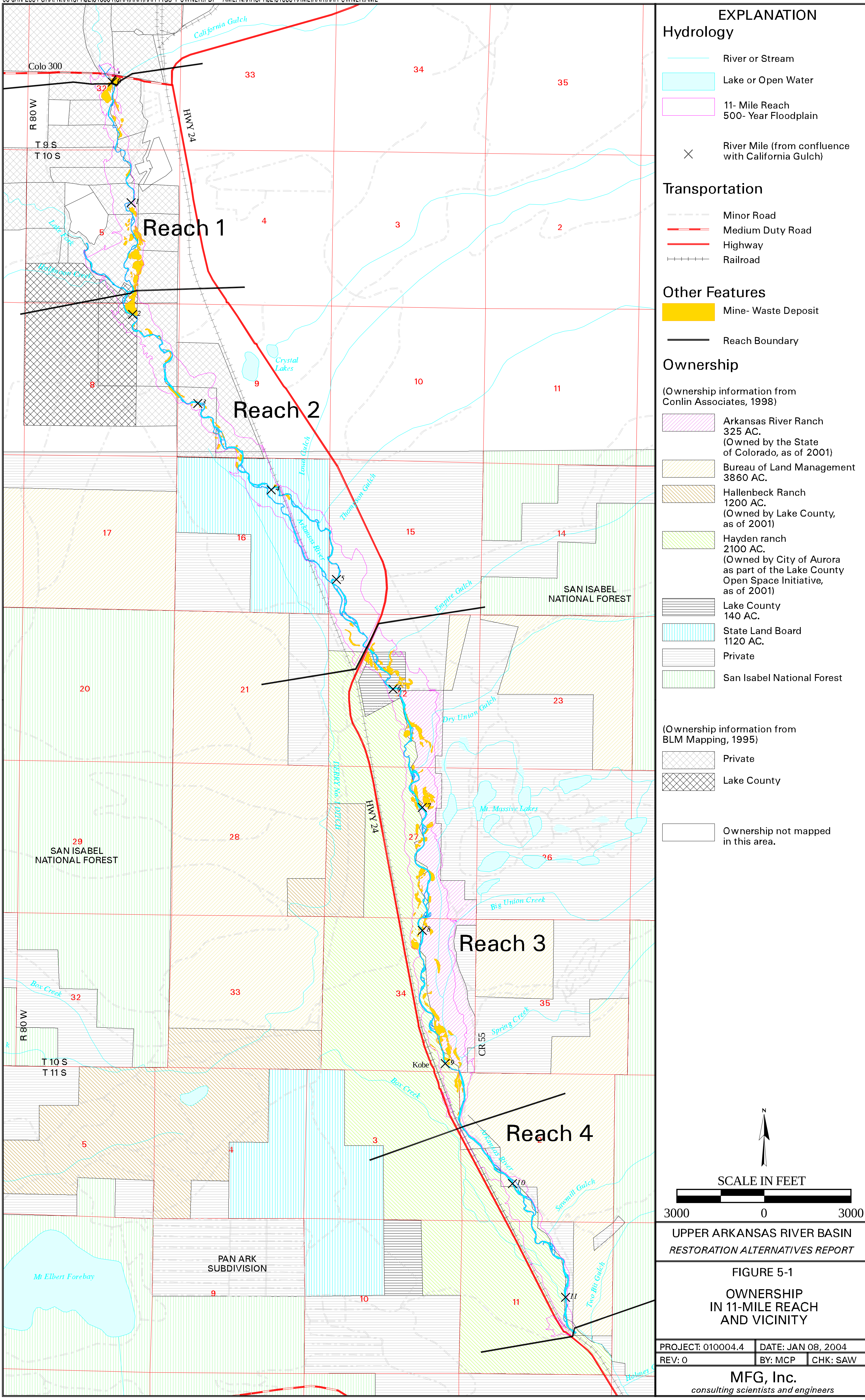
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
FLUVIAL MINE-WASTE DEPOSITS				
Low Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
Moderate Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
High Priority	No action Natural recovery	Lime and biosolids addition with deep tilling and reseeding	Lime addition with deep tilling, soil cover, grading and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT				
Subreach 2A	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Within upper portion of subreach 2A limited application of soft treatments for bank protection/channel stabilization, and riparian area grazing control (conservation lease/fencing)	------
Subreach 2B	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing)	------
AGRICULTURAL LANDS				
	No action Natural recovery	Deep tilling and reseeding	Liming, deep tilling and reseeding	------

TABLE 5-9
REACH 3 RESTORATION ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
FLUVIAL MINE-WASTE DEPOSITS				
Low Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
Moderate Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
High Priority	No action Natural recovery	Lime and biosolids addition with deep tilling and reseeding	Lime addition with deep tilling, soil cover, grading and reseeding	Removal, liming of underlying soil, soil replacement as necessary to bring back to surrounding grade and reseeding
RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT				
Subreach 3A	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Soft treatments for bank protection/channel stabilization/in-stream habitat improvements and riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing), In-stream habitat enhancement (pool excavation)
Subreach 3B	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	Soft treatments in the current channel for bank protection/channel stabilization/in-stream habitat improvements including riparian area grazing control (conservation lease/fencing)	Riparian area grazing control (conservation lease/fencing), In-stream habitat enhancement (pool excavation)
AGRICULTURAL LANDS				
	No action Natural recovery	Deep tilling and reseeding	Liming, deep tilling and reseeding	------

TABLE 5-11
REACH 4 RESTORATION ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
FLUVIAL MINE-WASTE DEPOSITS				
Low Priority	No action Natural recovery	Direct revegetation with mulch addition	Liming and reseeding	N/A
Moderate Priority	N/A	N/A	N/A	N/A
High Priority	N/A	N/A	N/A	N/A
RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT				
	No action Natural recovery	Riparian area grazing control (conservation lease/fencing)	N/A	N/A



UPPER ARKANSAS RIVER BASIN

RESTORATION ALTERNATIVES REPORT

FIGURE 5-1

OWNERSHIP IN 11-MILE REACH AND VICINITY

PROJECT: 010004.4	DATE: JAN 08, 2004	
REV: 0	BY: MCP	CHK: SAW

MFG, Inc.

consulting scientists and engineers

6.0 EVALUATION OF ALTERNATIVES

The evaluation of the expected performance of each restoration alternative is based upon USEPA's guidance for conducting an EE/CA (USEPA 1993a) and the DOI's NRD Restoration Planning Process (43 CFR 11.81-11.82). Correspondingly, the evaluation considers a composite of the feasibility criteria identified in the EE/CA guidance and criteria identified for evaluating the appropriateness of a restoration alternative under the NRD guidance. The effectiveness of each alternative is ultimately gauged relative to its expected ability to achieve the overarching restoration objectives identified in Section 3, or more specifically, the ability to restore the resource to baseline conditions. A No Action/Natural Recovery alternative provides a point of comparison.

The alternatives developed in Section 5 are evaluated under the general criteria of implementability, effectiveness and relative cost, taking into account conditions within the 11-Mile Reach. The specific considerations for each of the general criteria are described below.

Implementability

This criterion relates to the applicability and technical and administrative feasibility associated with each alternative. Technical feasibility, or implementability, is the ability to construct and reliably operate, or maintain, the system to meet the restoration objectives, in light of the site setting. Administrative feasibility, or implementability, is the ability to procure the necessary services, land, equipment, and expertise. Anticipated regulatory and community acceptance were also considered in evaluating the administrative implementability of each alternative. An alternative that is relatively easy to construct or put into practice at the site, and is technologically reliable will be considered readily, or highly, implementable. An alternative that is based upon commercially available technologies but not widely used for the specific application, or one that presents some challenges or difficulty related to site conditions was characterized as more difficult to implement. An alternative using technology that may not be commercially available, such as innovative or emerging technologies, or that may have significant construction or operational problems for the particular site was considered to have an even lower degree of implementability.

Effectiveness

This criterion relates to the potential effectiveness of the alternative to achieve the restoration objectives, considering the physical and chemical properties of the media addressed and the site-specific conditions. The effectiveness evaluation considers how well each alternative reduces the source of injury to specific resources and the extent to which the resource may be expected to be restored. Potential impacts to human health and the environment during the construction and implementation of the remedy, including the potential for additional injury, are effectiveness considerations. The time to achieve the restoration objectives and the short- and long-term reliability of the selected restoration action with respect to site conditions are also considered in determining the effectiveness of each alternative.

In addition to the overarching action objectives, the following specific considerations were identified:

- Reduce the potential for transport of hazardous substances to surface water;
  - Leaching
  - Erosion

- Reduce the potential for transport of hazardous substances to groundwater;

- Reduce the potential for direct exposure to hazardous substances in soil by wildlife and livestock;
  - Direct exposure to soils
  - Plant uptake

- Reduce the potential for phytotoxicity;

- Re-establish appropriate vegetation/habitat to meet land-use objectives; and

- Improve the physical condition of both riparian and in-stream habitat within the stream corridor.

Estimated Costs

The estimated costs to implement each of the alternatives include direct capital costs, or costs directly related to construction activities, and are intended to include all labor, materials and equipment costs to implement the restoration activities in 2003 dollars. Indirect capital costs are also included, such as engineering/design, construction management, and administrative costs related to the development and implementation of appropriate institutional controls. O&M costs including inspections, maintenance seeding and additional amendments are estimated on an annual basis. These O&M costs are extended over a twenty-year period and a net present value is calculated using a 5% rate of return. The total cost includes all capital costs and the net present value for the O&M costs. Per the FS criteria, these costs are expected to fall within a –30% to +50% range of actual costs. Detailed cost estimates are included as Appendix A.

The following evaluation is organized by reach. Within each reach, the range of alternatives for each Resource Category is considered individually, relative to the above criteria. A comparison of performance is provided in Section 7.

6.1 REACH 1

Reach 1 extends from the confluence of the Upper Arkansas River with California Gulch to the tributary input from Lake Fork (1.81 miles). Reach 1 is comprised of predominantly agricultural lands.

6.1.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 1 contains 24 fluvial mine-waste deposits with a combined volume of approximately 33,000 cu. yds. USEPA has conducted treatment on 16 of the Reach 1 deposits (Section 3). All of the mapped high priority deposits within Reach 1 have been or are being remediated by USEPA. It is assumed that with time, USEPA's activities will provide adequate stabilization and allow for establishment of good vegetation cover. Correspondingly, the treated deposits are not included in Reach 1 alternatives calling for in-place stabilization. Removal alternatives, however, consider all of the deposits regardless of prior amendments.

6.1.1.1 ALTERNATIVE 1

Alternative 1 for mine-waste deposits of all priorities (low, moderate and high) in Reach 1 is the No Action/Natural Recovery alternative. No additional work would be performed, in addition to that work already completed by the USEPA.

Implementability: No action would be taken.

Effectiveness: The majority of fluvial mine-waste deposits in Reach 1 have recently been remediated by USEPA. Only approximately 3 of the 18 acres of deposits have not been remediated. These remaining 3 acres are comprised of moderate and low priority deposits. USEPA's remediation of all high priority deposits in Reach 1 with approximately 100 tons/acre lime should be effective in terms of reducing metals mobility, thereby reducing the potential for leaching and plant uptake.

USEPA has not formally evaluated the success of their Reach 1 remediation, but has observed that moisture-holding capacity is an important consideration. However, their addition of over 100 tons of organic amendments per acre will improve moisture-holding capacity and increase plant nutrients, thereby allowing for the near term development of adequate vegetation cover and, over time, providing suitable habitat/pasture, effectively restoring conditions within the 15 acres of deposits to conditions similar to those observed in adjacent areas. Given the initial establishment of cover and small area of deposits, vegetation consistent with surrounding communities should be achieved and maintained, thereby restoring habitat.

Although the remaining low and medium priority deposits cover a small area, pose less concern than the treated deposits, and have lesser potential to pose injury, they will not recover without restoration measures. However, the consequence of no action for these deposits is limited, because the partial loss of habitat/agricultural services provided by roughly 3 acres of unremediated deposits within the approximately 1,175 acres of Reach 1 500-year floodplain is relatively small.

Overall, given the large amount of recent remediation by USEPA, the No Action alternative could very well be effective in meeting most, if not all, restoration objectives.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.1.1.2 ALTERNATIVE 2

Alternative 2 for the previously untreated low and moderate priority fluvial mine-waste deposits within Reach 1 consists of the combination of lime addition, deep tilling, and reseeding of the amended deposits, with mulch addition.

Implementability: The 3 acres of unremediated mine-waste deposits are accessible for lime addition, deep tilling and reseeding activities, although the incorporation of amendments to a depth of 18 inches may require special construction equipment and/or techniques to achieve adequate mixing. Incorporation to this depth may require the use of a "Roto-mill", a self-contained soil stabilization/mixing machine, or a specialty pull-behind attachment known as a modified Baker plow. This alternative is considered to be implementable with the use of appropriate equipment. With respect to administrative implementability, access and consent of the landowners will be required to implement this alternative. However, given the extent of work previously performed within this reach and the fact that most of the reach is under the control of a single landowner, access is not considered to be difficult to obtain.

Effectiveness: Alternative 2 will effectively reduce the availability of metals and, with the addition of lime and deep tilling to a depth of 18-inches, will potentially reduce surficial metals concentrations. Revegetation activities under Alternative 2 should meet the objectives of establishing cover/habitat with low potential for metals exposure within 3 to 5 years of implementation. Institutional controls addressing future land-use practices may be required for long-term effectiveness.

Cost: The total estimated cost for Alternative 2 is approximately $85,000 (Table A-1). The largest portion of the costs for this alternative is related to the procurement and incorporation of agricultural lime. Costs have also been included in this estimate to develop access to the deposits and to restore access routes following implementation. Because many of the deposits within this reach have previously been accessed without the construction of access roads, and the quantity of amendments to be delivered is relatively small, these costs are minor.

6.1.1.3 ALTERNATIVE 3

Alternative 3 for the previously untreated low and moderate priority deposits within Reach 1 consists of the combination of lime and biosolids addition, deep tilling, and reseeding of the amended deposits.

Implementability: The 3 acres of unremediated mine-waste deposits are accessible for lime and biosolids addition, deep tilling and reseeding activities, although the incorporation of amendments to a depth of 18 inches may require special construction equipment and/or techniques to achieve adequate mixing. Incorporation to this depth may require the use of a “Roto-mill”, a self-contained soil stabilization/mixing machine, or a specialty pull-behind attachment known as a modified Baker plow. This alternative is considered to be implementable with the use of appropriate equipment. The implementability of this treatment option for near bank deposits could be limited because USEPA regulations prohibit the use of non-composted biosolids within 10 feet of the river channel. It is assumed that suitably composted biosolids can be obtained. With respect to administrative implementability, access and consent of the landowners will be required to implement this alternative. However, given the extent of work previously performed within this reach and the fact that most of the reach is under the control of a single landowner, access is not considered to be difficult to obtain.

Effectiveness: Alternative 3 will effectively reduce the availability of metals and, with the addition of lime and deep tilling to a depth of 18-inches, will potentially reduce surficial metals concentrations prior to revegetation. The inclusion of biosolids will improve moisture-holding capacity and increase plant nutrients, thereby improving growth and restoring habitat. Alternative 3 should meet the objectives of establishing cover/habitat with low potential for metals exposure within 2-3 years after implementation. Institutional controls addressing future land-use practices may be required for long-term effectiveness.

Cost: The total estimated cost for Alternative 3 is approximately $89,000 (Table A-2). The largest portion of the costs for this alternative is related to the procurement and incorporation of agricultural lime. It is assumed that biosolids may be obtained from a municipality within 50 miles of the site at no cost, other than loading and transportation. Costs have also been included in this estimate to develop access to the deposits and to restore access routes following implementation. Because many of the deposits within this reach have previously been accessed without the construction of access roads, and the quantity of amendments to be delivered is relatively small, these costs are minor.

6.1.1.4 ALTERNATIVE 4

Alternative 4 for the fluvial mine-waste deposits of all priorities (low, moderate and high) within Reach 1 is complete removal, backfilling the excavation with replacement soil to match the surrounding grade and revegetation. Although the vast majority of fluvial deposits within Reach 1 have been treated in place, Alternative 4 includes removal of the treated deposits. As a matter of course and to ensure the complete removal of mine waste, an additional six inches of underlying soil will also be excavated beyond the waste-soil interface. The remaining subgrade soils beneath the high priority deposits will be amended with lime prior to backfilling. Banks will be stabilized where removals pose the potential for instability.

Excavated material will be transported to the California Gulch NPL Site repository to be established at the Black Cloud Mine site. For the purposes of this evaluation the capacity of the Black Cloud repository is assumed to be adequate to accommodate the volume of waste and soil removed.

Implementability: Excavation of the mine-waste deposits and underlying soil, to an average depth of 18 inches, is not anticipated to be difficult and can be accomplished with common earthmoving construction equipment. Appropriate control measures will be required when excavating along the riverbank to avoid release of waste material into the river, including the installation of silt fence and other sediment and erosion control BMPs. The Black Cloud Mine repository is located approximately nine miles from the confluence of California Gulch and the Arkansas River, near the headwaters of Iowa Gulch. This is a reasonable haul distance and although some steep grades exist, the roads are generally in good condition. The implementation of this alternative may also require the improvement of access routes to facilitate truck access from either US Highway 24, Colorado Highway 300, or from existing gravel access roads within the reach. While the majority of the deposits within this reach have been accessed previously, additional work may be required to better prepare the access routes to accommodate the larger volume of truck traffic. Dust control will be required to mitigate dust on temporary haul roads and gravel access roads. The implementation of this remedy will present some short-term risks associated with potential transport of contaminants, either as dust emissions or as releases to the river during excavation along the riverbank. Both potential release mechanisms may be mitigated through the implementation of appropriate engineering controls. In addition, increased truck traffic along the haul routes may create minor disruptions to residents and businesses along the haul route, through Stringtown and the southern end of Leadville, as well as an increased potential for traffic accidents.

With respect to administrative implementability, access and consent of the landowners will be required for temporary construction and removal activities. However, given the extent of work previously performed within this reach and the fact that most of the reach containing mine-waste deposits is under the control of a single landowner, access is not considered to be difficult to obtain. Because Asarco and Resurrection are developing the Black Cloud repository, with cooperation from the USEPA and the State of Colorado (all MOUP), authorization to use this repository is not considered to be an impediment to implementation. It is expected that USEPA would view transport of the mine wastes to the Black Cloud Repository as consolidation within the same general area of contamination. Excavation along the banks of the river and bank stabilization activities may hold permitting considerations, however, they would not prohibit the work.

Effectiveness: Complete removal of all mapped deposits to the Black Cloud repository within Reach 1 allows for all Restoration Objectives to be fulfilled. Liming of underlying soil and soil replacement eliminates concerns for plant uptake of any residual metals and allows for establishment of any desired cover type. Alternative 4 should meet the objectives of establishing cover/habitat with low potential for metals exposure within 2 years after implementation. The only potential limitations on effectiveness are related to plant access to moisture and grazing impacts, prior to full establishment of vegetation.

Complete removal also provides additional long-term effectiveness, in that no reliance on institutional controls (access control) would be required.

Cost: The total estimated cost for Alternative 4 is approximately $1,521,000 (Table A-3). The largest costs associated with this alternative are related to the removal of the deposits, the import of replacement soil, and lime amendment of the underlying soils. Transportation costs for transport of mine wastes and incoming clean soils make up a substantial portion of the overall cost. Costs are also included for the improvement of access routes, the restoration following construction of approximately 4,000 linear feet of temporary access/haul roads, and the implementation of engineering controls/BMPs. Costs for streambank stabilization are included, assuming that approximately 300 feet, or 15%, of bank associated with removals would require some specific stabilization measures. While the specific actions to be taken within these areas will require additional evaluation, the cost estimates included are representative of the average cost that may be associated with a range of options. Costs specifically related to developing or preparing, or related to the closure of, the repository at the Black Cloud Mine have not been included, however a $2.00 per cubic yard tipping fee has been included in the cost estimate.

6.1.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

6.1.2.1 ALTERNATIVE 1

Alternative 1 for Channel Morphology/In-Stream Habitat/Riparian Area in Reach 1 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: The relative role of habitat versus water quality in determining the quality of the fishery in Reach 1 is unknown. However, the in-stream physical habitat in Reach 1 could be improved. It is thought that improvements in physical in-stream habitat will off-set, to some degree, the current impacts of poor water quality. Without improvements in water quality and/or habitat, the quality of the fishery in Reach 1 is not expected to change significantly over time.

