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.

Surface Water

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

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	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.

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	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

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	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.

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	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.

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	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%.

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	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

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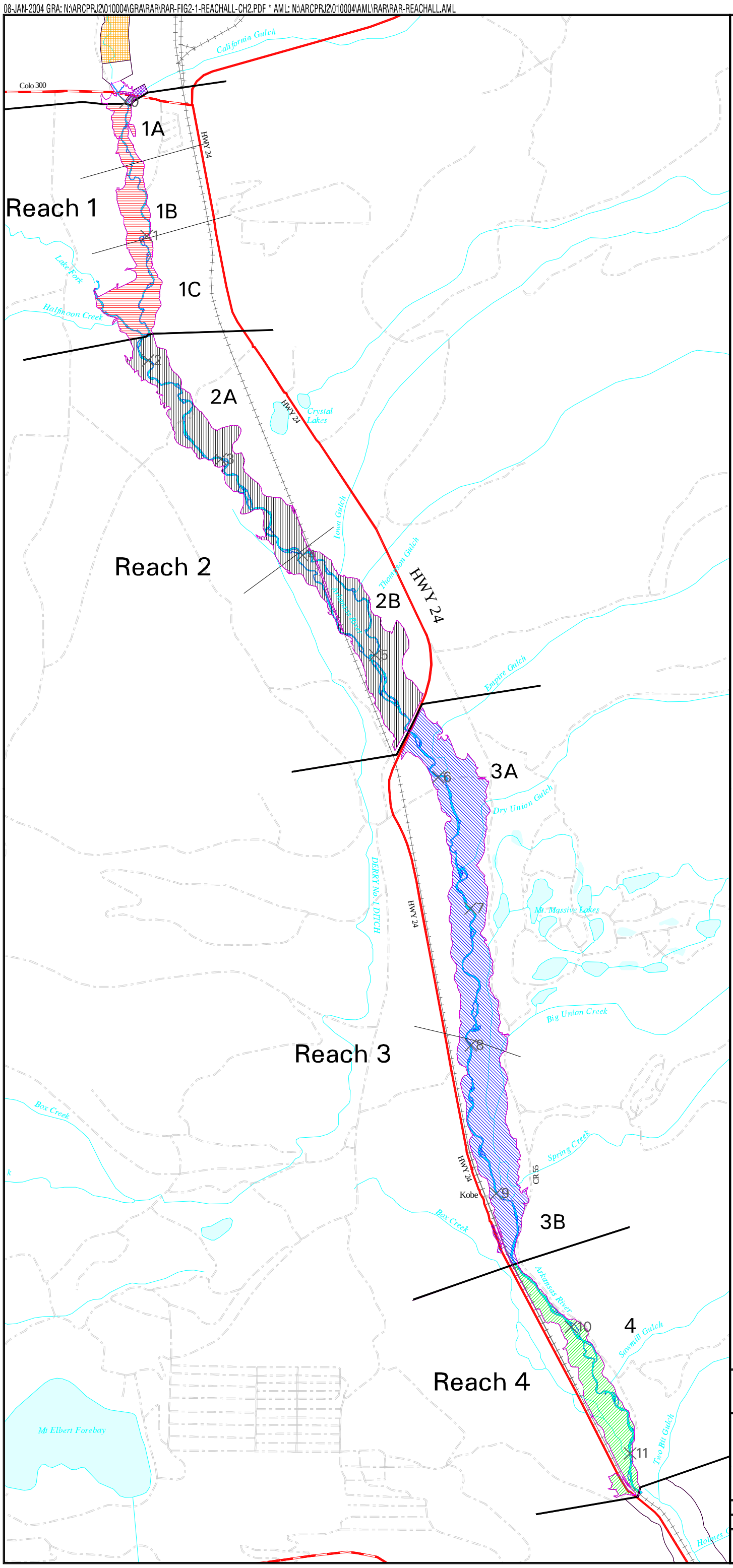
	Reach 1	Reach 2	Reach 3	Reach 4
Brown Trout	1. Has the Resource Been Injured: Yes 2. Description of Injury: Greatly reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in 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.

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
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.

	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.



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
- X 1 River Mile (from confluence with California Gulch)

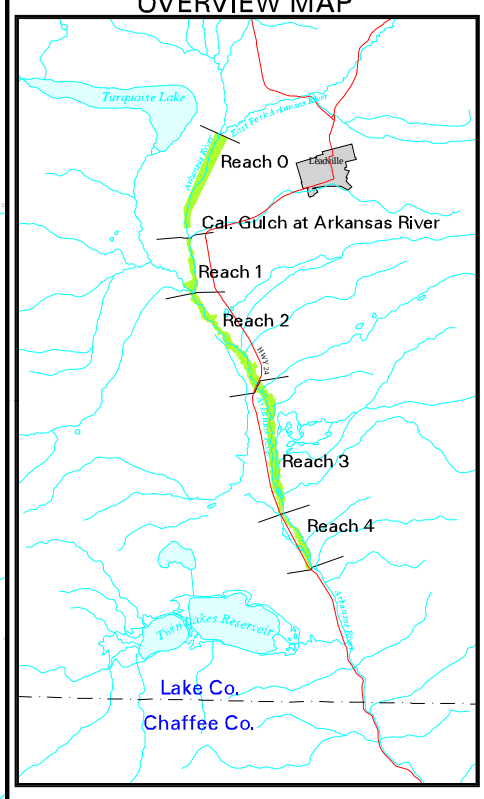
Transportation

- 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