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.

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, 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

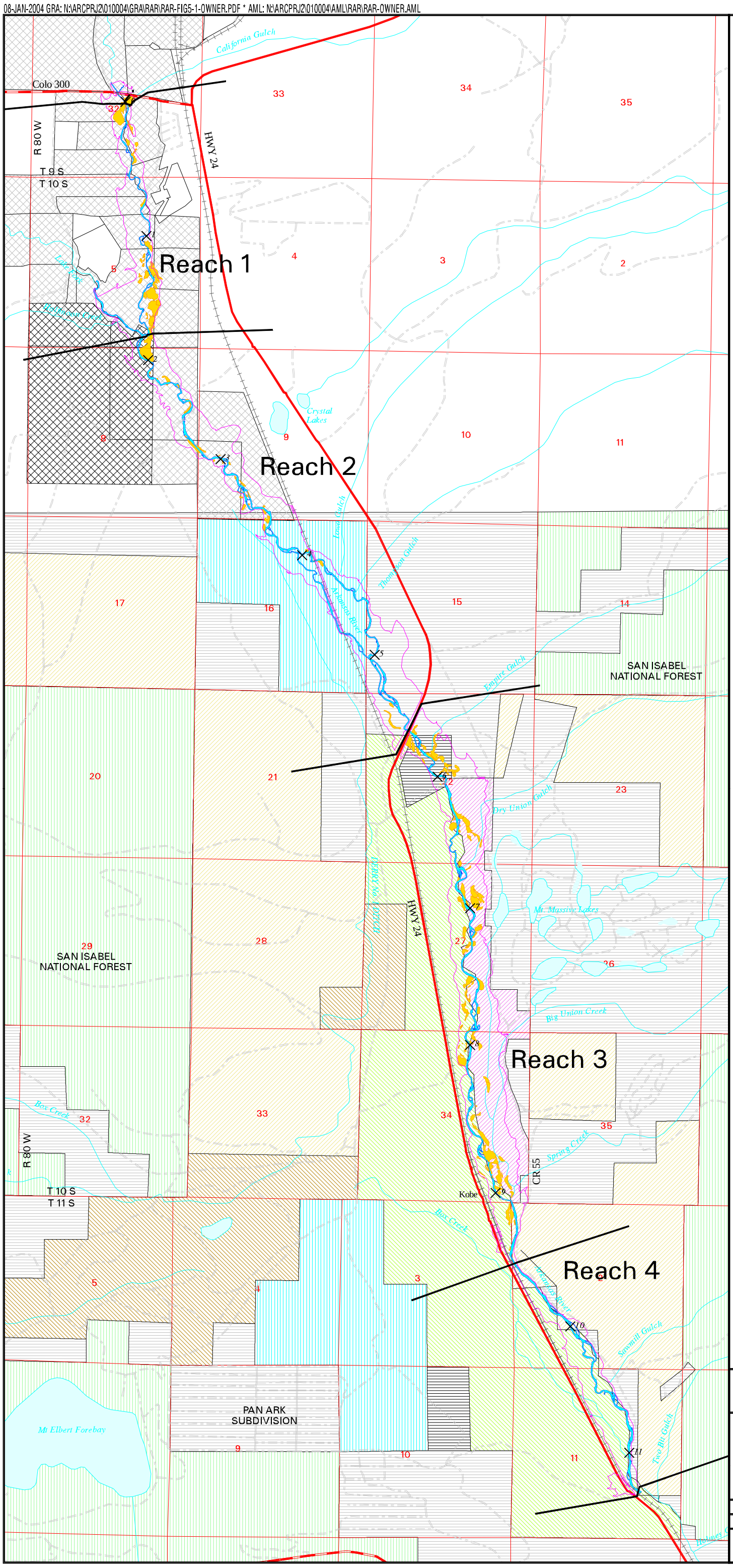
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
FLUVIAL MINE-WASTE DEPOSITS				
Low Priority	No action Natural recovery	Liming, deep tilling and reseeding with mulching	Lime and biosolids addition with deep tilling and reseeding	Removal, liming of underlying soil, soil replacement as necessary 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



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

- Mine- Waste Deposit
- Reach Boundary

Ownership

(Ownership information from Conlin Associates, 1998)

- Arkansas River Ranch 325 AC. (Owned by the State of Colorado, as of 2001)
- Bureau of Land Management 3860 AC.
- Hallenbeck Ranch 1200 AC. (Owned by Lake County, as of 2001)
- Hayden ranch 2100 AC. (Owned by City of Aurora as part of the Lake County Open Space Initiative, as of 2001)
- Lake County 140 AC.
- State Land Board 1120 AC.
- Private
- San Isabel National Forest

(Ownership information from BLM Mapping, 1995)

- Private
- Lake County

- Ownership not mapped in this area.

N

SCALE IN FEET

3000 0 3000

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