Reach 1

With regard to stream morphology and riparian zone habitat, rapid significant changes in channel morphology are not expected. USEPA has conducted some limited bank stabilization measures in Reach 1. It is thought that with no action, limited erosion of mine waste, loss of riparian habitat and agricultural impacts would not change from their current level. Impact from grazing is expected to be the ongoing primary factor that influences riparian zone habitat conditions, as well as bank stability.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.1.2.2 ALTERNATIVE 2

Alternative 2 identified for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 1 includes a combination of fencing paired with a 20-year conservation lease (a 25 foot offset, or setback, from the banks encompassing the fenced areas). This alternative may be coupled with any of the restoration alternatives for the fluvial mine-waste deposits, identified above.

Implementability: From a technical perspective, fencing of sensitive riparian zones to restrict and limit cattle access is readily implementable, but requires the cooperation and consent of the landowner. Administratively, the implementation of this alternative will require coordination with the landowners, to negotiate acceptable conservation leases that meet the requirements for restoration and address landowner concerns. This restriction would not significantly reduce the area currently available for grazing within the 500-year floodplain. Given the narrow width of the easement, it would not preclude the landowner from land uses other than grazing (e.g., development within 25 feet of the bank is unlikely), and should therefore be acceptable. Conservation easements/leases are quite often established in environmentally sensitive areas on private lands.

Effectiveness: Based on observations between reaches and experience in other watersheds, fencing of the riparian zone to limit grazing will provide the largest single benefit to the quality of riparian habitat, stream bank stability and overall channel stability within Reach 1.

Re-establishment of diminished woody vegetation, potentially including larger trees, will provide improved riparian habitat for wildlife. The increased woody vegetation and the absence of livestock traffic will reduce active erosion and strengthen streambanks. Over time, as larger woody vegetation reestablishes, there should be benefits to the in-stream habitat. Larger near bank woody vegetation should contribute woody debris, further improving in-stream habitat. Under Alternative 2, riparian vegetation is expected to improve substantially in the first five years. The benefits to bank stability and in-stream habitat would mature over the 20-year lease period. A potential landowner consideration is that the restored riparian vegetation may be more attractive to beavers, which often attempt to dam irrigation ditches.

Alternative 2 would be effective with or without companion actions for fluvial mine-waste deposits. The benefits to the brown trout fishery from Alternative 2 within Reach 1 cannot be quantified. However, the restoration of riparian vegetation is expected to provide benefits to the fishery with or without improvements in water quality.

Cost: The total estimated cost for Alternative 2 is approximately $66,000 (Table A-4). This cost estimate includes costs related to the installation of approximately 18,800 linear feet of three-strand solar-electric fence and maintenance of the fence. In addition, $350/acre has also been included, as a one-time capital cost, for the acreage included within the 20-year conservation lease boundaries on private property to compensate landowners for the loss of use to these areas.

6.1.2.3 ALTERNATIVE 3

Alternative 3 for Channel Morphology/In-Stream Habitat/Riparian Areas within Reach 1 is a combination of technologies in addition to the grazing control measures from Alternative 2. Within subreaches 1A and 1C, Alternative 3 includes soft treatments for bank protection, channel stabilization and in-stream habitat improvements. This alternative is intended to be paired with fluvial mine-waste deposit alternatives 2 and 3, involving in-place stabilization of deposits. Soft treatments would occur at locations where fluvial deposits are intersected by the active channel.

Implementability: As with Alternative 2, fencing of sensitive riparian zones is readily implementable, from a technical perspective, but requires the cooperation and consent of the landowner. Administratively, the implementation of this alternative will require coordination with the landowners, to obtain access to perform the bank protection and channel stabilization activities and address landowner concerns. The implementation of soft treatments for bank stabilization and in-stream habitat restoration is technically feasible applying commonly used procedures for stream restoration projects. Materials such as logs, large roots and willow cuttings are readily available. BMPs for construction in and along an active channel would be required. The design, permitting and implementation of such restoration activities will require additional evaluation and specialized expertise, although this is not considered to be an impediment to implementation. Actions addressing streambank stability adjacent to fluvial mine-waste deposits would best be conducted prior to any in-place stabilization restoration actions at a deposit to avoid disturbance of the restored deposit.

Effectiveness: Alternative 3 will provide accelerated improvements in riparian zone habitat associated with grazing restrictions (i.e., increased woody vegetation) as described for Alternative 2. Additional measures combining bank stabilization and near bank stream habitat will be effective in improving the overall quality of in-stream habitat, thereby providing additional benefits to the objectives of improving the brown trout fishery. The identified bank stabilization measures have proven to be effective in reducing areas of active erosion in other watersheds.

Alternative 3 offers additional short-term effectiveness relative to Alternative 2 in terms of bank stability, but over time, there will not likely be a significant difference. Riparian vegetation is expected to improve substantially in the first five years and should generally be fully recovered. The benefits to bank stability and in-stream habitat would mature over the 20-year lease period.

Cost: The total estimated cost for Alternative 3 is approximately $241,000 (Table A-5). Costs for streambank stabilization and in-stream habitat restoration are included, assuming that approximately 3,000 feet, or 150% of the total feet of bank intercepting mine-waste deposits, would require some specific stabilization measures. While the specific actions to be taken within these areas will require additional evaluation, the cost estimates included are representative of the average cost that may be associated with a range of options, including the soft treatments of willow waddling, anchored trees, root wads, rock structures, and log placement.

6.1.2.4 ALTERNATIVE 4

Alternative 4 for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 1 includes grazing control and limited in-stream habitat enhancement. This alternative can be paired with any of the alternatives for the fluvial mine-waste deposits, including the removal of all of the deposits within Reach

Reach 1

1. In addition to the grazing control measures from Alternative 2, Alternative 4 includes measures for in-stream habitat improvement, such as pool excavation, within subreaches 1A and 1C.

Implementability: The implementablility for grazing controls has been discussed above under Alternative 2. As with alternative 3, the implementation of pool excavation activities to enhance in-stream habitat can be completed using known and reliable techniques and equipment. The development of the specific requirements will require specialized expertise in the design and implementation of such restoration measures, although such expertise is considered to be readily available. BMPs for construction in and along an active channel would be required. The design, permitting and implementation of such restoration activities will require additional evaluation and specialized expertise, although this is not considered to be an impediment to implementation.

Effectiveness: The effectiveness of riparian zone fencing and associated conservation leases in restoring habitat is described under Alternatives 2 and 3. Observation indicates a current lack of pool habitat in subreaches 1A and 1C. Creation of pool habitat has proven effective in improving the quality of a fishery in other watersheds.

Cost: The total estimated cost for Alternative 4 is approximately $180,000 (Table A-6). Costs for pool excavations within subreaches 1A and 1C are included, assuming that one pool will be excavated within each subreach.

6.1.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

A predicted phytotoxicity pattern was digitized using Figure 6.1 from USEPA's Ecological Risk Assessment for the Terrestrial Ecosystem (USEPA 2003b) (See Section 3.3.2 and Figure 3-6). The alternatives evaluated in this section for agricultural lands would be implemented in those areas determined to have the greatest potential for phytotoxicity and/or having a HQ > 1, as identified on Figure 3-6 and summarized in Table 3-6. The areas meeting these criteria in each subreach are as follows: subreach 1A contains approximately 2.7 acres within the floodplain and 1.4 acres outside the floodplain; subreach 1B contains 2.4 acres within the floodplain and 1.9 acres outside the floodplain; and subreach

1C contains 0 acres within the floodplain and 26 acres outside the floodplain; for a total of approximately 35 acres.

6.1.3.1 ALTERNATIVE 1

Alternative 1 for Agricultural Lands (Irrigated Meadows) in Reach 1 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: It is likely that, over time, the available metals concentrations in surficial soils will decline and plant cover will improve as new surface soils are formed. Risks to wildlife and livestock associated with metals uptake will also decline. However, the rate of improvement over decades would be slow to imperceptible.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.1.3.2 ALTERNATIVE 2

Alternative 2 identified for Agricultural Lands (Irrigated Meadows) in Reach 1 is deep tilling and reseeding.

Implementability: Deep tilling, to an average depth of 12 inches, is easily implementable in conjunction with standard agricultural practices for preparing land for planting. Deep tilling in riparian corridors containing dense woody vegetation is not readily implementable. As with each of the other alternatives, landowner consent will be required.

Effectiveness: Deep tilling would rapidly decrease surficial soil metals concentrations and the addition of seeding would result in rapid re-establishment of vegetation consistent with adjacent areas.

Alternative 2 would be effective in meeting the objective of reducing potentially harmful metals exposure to wildlife and livestock within Reach 1. Alternative 2 should restore the identified portions of the irrigated meadows to full use within 3 years.

Cost: The estimated cost for this restoration alternative is approximately $148,000 (Table A-7). Because the actions under this alternative are anticipated to be fully effective within 3 years after implementation, and maintenance activities are anticipated to be limited to maintenance fertilizer and spot reseeding (10% of the total area), the O&M costs included for this estimate are presented as totals rather than annual costs and a net-present value analysis has not been included.

6.1.3.3 ALTERNATIVE 3

Alternative 3 for Agricultural Lands (Irrigated Meadows) in Reach 1 is the application of agricultural lime in conjunction with deep tilling and reseeding.

Implementability: Deep tilling, to an average depth of 12 inches, is easily implementable in conjunction with standard agricultural practices for preparing land for planting, and the addition of lime does not significantly affect the implementability. As with Alternative 2, deep tilling in riparian corridors containing dense woody vegetation is not readily implementable. As with each of the other alternatives, landowner consent will be required.

Effectiveness: Alternative 3 has the same level of physical effectiveness as Alternative 2. The addition of lime as a soil amendment will help to buffer any residual acidity, reduce the potential for metals uptake by plants and should be effective in establishing cover consistent with the adjacent areas within two years.

Cost: The total estimated cost for Alternative 3 is approximately $173,000 (Table A-8). In addition to the costs associated with deep tilling, estimated costs are included for lime amendment (at a rate of 10 tons/acre) and revegetation, similar to the fluvial mine waste alternatives. Because the actions under this alternative are anticipated to be fully effective within 3 years after implementation, and maintenance activities are anticipated to be limited to maintenance fertilizer and spot reseeding (10% of the total area), the O&M costs included for this estimate are presented as totals rather than annual costs and a net-present value analysis has not been included.

6.2 REACH 2

Reach 2 extends 3.79 river miles from the confluence of Lake Fork to the Highway 24 bridge. Flow in Lake Fork can be heavily augmented from “trans mountain” diversions. Access to the river is limited to driveways and ranch roads.

6.2.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 2 contains 35 fluvial mine-waste deposits totaling approximately 9,000 cu. yds. Of the 35 deposits, 3 are high priority, 27 are moderate priority and 5 are low priority. USEPA has not conducted any significant remediation within Reach 2.

6.2.1.1 ALTERNATIVE 1

Alternative 1 for mine-waste deposits of all priorities (low, moderate and high) in Reach 2 is the No Action/Natural Recovery alternative. The No Action/Natural Recovery alternative is included to provide a baseline against which other alternatives can be compared. No additional work would be performed.

Implementability: No action would be taken.

Effectiveness: The majority of Reach 2 fluvial deposits are near the confluence of Lake Fork and the UAR. Most of the deposits are moderate priority and roughly one third have good plant cover. However, approximately one half of the approximately 9 acres of fluvial deposits is comprised of 3 larger high priority deposits. Although the overall risk to wildlife within Reach 2 is low, these deposits, in particular, contribute to the local potential for unacceptable risks to wildlife and livestock. Without action, the potential for wildlife exposure at levels of concern will remain for these small areas. No significant recovery of the areas impacted by fluvial tailings deposits is expected without further action. With time, vegetation will slowly increase around the margins of the deposits, however, habitat/pasture will not be restored to these areas without further action. Under the Natural Recovery alternative, it is unlikely that any portion of the fluvial deposits in Reach 2 would be substantially eroded due to channel migration.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.2.1.2 ALTERNATIVE 2

Alternative 2 consists of a combination of Process Options depending on the priority classification of the deposit. The combination of lime addition, deep tilling and reseeding of the amended deposits with mulch addition is prescribed for the low and moderate priority fluvial mine-waste deposits within Reach 2. For the high priority deposits, Alternative 2 is the combination of lime and biosolids addition, deep tilling and reseeding of the amended deposits.

Implementability: The mine-waste deposits are accessible for lime and biosolids addition, deep tilling and reseeding activities, although the incorporation of amendments to a depth of 18 inches may require special construction equipment and/or techniques to achieve adequate mixing. Incorporation to this depth may require the use of a "Roto-mill", a self-contained soil stabilization/mixing machine, or a specialty pull-behind attachment known as a modified Baker plow. This alternative is considered to be implementable with the use of appropriate equipment. The implementability of this treatment option for high priority near bank deposits could be limited because USEPA regulations prohibit use of non-composted biosolids within 10 feet of the river channel. It is assumed that suitably composted biosolids can be obtained. With respect to administrative implementability, access and consent of the landowners will be required for implementation. Ownership of the land within Reach 2 is limited to two private owners and the State. Based on USEPA's prior work within the 11-Mile Reach, obtaining access is not anticipated to be difficult.

Effectiveness: Alternative 2 will effectively reduce the availability of surficial metals with the addition of lime and deep tilling to a depth of 18-inches, prior to revegetation. The inclusion of biosolids for the high priority deposits will improve moisture-holding capacity and increase plant nutrients, thereby improving growth and restoring habitat. Alternative 2 should meet the objectives of establishing cover/habitat with low potential for metals exposure within 3 to 5 years after implementation for the low and moderate priority deposits and within 2-3 years after implementation for the high priority deposits. Institutional controls addressing future land-use practices may be required to provide long-term assurance that the restored areas will not be disturbed.

Cost: The total estimated cost for this alternative is approximately $178,000 (Table A-9). The largest costs associated with this alternative are related to the procurement and incorporation of lime and biosolids. It is assumed that biosolids may be obtained from a municipality within 50 miles of the site at no cost, other than loading and transportation.

6.2.1.3 ALTERNATIVE 3

Alternative 3 for Fluvial Mine-Waste Deposits within Reach 2 also consists of a combination of process options depending on the priority classification of the deposit. Alternative 3 for low and moderate priority deposits is a combination of lime and biosolids addition, deep tilling and reseeding of the amended deposits. For the high priority mine-waste deposits, Alternative 3 is a combination of lime addition and deep tilling, with the addition of a 12-inch soil cover prior to reseeding. Potential sources of cover soil include stockpiled soil/sediment previously removed during the dredging operations at Mt. Massive Lakes and/or new materials to be removed from the lakes in 2004 (stockpiled within the 11-Mile Reach and within 5-miles of the Reach 2 deposits), and the Malta Gulch borrow pit, located just north of the Malta Gulch tailing impoundments (approximately 3 miles from the confluence of California Gulch and the Arkansas River).

Implementability: The mine-waste deposits are accessible for the Alternative 3 activities, although incorporation of amendments to a depth of 18 inches may require special construction equipment and/or techniques to achieve adequate mixing. The implementability of this treatment option for near bank deposits could be limited because USEPA regulations prohibit use of non-composted biosolids within 10 feet of the river channel. It is assumed that suitably composted biosolids can be obtained.

The application of a 12-inch soil cover over the amended high priority deposits adds some difficulty to the implementation of this alternative, related to the identification and acquisition of a borrow source and increased truck traffic. The placement of a soil cover should not present any construction challenges. While access to the deposits is considered to be good, the implementation of this alternative may require some improvements to accommodate increased truck traffic, related to transporting cover soil, from either US Highway 24, Colorado Highway 300, or from existing gravel access roads within the reach.

Effectiveness: Alternative 3 will effectively reduce the availability of metals in the low and moderate priority deposits with the addition of lime and biosolids, and deep tilling to a depth of 18-inches prior to reseeding will potentially reduce the surficial metals concentrations. The inclusion of biosolids will improve moisture-holding capacity and increase plant nutrients, thereby improving growth and restoring habitat. Alternative 3 for the low and moderate priority deposits should meet the objectives of establishing cover/habitat with low potential for metals exposure within 2-3 years after implementation.

For high priority deposits, Alternative 3 should be very effective in terms of establishing habitat/pasture at all locations. The 12-inch soil cover will also reduce the potential for metals uptake and thereby reduce future exposure concerns. The soil should also improve moisture-holding capacity, if a relatively higher silt/clay content is provided. The 12-inch soil cover should be durable once vegetation is established (2 growing seasons) and will continue to be effective over time. However, given that Reach 2 is comprised of private land, there is a possibility that without institutional controls/deed restrictions, changes in land use or agricultural practices could result in disruption of the soil cover. Institutional controls addressing future land-use practices may be required to provide long-term assurance that the restored areas will not be disturbed.

Cost: The total estimated cost for Alternative 3 is approximately \$263,000 (Table A-10). For the purposes of estimating costs for the low and moderate priority deposits it is assumed that biosolids may be obtained from a municipality within 50 miles of the site at no cost, other than loading and transportation. For the high priority deposits it has been assumed that: a borrow source within 10 miles from the work areas can be identified; borrow material may be procured for a nominal price of \$2.00 per cubic yard; and that no screening or other processing of the material would be required. Costs are included for relatively minor improvements to haul routes and related restoration. The largest costs associated with implementing this alternative are related to the procurement and incorporation of lime and the placement of the soil cover.

6.2.1.4 ALTERNATIVE 4

Alternative 4 for Fluvial Mine-Waste deposits of all priorities (low, moderate and high) within Reach 2 is complete removal, backfilling the excavation with replacement soil to match the surrounding grade and reseeding. As a matter of course and to ensure the complete removal of mine waste, an additional six inches of underlying soil will also be excavated beyond the waste-soil interface. The remaining subgrade soils beneath the high priority deposits will be amended with lime prior to backfilling. Banks will be stabilized where removals pose the potential for instability.

Excavated material will be transported to the California Gulch NPL Site repository to be established at the Black Cloud Mine tailings impoundment. For the purposes of this evaluation the capacity of the Black Cloud repository is assumed to be adequate to accommodate the volume of waste and soil removed.

Implementability: Excavation of the mine-waste deposits and underlying soil, to an average depth of 12 inches, is not anticipated to be difficult and can be accomplished with common earthmoving construction equipment. Appropriate control measures will be required when excavating along the riverbank to avoid release of waste material into the river, including the installation of silt fence and other BMPs. The Black Cloud Mine repository is located approximately 10 to 12 miles from the central point of subreach 2A (where the majority of the deposits within Reach 2 are located). This is a reasonable haul distance and although some steep grades exist, the roads are generally in good condition. The implementation of this alternative may also require improvements to access routes to facilitate increased truck traffic from either US Highway 24, Colorado Highway 300, or from existing gravel access roads within the reach. Dust control will be required to mitigate dust on temporary haul roads and gravel access roads. The implementation of this remedy will present some short-term risks associated with potential transport of contaminants, either as dust emissions or as releases to the river during excavation along the riverbank. Both potential release mechanisms may be mitigated through the implementation of appropriate engineering controls. In addition, increased truck traffic along the haul routes may create minor disruptions to residents and businesses along the haul route, through Stringtown and the southern end of Leadville, as well as an increased potential for traffic accidents.

With respect to administrative implementability, access and consent of the landowners will be required for temporary construction and removal activities. Because Asarco and Resurrection are developing the Black Cloud repository, with cooperation from the EPA and the State of Colorado (all MOUP), authorization to use this repository is not considered to be an impediment to implementation. It is expected that USEPA would view transport of the mine wastes to the Black Cloud Repository as consolidation within the same general area of contamination. Excavation along the banks of the river and bank stabilization activities may hold permitting considerations, however, they would not prohibit the work.

Effectiveness: Complete removal of all mapped deposits to the Black Cloud repository within Reach 2 allows for all RAOs to be fulfilled. Liming of underlying soil and soil replacement eliminates concerns for plant uptake of residual metals and allows for establishment of any desired cover type within 2 years. Habitat will be restored consistent with vegetation in surrounding areas. The only potential limitation on effectiveness is related to grazing impacts prior to full establishment of vegetation.

Complete removal also provides additional long-term effectiveness in that no reliance on institutional controls (access control) would be required.

Cost: The total estimated cost for Alternative 4 is approximately $597,000 (Table A-11). The largest costs associated with this alternative are related to the removal of the deposits, transport to the Black Cloud repository, the import of replacement soil, and lime amendment of the underlying soils. Costs are included for the improvement of access routes, the restoration of approximately 2 miles of temporary access/haul roads necessary to access the deposits, and the implementation of engineering controls/BMPs. Costs for streambank stabilization are included, assuming that approximately 500 feet, or 15%, of bank associated with removals would require some specific stabilization measures. While the specific actions to be taken within these areas will require additional evaluation, the cost estimates included are representative of the average cost that may be associated with a range of options. Costs specifically related to developing or preparing, or related to the closure of, the repository at the Black Cloud Mine have not been included, however a $2.00 per cubic yard tipping fee is included.

6.2.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

The in-stream habitat condition within Reach 2 was evaluated to be good. For the upper portion of Reach 2, riparian vegetation cover and streambank stability is also good. In the most down valley portions of Reach 2, the combination of grazing and flow augmentation have had a greater impact on riparian vegetation and bank stability. Impact from grazing is expected to be the ongoing primary factor influencing the quality of riparian habitat, stream bank stability and overall channel stability.

