

**RESTORATION ALTERNATIVES REPORT FOR THE
UPPER ARKANSAS RIVER BASIN**

December 31, 2003

TABLE OF CONTENTS

	<u>Page</u>
TABLE OF CONTENTS.....	i
LIST OF TABLES.....	vi
LIST OF FIGURES.....	viii
LIST OF APPENDICES.....	ix
LIST OF ACRONYMS.....	x
1.0 INTRODUCTION.....	1-1
1.1 Overview of RAR Project Elements.....	1-1
1.2 SCR/RAR Relationship.....	1-2
1.3 Report Structure and Content.....	1-3
1.3.1 Issues Beyond the Scope of the RAR.....	1-4
2.0 SUMMARY OF RELEVANT SCR FINDINGS.....	2-1
2.1 Background.....	2-1
2.2 Summary of Conditions within the 11-Mile Reach.....	2-3
3.0 RESTORATION NEEDS.....	3-1
3.1 Restoration Objectives.....	3-1
3.2 Approach for Identifying Restoration Needs.....	3-2
3.3 Restoration Needs.....	3-5
3.3.1 Fluvial Mine-Waste Deposits.....	3-5
3.3.2 Agricultural Lands.....	3-14
3.3.3 Channel Morphology, In-Stream Habitat and Riparian Areas.....	3-19
4.0 IDENTIFICATION AND SCREENING OF RESTORATION APPROACHES.....	4-1
4.1 Other Considerations.....	4-3
4.2 Screening.....	4-4
4.2.1 Fluvial Mine-Waste Deposits.....	4-5
4.2.1.1 Institutional Controls.....	4-5
4.2.1.2 Containment/Engineering Controls.....	4-6
4.2.1.3 In-Situ Stabilization.....	4-8
4.2.1.4 Removal/Replacement.....	4-11
4.2.1.5 Treatment.....	4-13
4.2.2 Agricultural/Floodplain Lands.....	4-15
4.2.2.1 Institutional Controls.....	4-15
4.2.2.2 Soil Mixing.....	4-17
4.2.2.3 In-Situ Stabilization.....	4-18
4.2.3 Riparian Areas.....	4-18

4.2.3.1	Institutional Controls.....	4-19
4.2.3.2	Streambank Restoration	4-20
4.2.4	Channel Morphology/In-Stream Habitat.....	4-22
4.2.4.1	River Channel Alteration	4-22
4.2.4.2	In-Stream Habitat Enhancement	4-25
5.0	DEVELOPMENT OF RESTORATION ALTERNATIVES	5-1
5.1	Reach 1	5-3
5.1.1	Fluvial Mine-Waste Deposits.....	5-3
5.1.1.1	Alternative 1: Natural Recovery	5-4
5.1.1.2	Alternative 2: Liming, Deep Tilling & Reseeding.....	5-5
5.1.1.3	Alternative 3: Liming, Biosolids, Deep Tilling & Reseeding.....	5-5
5.1.1.4	Alternative 4: Removal	5-5
5.1.2	Riparian Areas/Channel Morphology/In-Stream Habitat	5-6
5.1.2.1	Alternative 1: Natural Recovery	5-7
5.1.2.2	Alternative 2: Grazing Control.....	5-7
5.1.2.3	Alternative 3: Soft Treatments	5-7
5.1.2.4	Alternative 4: Pool Excavation	5-8
5.1.3	Agricultural Lands Within the Arkansas River Floodplain (irrigated meadows)	5-8
5.1.3.1	Alternative 1: Natural Recovery	5-8
5.1.3.2	Alternative 2: Deep Tilling & Reseeding.....	5-8
5.1.3.3	Alternative 3: Liming, Deep Tilling & Reseeding.....	5-9
5.2	Reach 2	5-10
5.2.1	Fluvial Mine-Waste Deposits.....	5-10
5.2.1.1	Alternative 1: Natural Recovery	5-11
5.2.1.2	Alternative 2: Liming, Deep Tilling and Reseeding	5-11
5.2.1.3	Alternative 3: Soil Cover	5-11
5.2.1.4	Alternative 4: Removal	5-12
5.2.2	Riparian Areas/Channel Morphology/In-Stream Habitat	5-12
5.2.2.1	Alternative 1: Natural Recovery	5-13
5.2.2.2	Alternative 2: Grazing Control.....	5-13
5.2.2.3	Alternative 3: Soft Treatments	5-13
5.2.3	Agricultural Lands Within the Arkansas River Floodplain (irrigated meadows)	5-14
5.2.3.1	Alternative 1: Natural Recovery	5-14
5.2.3.2	Alternative 2: Deep Tilling & Reseeding.....	5-14
5.2.3.3	Alternative 3: Liming, Deep Tilling & Reseeding.....	5-15
5.3	Reach 3	5-16