6.2.2.1 ALTERNATIVE 1

Alternative 1 for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 2 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: Although water quality in Reach 2 is better than Reach 1, the relative role of flow augmentation on in-stream habitat versus water quality in determining the quality of the fishery in Reach 2 is unknown. However, the in-stream habitat condition within Reach 2 was evaluated to be good. For the upper portion of Reach 2, riparian vegetation cover and streambank stability is also good. In the most down valley portions of Reach 2, the combination of grazing and flow augmentation have had a greater impact on riparian vegetation and bank stability. It is likely these conditions will persist without action. However, overall, channel stability, in-stream habitat and riparian vegetation conditions within Reach 2 would remain good under the current flow management requirements and agricultural practices.

With regard to stream morphology and riparian zone habitat, rapid changes in channel morphology are not expected. With no action, some areas of bank erosion will continue to be active. However, it is thought that without action, limited erosion of mine waste, loss of riparian habitat and agricultural impacts would not change from their current levels. Impact from grazing is expected to be the ongoing primary factor that influences riparian zone habitat conditions, as well as bank stability.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.2.2.2 ALTERNATIVE 2

Alternative 2 identified for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 2 includes a combination of riparian fencing paired with a 20-year conservation lease (a 25 foot offset, or setback, from the banks encompassing the fenced areas). This alternative may be coupled with any of the restoration alternatives for the fluvial mine-waste deposits, identified above.

Implementability: From a technical perspective, fencing of sensitive riparian zones to restrict and limit cattle access is readily implementable, but requires the cooperation and consent of the landowner. Administratively, the implementation of this alternative will require coordination with the landowners, to negotiate acceptable conservation leases that meet the requirements for restoration and address landowner concerns. This restriction would not significantly reduce the area currently available for grazing within the 500-year floodplain. Given the narrow width of the easement, it would not preclude the landowner from land uses other than grazing (e.g., development within 25 feet of the bank is unlikely), and should therefore be acceptable. Conservation easements/leases are quite often established in environmentally sensitive areas on private lands.

Effectiveness: Based on observations between reaches and experience in other watersheds, fencing of the riparian zone to limit grazing, in areas where this is not already occurring, will provide the largest single benefit to the quality of riparian habitat, stream bank stability and overall channel stability within Reach 2.

Reestablishment of diminished woody vegetation, potentially including larger trees, will provide improved riparian habitat for wildlife. The increased woody vegetation and the absence of livestock traffic will reduce active erosion and strengthen the streambanks. Over time, as larger woody vegetation reestablishes, there should be benefits to the in-stream habitat. Larger near bank woody vegetation should contribute woody debris, further improving in-stream habitat. Under Alternative 2, riparian vegetation is expected to improve substantially in the first five years. The benefits to bank stability and in-stream habitat would mature over the 20-year lease period. A potential landowner consideration is that the restored riparian vegetation may be more attractive to beavers, which often attempt to dam irrigation ditches.

Alternative 2 would be effective with or without companion actions for fluvial mine-waste deposits. The benefits to the brown trout fishery from Alternative 2 within Reach 2 cannot be quantified. However, the restoration of riparian vegetation is expected to provide benefits to the fishery with or without improvements in water quality.

Cost: The total estimated cost for Alternative 2 is approximately $136,000 (Table A-12). This cost estimate includes costs related to the installation of approximately 40,400 linear feet of three-strand solar-electric fence and maintenance of the fence. In addition, $350/acre has also been included, as a one-time capital cost, for the acreage included within the 20-year conservation lease boundaries on private property to compensate landowners for the loss of use to these areas.

6.2.2.3 ALTERNATIVE 3

Alternative 3 for Channel Morphology/In-Stream Habitat/Riparian Areas within Reach 2 is a combination of technologies, in addition to the grazing control measures from Alternative 2, within subreach 2A including soft treatments for bank protection, channel stabilization and in-stream habitat improvements. Alternative 3 for subreach 2B includes the riparian area grazing control techniques described in Alternative 2. This alternative is intended to be paired with fluvial mine-waste deposit alternatives 2 and 3, involving in-place stabilization of deposits.

Implementability: As with Alternative 2, fencing of sensitive riparian zones is readily implementable, from a technical perspective, but requires the cooperation and consent of the landowner. Administratively, the implementation of this alternative will require coordination with the landowners, to obtain access to perform the bank protection and channel stabilization activities and address landowner concerns. The implementation of soft treatments for bank stabilization and in-stream habitat restoration is technically feasible applying commonly used procedures for stream restoration projects. Materials such as logs, large roots and willow cuttings are readily available. BMPs for construction in and along an active channel would be required. The design, permitting and implementation of such restoration activities will require additional evaluation and specialized expertise, although this is not considered to be an impediment to implementation. Actions addressing streambank stability adjacent to fluvial mine-waste deposits would best be conducted prior to any in-place stabilization restoration actions at a deposit to avoid disturbance of the restored deposit.

Effectiveness: Alternative 3 will provide the improvements in riparian zone habitat described for Alternative 2. It is expected that riparian vegetation would rapidly recover from the impacts of grazing within the first 5 years, and bank stability would improve correspondingly. The bank stabilization measures have proven to be effective in reducing areas of active erosion in other watersheds. Additional measures combining bank stabilization and near bank stream habitat will be effective in improving the overall quality of in-stream habitat providing additional benefits to the objectives of improving the brown trout fishery.

Cost: The total estimated cost for Alternative 3 is approximately $428,000 (Table A-13). Costs for streambank stabilization and in-stream habitat restoration are included, assuming that approximately 5,000 feet, or 150% of the total feet of bank intercepting mine-waste deposits, would require some specific stabilization measures. While the specific actions to be taken within these areas will require additional evaluation, the cost estimates included are representative of the average cost that may be associated with a range of options, including the soft treatments of willow waddling, anchored trees, root wads, rock structures, and log placement.

6.2.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

A predicted phytotoxicity pattern was digitized using Figure 6.1 from USEPA's Ecological Risk Assessment for the Terrestrial Ecosystem (USEPA 2003b) (See Section 3.3.2 and Figure 3-6). The alternatives evaluated in this section for agricultural lands would be implemented in those areas determined to have the greatest potential for phytotoxicity and/or having a HQ > 1, as identified on Figure 3-6 and summarized in Table 3-7. The areas meeting these criteria in each subreach are as follows: subreach 2A contains approximately 4.7 acres within the floodplain and 27 acres outside the floodplain and subreach 2B contains 28.8 acres within the floodplain and 5.6 acres outside the floodplain.

6.2.3.1 ALTERNATIVE 1

Alternative 1 for Agricultural Lands (Irrigated Meadows) in Reach 2 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: It is likely that, over time, the available metals concentrations in surficial soils will decline and plant cover will improve as new soils are formed. Risks to wildlife and livestock associated with metals uptake in those areas will also decline. However, the rate of improvement would be slow to imperceptible.

Cost: There is no cost associated with Alternative 1, since no action would be taken.

6.2.3.2 ALTERNATIVE 2

Alternative 2 identified for Agricultural Lands (Irrigated Meadows) in Reach 2 is deep tilling and reseeding.

Implementability: Deep tilling, to an average depth of 12 inches, is easily implementable in conjunction with standard agricultural practices for preparing land for planting. Deep tilling in areas of overlay with riparian corridors containing dense woody vegetation is not readily implementable. However, it is not anticipated that any areas of overlay within Reach 2 would be substantial. As with each of the other alternatives, landowner consent will be required.

Effectiveness: Deep tilling would rapidly decrease surficial soil metals concentrations and the addition of seeding would result in rapid re-establishment of vegetation consistent with adjacent areas. Alternative 2 would be effective in meeting the objective of reducing potentially harmful metals exposure to wildlife and livestock within Reach 2. Alternative 2 should restore the identified portions of the irrigated meadows to full use within 3 years.

Cost: The total estimated cost for Alternative 2 is approximately $275,000 (Table A-14). Because the actions under this alternative are anticipated to be fully effective within 3 years after implementation, and maintenance activities are anticipated to be limited to maintenance fertilizer and spot reseeding (10% of the total area), the O&M costs included for this estimate are presented as totals rather than annual costs and a net-present value analysis has not been included.

6.2.3.3 ALTERNATIVE 3

Alternative 3 for Agricultural Lands (Irrigated Meadows) in Reach 2 is the application of agricultural lime in conjunction with deep tilling and re-seeding with a metals tolerant/low uptake species.

Implementability: Deep tilling, to an average depth of 12 inches, is easily implementable in conjunction with standard agricultural practices for preparing land for planting, and the addition of lime does not significantly affect the implementability. As with Alternative 2, deep tilling in riparian corridors containing dense woody vegetation is not readily implementable. As with each of the other alternatives, landowner consent will be required.

Effectiveness: Alternative 3 has the same level of physical effectiveness as Alternative 2. The addition of lime as a soil amendment will help to buffer any residual acidity, reduce the potential for metals uptake by plants and should be effective in establishing cover consistent with the adjacent areas in two years.

Cost: The total estimated cost for Alternative 3 is approximately $308,000 (Table A-15). The unit prices for lime amendment and revegetation activities are the same as those used for the fluvial mine-waste alternatives. O&M costs are presented the same as under Alternative 2.

6.3 REACH 3

Reach 3 extends 3.88 river miles from the Highway 24 bridge to the valley constriction just below Kobe. Cattle grazing still occurs on the Hayden Ranch, however the Arkansas River Ranch is open to the public for recreation. Lake County owns the remaining portion of Reach 3, with the exception of a very small portion of private land (Moyer Ranch) near the highway 24 bridge. There are a number of former ranch roads that serve as access to Reach 3.

6.3.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 3 contains the highest volume (58,500 cu. yds.) and largest number of fluvial deposits (94) of all four reaches. 69 of the deposits are ranked moderate priority. USEPA has conducted treatment on 31 of the Reach 3 deposits (Section 3.3.1). It is assumed that USEPA's activities will provide adequate stabilization and allow for establishment of good vegetation cover. Correspondingly, the treated deposits are not included in Reach 3 alternatives calling for in-place stabilization. Removal alternatives, however, consider all of the deposits regardless of prior amendments.

6.3.1.1 ALTERNATIVE 1

Alternative 1 for mine-waste deposits of all priorities (low, moderate and high) in Reach 3 is the No Action/Natural Recovery alternative. The No Action/Natural Recovery alternative is included to provide a baseline against which other alternatives can be compared. No additional work would be performed, in addition to that work already completed by the USEPA.

Implementability: No action would be taken.

Effectiveness: A substantial amount of work has been conducted by USEPA in Reach 3. Their scope of work included treatment of 31 of the 94 deposits. Treatments generally involving the integration of a variety of combinations of organic matter and lime with the fluvial mine-waste deposits, followed by reseeding, have been utilized for approximately 17 of the 38 acres within Reach 3. Injuries linked to the presence of fluvial deposits are expected to persist absent further action.

__Reach 3__

USEPA has not formally evaluated the success of their Reach 3 remediation, but has observed that moisture-holding capacity is an important consideration. Their addition of over 100 tons/acre organic amendments should improve the moisture-holding capacity and allow for the near-term development of adequate vegetation cover and, over time, provide suitable habitat/pasture for grazers, effectively restoring conditions within the 17 acres of deposits to the same as those in adjacent areas. Given the initial establishment of cover on these treated deposits, vegetation consistent with surrounding communities should be achieved and maintained, thereby restoring habitat.

Although with time vegetation will slowly increase around the margins of the 21 acres of untreated deposits, habitat/pasture will not be restored to the untreated areas without further action. Although the overall risk to wildlife within Reach 3 is low, these deposits contribute to the local potential for unacceptable risks to wildlife and livestock. Without further action the potential for wildlife/livestock exposure at levels of concern will remain for these 21 acres. No significant recovery of the 21 acres of untreated deposits is expected. It is also unlikely that any substantial portion of the treated or untreated deposits within Reach 3 would be substantially eroded.

Cost: There is no cost associated with Alternative 1, since no action would be taken.

6.3.1.2 ALTERNATIVE 2

Alternative 2 consists of a combination of process options depending on the priority classification of the deposit. The combination of lime addition, deep tilling and reseeding of the amended deposits with mulch addition is prescribed for the previously untreated low and moderate priority fluvial mine-waste deposits within Reach 3. For the previously untreated high priority deposits, Alternative 2 is the combination of lime and biosolids addition, deep tilling and reseeding of the amended deposits.

Implementability: The 21 acres of unremediated mine-waste deposits are accessible for lime and biosolids addition, deep tilling and reseeding activities, although the incorporation of amendments to a depth of 18 inches may require special construction equipment and/or techniques to achieve adequate mixing. Incorporation to this depth may require the use of a "Roto-mill", a self-contained soil stabilization/mixing machine, or a specialty pull-behind attachment known as a modified Baker plow. This alternative is considered to be implementable with the use of appropriate equipment. The implementability of this treatment option for high priority near bank deposits could be limited because

USEPA regulations prohibit use of non-composted biosolids within 10 feet of the river channel. It is assumed that suitably composted biosolids can be obtained. With respect to administrative implementability, access and consent of the landowners will be required for implementation. Based on USEPA's prior work within the 11-Mile Reach, and because the majority of Reach 3 is under public ownership, obtaining access is not anticipated to be difficult. Improvements to existing gravel roads (former ranch access roads) within the reach and construction of temporary access roads would likely be required to facilitate the delivery of amendments to the moderate and high priority deposits. Overall the implementability of this restoration alternative is considered to be good.

Effectiveness: Alternative 2 will effectively reduce the availability of metals and, with the addition of lime and deep tilling to a depth of 18-inches, will potentially reduce surficial metals concentrations prior to reseeding. Revegetation activities under Alternative 2 should meet the objectives of establishing cover/habitat with low potential for metals exposure within 3 to 5 years of implementation. Institutional controls addressing future land-use practices may be required for long-term effectiveness. There is further assurance that the restored areas will not be disturbed by future land-use practices because the majority of Reach 3 is under public ownership.

Cost: The total estimated cost for Alternative 2 is approximately $314,000 (Table A-16). The largest costs associated with this alternative are related to the procurement and incorporation of lime and biosolids. It is assumed that biosolids may be obtained from a municipality within 50 miles of the site at no cost, other than loading and transportation.

6.3.1.3 ALTERNATIVE 3

Alternative 3 for Fluvial Mine-Waste Deposits within Reach 3 also consists of a combination of process options depending on the priority classification of the deposit. Alternative 3 for the previously untreated low and moderate priority deposits is the combination of lime and biosolids addition, deep tilling and reseeding of the amended deposits. For the high priority mine-waste deposits, Alternative 3 is a combination of lime addition and deep tilling, with the addition of a 12-inch soil cover prior to reseeding. Potential sources of cover soil include stockpiled soil/sediment previously removed during the dredging operations at Mt. Massive Lakes and/or new materials to be removed from the lakes in 2004 (stockpiled within the 11-Mile Reach and within 2 miles of the Reach 3 deposits), and the Malta Gulch borrow pit, located just north of the Malta Gulch tailing impoundments (approximately 3 miles from the confluence of California Gulch and the Arkansas River).

Implementability: As with Alternative 2, the 21 acres of unremediated mine-waste deposits are accessible for revegetation, although incorporation of amendments to a depth of 18 inches may require special construction equipment and/or techniques to achieve adequate mixing. The application of a 12-inch soil cover over the amended high priority deposits adds some difficulty to the implementation of this alternative, related to the identification and acquisition of a borrow source and increased truck traffic. The placement of a soil cover should not present any construction challenges. Improvements to existing gravel roads (former ranch access roads) within the reach and construction of temporary access roads would likely be required to facilitate the delivery of amendments and cover soil to the moderate and high priority deposits. Because the majority of Reach 3 is under public ownership, legal access necessary to develop access routes and perform the revegetation activities is not anticipated to be an impediment to implementation.

Effectiveness: Alternative 3 will effectively reduce the availability of metals in the low and moderate priority deposits with the addition of lime and biosolids, deep tilling to a depth of 18-inches prior to reseeding, will potentially reduce the surficial metals concentrations. The inclusion of biosolids will improve moisture-holding capacity and increase plant nutrients, thereby improving growth and restoring habitat. Alternative 3 for the low and moderate priority deposits should meet the objectives of establishing cover/habitat with low potential for metals exposure within 3 to 5 years after implementation.

For high priority deposits, Alternative 3 should be very effective in terms of establishing habitat/pasture at all locations. The 12-inch soil cover will also reduce the potential for metals uptake and thereby reduce future exposure concerns. The soil should also improve moisture-holding capacity, if a relatively higher silt/clay content is provided. The 12-inch soil cover should be durable once vegetation is established (2 growing seasons) and will continue to be effective over time.

An important consideration regarding effectiveness for all of the above Alternative 3 actions is the public ownership of the majority of Reach 3. In the near term, the ability to readily implement restrictions on grazing will allow for effective initial establishment of vegetation. Over the long-term, the ability to monitor and control future land use will assure long-term effectiveness of Alternative 3 actions.

<u>Cost:</u> The total estimated cost for Alternative 3 is approximately $447,000 (Table A-17). For the purposes of estimating costs, it has been assumed that: a borrow source within 5 miles from the work areas can be identified; borrow material may be procured for a nominal price of $2.00 per cubic yard; and that no screening or other processing of the material would be required. Costs are included for relatively minor improvements to haul routes and related restoration. The largest costs associated with implementing this alternative are related to the procurement and incorporation of lime and the placement of the soil cover.

6.3.1.4 ALTERNATIVE 4

Alternative 4 for Fluvial Mine-Waste deposits of all priorities (low, moderate and high) within Reach 3 is complete removal, backfilling the excavation with replacement soil to match the surrounding grade and revegetation. As a matter of course and to ensure the complete removal of mine waste, an additional six inches of underlying soil will also be excavated beyond the waste-soil interface. The remaining subgrade soils beneath the high priority deposits will be amended with lime prior to backfilling. Banks will be stabilized where removals pose the potential for instability.

Excavated material will be transported to, and placed in an on-site repository located within Reach 3. For the purposes of this evaluation, the repository is assumed to be located approximately one-half mile south of the US Highway 24 bridge over the Arkansas River, at the upgradient end of Reach 3, between Highway 24 and the river. The repository is assumed to encompass an area of 5 to 6 acres, allowing the depth of the deposited waste to be limited to approximately 10 feet. The repository will be unlined and will be covered with an 18-inch thick soil cover.

<u>Implementability:</u> Excavation of the mine-waste deposits and underlying soil, to an average depth of 18 inches, is not anticipated to be difficult and can be accomplished with common earthmoving construction equipment. Appropriate control measures will be required when excavating along the riverbank to avoid release of waste material into the river. The development of an on-site repository within Reach 3 will result in relatively short haul distances from the deposits. Development of the repository is not anticipated to be difficult, as it will require standard excavating/construction equipment. The implementation of this alternative may also require the improvement of access routes to facilitate truck traffic from the deposits to the repository location. The development of suitable haul roads is not anticipated to be problematic, although the deposits are widely distributed throughout the reach. Dust control will be required to mitigate dust on temporary haul roads and gravel access roads. The implementation of this remedy will present some short-term risks associated with potential transport of contaminants, either as dust emissions or as releases to the river during excavation along the riverbank. Both potential release mechanisms may be mitigated through the implementation of appropriate engineering controls.

With respect to administrative implementability, access and consent of the landowners will be required for the development of the repository, temporary construction and removal activities. Excavation along the banks of the river and bank stabilization activities may also hold permitting considerations. It is expected that USEPA would view the consolidation of Reach 3 mine waste within a local repository as consolidation within the same general area of contamination. The conceptual repository design is similar to the USEPA selected closure plan for the Apache Tailings, and should, therefore, meet with regulatory approval.

Effectiveness: Complete removal of all mapped deposits to an on-site repository within Reach 3 allows for all of the restoration objectives to be fulfilled. Liming of underlying soil and soil replacement eliminates concerns for plant uptake of residual metals and allows for establishment of any desired cover type. Habitat should be restored consistent with vegetation in surrounding areas within 2 growing seasons. Although not as large a concern within Reach 3, complete removal also provides additional long-term effectiveness regarding the potential for changes in land use.

Cost: The total estimated cost for Alternative 4 is approximately $2,385,000 (Table A-18). The largest costs associated with this alternative are related to removal of the deposits, the import of replacement soil and the development of the on-site repository. For the purposes of estimating, the repository excavation is assumed to be approximately 8 feet deep, with material from the excavation utilized for berm construction, as replacement soil, and for the cover of the repository. Costs are included for the improvement of access routes, the restoration of approximately 2 miles of temporary access/haul roads necessary to access the deposits, an the implementation of engineering controls/BMPs. Costs for streambank stabilization are included, assuming that approximately 750 feet, or 15%, of bank associated with removals would require some specific stabilization measures. While the specific actions to be taken within these areas will require additional evaluation, the cost estimates included are representative of the average cost that may be associated with a range of options.

6.3.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

6.3.2.1 ALTERNATIVE 1

Alternative 1 for Channel Morphology/In-Stream Habitat/Riparian Area in Reach 3 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: As discussed above for fluvial mine-waste deposits, if the current lack of grazing for a large portion of Reach 3 is maintained, improvements in riparian vegetation and streambank stability will result. Over time, a narrowing of the channel width should also occur, if grazing no longer occurs and if augmented flows continue to be managed to control rapid water level fluctuations and extreme peak flows. It is also expected that near bank in-stream habitat would improve with the addition of larger woody debris. However, without establishment of formal restrictions on grazing, the effectiveness cannot be assured. In addition, the lack of larger in-stream habitat structures (e.g., deep pools) would not change without action.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.3.2.2 ALTERNATIVE 2

Alternative 2 identified for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 3 includes a combination of fencing paired with a 20-year conservation lease (a 25 foot offset, or setback, from the banks encompassing the fenced areas). This alternative may be coupled with any of the restoration alternatives for the fluvial mine-waste deposits, identified above.

Implementability: From a technical perspective, fencing of sensitive riparian zones to restrict and limit cattle access is easily implementable from a construction perspective. The cooperation and consent of the landowner should be readily achieved over a majority of Reach 3, as they are public lands. The CDOW holds a lease or easement for public recreation areas. Additional long-term provisions for grazing restriction should be highly implementable for public lands within Reach 3. Given the relatively small portion of Reach 3 in private ownership, it is expected that agreements could also be reached for a conservation lease in these areas. In addition, given the narrow width of the easement, it would not preclude the landowner from land uses other than grazing (e.g., development), and should therefore be acceptable. Conservation easements/leases are quite often established in environmentally sensitive areas on private lands.

Effectiveness: Alternative 2 would provide assurance that limitations on grazing within the riparian zone would continue until vegetation was fully established and the benefits of a mature riparian zone could be achieved within 5 years. The primary limitation for the effectiveness of Alternative 2 would be the time to achieve improvements in in-stream habitat and the near term lack of in-stream habitat structures. A potential landowner consideration is that the restored riparian vegetation may be more attractive to beavers, which often attempt to dam irrigation ditches.

Cost: The total estimated cost for Alternative 2 is approximately $138,000 (Table A-19). This cost estimate includes costs related to the installation of approximately 41,000 linear feet of three-strand solar-electric fence and maintenance of the fence. In addition, $350/acre has also been included, as a one-time capital cost, for the acreage included within the 20-year conservation lease boundaries on private property to compensate landowners for the loss of use to these areas.

6.3.2.3 ALTERNATIVE 3

Alternative 3 for Channel Morphology/In-Stream Habitat/Riparian Areas within Reach 3 is a combination of technologies, in addition to the grazing control measures from Alternative 2, including soft treatments for bank protection, channel stabilization and in-stream habitat improvements. This alternative is intended to be paired with fluvial mine-waste deposit alternatives 2 and 3, involving in-place stabilization of deposits.

Implementability: As with Alternative 2, fencing of sensitive riparian zones is readily implementable. Administratively, the implementation of this alternative will require coordination with the landowners, to obtain access to perform the bank protection and channel stabilization activities and to negotiate acceptable conservation leases that meet the requirements for restoration and address landowner concerns. The cooperation and consent of the landowner should be readily achieved over a majority of Reach 3, as they are public lands. The CDOW holds a lease or easement for public recreation areas. Additional long-term provisions for grazing restriction should be highly implementable for public lands within Reach 3. Given the relatively small portion of Reach 3 in private ownership, it is expected that agreements could also be reached for a conservation lease in these areas. The implementation of soft treatments for bank stabilization and in-stream habitat restoration is technically feasible applying commonly used procedures for stream restoration projects and BMPs for construction. The design, permitting and implementation of such restoration activities will require additional evaluation and specialized expertise, although this is not considered to be an impediment to implementation. Actions addressing streambank stability adjacent to fluvial mine-waste deposits would best be conducted prior to any in-place stabilization restoration actions at a deposit to avoid disturbance of the restored deposit.

Effectiveness: Alternative 3 would be effective in rapidly improving bank stability and in-stream structural habitat. Within 5 years, the grazing restrictions in conjunction with the bank stabilization/in-stream habitat treatments should result in full achievement of the restoration objectives. Any limitations on effectiveness would be linked to the management of augmented flows from Lake Fork.

Cost: The total estimated cost for Alternative 3 is approximately $559,000 (Table A-20). Costs for streambank stabilization and in-stream habitat restoration are included, assuming that approximately 7,200 feet, or 150% of the total feet of bank intercepting mine-waste deposits, would require some specific stabilization measures. While the specific actions to be taken within these areas will require additional evaluation, the cost estimates included are representative of the average cost that may be associated with a range of options, including the soft treatments of willow waddling, anchored trees, root wads, rock structures, and log placement.

6.3.2.4 ALTERNATIVE 4

Alternative 4 for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 3 includes the same riparian area grazing control measures as Alternative 2, coupled with in-stream habitat improvements in the form of excavating 10 deep pools (5 pools within each subreach). Both subreaches 3A and 3B currently lack pool habitat.

Implementability: The excavation of pool habitat as an in-stream habitat restoration Process Option is technically feasible applying commonly used procedures for stream restoration projects. The design, permitting and implementation of such restoration activities will require additional evaluation and specialized expertise, although this is not considered to be an impediment to implementation. Fencing of sensitive riparian zones to restrict and limit cattle access is readily implementable. Administratively, the implementation of this alternative will require coordination with the landowners, to negotiate acceptable conservation leases that meet the requirements for restoration and address landowner concerns. Actions addressing streambank stability adjacent to fluvial mine-waste deposits would best be conducted prior to any in-place stabilization restoration actions at a deposit to avoid disturbance of the restored deposit.

Effectiveness: Alternative 4 would be effective in improving bank stability and in-stream structural habitat. Alternative 4 measures, including grazing restrictions, should result in achievement of the restoration objectives within 5 years. As for Alternative 3, the primary limitations would be linked to management of extreme flow conditions that can be associated with trans-mountain diversions through Lake Fork.

Cost: The total estimated cost for Alternative 4 is approximately $692,000 (Table A-21). This cost estimate includes costs related to excavating 10 deep pools and the installation of approximately 41,000 linear feet of three-strand solar-electric fence and maintenance of the fence. In addition, $350/acre has also been included, as a one-time capital cost, for the acreage included within the 20-year conservation lease boundaries on private property to compensate landowners for the loss of use to these areas.

6.3.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

A predicted phytotoxicity pattern was digitized using Figure 6.1 from USEPA's Ecological Risk Assessment for the Terrestrial Ecosystem (USEPA 2003b) (See Section 3.3.2 and Figure 3-6). The alternatives evaluated in this section for agricultural lands would be implemented in those areas determined to have the greatest potential for phytotoxicity and/or having a HQ > 1, as identified on Figure 3-6 and summarized in Table 3-7. The areas meeting these criteria in each subreach are as follows: subreach 3A contains approximately 19.9 acres within the floodplain and 3.5 acres outside the floodplain and subreach 3B contains 8.9 acres within the floodplain and 37.9 acres outside the floodplain.

Currently, there is only a small parcel within the upper portion of Reach 3 that is actively ranched. Overall exposure concerns for deer and elk within Reach 3 are limited.

6.3.3.1 ALTERNATIVE 1

Alternative 1 for Agricultural Lands (Irrigated Meadows) in Reach 3 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: It is likely that, over decades, the available metals concentrations in surficial soils in Reach 3 will decline and plant cover will improve. Risks to wildlife and livestock associated with metals uptake will also decline. However, the rate of improvement would be slow to imperceptible.

Cost: There is no cost associated with Alternative 1, since no action would be taken.

6.3.3.2 ALTERNATIVE 2

Alternative 2 identified for Agricultural Lands (Irrigated Meadows) in Reach 3 is deep tilling and reseeding.

Implementability: Deep tilling to an average depth of 12 inches is easily implementable in conjunction with standard agricultural practices for preparing land for planting. Deep tilling in riparian corridors containing dense woody vegetation is not readily implementable. As with each of the other alternatives, landowner consent will be required.

Effectiveness: Deep tilling would rapidly decrease surficial soil metals concentrations, and the addition of seeding would result in rapid re-establishment of cover consistent with adjacent areas.

Reach 3

Alternative 2 would be effective in meeting the objective of reducing potentially harmful metals exposure to wildlife and livestock within Reach 3. Alternative 2 should restore the identified portions of the irrigated meadows to full use within 3 years.

Cost: The estimated cost for Alternative 2 is approximately $291,000 (Table A-22). Because the actions under this alternative are anticipated to be fully effective within 3 years after implementation, and maintenance activities are anticipated to be limited to maintenance fertilizer and spot reseeding (10% of the total area), the O&M costs included for this estimate are presented as totals rather than annual costs and a net-present value analysis has not been included.

6.3.3.3 ALTERNATIVE 3

Alternative 3 for Agricultural Lands (Irrigated Meadows) in Reach 3 is the application of agricultural lime in conjunction with deep tilling and re-seeding with an appropriate species.

Implementability: Deep tilling to an average depth of 12 inches is easily implementable in conjunction with standard agricultural practices for preparing land for planting, and the addition of lime does not significantly affect the implementability. As with Alternative 2, deep tilling in riparian corridors containing dense woody vegetation is not readily implementable. As with each of the other alternatives, landowner consent will be required.

Effectiveness: Alternative 3 has the same level of physical effectiveness as Alternative 2. The addition of lime as a soil amendment will help to buffer any residual acidity, reduce the potential for metals uptake by plants and should be effective in establishing cover consistent with the adjacent areas within two growing seasons.

Cost: The estimated cost for Alternative 3 is approximately $326,000. Unit prices for lime amendment and revegetation are the same as those used for the fluvial mine waste alternatives. Because the actions under this alternative are anticipated to be fully effective within 3 years after implementation, and maintenance activities are anticipated to be limited to maintenance fertilizer and spot reseeding (10%

of the total area), the O&M costs included for this estimate are presented as totals rather than annual costs and a net-present value analysis has not been included.

6.4 REACH 4

6.4.1 FLUVIAL MINE-WASTE DEPOSITS

6.4.1.1 ALTERNATIVE 1

Alternative 1 for mine-waste deposits (all low priority) in Reach 4 is the No Action/Natural Recovery alternative. The No Action/Natural Recovery alternative is included to provide a baseline against which other alternatives can be compared.

Implementability: No action would be taken.

Effectiveness: Given the limited area of low priority fluvial mine-waste deposits within Reach 4, the natural recovery alternative would result in improved vegetation cover with time. However, it is expected that it would require decades for complete restoration of vegetation, even in these small areas, without action.

Cost: There is no cost associated with Alternative 1, since no action would be taken.

6.4.1.2 ALTERNATIVE 2

Alternative 2 for Fluvial Mine-Waste Deposits within Reach 4 consists of the direct revegetation, without amendment, for the low and moderate priority deposits. Direct revegetation will consist of the application of an appropriate planting mixture and mulch.

Implementability: Because of the relatively small area of the suspected mine-waste deposits within Reach 4 and the potential difficulty of accessing the deposits, it is assumed that the direct revegetation activities will be performed using ATVs. Administrative considerations include the requirement to obtain landowner access, which is not anticipated to be problematic. This alternative is considered to be highly implementable.

Effectiveness: Alternative 2 would be effective in accelerating the restoration of vegetation on the few small identifiable deposits of mine waste within Reach 4.

Cost: The total estimated cost for Alternative 2 is approximately $25,000 (Table A-24).

6.4.1.3 ALTERNATIVE 3

Alternative 3 for Fluvial Mine-Waste Deposits within Reach 4 consists of the incorporation of agricultural lime and revegetation.

Implementability: As with Alternative 2, access to the suspected mine-waste deposits will be by ATV. Lime may be applied using a broadcast spreader attachment, however incorporation will be difficult. The lime may be incorporated using a ripper or disc attachment or by hand and therefore the depth of incorporation will be limited to six inches or less.

Effectiveness: Alternative 3 would be effective in accelerating the restoration of vegetation on the few small identifiable deposits of mine waste within Reach 4.

Cost: The total estimated cost for Alternative 3 is approximately $55,000 (Table A-25).

6.4.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

6.4.2.1 ALTERNATIVE 1

Alternative 1 for Channel Morphology/In-Stream Habitat/Riparian Area in Reach 4 is the No Action/Natural Recovery alternative.

Implementability: This alternative is easily implementable since no action would be taken.

Effectiveness: Overall, the level of in-stream habitat and channel stability in Reach 4 is viewed to be good. Grazing in riparian zone and/or the small area of mine-waste deposits does not appear to be occurring. Continued improvements in resource conditions are expected under the No Action/Natural Recovery Alternative.

Cost: There is no cost associated with Alternative 1 since no action would be taken.

6.4.2.2 ALTERNATIVE 2

Alternative 2 identified for Channel Morphology/In-Stream Habitat/Riparian Areas in Reach 4 includes a combination of fencing paired with a 20-year conservation lease (a 25 foot offset, or setback, from the banks encompassing the fenced areas). This alternative may be coupled with any of the restoration alternatives for the fluvial mine-waste deposits, identified above.

Implementability: From a technical perspective, fencing of sensitive riparian zones to restrict and limit cattle access is readily implementable, but requires the cooperation and consent of the landowner. Administratively, the implementation of this alternative will require coordination with the landowners, to negotiate acceptable conservation leases that meet the requirements for restoration and address landowner concerns. This restriction would not significantly reduce the area currently available for grazing within the 500-year floodplain. Given the narrow width of the easement, it would not preclude the landowner from land uses other than grazing (e.g., development within 25 feet of the bank is unlikely), and should therefore be acceptable. Conservation easements/leases are quite often established in environmentally sensitive areas on private lands.

Effectiveness: Alternative 2 would provide additional assurance that the good conditions of the riparian zone and streambanks within Reach 4 remain.

Cost: The total estimated cost for Alternative 2 is approximately $65,000 (Table A-26). This cost estimate includes costs related to the installation of approximately 18,600 linear feet of three-strand solar-electric fence and maintenance of the fence. In addition, $350/acre has also been included, as a one-time capital cost, for the acreage included within the 20-year conservation lease boundaries on private property to compensate landowners for the loss of use to these areas.

7.0 COMPARATIVE ANALYSIS

The findings of the detailed analysis presented in Section 6 are further considered in terms of relative performance of the alternatives. In particular, the relative implementability and effectiveness of the alternatives in terms of achieving and maintaining the general restoration objectives are discussed. Differences in the time to achieve those objectives and the relative cost are also considered. As detailed in Section 3, the general restoration objectives are to:

- Restore, replace or acquire the equivalent of injured resources with lost services within the 11-Mile Reach to levels consistent with applicable baseline conditions; and

- Provide for restoration actions that are protective of human health and the environment.

The Comparative Analysis is organized by reach (Sections 7-1 through 7-4). A summary organized by restoration need category is also included (Section 7-5). The summary considers the compatibility of alternatives between reaches to provide additional assurance that the relative implementability, effectiveness and cost are fully understood. Tables 7-1 through 7-3 briefly summarize the key finding regarding implementability, effectiveness, cost and time to achieve restoration objectives for each alternative within each restoration need category.

For the purpose of the Comparative Analysis, it is expected that the implementation of all the considered alternatives for a reach could occur within one or two construction seasons. Correspondingly, there are no significant distinctions between alternatives for time of implementation. Time frames for achievement of restoration objectives discussed in the Comparative Analysis generally relate to differences in the expected time for recovery of vegetation/cover, after the initial construction activity is complete.

7.1 REACH 1

Reach 1 extends from the confluence of California Gulch to tributary flow from Lake Fork. A full range of alternatives was considered for each Restoration Need category in Reach 1 (Table 5-1).

7.1.1 FLUVIAL MINE-WASTE DEPOSITS

A significant distinction for Reach 1 relative to other reaches is the large amount of fluvial mine-waste remediation work conducted by USEPA since 1998. Over the last 5 construction seasons, USEPA has remediated all of the high priority fluvial mine-waste deposits using varying amendments of lime and organic matter. The amended deposits were also seeded. The exact planting mixture varied by deposit. Approximately 3 out of the 18 acres of Reach 1 mine-waste deposits remain untreated (2 low priority and 6 moderate priority deposits).

The primary considerations for the No Action/Natural Recovery alternative are the expected effectiveness of USEPA's recent remediation and the importance of the 3 acres of untreated deposits in terms of achieving the restoration objectives. Given the initial establishment of cover and small area of the deposits, vegetation consistent with surrounding communities should be achieved and maintained, thereby restoring habitat. USEPA's remedy should also reduce the relative bioavailability and plant uptake of metals of the treated fluvial mine-waste deposits, assuring that the potential for wildlife exposure to metals remains below levels of concern. However, without further action, it is unlikely that the remaining 3 acres of untreated deposits will achieve the restoration objectives.

Alternatives 2 and 3 address the issue of the remaining 3 acres through the addition of amendments (lime or lime and biosolids) and deep tilling with reseeding. Both alternatives are expected to achieve the restoration objectives through the establishment of cover/habitat consistent with the surrounding Reach 1 areas and the deep tilling component of both alternatives has the added benefit of potentially reducing surficial metals concentrations at some locations. The incorporation of lime by deep tilling, in conjunction with seeding and mulch addition under Alternative 2 is considered to be effective and the restoration objectives will be achieved within approximately 3 to 5 years after implementation of the alternative. However, the inclusion of biosolids for Alternative 3 will improve moisture-holding capacity and increase plant nutrients, thereby improving growth and possibly accelerating the time to achieve the restoration objectives to 2 to 3 years after implementation of the alternative.

Reach 1

Alternative 4, which calls for removal of all mapped mine-waste deposits, regardless of prior remediation, provides the highest level of certainty that the restoration objectives will be achieved for fluvial mine-waste deposits within Reach 1. For the 3 acres of untreated deposits, the time frame for removal, soil replacement and restoration of cover/habitat would be consistent with Alternative 3. Considering USEPAs progress to date on the high priority deposits, Alternatives 3 and 4 are generally expected to provide a similar time frame for restoration of cover/habitat within Reach 1. In terms of effectiveness, the complete removal of all mine-waste deposits in Reach 1 provides additional benefit over Alternatives 2 and 3, where long-term restrictions of land use may be needed to protect the integrity of the restoration measures.

All of the alternatives are considered implementable. Alternative 4 involves somewhat greater logistical considerations than Alternatives 2 and 3, including stabilization of 300 feet of streambanks where removed mine-waste deposits intersect the channel. It is expected that for Alternative 4, disposal at the Black Cloud Repository can be arranged and adequate material for fill can be obtained locally.

With regard to cost, Alternatives 2 and 3 have similar estimated total costs of approximately $85,000 and $89,000, respectively. O&M component costs are also similar for these two alternatives. The costs for removal of the fluvial mine-waste deposits under Alternative 4 are more than an order of magnitude greater ($1,521,000) than the costs for in-place stabilization under Alternatives 2 or 3.

Overall, Alternative 3 provides the highest level of cost effectiveness in terms of restoring acceptable cover/habitat for the fluvial mine-waste deposits in Reach 1. Given the large Reach 1 remediation effort already conducted by USEPA, and the reasonable likelihood that it will be successful in achieving the objectives of restoring cover/habitat on the deposits consistent with baseline conditions, the removal considered under Alternative 4 offers no significant advantage for a much greater cost. Although Alternative 2 is also considered to be effective, the small difference in cost between Alternative 2 and Alternative 3 is outweighed by the anticipated benefits offered by the addition of biosolids, including improved moisture-holding capacity and plant nutrient availability, and the slightly accelerated time to achieve the restoration objectives.

7.1.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/ IN-STREAM HABITAT

Improvements in riparian cover/habitat, bank stability and the quality of in-stream habitat are the primary restoration needs to be addressed by the developed alternatives in Reach 1. The No Action/Natural Recovery alternative would not result in improvements in the resource conditions. In contrast, Alternative 2 comprised of 20-year conservation leases and fencing to restrict cattle grazing within 25 feet of the channel banks would be effective in improving riparian habitat, thereby increasing bank stability and providing some improvement in in-stream habitat through overhanging vegetation. In addition, with time, the development of more bank side fish habitat would develop. Riparian vegetation is expected to improve substantially in the first 5 years and the benefits to bank stability and in-stream habitat would mature over the 20-year lease period.

Alternative 3 provides the additional benefit of combined bank stabilization/in-stream habitat improvements at the locations where fluvial deposits comprise a portion of the bank (approximately 3,000 feet). Although Alternative 3 potentially offers additional short-term effectiveness relative to Alternative 2 in terms of bank stability, there will be not likely be a significant difference in overall bank stability between the two alternatives. This is because the largest benefit should come from the grazing restrictions offered under both Alternatives 2 and 3. However, the bank stabilization actions included in Alternative 3 will result in more rapid improvements in in-stream habitat. Alternative 4 also provides the same benefits as Alternatives 2 and 3 through restriction of grazing, but provides for the excavation of pool habitat within sub-reaches 1A and 1C. Lack of pool habitat was identified as a specific restoration need within Reach 1.

Alternatives 2, 3 and 4 are all readily implementable. Alternatives 3 and 4 involve significantly more design and construction management effort than Alternative 2. However, the streambank stabilization and pool excavation actions contemplated under these alternatives are routinely utilized and could be conducted during periods of low flow to minimize associated sediment transport.

In terms of estimated costs, Alternative 4 (approximately $180,000) is roughly $100,000 more than Alternative 2 (approximately $66,000). The costs associated with approximately 3,000 feet of streambank stabilization for Alternative 3 (approximately $241,000) are roughly $60,000 more than the estimated costs of Alternative 4.

The primary benefits within Reach 1 for restoration of riparian habitat and improvements in streambank stability are provided by the institutional and physical restrictions to grazing included in Alternatives 2, 3 and 4. The main difference between Alternatives 3 and 4 is the combined addition of approximately 3,000 feet of bank stabilization/in-stream habitat improvements, at the locations of certain fluvial deposits, called for under Alternative 3. Although there may be some additional short-term benefit to bank stability, it is not anticipated that there would be a significant long-term effectiveness in bank stability over the grazing restrictions alone. Furthermore, analyses conducted in support of the SCR (MOUP CT 2002) indicated that erosion of mine-waste deposits would not have a measurable effect on water quality within the UARB. Therefore, the difference in approach and cost for the in-stream habitat improvements offered by Alternatives 3 and 4 are the main comparison considerations.

Even with detailed modeling it would be difficult to determine the long-term difference in brown-trout productivity offered by the combined bank stabilization/habitat improvement measures of Alternative 3 vs. the construction of pool habitat prescribed under Alternative 4. Some of the immediate habitat improvements offered by Alternative 3 would likely also occur over time under Alternative 4, as grazing restrictions allow larger woody vegetation to develop and contribute woody debris to the stream. However, it is unlikely that the lack of pool habitat within Reach 1 will change without the pool excavation component of Alternative 4. Assuming relatively equal benefits to the brown trout fishery for Alternatives 3 and 4, the additional Alternative 3 cost of approximately $60,000 would provide a limited benefit in terms of short-term improvements in bank stability.

7.1.3 AGRICULTURAL LANDS

The areas of agricultural lands comprised of irrigated meadows within Reach 1 that were identified by USEPA as potentially posing unacceptable risk to deer and elk and livestock are small. When examined in the context of the whole reach, which is a reasonable exposure range for grazing animals, unacceptable risks were not identified. Nonetheless, Alternatives 2 and 3 were developed to address the smaller areas of elevated surficial soil metals concentrations that appear to have resulted due to historic irrigation.

As noted above, the potential for injury to wildlife associated with Reach 1 irrigated meadows is small. Under the Natural Recovery alternative, that potential would over decades continue to slowly diminish. This is due both to the ongoing improvements in the quality of the UAR water used for irrigation, and the gradual dilution of surficial soils with the natural soil building cycle. In contrast, Alternative 2 would immediately reduce surficial soils metals concentrations in the identified areas through deep tilling. Re-seeding should be effective in establishing cover consistent with the adjacent areas in two growing seasons. Alternative 3 calls for the same deep tilling and seeding, with the addition of agricultural lime. The addition of lime for Alternative 3 would increase effectiveness where low soil pH may be a limiting factor.

Both Alternatives 2 and 3 are readily implementable. The cost difference of approximately $25,000 between the two alternatives is associated with the amending of the tilled soil (lime addition) under Alternative 3.

Reach 1

Overall, Alternatives 2 and 3 would be equally effective in addressing any exposure/phytotoxicity concerns associated with surficial soil metals concentrations in these irrigated areas. Alternative 3 provides the highest level of effectiveness in terms of rapidly restoring the desired cover/habitat in the tilled areas where low soil pH is the limiting factor.

7.2 REACH 2

Reach 2 extends from the confluence of Lake Fork to the Highway 24 bridge. Significant baseline considerations for Reach 2 are flow augmentation through Lake Fork and grazing. A full range of alternatives was considered for each restoration need category in Reach 2 (Table 5-7).

7.2.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 2 contains approximately 9 acres of fluvial mine-waste deposits. Nearly half of the acreage is comprised of 3 overlapping high priority deposits at the boundary with Reach 1. The majority of Reach 2 fluvial deposits are within the Smith Ranch property. No significant remediation has occurred or is planned by USEPA for Reach 2.

Conditions of the fluvial deposits within Reach 2 are not expected to change under Alternative 1, the Natural Recovery Alternative. The fluvial deposits would continue to have the same basic chemical and physical characteristics they currently have for decades. It is not expected that there would be significant erosion of the deposits.

Alternatives 2 and 3 combine several different actions depending upon the priority of the deposits. Alternatives 2 and 3 address the low and moderate priority deposits through the addition of amendments (lime or lime and biosolids) and deep tilling with reseeding. Both alternatives are expected to achieve the restoration objectives through the establishment of cover/habitat consistent with the surrounding Reach 2 areas. The deep tilling component of both alternatives has the added benefit of potentially reducing surficial metals concentrations at some locations. The incorporation of lime by deep tilling, in conjunction with seeding and mulch addition under Alternative 2 should effectively meet the restoration objectives for low and moderate priority deposits within approximately 3 to 5 years after implementation of the alternative. However, the inclusion of biosolids for Alternative 3 will improve moisture-holding capacity and plant nutrients, thereby improving growth and possibly accelerating the time to achieve the restoration objectives to 2 to 3 years after implementation of the alternative.

For high priority deposits, Alternative 2 includes biosolids application, deep tilling and liming, prior to reseeding. Alternative 3 adds a 12-inch soil cover to the high priority deposits. Again, the expected level of effectiveness in terms of the restoration objectives is similar, however, the soil cover would provide more rapid restoration and greater assurance of continued protection. It may take 2-5 years to restore low to high priority mine-waste deposits under Alternative 2, where Alternative 3 for the high priority deposits provides greater assurance that the restoration objectives would achieved after 2 growing seasons. A long-term effectiveness consideration for both Alternatives 2 and 3 is private ownership of Reach 2. Without institutional controls, changes in land use could result in disturbances of the treated deposits, potentially reducing the effectiveness of the remedy.

In contrast to the in-situ stabilization measures of Alternatives 2 and 3, Alternative 4 calls for the complete removal of mapped fluvial mine-waste deposits. In terms of overall effectiveness in achieving the restoration objectives, it is not expected that Alternative 4 will substantially differ from Alternative 3. For high priority deposits, it is expected that the soil cover of Alternative 3 will provide the same level of effectiveness as removal and replacement, within the same time period. However, given the private ownership of Reach 2, Alternative 4 has an advantage in terms of expected long-term effectiveness. Removal of the mine-waste also eliminates the need for associated institutional controls, such as deed restrictions.

All of the alternatives are equally implementable. Alternative 4 is a slightly more complex construction scenario than Alternatives 2 or 3. Access needs are similar between alternatives and it is expected that the landowner will provide the same level of cooperation under each alternative.

The relative cost of the alternatives varies substantially. Alternatives 2 and 3 have estimated costs of approximately $178,000 and $263,000, respectively. Alternative 4 has the highest estimated cost (approximately $597,000) assuming a nominal tipping fee for disposal at the Black Cloudy repository. It should be noted that neither Alternative 2 nor 3 include possible costs associated with long-term land-use restrictions for the 9 acres (e.g., deed restrictions).

Overall, the primary distinction between Alternatives 2, 3 and 4 relate to the likelihood of effectively achieving and maintaining the restoration objectives over the long-term. Although it is expected that all of these alternatives would meet the goal of restoring acceptable cover/habitat to the areas occupied by fluvial deposits, Alternatives 2, 3 and 4 incrementally provide additional benefits in terms of the time to achieve the objectives and/or the assurance that the restoration measures will remain effective. For example, the soil cover for high priority deposits under Alternative 3 will allow for more rapid establishment of safe cover/habitat than the biosolids amendment of Alternative 2. In terms of time to establish habitat/cover and the quality of that habitat, there is no significant distinction expected between the actions of Alternatives 3 and 4. However, Alternative 4 offers improvement in terms of long-term effectiveness over Alternatives 2 and 3, in that reliance on private land institutional controls are not necessary. The relative difference in cost over Alternative 3, for the additional long-term effectiveness and lower long-term O & M requirements of Alternative 4, is roughly $330,000.

7.2.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

Improvements in riparian cover/habitat and the related localized conditions of streambank stability were identified as the restoration needs to be addressed by the developed alternatives. The need for restoration of these conditions is greater near the downstream end of subreach 2B, where the riparian vegetation appears to be diminished.

The No Action/Natural Recovery alternative would not result in improvements in the riparian vegetation or streambank stability. However, both Alternatives 2 and 3 would achieve improvements in cover and habitat to be consistent with the upstream reference reach (Reach 0). As described for Reach 1, the riparian area conservation lease and electric fencing provided under Alternative 2 would be effective in meeting the restoration objectives. It is expected that riparian vegetation would rapidly recover from the impacts of grazing within the first 5 years, and bank stability would improve correspondingly. Some additional short-term improvement in bank stability could be achieved through the soft stabilization treatments of the banks at stream locations intersecting fluvial mine-waste deposits under Alternative 3. These Alternative 3 measures would also provide additional in-stream habitat.

Alternatives 2 and 3 are both readily implementable but require coordination with the landowner. Alternative 3 is more involved in terms of design and construction requirements. Correspondingly, the estimated cost of Alternative 3 is approximately $428,000 vs. approximately $136,000 for Alternative 2.

Over the long-term (5-10 years), it is not expected that Alternatives 2 and 3 will differ greatly in terms of improving bank stability. Considering that the in-stream habitat within Reach 2 is generally good and that the improvements in riparian zone vegetation offered by both Alternatives 2 and 3 will also benefit the fishery, the difference in effectiveness offered by the more rapid in-stream habitat improvements of Alternative 3 is small in comparison to the approximately $300,000 difference in cost.

7.2.3 AGRICULTURAL LANDS

Approximately 66 acres of irrigated meadows were identified for restoration measures within Reach 2. Sixty-six acres comprises a small portion of Reach 2 agricultural lands. When the potential risks to wildlife and livestock associated with these areas were evaluated by USEPA, unacceptable risks were not identified in the context of the entire reach. Even so, Alternatives 2 and 3 were developed to address areas exhibiting a high potential for phytotoxicity and/or HQ > 1 for grazing animals associated with the 66 acres.

Reach 2

Under the No Action/Natural Recovery alternative, the small potential for injury to plants and grazing animals associated with the 66 acres would remain into the foreseeable future. Alternative 2 would immediately reduce the potential for injury through deep tilling. Deep tilling would lower metals concentrations in surficial soil and seeding would result in rapid re-establishment of cover consistent with adjacent areas. The addition of lime for Alternative 3 would increase effectiveness where low soil pH may be a limiting factor.

Both Alternatives 2 and 3 are common agricultural practices that are readily implementable in Reach 2. Both would involve coordination with the landowner(s). The addition of lime under Alternative 3 results in an estimated cost of approximately $308,000 vs. approximately $275,000 for Alternative 2.

Both Alternatives 2 and 3 would be equally effective in rapidly addressing any exposure/phytotxoicity concerns associated with surficial soil metals concentrations in these irrigated areas. Alternative 3 provides the highest level of effectiveness in terms of rapidly restoring the desired cover/habitat in the tilled areas where low soil pH is the limiting factor.

7.3 REACH 3

Reach 3 extends from the Highway 24 bridge downstream to the valley constriction just below Kobe. The vast majority of land within Reach 3 is controlled by the State of Colorado, the City of Aurora and Lake County. A full range of alternatives was considered for each restoration need category in Reach 3 (Table 5-9).

7.3.1 FLUVIAL MINE-WASTE DEPOSITS

Reach 3 contains 37.62 acres of fluvial deposits and the largest volume of mine waste of the 4 reaches. USEPA has conducted a substantial amount of work within Reach 3, treating 16.8 acres. Their work addresses slightly less than half of the deposits. USEPA's work is expected to be effective in restoring cover/habitat to the treated areas. Injuries associated with the untreated fluvial deposits are expected to persist under the No Action/Natural Recovery Alternative.

Alternatives 2 and 3 combine several different actions depending upon the priority of the deposits. Alternative 2 for the low, moderate and high priority deposits and Alternative 3 for the low and moderate priority deposits include the addition of amendments and deep tilling with reseeding. Both Alternatives 2 and 3 are expected to achieve the restoration objectives through the establishment of cover/habitat consistent with the surrounding Reach 3 areas. The deep tilling component of both alternatives has the added benefit of potentially reducing surficial metals concentrations at some locations. The incorporation of lime by deep tilling, in conjunction with seeding and mulch addition under Alternative 2 should effectively meet the restoration objectives for low and moderate priority deposits within approximately 3 to 5 years after implementation of the alternative. However, the inclusion of biosolids for Alternative 3 will improve moisture-holding capacity and increase plant nutrients, thereby improving growth and possibly accelerating the time to achieve the restoration objectives to 2 to 3 years after implementation of the alternative.

Alternative 3 for the high priority deposits provides a greater level of certainty that restoration objectives would be rapidly and effectively achieved. Under Alternative 3, the high priority deposits would be deep tilled with lime addition prior to placement of a 12-inch soil cover and seeding. The soil cover would provide slightly more rapid restoration of habitat and greater assurance of continued protection than the incorporation of amendments alone. It may take 2 to 5 years to restore low to high priority mine-waste deposits under Alternative 2, where Alternative 3 for the high priority deposits provides greater assurance that the restoration objectives would be achieved after 2 growing seasons.

Reach 3

Alternative 4 calls for the complete removal of all mapped fluvial deposits, regardless of prior remediation, with consolidation in a constructed repository within the reach.

As for Reaches 1 and 2, it is expected that over time, Alternatives 2, 3 and 4 would be effective in meeting the restoration objectives of safely restoring baseline conditions at the locations of the untreated fluvial mine-waste deposits. Alternatives 2, 3 and 4 would allow for re-establishment of cover consistent with the surrounding areas and would reduce or eliminate the potential for wildlife exposure to metals in plants and soil at these locations. The primary difference in effectiveness between alternatives is related to the time to achieve the restoration objectives and over the long-term, the reliability of maintaining the restoration objectives. The differences between Alternatives 2 and 3 are more distinct for the high priority deposits. For low and moderate priority deposits, the difference in effectiveness between Alternatives 2 and 3 is expected to be small. For low and moderate priority deposits, the addition of biosolids under Alternative 3 should somewhat shorten the time required to achieve cover relative to limiting amendments to lime under Alternative 2. For high priority deposits, the use of a 12-inch soil cover under Alterative 3 will provide for more rapid restoration of habitat (after 2 growing seasons) and greater assurance that habitat will remain established over time than for Alternative 2.

Alternatives 3 and 4 have a similar level of near-term effectiveness, in that they will both rapidly provide acceptable restoration of habitat. Over the long-term, Alternative 4 may be slightly more effective because the mine-waste deposits are removed from the floodplain and consolidated in a central repository within the reach. However, the greater ability to control future land use and establish institutional controls on lands in public ownership lessens any long-term effectiveness distinction between Alternatives 3 and 4.

All of the alternatives are considered to be implementable. Construction of an on-site repository in Reach 3 would require landowner acceptance. However, it is assumed that in-place stabilization and soil covers would also require acceptance from the landowner. The footprint of the repository could be approximately 6 acres, which is smaller than the roughly 38 acres currently occupied by the fluvial mine-waste deposits. Locating a repository in Reach 3 may pose some administrative and legal issues, but they are not assumed to be more significant than for other actions. If the repository is located on public lands, there may be fewer administrative implementability concerns, given that some institutional controls are already in place (e.g., restrictions on vehicle access). There are no significant distinguishing factors related to the construction aspects of the alternatives.

Cost for the alternatives varies substantially. Alternative 2 estimated costs are approximately $314,000. Total costs for Alternative 3 are estimated to be approximately $447,000. The cost for implementation of Alternative 3 could be reduced if a substantial volume of organics-rich sediment, excavated from Mt. Massive Lakes, was available for use as a soil cover. The estimated cost for Alternative 4 is approximately $2,385,000. A large difference in cost between Alternatives 3 and 4 is due to the greater amount of replacement soil and repository cover soil required to address both the treated and untreated deposits under Alternative 4. Although not evaluated as an alternative, the costs for disposal of excavated fluvial deposits at the Black Cloud Repository vs. construction of a repository were also estimated. The difference in cost between these two disposal options is an increase of approximately $650,000 for transportation to the Black Cloud Repository (i.e., total cost of roughly $3,000,000).

With time, it is expected that all of the alternatives would meet the objectives of restoring habitat consistent with adjacent areas. Alternatives 3 and 4 would meet the restoration objectives more rapidly (2-3 years after implementation) than Alternative 2 (3-5 years after implementation). Alternatives 3 and 4 are also expected to be slightly more effective than Alternative 2 over the long-term. All of the alternatives are expected to achieve an acceptable reduction in the potential for metals exposure at the fluvial mine-waste deposits. In general, Alternatives 3 and 4 are expected to provide a similar level of effectiveness and implementability. The O & M burden associated with the Alternative 4 repository would be slightly less than for the deposits in place. The estimated total cost for Alternative 4 is roughly $1,900,000 more than for Alternative 3.

7.3.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

The primary restoration needs to be addressed by the developed alternatives are improvements in riparian habitat, streambank stability and in-stream habitat. Observation indicates that Reach 3 has monotonous riffle habitat and a broad shallow channel.

It is not known whether the informal exclusion of grazing associated with the recent transition from private to public lands along portions of Reach 3 riparian areas will continue. As there are no formal restrictions on grazing currently in place, grazing could resume within the Reach 3 areas. Based on the lack of formal restrictions, it is not assured that the No Action/Natural Recovery alternative would result in continued improvements in riparian vegetation, bank stability or in-stream habitat.

Alternatives 2, 3 and 4 all would provide substantial improvements in riparian habitat through the purchase of conservation easements and fencing at a 25 foot offset from the channel. These measures would allow the riparian habitat to recover to expected baseline levels within the first 5 years. With time, bank stability would also improve with increasing vegetation and lack of cattle traffic. Restored riparian vegetation would benefit the fishery in Reach 3 through a narrowing of the active channel and the development of near bank habitat, and would increase terrestrial food sources. Alternatives 3 and 4 include additional measures to address bank stability and/or in-stream habitat. Alternative 3 includes combined soft bank stabilization/in-stream habitat improvement actions (e.g., root wads, log placement, boulder placement). Alternative 4 includes pool excavation for habitat improvements. Ten pool habitats (5 in subreach 3A and 5 in subreach 3B) would be excavated under Alternative 4.

Alternative 3 provides more rapid improvements in bank stability and somewhat greater assurance of effectiveness over the long-term, relative to Alternatives 2 and 4. However, as riparian vegetation matures during the 20-year riparian zone conservation lease, the relative benefits of bank stability for Alternative 3 decrease. For Reach 3, in terms of in-stream habitat improvements, there is no clear distinction between the restoration benefits of pool excavation under Alternative 4 and the placement of logs, root wads, and boulders to be utilized under Alternative 3. Alternatives 3 and 4 are viewed to be equally effective in terms of improving in-stream habitat.

All of the alternatives are believed to be readily implementable. The level of construction complexity is greater for Alternatives 3 and 4. Some levels of institutional controls are already in place in the public areas (e.g., vehicle access restrictions). If broader restrictions on grazing are instituted in conjunction with the current public access policy for the Hayden Meadows, Hayden Ranch and Arkansas River Ranch properties, the need for fencing and a lease would be limited to a small segment of private property (Moyer Ranch) at the north end of Reach 3.

The difference in cost between alternatives is commensurate with the level of construction included. Total costs for Alternative 2 are estimated to be approximately $138,000 compared to approximately $559,000 for Alternative 3, and approximately $692,000 for Alternative 4. The costs for all of these alternatives include fencing, which may or may not be necessary.

The vast majority of restoration of the Reach 3 riparian area habitat would be equally achieved under Alternatives 2, 3 and 4 through conservation leases and fencing. Alternatives 3 and 4 will also provide improvements in in-stream habitat. The net benefits to in-stream habitat quality are assumed to be equivalent between Alternatives 3 and 4.

7.3.3 AGRICULTURAL LANDS

Overall, agricultural lands within Reach 3 were not identified as posing unacceptable risks to deer and elk or livestock. However, some specific locations of potential concern associated with historic irrigation exist. Approximately 70 acres within Reach 3 were identified as having surficial soil metals concentrations that could pose a risk to grazing livestock and/or limit plant growth.

Under the No Action/Natural Recovery alternative, the potential for injury to plants and grazing animals at these locations would remain for decades. Surficial soil conditions in these areas will not significantly change without restoration. Alternative 2 would immediately reduce the potential for injury through deep tilling by lowering metals concentrations in surficial soil. Re-seeding would result in rapid re-establishment of cover consistent with adjacent areas. In contrast, the addition of lime under Alternative 3 would increase the effectiveness where low soil pH may be a limiting factor.

Both Alternatives 2 and 3 are common agricultural practices that are readily implementable in Reach 3. Both would involve coordination with the landowner(s). The addition of lime under Alternative 3 results in an estimated cost of approximately $326,000 vs. approximately $291,000 for Alternative 2.

Both Alternatives 2 and 3 would be equally effective in rapidly addressing any exposure/phytotxoicity concerns associated with surficial soil metals concentrations in these irrigated areas. Alternative 3 provides the highest level of effectiveness in terms of rapidly restoring the desired cover/habitat in the tilled areas where low soil pH is the limiting factor.

7.4 REACH 4

The conditions of the riparian area vegetation and in-stream habitat within Reach 4 are considered to be consistent with Reach 0. There are no mapped fluvial deposits and only a few small areas of fluvial mine-waste deposition observed in Reach 4. Table 5-10 summarizes the alternatives considered for each restoration need category in Reach 4.

7.4.1 FLUVIAL MINE-WASTE DEPOSITS

Conditions within Reach 4 would not change substantially under the No Action/Natural Recovery alternative. However, it appears that there is considerably less than 2 acres where mine wastes can be observed. In these areas, vegetation is only slightly diminished and it is likely to improve with time. Alternative 2 would enhance the rate of natural recovery in these areas through reseeding and mulch. Alternative 3 has the same group of actions, but also includes lime as an amendment. It is anticipated that Alternative 3 may be slightly more effective in restoring plant cover, however, it is not known if soil pH is low in these areas. Overall, the distinction in effectiveness between Alternatives 1, 2 and 3 will be small given the limited area of Reach 4 mine-waste deposition.

Both Alternatives 2 and 3 could be readily implemented with landowner approvals. The relative estimated costs for the two alternatives are approximately $25,000 for Alternative 2 and approximately $55,000 for Alternative 3.

7.4.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

As noted above, the overall condition of riparian habitat in Reach 4 appears to be good. Grazing of riparian areas appears to be limited. Given the good condition of the riparian resource, it appears that if there were historic impacts to the riparian areas, natural recovery has occurred. Alternative 1 assumes no addition work. Alternative 2 is included for consideration as a potential mechanism for assuring that riparian habitat and bank stability remain good. Implementation of Alternative 2 would require coordination with several landowners to establish leases. The primary capital costs for Alternative 2 are for fencing of the riparian corridor (approximately $65,000).

7.5 SUMMARY OF COMPARATIVE ANALYSIS

The following provides a brief summary of the primary distinctions between alternatives identified through the detailed and comparative analyses. Considerations regarding the implementability, effectiveness and cost across reaches are also identified.

7.5.1 FLUVIAL MINE-WASTE DEPOSITS

Across all reaches the primary considerations related to implementability, effectiveness and cost of remedial alternatives for the fluvial mine-waste deposits are:

- Level of remediation already conducted;
- Volume of mine waste within a reach;
- Distance to the Black Cloud repository; and
- Private versus public ownership of lands.

These considerations are balanced by detailed analyses that indicate restoration objectives related to establishment of habitat and acceptable levels of metals exposure can be met by alternatives for both in-place stabilization and removal. A further consideration is the low potential for mass erosion of deposits stabilized in place and the negligible impacts to surface water, if such an event were to occur.

Within Reach 1, the Comparative Analysis indicates that in-place stabilization of the few remaining low and moderate priority fluvial mine-waste deposits (Alternative 3), consistent with the USEPA remedy already applied to a majority of the deposits, would be the most cost effective approach. This evaluation is based upon the expectation that USEPA's work to date will be effective in restoring cover/habitat. Completion of the USEPA initiated remedy should also decrease the potential for metals uptake by wildlife at the treated deposits.

Given the expected level of effectiveness for Alternative 3 in achieving the restoration objectives, the removal contemplated under Alternative 4 offers little advantage, for a large additional cost (approximately $1,500,000). The expected cost/benefit ratio difference between Alternatives 3 and 4 is even greater when the substantial investment for remediation already made by USEPA in Reach 1 is considered. Alternatives 2 and 3 are of similar cost, however, the addition of biosolids under Alternative 3 provides somewhat greater assurance that the restoration objectives will be achieved in the remaining deposits.

Within Reach 2, the absence of prior remediation by USEPA and the relatively small volume of mine-waste deposit influences the analysis. The relatively small volume of mine waste in comparison to Reaches 1 and 2 results in a lower cost difference between in-place stabilization (Alternatives 2 and 3) and removal (Alternative 4). Alternative 3 offers more rapid achievement of the restoration objectives and greater assurance of long-term effectiveness for the high priority deposits than Alternative 2. Although no real difference in expected performance was identified for Alternatives 3 and 4 in terms of achieving the restoration objectives, the removal of mine-waste under Alternative 4 would eliminate the need for long-term O & M and possible institutional controls on private lands. In contrast to Reach 1, the additional cost for the improvement in long-term effectiveness associated with Alternative 4 is not as disproportionate. It should also be noted that if a repository were established in Reach 3, the cost differential between Alternatives 3 and 4 would be reduced because of the shorter haul distance.

Within Reach 3, the combination of a significant amount of remediation already conducted by USEPA, the large total volume of mine-waste, and public ownership of the majority of the 500-year floodplain, influence the alternatives analysis somewhat differently. As for Reach 1, the cost differential between the in-place stabilization alternatives 2 and 3, and the removal prescribed in Alternative 4, is large (over $2,000,000), even with a local repository. Again, like Reach 1, the differential is even larger if USEPA's expenditures to date are considered. In contrast to Reach 2, the expected difference in long-term effectiveness between the in-situ stabilization alternatives (Alternatives 2 and 3), and the removal alternative (Alternative 4) is lessened by the public ownership of most of Reach 3. The public ownership allows for a greater potential to establish effective long-term institutional controls and an O & M program, and thereby lessens the likelihood that changes in land use would reduce the effectiveness of in-place stabilization.

With regard to comparisons between Alternatives 2 and 3 for Reach 3, the primary difference is the slightly shortened time to achieve the restoration objectives and the somewhat greater certainty that the high priority deposits will be effectively restored over the long-term under Alternative 3 utilizing soil covers.

For Reach 4, the level of restoration need is so low that the in-place stabilization offered by Alternatives 2 or 3 would not be discernibly different in terms of achieving the restoration objectives of restoring safe habitat. Correspondingly, there are no comparative analysis considerations that are related to other reaches.

7.5.2 RIPARIAN AREAS/CHANNEL MORPHOLOGY/IN-STREAM HABITAT

For all reaches, the analysis of alternatives indicates that the greatest benefits in terms of restoration objectives achievement will come from the combination of conservation leases and fencing. Fencing of the riparian areas will allow for recovery of vegetation/habitat and improve bank stability. Over time, in some areas, these changes will also lead to improvements in in-stream habitat through narrowing of the channel and accumulation of near bank woody vegetation. This alternative would have similar implementability and effectiveness across all reaches. The only potential landowner consideration identified is that the restored riparian vegetation may be more attractive to beavers, which often attempt to dam irrigation ditches. Because of the high benefit to cost ratio, fencing and conservation easements are included for all reaches in all but the No Action/Natural Recovery alternative.

There are no significant cross-reach implementability and cost considerations for the other Riparian Area/Channel Morphology/In-Stream Habitat alternatives. However, it should be noted that the more contiguous the restoration of the riparian areas within the 11-Mile Reach, the greater benefit to wildlife and the fishery.

Between reaches, the primary implementability, effectiveness and cost considerations are:

- The quality of existing in-stream habitat and bank stability; and
- The rate at which in-stream habitat improvements occur.

The quality of existing in-stream habitat and degree of bank instability within a reach influences the comparison, primarily in terms of cost effectiveness and the rate at which in-stream habitat improvements occur. Within Reach 1, the habitat is generally good and signs of rapidly eroding streambanks were not observed. However, lack of pool habitat was identified as a specific subreach (1A and 1C) restoration need. Alternatives 3 and 4 both offer improvements in in-stream habitat. Alternative 4 is focused specifically on the restoration need of pool habitat. Alternative 3 offers a combination of bank stability measures coupled with in-stream habitat improvements. As noted above, the fencing and conservation leases included for all action alternatives will provide the primary benefits in terms of bank stability. The additional measures of Alternative 3 are expected to provide only a small level of incremental benefit to near-term bank stability relative to Alternative 4. However, Alternative 4 offers more direct improvements in in-stream habitat.

Within Reach 2, the existing in-stream habitat structure is generally evaluated to be good, as is bank stability. For this reason, only three alternatives were developed. The additional incremental benefits from the bank stabilization/in-stream habitat measures of Alternative 3 are limited and are primarily related to more rapidly improving conditions than Alternative 2. However, it does not appear that the incremental benefits of Alternative 3 are commensurate with the roughly $290,000 cost increase over Alternative 2.

Within Reach 3, the physical in-stream habitat needs and bank stability concerns are the greatest of the 4 reaches. Correspondingly, the incremental benefits from actions beyond the fencing and conservation leases are expected to be larger than for other reaches. As for Reach 1, Alternatives 3 and 4 contrast broader bank stability/in-stream habitat actions with the development of pool habitat. For Reach 3, however, the pool habitat creation is more intensive than for Reach 1. Overall, the net benefit to the fishery is expected to be similar between Alternatives 3 and 4. Alternative 3 offers more short-term effectiveness in terms of bank stability at a cost of approximately $558,000 versus approximately $692,000 for Alternative 4. However, given the varying conditions along Reach 3, it may be that during the design phase, elements of Alternative 3 and Alternative 4 may be alternately more appropriate depending upon the specific stream segments.

7.5.3 AGRICULTURAL LANDS WITHIN THE ARKANSAS RIVER FLOODPLAIN (IRRIGATED MEADOWS)

Both Alternatives 2 and 3 include deep tilling and reseeding of impacted agricultural lands to dilute surficial metals concentrations and rapidly re-establish cover/habitat. This technology will rapidly achieve restoration goals.

For Reaches 1, 2 and 3, the primary consideration for effectiveness of Alternatives 2 and 3 for the agricultural lands is the acidity of the soils being addressed. Since information on soil acidity is not available, it was inferred that the soil had slightly depressed pH and the addition of lime would increase the effectiveness of the deep tilling, both in terms of reducing the availability of metals and enhancing plant growth. The incremental cost for potential additional effectiveness is small, approximately $25,000 to $35,000, depending upon the reach. There were no reach specific distinctions identified in the comparative analysis.

Table 7-1
Comparative Analysis Summary
Fluvial Mine-Waste Deposits

	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
Reach 1				
Alternative	*Natural Recovery*	*Liming, Deep Tilling, Reseeding, Mulch*	*Liming, Biosolids, Deep Tilling, Reseeding*	*Removal, Lime Addition, Reseeding*
Implementability	No Action	Readily implementable	Similar implementability to Alternative 2. Use of composted biosolids necessary.	More complex construction scenario than Alternatives 2 and 3. Requires stabilization of banks where deposits intersect channel. Disposal considerations.
Effectiveness	Not effective for meeting ROs	Effective in establishing cover/habitat and potentially reducing surficial metals concentrations at some locations. Institutional controls required for long-term effectiveness.	Somewhat more effective than Alternative 2 because of increased moisture-holding capacity and plant nutrients	Higher level of certainty than Alternatives 2 and 3. Waste is removed and therefore no reliance on institutional controls is required. However, given the large amount of remediation already conducted, this alternative offers no significant advantage for a greater cost.
Time to Achieve ROs*	N/A	3 to 5 years	2 to 3 years	2 years
Cost	**$0**	**$85,000**	**$89,000**	**$1,521,000**
Reach 2				
Alternative	*Natural Recovery*	*Liming, Deep Tilling, Reseeding, Mulch (low and moderate)* *Lime, Biosolids, Deep Tilling, Reseeding (high)*	*Liming, Biosolids, Deep Tilling, Reseeding (low and moderate)* *Lime, Deep Tilling, Soil Cover, Reseeding (high)*	*Removal, Lime Addition, Reseeding*
Implementability	No Action	Readily implementable	Similar implementability to Alternative 2. Use of composted biosolids necessary. Availability of soil for cover may be limited.	More complex construction scenario than Alternatives 2 and 3. Requires stabilization of banks where deposits intersect channel. Disposal considerations.
Effectiveness	Not effective for meeting ROs	Effective in establishing cover/habitat and potentially reducing surficial metals concentrations at some locations. For high priority deposits, there is the added benefit of increased moisture-holding capacity and plant nutrients from biosolids addition. Institutional controls required for long-term effectiveness.	Effective in establishing cover/habitat and potentially reducing surficial metals concentrations at some locations with the added benefit of increased moisture-holding capacity and plant nutrients from biosolids addition. For high priority deposits the soil cover would provide more rapid restoration and greater assurance of continued protection than Alternative 2. Institutional controls required for long-term effectiveness.	Higher level of certainty than Alternatives 2 and 3. Waste is removed and therefore no reliance on institutional controls is required.
Time to Achieve ROs*	N/A	3 to 5 years *(low and moderate priority)* 2 to 3 years *(high priority)*	2 to 3 years *(low and moderate priority)* 2 years *(high priority)*	2 years
Cost	**$0**	**$178,000**	**$263,000**	**$597,000**

Table 7-1
Comparative Analysis Summary
Fluvial Mine-Waste Deposits

	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
Reach 3				
Alternative	*Natural Recovery*	*Lime, Deep Tilling, Reseeding, Mulch (low and moderate)* *Lime, Biosolids, Deep Tilling, Reseeding (high)*	*Lime, Deep Tilling, Reseeding, Mulch (low)* *Lime, Biosolids, Deep Tilling, Reseeding (moderate)* *Lime, Deep Tilling, Soil Cover, Reseeding (high)*	*Removal, Lime Addition, Reseeding*
Implementability	No Action	Readily implementable. Public ownership allows for rapid establishment of institutional controls.	Readily implementable. Public ownership allows for rapid establishment of institutional controls.	More complex construction scenario than Alternatives 2 and 3 – construction of repository might pose administrative and legal issues.
Effectiveness	Not effective for meeting ROs	In combination, treatments for the low, moderate and high priority deposits are expected to effectively meet ROs. Institutional controls required for long-term effectiveness.	Higher level of certainty than Alternative 2 that habitat will remain established over time. Institutional controls required for long-term effectiveness.	Similar level of short-term effectiveness as Alternative 3. Slightly higher level of long-term effectiveness because there is no need for reliance on institutional controls.
Time to Achieve ROs*	N/A	3 to 5 years *(low and moderate priority)* 2 to 3 years *(high priority)*	3 to 5 years *(low priority)* 2 to 3 years *(moderate priority)* 2 years *(high priority)*	2 years
Cost	**$0**	**$314,000**	**$447,000**	**$2,385,000**
Reach 4				
Alternative	*Natural Recovery*	*Direct Revegetation*	*Lime, Direct Revegetation*	*N/A*
Implementability	No Action	Readily implementable	Readily implementable	N/A
Effectiveness	Not effective for meeting ROs	Effective at enhancing the rate of natural recovery	Slightly more effective than Alternative 2 if soil pH is an issue.	N/A
Time to Achieve ROs*	N/A	5 years	5 years	N/A
Cost	**$0**	**$25,000**	**$55,000**	**N/A**

RO = Restoration Objectives
* Time frames for achievement of ROs relate to the expected time for recovery of vegetation/cover after the initial construction activity is complete.

Table 7-2
Comparative Analysis Summary
Riparian Areas/Channel Morphology/In-Stream Habitat

	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
Reach 1				
Alternative	*Natural Recovery*	*Riparian Area Grazing Control (conservation leases/fencing)*	*Soft Treatments for Bank Protection/Channel Stabilization/In-stream Habitat Improvements and Riparian Area Grazing Control*	*Riparian Area Grazing Control and Pool Excavations in subreaches 1A and 1C*
Implementability	No Action	Readily implementable with landowner approval	Readily implementable, but involves significantly more design and construction management effort than Alternative 2	Similar level of implementability as Alternative 3
Effectiveness	Not effective for meeting ROs	Effective in improving riparian habitat and bank stability.	Offers limited additional short-term effectiveness over Alternative 2, because of the additional bank stabilization/in-stream habitat improvements. However, not a significant improvement over Alternative 2 for long-term effectiveness.	More effective in improving pool to riffle ratio than Alternatives 2 and 3. .
Time to Achieve ROs*	N/A	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease.	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease. 2 years for banks/in-stream habitat.	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease. 2 years for banks/in-stream habitat.
Cost	**$0**	**$66,000**	**$241,000**	**$180,000**
Reach 2				
Alternative	*Natural Recovery*	*Riparian Area Grazing Control (conservation leases/fencing)*	*Riparian Area Grazing Control (conservation leases/fencing) and Soft Treatments in Upper Portions of subreach 2A.*	*N/A*
Implementability	No Action	Readily implementable with landowner approval	Involves significantly more design and construction management effort than Alternative 2.	N/A
Effectiveness	Not effective for meeting ROs	Effective in improving riparian habitat and bank stability.	Offers limited additional short-term effectiveness over Alternative 2, because of the additional bank stabilization/in-stream habitat improvements. However, not a significant improvement over Alternative 2 for long-term effectiveness.	N/A
Time to Achieve ROs*	N/A	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease.	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease. 2 years for banks/in-stream habitat.	**N/A**
Cost	**$0**	**$136,000**	**$428,000**	**N/A**

Table 7-2
Comparative Analysis Summary
Riparian Areas/Channel Morphology/In-Stream Habitat

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Reach 3				
Alternative	*Natural Recovery*	*Riparian Area Grazing Control (conservation leases/fencing)*	*Soft Treatments for Bank Protection/Channel Stabilization/In-stream Habitat Improvements and Riparian Area Grazing Control*	*Riparian Area Grazing Control and Pool Excavations in subreaches 3A and 3B*
Implementability	No Action	Readily implementable	Readily implementable, but involves significantly more design and construction management effort than Alternative 2	Readily implementable, but involves significantly more design and construction management effort than Alternative 2, equally implementable as Alternative 3.
Effectiveness	Not effective for meeting ROs if there are no formal grazing restrictions in place.	Effective in improving riparian habitat and bank stability.	Offers limited additional short-term effectiveness over Alternative 2, because of the additional bank stabilization/in-stream habitat improvements. However, not a significant improvement over Alternative 2 for long-term effectiveness.	More effective in improving pool to riffle ratio than Alternatives 2 and 3.
Time to Achieve ROs*	N/A	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease.	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease. 2 years for banks/in-stream habitat.	Riparian cover and habitat restored in 5 years and would continue to mature over 20-year lease. 2 years for banks/in-stream habitat.
Cost	**$0**	**$138,000**	**$559,000**	**$692,000**
Reach 4				
Alternative	*Natural Recovery*	*Riparian Area Grazing Control (conservation leases/fencing)*	*N/A*	*N/A*
Implementability	No Action	Readily implementable	N/A	N/A
Effectiveness	Effective for meeting ROs	Effective in assuring the riparian habitat and bank stability remain good.	N/A	N/A
Time to Achieve ROs*	N/A	Riparian cover and habitat improved in 5 years and would continue to mature over 20-year lease.	N/A	N/A
Cost	**$0**	**$65,000**	**N/A**	**N/A**

RO = Restoration Objectives
* Time frames for achievement of ROs relate to the expected time for recovery of vegetation/cover after the initial construction activity is complete.

Table 7-3
Comparative Analysis Summary
Agricultural Lands

	Alternative 1	**Alternative 2**	**Alternative 3**
Reach 1			
Alternative	*Natural Recovery*	*Deep Tilling and Reseeding*	*Liming, Deep Tilling and Reseeding*
Implementability	No Action	Readily Implementable	Readily Implementable
Effectiveness	Effective for meeting ROs	Effective in reducing surficial soil metals concentrations by deep tilling and in establishing cover by reseeding.	Effective in reducing surficial soil metals concentrations by deep tilling and in establishing cover by reseeding. Addition of lime would increase effectiveness where low soil pH may be a limiting factor.
Time to Achieve ROs*	Decades	Immediate	Immediate
Cost	**$0**	**$148,000**	**$173,000**
Reach 2			
Alternative	*Natural Recovery*	*Deep Tilling and Reseeding*	*Liming, Deep Tilling and Reseeding*
Implementability	No Action	Readily Implementable	Readily Implementable
Effectiveness	Effective for meeting ROs	Effective in reducing surficial soil metals concentrations by deep tilling and in establishing cover by reseeding.	Effective in reducing surficial soil metals concentrations by deep tilling and in establishing cover by reseeding. Addition of lime would increase effectiveness where low soil pH may be a limiting factor.
Time to Achieve ROs*	Decades	Immediate	Immediate
Cost	**$0**	**$275,000**	**$308,000**
Reach 3			
Alternative	*Natural Recovery*	*Deep Tilling and Reseeding*	*Liming, Deep Tilling and Reseeding*
Implementability	No Action	Readily Implementable	Readily Implementable
Effectiveness	Effective for meeting ROs	Effective in reducing surficial soil metals concentrations by deep tilling and in establishing cover by reseeding.	Effective in reducing surficial soil metals concentrations by deep tilling and in establishing cover by reseeding. Addition of lime would increase effectiveness where low soil pH may be a limiting factor.
Time to Achieve ROs*	Decades	Immediate	Immediate
Cost	**$0**	**$291,000**	**$326,000**

RO = Restoration Objectives
* Time frames for achievement of ROs relate to the expected time for recovery of vegetation/cover after the initial construction activity is complete.

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TABLE A-1
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 1 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	16	hr	125.00	$2,000
road restoration (incl. reveg)	4000	lf	0.75	$3,000
Low & Moderate Priority Deposits				
Direct revegetation				
seed/ fertilizer/ mulch	3	ac	1,500.00	$4,500
Lime application				
agricultural limestone (75 T/Acre)	225	ton	25.00	$5,625
deliver/ spread lime (50 mi one way)	225	ton	15.00	$3,375
18" tilling	3	ac	1,900.00	$5,700
Dust control	5	day	540.00	$2,700
Silt fencing	1000	lf	0.97	$970
SUBTOTAL DIRECT CAPITAL COSTS				$27,870
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$2,787
Engineering/Administration Costs			20%	$5,574
Construction Management Costs			20%	$5,574
SUBTOTAL INDIRECT CAPITAL COSTS				$13,935
Contingency			25%	$10,451
TOTAL ESTIMATED CAPITAL COST				**$52,256**
ANNUAL OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas - every other year for 6 years - 3 applications)	1.5	A/yr	400.00	$600
Maintenance Seeding (5% per year for first 3 yrs)	0.15	A/yr	500.00	$75
Maintenance Liming (5% per year for first 3 yrs)	0.15	A/yr	3,000.00	$450
Periodic inspection & reporting (avg annual cost)	1	yr	1,600.00	$1,600
SUBTOTAL ANNUAL O&M COSTS				$2,725
O&M Administration			10%	$160
O&M Contingency			25%	$400
TOTAL ANNUAL O&M COSTS				**$3,285**
O&M COSTS NPV (5% rate of return over 20 years)				$32,960
TOTAL COSTS (NPV)				**$85,216**

TABLE A-2
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 1 - ALTERNATIVE 3

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	16	hr	125.00	$2,000
road restoration (incl. reveg)	4000	lf	0.75	$3,000
Low & Moderate Priority Deposits				
Direct revegetation				
seed/ fertilizer/ mulch	3	ac	1,500.00	$4,500
Lime/Biosolids application				
agricultural limestone (75 ton/acre)	225	ton	25.00	$5,625
deliver/ spread lime (50 mi one way)	225	ton	15.00	$3,375
deliver/ spread biosolids (40 ton/acre)	120	ton	15.00	$1,800
18" tilling	3	ac	1,900.00	$5,700
Dust control	5	day	540.00	$2,700
Silt fencing	1000	lf	0.97	$970
SUBTOTAL DIRECT CAPITAL COSTS				$29,670
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$2,967
Engineering/Administration Costs			20%	$5,934
Construction Management Costs			20%	$5,934
SUBTOTAL INDIRECT CAPITAL COSTS				$14,835
Contingency			25%	$11,126
TOTAL ESTIMATED CAPITAL COST				**$55,631**
ANNUAL OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas - every other year for 6 years)	1.5	A/yr	400.00	$600
Maintenance Seeding (5% per year for first 3 yrs)	0.15	A/yr	500.00	$75
Maintenance Liming (5% per year for first 3 yrs)	0.15	A/yr	3,000.00	$450
Periodic inspection & reporting (avg, annual cost)	1	yr	1,600.00	$1,600
SUBTOTAL ANNUAL O&M COSTS				$2,725
O&M Administration			10%	$273
O&M Contingency			25%	$681
TOTAL ANNUAL O&M COSTS				**$3,679**
O&M COSTS NPV (5% rate of return over 20 years)				$32,960
TOTAL COSTS (NPV)				**$88,591**

TABLE A-3
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 1 - ALTERNATIVE 4

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	24	hr	125.00	$3,000
gravel roadbase (incl. haul and spread)	100	ton	12.50	$1,250
road restoration (incl. Reveg)	4000	lf	0.75	$3,000
Low & Moderate Priority Deposits				
Excavation of mine waste piles plus an additional six inches of soil				
excavate/ load	11000	cy	1.80	$19,800
haul/ place (9 mi)	11000	cy	6.00	$66,000
Tipping fee @ Black Cloud Repository	11000	cy	2.00	$22,000
Replacement Soil				
excavate/ haul/ place (within 5 miles)	11000	cy	7.50	$82,500
Revegetation				
seed/ fertilizer/ mulch	4.5	ac	1,500.00	$6,750
High Priority Deposits				
Excavation of mine waste piles plus an additional six inches of soil				
excavate/ load	36500	cy	1.80	$65,700
haul/ place (9 mi)	36500	cy	6.00	$219,000
Tipping fee @ Black Cloud Repository	36500	cy	2.00	$73,000
Lime application				
limerock (incl. loading)	1020	ton	25.00	$25,500
deliver/ spread lime (50 mi one way)	1020	ton	15.00	$15,300
Replacement Soil				
excavate/ haul/ place (within 5 miles)	36500	cy	7.50	$273,750
Revegetation				
seed/ fertilizer/ mulch	13.5	ac	1,500.00	$20,250
Dust control	20	day	540.00	$10,800
Stream bank stabilization	300	lf	35.00	$10,500
Silt fencing	3000	lf	0.97	$2,910
SUBTOTAL DIRECT CAPITAL COSTS				$921,010
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$92,101
Engineering/Administration Costs			10%	$92,101
Construction Management Costs			10%	$92,101
SUBTOTAL INDIRECT CAPITAL COSTS				$276,303
Contingency			25%	$299,328
TOTAL ESTIMATED CAPITAL COST				**$1,496,641**
ANNUAL OPERATION & MAINTENANCE COSTS				
Annual Inspection & Reporting (first 3 years only)	1	yr	5,000.00	$5,000
Vegetation Maintenance (10% fert/seed within first 3 years)	1.5	A/yr	1,000.00	$1,500
SUBTOTAL ANNUAL O&M COSTS				$6,500
O&M Administration and Fees			10%	$650
O&M Contingency			25%	$1,625
TOTAL ANNUAL O&M COSTS				**$8,775**
O&M COSTS NPV (5% rate of return over 20 years)				$23,897
TOTAL COSTS (NPV)				**$1,520,538**

TABLE A-4
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 1 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	18800	lf	1.70	$31,960
20 yr conservation lease (approx 11 acres)	11	ac	350.00	$3,850
SUBTOTAL DIRECT CAPITAL COSTS				$35,810
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$3,581
Engineering/Administration Costs			10%	$3,581
Construction Management Costs			10%	$3,581
SUBTOTAL INDIRECT CAPITAL COSTS				$10,743
Contingency			25%	$11,638
TOTAL ESTIMATED CAPITAL COST				**$58,191**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	940	lf	1.00	$940
SUBTOTAL ANNUAL O&M COSTS				$2,540
O&M Administration and Fees			10%	$254
O&M Contingency			25%	$635
TOTAL ANNUAL O&M COSTS				**$3,429**
O&M COSTS NPV (5% rate of return over 20 years)				$7,734
TOTAL COSTS (NPV)				**$65,925**

TABLE A-5
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 1 - ALTERNATIVE 3

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	18800	lf	1.70	$31,960
20 yr conservation lease (approx 11 acres)	11	ac	350.00	$3,850
Bank/Channel Stabilization				
Soft treatment	3000	lf	35.00	$105,000
Silt fencing	3000	lf	0.97	$2,910
SUBTOTAL DIRECT CAPITAL COSTS				$143,720
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$14,372
Engineering/Administration Costs			10%	$14,372
Construction Management Costs			10%	$14,372
SUBTOTAL INDIRECT CAPITAL COSTS				$43,116
Contingency			25%	$46,709
TOTAL ESTIMATED CAPITAL COST				**$233,545**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	940	lf	1.00	$940
SUBTOTAL ANNUAL O&M COSTS				$2,540
O&M Administration and Fees			10%	$254
O&M Contingency			25%	$635
TOTAL ANNUAL O&M COSTS				**$3,429**
O&M COSTS NPV (5% rate of return over 20 years)				$7,734
TOTAL COSTS (NPV)				**$241,279**

TABLE A-6
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 1 - ALTERNATIVE 4

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	18800	lf	1.70	$31,960
20 yr conservation lease (approx 11 acres)	11	ac	350.00	$3,850
In-Stream Habitat Improvement				
Pool Excavation (2 Pools each - 2' deep x 25 - 50' wide x 100' long)				
Sheet Piling/Coffer Dam - 10' deep x 150' (each location)	3000	sf	15.00	$45,000
Excavate w/ clamshell or dragline	1000	cy	12.00	$12,000
Haul & place excavated material - 9 mil haul	1000	cy	6.00	$6,000
Gabions/Boulder control structures	70	sy	100.00	$7,000
Silt fencing	500	lf	0.97	$485
SUBTOTAL DIRECT CAPITAL COSTS				$106,295
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$10,630
Engineering/Administration Costs			10%	$10,630
Construction Management Costs			10%	$10,630
SUBTOTAL INDIRECT CAPITAL COSTS				$31,889
Contingency			25%	$34,546
TOTAL ESTIMATED CAPITAL COST				**$172,729**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	940	lf	1.00	$940
SUBTOTAL ANNUAL O&M COSTS				$2,540
O&M Administration and Fees			10%	$254
O&M Contingency			25%	$635
TOTAL ANNUAL O&M COSTS				**$3,429**
O&M COSTS NPV (5% rate of return over 20 years)				$7,734
TOTAL COSTS (NPV)				**$180,463**

TABLE A-7
DETAILED COST ESTIMATE
AGRICULTURAL LANDS
REACH 1 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
12" tilling	35	ac	1,250.00	$43,750
Revegetation				
seed & fertilizer	35	ac	900.00	$31,500
SUBTOTAL DIRECT CAPITAL COSTS				$75,250
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$7,525
Engineering/Administration Costs			10%	$7,525
Construction Management Costs			10%	$7,525
SUBTOTAL INDIRECT CAPITAL COSTS				$22,575
Contingency			25%	$24,456
TOTAL ESTIMATED CAPITAL COST				**$122,281**
OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas within first 3 yrs)	35.0	Acre	400.00	$14,000
Maintenance Seeding (10% within first 2 years)	3.5	Acre	500.00	$1,750
Inspection & reporting (one time only)	1	yr	3,200.00	$3,200
SUBTOTAL O&M COSTS				$18,950
O&M Administration			10%	$1,895
O&M Contingency			25%	$4,738
TOTAL O&M COSTS				**$25,583**
O&M COSTS NPV (5% rate of return over 20 years)				N/A
TOTAL COSTS				**$147,864**

TABLE A-8
DETAILED COST ESTIMATE
AGRICULTURAL LANDS
REACH 1 - ALTERNATIVE 3

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Revegetation				
seed & fertilizer	35	ac	900.00	$31,500
Lime application				
limerock (incl. loading)	350	ton	25.00	$8,750
deliver/ spread lime (50 mi one way)	350	ton	15.00	$5,250
12" tilling	35	ac	1,250.00	$43,750
SUBTOTAL DIRECT CAPITAL COSTS				$89,250
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$8,925
Engineering/Administration Costs			10%	$8,925
Construction Management Costs			10%	$8,925
SUBTOTAL INDIRECT CAPITAL COSTS				$26,775
Contingency			25%	$29,006
TOTAL ESTIMATED CAPITAL COST				**$145,031**
OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas within first 2 yrs)	35.0	Acre	400.00	$14,000
Maintenance Seeding (10% within first 2 years)	3.5	Acre	500.00	$1,750
Maintenance Liming (10% within first 2 yrs)	3.5	acre	600.00	$2,100
Inspection & reporting (one-time)	1	yr	3,200.00	$3,200
SUBTOTAL O&M COSTS				$21,050
O&M Administration			10%	$2,105
O&M Contingency			25%	$5,263
TOTAL O&M COSTS				**$28,418**
O&M COSTS NPV (5% rate of return over 20 years)				N/A
TOTAL COSTS				**$173,449**

TABLE A-9
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 2 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	16	hr	125.00	$2,000
road restoration (incl. reveg)	5000	lf	0.75	$3,750
Low & Moderate Priority Deposits				
Lime application				
limerock (incl. loading)	383	ton	25.00	$9,575
deliver/ spread lime (50 mi one way)	383	ton	15.00	$5,745
18" tilling	5.1	ac	1,900.00	$9,690
Direct Revegetation				
seed/ fertilizer/ mulch	5.1	ac	1,500.00	$7,650
18" tilling	5.1	ac	1,900.00	$9,690
High Priority Deposits				
Lime/Biosolids application				
agricultural limestone (75 ton/acre)	300	ton	25.00	$7,500
deliver/ spread lime (50 mi one way)	300	ton	15.00	$4,500
deliver/ spread biosolids (40 ton/acre)	160	ton	15.00	$2,400
18" tilling	4.1	ac	1,900.00	$7,790
Direct revegetation				
seed/ fertilizer/ mulch	4.1	ac	1,500.00	$6,150
Silt fencing	1000	lf	0.97	$970
SUBTOTAL DIRECT CAPITAL COSTS				$77,410
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$7,741
Engineering/Administration Costs			10%	$7,741
Construction Management Costs			10%	$7,741
SUBTOTAL INDIRECT CAPITAL COSTS				$23,223
Contingency			25%	$25,158
TOTAL ESTIMATED CAPITAL COST				**$125,791**
ANNUAL OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas - every other year for 6 years)	4.5	A/yr	400.00	$1,800
Maintenance Seeding (5% per year for first 3 yrs)	0.45	A/yr	500.00	$225
Maintenance Liming (5% per year for first 3 yrs)	0.45	A/yr	3,000.00	$1,350
Periodic inspection & reporting (avg. annual cost)	1	yr	2,000.00	$2,000
SUBTOTAL ANNUAL O&M COSTS				$5,375
O&M Administration			10%	$538
O&M Contingency			25%	$1,344
TOTAL ANNUAL O&M COSTS				**$7,256**
O&M COSTS NPV (5% rate of return over 20 years)				$51,772
TOTAL COSTS (NPV)				**$177,563**

TABLE A-10
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 2 - ALTERNATIVE 3

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	16	hr	125.00	$2,000
road restoration (incl reveg)	5000	lf	0.75	$3,750
Low & Moderate Priority Deposits				
Lime/Biosolids application				
agricultural limestone (75 ton/acre)	383	ton	25.00	$9,575
deliver/ spread lime (50 mi one way)	383	ton	15.00	$5,745
deliver/ spread biosolids (40 ton/acre)	204	ton	15.00	$3,060
18" tilling	5.1	ac	1,900.00	$9,690
Direct Revegetation				
seed/ fertilizer/ mulch	5.1	ac	1,500.00	$7,650
High Priority Deposits				
Lime application				
limerock (incl. loading)	308	ton	25.00	$7,700
deliver/ spread lime (50 mi one way)	308	ton	15.00	$4,620
18" tilling	4.1	ac	1,900.00	$7,790
Cover				
excavate/ haul/ place	7607	cy	7.50	$57,053
Cover revegetation				
seed/ fertilizer/ mulch	4.1	ac	1,500.00	$6,150
Dust control	15	day	540.00	$8,100
Silt fencing	2000	lf	0.97	$1,940
SUBTOTAL DIRECT CAPITAL COSTS				$134,823
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$13,482
Engineering/Administration Costs			10%	$13,482
Construction Management Costs			10%	$13,482
SUBTOTAL INDIRECT CAPITAL COSTS				$40,447
Contingency			25%	$43,817
TOTAL ESTIMATED CAPITAL COST				**$219,087**
ANNUAL OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (direct reveg areas - every other year for 6 years)	2.5	A/yr	400.00	$1,000
Maintenance Seeding (all areas 5% per year for first 3 yrs)	0.45	A/yr	500.00	$225
Maintenance Liming (direct reveg areas 5% per year for first 3 yrs)	0.25	A/yr	3,000.00	$750
Periodic inspection & reporting (avg. annual cost)	1	yr	2,000.00	$2,000
SUBTOTAL ANNUAL O&M COSTS				$3,975
O&M Administration			10%	$0
O&M Contingency			25%	$0
TOTAL ANNUAL O&M COSTS				**$3,975**
O&M COSTS NPV (5% rate of return over 20 years)				$44,085
TOTAL COSTS (NPV)				**$263,171**

TABLE A-11
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 2 - ALTERNATIVE 4

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	24	hr	125.00	$3,000
road restoration (incl reveg)	5000	lf	0.75	$3,750
Low & Moderate Priority Deposits				
Excavation of mine waste piles plus an additional six inches of soil				
excavate/ load	10500	cy	1.80	$18,900
haul/ place (12 mi)	10500	cy	7.00	$73,500
Tipping fee @ Black Cloud Repository	10500	cy	2.00	$21,000
Replacement Soil				
excavate/ haul/ place (within 5 miles)	10500	cy	7.50	$78,750
Revegetation				
seed/ fertilizer/ mulch	5.2	ac	1,500.00	$7,800
High Priority Deposits				
Excavation of mine waste piles plus an additional six inches of soil				
excavate/ load	5500	cy	1.80	$9,900
haul/ place (12 mi)	5500	cy	7.00	$38,500
Tipping fee @ Black Cloud Repository	5500	cy	2.00	$11,000
Lime application				
limerock (incl. loading)	300	ton	25.00	$7,500
deliver/ spread lime (50 mi one way)	300	ton	15.00	$4,500
Replacement Soil				
excavate/ haul/ place (within 5 miles)	5500	cy	7.50	$41,250
Revegetation				
seed/ fertilizer/ mulch	4.1	ac	1,500.00	$6,150
Stream bank stabilization	500	lf	35.00	$17,500
Dust control	15	day	540.00	$8,100
Silt fencing	3000	lf	0.97	$2,910
SUBTOTAL DIRECT CAPITAL COSTS				$354,010
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$35,401
Engineering/Administration Costs			10%	$35,401
Construction Management Costs			10%	$35,401
SUBTOTAL INDIRECT CAPITAL COSTS				$106,203
Contingency			25%	$115,053
TOTAL ESTIMATED CAPITAL COST				**$575,266**
ANNUAL OPERATION & MAINTENANCE COSTS				
Annual Inspection & Reporting (first 3 years only)	1	yr	5,000.00	$5,000
Vegetation Maintenance (10% fert/seed within first 3 years)	1	A/yr	1,000.00	$1,000
SUBTOTAL ANNUAL O&M COSTS				$6,000
O&M Administration and Fees			10%	$600
O&M Contingency			25%	$1,500
TOTAL ANNUAL O&M COSTS				**$8,100**
O&M COSTS NPV (5% rate of return over 20 years)				$22,058
TOTAL COSTS (NPV)				**$597,325**

TABLE A-12
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 2 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	40400	lf	1.70	$68,680
20 yr conservation lease (approx 23 acres)	23	ac	350.00	$8,050
SUBTOTAL DIRECT CAPITAL COSTS				$76,730
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$7,673
Engineering/Administration Costs			10%	$7,673
Construction Management Costs			10%	$7,673
SUBTOTAL INDIRECT CAPITAL COSTS				$23,019
Contingency			25%	$24,937
TOTAL ESTIMATED CAPITAL COST				**$124,686**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	2020	lf	1.00	$2,020
SUBTOTAL ANNUAL O&M COSTS				$3,620
O&M Administration and Fees			10%	$362
O&M Contingency			25%	$905
TOTAL ANNUAL O&M COSTS				**$4,887**
O&M COSTS NPV (5% rate of return over 20 years)				$11,022
TOTAL COSTS (NPV)				**$135,708**

TABLE A-13
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 2 - ALTERNATIVE 3

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	40400	lf	1.70	$68,680
20 yr conservation lease (approx 23 acres)	23	ac	350.00	$8,050
Bank/Channel Stabilization				
Soft treatment	5000	lf	35.00	$175,000
Silt fencing	5000	lf	0.97	$4,850
SUBTOTAL DIRECT CAPITAL COSTS				$256,580
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$25,658
Engineering/Administration Costs			10%	$25,658
Construction Management Costs			10%	$25,658
SUBTOTAL INDIRECT CAPITAL COSTS				$76,974
Contingency			25%	$83,389
TOTAL ESTIMATED CAPITAL COST				**$416,943**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	2020	lf	1.00	$2,020
SUBTOTAL ANNUAL O&M COSTS				$3,620
O&M Administration and Fees			10%	$362
O&M Contingency			25%	$905
TOTAL ANNUAL O&M COSTS				**$4,887**
O&M COSTS NPV (5% rate of return over 20 years)				$11,022
TOTAL COSTS (NPV)				**$427,964**

TABLE A-14
DETAILED COST ESTIMATE
AGRICULTURAL LANDS
REACH 2 - ALTERNATIVE 2

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Revegetation				
seed & fertilize	66	ac	900.00	$59,400
12" tilling	66	ac	1,250.00	$82,500
SUBTOTAL DIRECT CAPITAL COSTS				$141,900
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$14,190
Engineering/Administration Costs			10%	$14,190
Construction Management Costs			10%	$14,190
SUBTOTAL INDIRECT CAPITAL COSTS				$42,570
Contingency			25%	$46,118
TOTAL ESTIMATED CAPITAL COST				**$230,588**
OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas within first 3 yrs)	66.0	acre	400.00	$26,400
Maintenance Seeding (10% within first 2 years)	6.6	acre	500.00	$3,300
Inspection & reporting (one time only)	1	yr	3,200.00	$3,200
SUBTOTAL O&M COSTS				$32,900
O&M Administration			10%	$3,290
O&M Contingency			25%	$8,225
TOTAL O&M COSTS				**$44,415**
O&M COSTS NPV (5% rate of return over 20 years)				N/A
TOTAL COSTS				**$275,003**

TABLE A-15
DETAILED COST ESTIMATE
AGRICULTURAL LANDS
REACH 2 - ALTERNATIVE 3

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Revegetation				
seed & fertilize	66	ac	900.00	$59,400
Lime application				
limerock (incl. loading)	660	ton	25.00	$16,500
deliver/ spread lime (50 mi one way)	660	ton	15.00	$9,900
12" tilling	66	ac	1,250.00	$82,500
SUBTOTAL DIRECT CAPITAL COSTS				$168,300
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$16,830
Engineering/Administration Costs			10%	$16,830
Construction Management Costs			10%	$16,830
SUBTOTAL INDIRECT CAPITAL COSTS				$50,490
Contingency			25%	$54,698
TOTAL ESTIMATED CAPITAL COST				**$273,488**
OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas within first 3 yrs)	66.0	acre	400.00	$26,400
Maintenance Seeding (10% within first 2 years)	6.6	acre	500.00	$3,300
Inspection & reporting (one time)	1	yr	3,200.00	$3,200
SUBTOTAL O&M COSTS				$32,900
O&M Administration			10%	$330
O&M Contingency			25%	$825
TOTAL O&M COSTS				**$34,055**
O&M COSTS NPV (5% rate of return over 20 years)				N/A
TOTAL COSTS				**$307,543**

TABLE A-16
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 3 - ALTERNATIVE 2

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	32	hr	125.00	$4,000
road restoration (incl reveg)	10000	lf	0.75	$7,500
Low & Moderate Priority Deposits				
Lime application				
agricultural limestone (75 tons/acre)	1100	ton	25.00	$27,500
deliver/ spread lime (50 mi one way)	1100	ton	15.00	$16,500
18" tilling	14.5	ac	1,900.00	$27,550
Direct Revegetation				
seed/ fertilizer/ mulch	15	ac	1,500.00	$22,500
High Priority Deposits				
Lime/Biosolids application				
agricultural limestone (75 tons/acre)	410	ton	25.00	$10,250
deliver/ spread lime (50 mi one way)	410	ton	15.00	$6,150
deliver/ spread biosolids (40 tons/acre)	220	ton	15.00	$3,300
18" tilling	5.5	ac	1,900.00	$10,450
Direct revegetation				
seed/ fertilizer/ mulch	5.5	ac	1,500.00	$8,250
Dust control	5	day	540.00	$2,700
Silt fencing	1000	lf	0.97	$970
SUBTOTAL DIRECT CAPITAL COSTS				$147,620
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$14,762
Engineering/Administration Costs			10%	$14,762
Construction Management Costs			10%	$14,762
SUBTOTAL INDIRECT CAPITAL COSTS				$44,286
Contingency			25%	$47,977
TOTAL ESTIMATED CAPITAL COST				**$239,883**
ANNUAL OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas - every other year for 6 years)	10.0	A/yr	400.00	$4,000
Maintenance Seeding (5% per year for first 3 yrs)	1	A/yr	500.00	$500
Maintenance Liming (5% per year for first 3 yrs)	1	A/yr	3,000.00	$3,000
Periodic inspection & reporting (avg. annual cost)	1	yr	2,000.00	$2,000
SUBTOTAL ANNUAL O&M COSTS				$9,500
O&M Administration			10%	$950
O&M Contingency			25%	$2,375
TOTAL ANNUAL O&M COSTS				**$12,825**
O&M COSTS NPV (5% rate of return over 20 years)				$73,924
TOTAL COSTS (NPV)				**$313,807**

TABLE A-17
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 3 - ALTERNATIVE 3

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements (motor grader)	32	hr	125.00	$4,000
road restoration (incl reveg)	5000	lf	0.75	$3,750
Low & Moderate Priority Deposits				
Lime/Biosolids application				
agricultural limestone (75 tons/acre)	1125	ton	25.00	$28,125
deliver/ spread lime (50 mi one way)	1125	ton	15.00	$16,875
deliver/ spread biosolids (40 tons/acre)	600	ton	15.00	$9,000
18" tilling	15	ac	1,900.00	$28,500
Direct Revegetation				
seed/ fertilizer/ mulch	15	ac	1,500.00	$22,500
High Priority Deposits				
Lime/Biosolids application				
limerock (incl. loading)	410	ton	25.00	$10,250
deliver/ spread lime (50 mi one way)	410	ton	15.00	$6,150
18" tilling	5.5	ac	1,900.00	$10,450
Cover				
excavate/ haul/ place (within 5 miles)	10350	cy	7.50	$77,625
Cover revegetation				
seed/ fertilizer/ mulch	5.5	ac	1,500.00	$8,250
Dust control	15	day	540.00	$8,100
Silt fencing	2000	lf	0.97	$1,940
SUBTOTAL DIRECT CAPITAL COSTS				$235,515
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$23,552
Engineering/Administration Costs			10%	$23,552
Construction Management Costs			10%	$23,552
SUBTOTAL INDIRECT CAPITAL COSTS				$70,655
Contingency			25%	$76,542
TOTAL ESTIMATED CAPITAL COST				**$382,712**
ANNUAL OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (direct reveg areas - every other year for 6 years)	7.5	A/yr	400.00	$3,000
Maintenance Seeding (all areas 5% per year for first 3 yrs)	1	A/yr	500.00	$500
Maintenance Liming (direct reveg areas 5% per year for first 3 yrs)	0.75	A/yr	3,000.00	$2,250
Periodic inspection & reporting (avg. annual cost)	1	yr	2,000.00	$2,000
SUBTOTAL ANNUAL O&M COSTS				$7,750
O&M Administration			10%	$775
O&M Contingency			25%	$1,938
TOTAL ANNUAL O&M COSTS				**$10,463**
O&M COSTS NPV (5% rate of return over 20 years)				$64,315
TOTAL COSTS (NPV)				**$447,026**

TABLE A-18
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 3 - ALTERNATIVE 4

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Access roads				
access road improvements & maint. (motor grader)	40	hr	125.00	$5,000
road restoration (incl reveg)	5000	lf	0.75	$3,750
Low & Moderate Priority Deposits				
Excavation of mine waste piles plus an additional six inches of soil				
excavate/ load	60000	cy	1.80	$108,000
haul/ place	60000	cy	3.80	$228,000
Replacement Soil				
haul & place - utilize excess from repository excavation	54000	cy	5.00	$270,000
import fill - excav/haul/place (within 5 miles)	6000	cy	7.50	$45,000
Cover revegetation				
seed/ fertilizer/ mulch	26.5	ac	1,500.00	$39,750
High Priority Deposits				
Excavation of mine waste piles plus an additional six inches of soil				
excavate/ load	28750	cy	1.80	$51,750
haul/ place	28750	cy	3.80	$109,250
Lime application				
agricultural limestone (75 tons/acre)	825	ton	25.00	$20,625
deliver/ spread lime (50 mi one way)	825	ton	15.00	$12,375
Replacement Soil				
import fill - excav/haul/place (within 5 miles)	28750	cy	7.50	$215,625
Cover revegetation				
seed/ fertilizer/ mulch	11	ac	1,500.00	$16,500
Stream bank stabilization	750	lf	35.00	$26,250
Repository				
Access roads				
road construction	2000	lf	0.55	$1,100
gravel roadbase (incl. haul and spread)	200	ton	12.50	$2,500
Excavate repository				
excavate borrow	72000	cy	3.00	$216,000
place fill for embankment	2400	cy	3.50	$8,400
Repository cover (18" thick - utilize mat'l from excavation)				
spread stockpiled fill	15600	cy	2.75	$42,900
Revegetate repostiory				
seed/ fertilizer/ mulch	6	ac	1,500.00	$9,000
Dust control	25	day	540.00	$13,500
Silt fencing	3000	lf	0.97	$2,910
SUBTOTAL DIRECT CAPITAL COSTS				$1,448,185

TABLE A-18
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 3 - ALTERNATIVE 4

INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$144,819
Engineering/Administration Costs			10%	$144,819
Construction Management Costs			10%	$144,819
SUBTOTAL INDIRECT CAPITAL COSTS				$434,456
Contingency			25%	$470,660
TOTAL ESTIMATED CAPITAL COST				**$2,353,301**
ANNUAL OPERATION & MAINTENANCE COSTS				
Annual Inspection & Reporting (first 3 years only)	1	yr	5,000.00	$5,000
Vegetation Maintenance (10% fert/seed within first 3 years)	3.5	A/yr	1,000.00	$3,500
SUBTOTAL ANNUAL O&M COSTS				$8,500
O&M Administration and Fees			10%	$850
O&M Contingency			25%	$2,125
TOTAL ANNUAL O&M COSTS				**$11,475**
O&M COSTS NPV (5% rate of return over 20 years)				$31,249
TOTAL COSTS (NPV)				**$2,384,550**

TABLE A-19
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 3 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	41000	lf	1.70	$69,700
20 yr conservation lease (approx 24 acres)	24	ac	350.00	$8,400
SUBTOTAL DIRECT CAPITAL COSTS				$78,100
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$7,810
Engineering/Administration Costs			10%	$7,810
Construction Management Costs			10%	$7,810
SUBTOTAL INDIRECT CAPITAL COSTS				$23,430
Contingency			25%	$25,383
TOTAL ESTIMATED CAPITAL COST				**$126,913**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	2050	lf	1.00	$2,050
SUBTOTAL ANNUAL O&M COSTS				$3,650
O&M Administration and Fees			10%	$365
O&M Contingency			25%	$913
TOTAL ANNUAL O&M COSTS				**$4,928**
O&M COSTS NPV (5% rate of return over 20 years)				$11,113
TOTAL COSTS (NPV)				**$138,026**

TABLE A-20
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 3 - ALTERNATIVE 3

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	41000	lf	1.70	$69,700
20 yr conservation lease (approx 24 acres)	24	ac	350.00	$8,400
Bank/Channel Stabilization				
Soft treatment	7200	lf	35.00	$252,000
Silt fencing	7200	lf	0.97	$6,984
SUBTOTAL DIRECT CAPITAL COSTS				$337,084
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$33,708
Engineering/Administration Costs			10%	$33,708
Construction Management Costs			10%	$33,708
SUBTOTAL INDIRECT CAPITAL COSTS				$101,125
Contingency			25%	$109,552
TOTAL ESTIMATED CAPITAL COST				**$547,762**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	2050	lf	1.00	$2,050
SUBTOTAL ANNUAL O&M COSTS				$3,650
O&M Administration and Fees			10%	$365
O&M Contingency			25%	$913
TOTAL ANNUAL O&M COSTS				**$4,928**
O&M COSTS NPV (5% rate of return over 20 years)				$11,113
TOTAL COSTS (NPV)				**$558,875**

TABLE A-21
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 3 - ALTERNATIVE 4

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	41000	lf	1.70	$69,700
20 yr conservation lease (approx 24 acres)	24	ac	350.00	$8,400
Bank/Channel Stabilization				
Access roads				
acces roads built for mine waste deposit access				
can be used for channel stabilization		lf		$0
Pool Excavation (10 Pools each - 2' deep x 25 - 50' wide x 100' long)				
Sheet Piling/Coffer Dam - 10' deep x 150' (each location)	15000	sf	15.00	$225,000
Excavate w/ clamshell or dragline	5000	cy	12.00	$60,000
Haul & place excavated material - within reach	5000	cy	3.80	$19,000
Gabions/Boulder control structures	350	sy	100.00	$35,000
Silt fencing	2000	lf	0.97	$1,940
SUBTOTAL DIRECT CAPITAL COSTS				$419,040
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$41,904
Engineering/Administration Costs			10%	$41,904
Construction Management Costs			10%	$41,904
SUBTOTAL INDIRECT CAPITAL COSTS				$125,712
Contingency			25%	$136,188
TOTAL ESTIMATED CAPITAL COST				**$680,940**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	2050	lf	1.00	$2,050
SUBTOTAL ANNUAL O&M COSTS				$3,650
O&M Administration and Fees			10%	$365
O&M Contingency			25%	$913
TOTAL ANNUAL O&M COSTS				**$4,928**
O&M COSTS NPV (5% rate of return over 20 years)				$11,113
TOTAL COSTS (NPV)				**$692,053**

TABLE A-22
DETAILED COST ESTIMATE
AGRICULTURAL LANDS
REACH 3 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Revegetation				
seed & fertilize	70	ac	900.00	$63,000
12" tilling	70	ac	1,250.00	$87,500
SUBTOTAL DIRECT CAPITAL COSTS				$150,500
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$15,050
Engineering/Administration Costs			10%	$15,050
Construction Management Costs			10%	$15,050
SUBTOTAL INDIRECT CAPITAL COSTS				$45,150
Contingency			25%	$48,913
TOTAL ESTIMATED CAPITAL COST				**$244,563**
OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas within first 3 yrs)	70.0	acre	400.00	$28,000
Maintenance Seeding (10% within first 2 years)	7	acre	500.00	$3,500
Inspection & reporting (one time only)	1	yr	3,200.00	$3,200
SUBTOTAL O&M COSTS				$34,700
O&M Administration			10%	$3,470
O&M Contingency			25%	$8,675
TOTAL O&M COSTS				**$46,845**
O&M COSTS NPV (5% rate of return over 20 years)				N/A
TOTAL COSTS				**$291,408**

TABLE A-23
DETAILED COST ESTIMATE
AGRICULTURAL LANDS
REACH 3 - ALTERNATIVE 3

Item/Description	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Revegetation				
seed & fertilize	70	ac	900.00	$63,000
Lime application				
limerock (incl. loading)	700	ton	25.00	$17,500
deliver/ spread lime (50 mi one way)	700	ton	15.00	$10,500
12" tilling	70	ac	1,250.00	$87,500
SUBTOTAL DIRECT CAPITAL COSTS				$178,500
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$17,850
Engineering/Administration Costs			10%	$17,850
Construction Management Costs			10%	$17,850
SUBTOTAL INDIRECT CAPITAL COSTS				$53,550
Contingency			25%	$58,013
TOTAL ESTIMATED CAPITAL COST				**$290,063**
OPERATION & MAINTENANCE COSTS				
Maintenance Fertilizer (all areas within first 3 yrs)	70.0	acre	400.00	$28,000
Maintenance Seeding (10% within first 2 years)	7	acre	500.00	$3,500
Inspection & reporting (one time)	1	yr	3,200.00	$3,200
SUBTOTAL O&M COSTS				$34,700
O&M Administration			10%	$350
O&M Contingency			25%	$875
TOTAL O&M COSTS				**$35,925**
O&M COSTS NPV (5% rate of return over 20 years)				N/A
TOTAL COSTS				**$325,988**

TABLE A-24
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 4 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Low & Moderate Priority Deposits				
Direct revegetation (ATV access)				
ATV rental	1	wk	500.00	$500
seed/ fertilizer/ mulch	2	ac	3,000.00	$6,000
SUBTOTAL DIRECT CAPITAL COSTS				$6,500
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$650
Engineering/Administration Costs			10%	$650
Construction Management Costs			10%	$650
SUBTOTAL INDIRECT CAPITAL COSTS				$1,950
Contingency			25%	$2,113
TOTAL ESTIMATED CAPITAL COST				**$10,563**
ANNUAL OPERATION & MAINTENANCE COSTS				
Annual inspection & reporting (first 3 years only)	1	yr	1,600.00	$1,600
Maintenance Fertilizer (all areas - 2x over first 3 years)	1.3	A/yr	1,500.00	$1,995
Maintenance Seeding (5% per year for first 3 yrs)	0.1	A/yr	2,000.00	$200
SUBTOTAL ANNUAL O&M COSTS				$3,795
O&M Administration			10%	$380
O&M Contingency			25%	$949
TOTAL ANNUAL O&M COSTS				**$5,123**
O&M COSTS NPV (5% rate of return over 20 years)				$13,952
TOTAL COSTS (NPV)				**$24,514**

TABLE A-25
DETAILED COST ESTIMATE
FLUVIAL MINE-WASTE DEPOSITS
REACH 4 - ALTERNATIVE 3

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Low & Moderate Priority Deposits				
All Terrain Vehicle	1	ea	5,500.00	$5,500
Direct revegetation (ATV access)				
seed/ fertilizer/ mulch	2	ac	3,000.00	$6,000
Lime application (ATV access)				
limerock (incl. loading)	150	ton	25.00	$3,750
deliver (50 mi one way)	150	ton	15.00	$2,250
spread lime	150	ton	50.00	$7,500
SUBTOTAL DIRECT CAPITAL COSTS				$25,000
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$2,500
Engineering/Administration Costs			10%	$2,500
Construction Management Costs			10%	$2,500
SUBTOTAL INDIRECT CAPITAL COSTS				$7,500
Contingency			25%	$8,125
TOTAL ESTIMATED CAPITAL COST				**$40,625**
ANNUAL OPERATION & MAINTENANCE COSTS				
Annual inspection & reporting (first 3 years only)	1	yr	1,600.00	$1,600
Maintenance Fertilizer (all areas - 2x over first 3 years)	1.3	A/yr	1,500.00	$1,995
Maintenance Seeding (5% per year for first 3 yrs)	0.1	A/yr	2,000.00	$200
SUBTOTAL ANNUAL O&M COSTS				$3,795
O&M Administration			10%	$380
O&M Contingency			25%	$949
TOTAL ANNUAL O&M COSTS				**$5,123**
O&M COSTS NPV (5% rate of return over 20 years)				$13,952
TOTAL COSTS (NPV)				**$54,577**

TABLE A-26
DETAILED COST ESTIMATE
IN-STREAM HABITAT/RIPARIAN AREAS
REACH 4 - ALTERNATIVE 2

Item/Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
DIRECT CAPITAL COSTS				
Riparian Area Isolation				
Fencing				
3 strand solar electric fence (incl. delivery/installation)	18600	lf	1.70	$31,620
20 yr conservation lease (approx 11 acres)	11	ac	350.00	$3,850
SUBTOTAL DIRECT CAPITAL COSTS				$35,470
INDIRECT CAPITAL COSTS				
Mob/Demob			10%	$3,547
Engineering/Administration Costs			10%	$3,547
Construction Management Costs			10%	$3,547
SUBTOTAL INDIRECT CAPITAL COSTS				$10,641
Contingency			25%	$11,528
TOTAL ESTIMATED CAPITAL COST				**$57,639**
ANNUAL OPERATION & MAINTENANCE COSTS				
Incremental Annual O&M Costs				
Inspection (every 5 years)	1	yr	1,600.00	$1,600
Fencing Maintenance (5% every 5th year)	930	lf	1.00	$930
SUBTOTAL ANNUAL O&M COSTS				$2,530
O&M Administration and Fees			10%	$253
O&M Contingency			25%	$633
TOTAL ANNUAL O&M COSTS				**$3,416**
O&M COSTS NPV (5% rate of return over 20 years)				$7,703
TOTAL COSTS (NPV)				**$65,342**