5.3.1	Fluvial Mine-Waste Deposits.....	5-16
5.3.1.1	Alternative 1: Natural Recovery	5-17
5.3.1.2	Alternative 2: Biosoils.....	5-17
5.3.1.3	Alternative 3: Soil Cover	5-18
5.3.1.4	Alternative 4: Removal	5-18
5.3.2	Riparian Areas/Channel Morphology/In-Stream Habitat	5-19
5.3.2.1	Alternative 1: Natural Recovery	5-20
5.3.2.2	Alternative 2: Grazing Control.....	5-20
5.3.2.3	Alternative 3: Soft Treatments	5-20
5.3.2.4	Alternative 4: Pool Excavation	5-20
5.3.3	Agricultural Lands Within the Arkansas River Floodplain (irrigated meadows)	5-21
5.3.3.1	Alternative 1: Natural Recovery	5-21
5.3.3.2	Alternative 2: Deep Tilling & Reseeding.....	5-21
5.3.3.3	Alternative 3: Liming, Deep Tilling & Reseeding.....	5-22
5.4	Reach 4	5-23
5.4.1	Fluvial Mine-Waste Deposits.....	5-23
5.4.1.1	Alternative 1: Natural Recovery	5-23
5.4.1.2	Alternative 2: Direct Revegetation.....	5-23
5.4.1.3	Alternative 3: Liming, Deep Tilling & Reseeding.....	5-24
5.4.2	Riparian Areas/Channel Morphology/In-Stream Habitat	5-24
5.4.2.1	Alternative 1: Natural Recovery	5-24
5.4.2.2	Alternative 2: Grazing Control.....	5-24
6.0	EVALUATION OF ALTERNATIVES	6-1
6.1	Reach 1	6-4
6.1.1	Fluvial Mine-Waste Deposits.....	6-4
6.1.1.1	Alternative 1.....	6-4
6.1.1.2	Alternative 2.....	6-5
6.1.1.3	Alternative 3.....	6-6
6.1.1.4	Alternative 4.....	6-7
6.1.2	Riparian Areas/Channel Morphology/In-Stream Habitat	6-9
6.1.2.1	Alternative 1.....	6-9
6.1.2.2	Alternative 2.....	6-10
6.1.2.3	Alternative 3.....	6-11
6.1.2.4	Alternative 4.....	6-12
6.1.3	Agricultural Lands Within the Arkansas River Floodplain (Irrigated Meadows).....	6-13
6.1.3.1	Alternative 1.....	6-14

6.1.3.2	Alternative 2.....	6-14
6.1.3.3	Alternative 3.....	6-15
6.2	Reach 2	6-17
6.2.1	Fluvial Mine-Waste Deposits.....	6-17
6.2.1.1	Alternative 1.....	6-17
6.2.1.2	Alternative 2.....	6-18
6.2.1.3	Alternative 3.....	6-19
6.2.1.4	Alternative 4.....	6-20
6.2.2	Riparian Areas/Channel Morphology/In-Stream Habitat	6-22
6.2.2.1	Alternative 1.....	6-22
6.2.2.2	Alternative 2.....	6-23
6.2.2.3	Alternative 3.....	6-25
6.2.3	Agricultural Lands Within the Arkansas River Floodplain (Irrigated Meadows).....	6-26
6.2.3.1	Alternative 1.....	6-26
6.2.3.2	Alternative 2.....	6-27
6.2.3.3	Alternative 3.....	6-27
6.3	Reach 3	6-29
6.3.1	Fluvial Mine-Waste Deposits.....	6-29
6.3.1.1	Alternative 1.....	6-29
6.3.1.2	Alternative 2.....	6-30
6.3.1.3	Alternative 3.....	6-31
6.3.1.4	Alternative 4.....	6-33
6.3.2	Riparian Areas/Channel Morphology/In-Stream Habitat	6-35
6.3.2.1	Alternative 1.....	6-35
6.3.2.2	Alternative 2.....	6-35
6.3.2.3	Alternative 3.....	6-36
6.3.2.4	Alternative 4.....	6-37
6.3.3	Agricultural Lands within the Arkansas River Floodplain (Irrigated Meadows)	6-38
6.3.3.1	Alternative 1.....	6-39
6.3.3.2	Alternative 2.....	6-39
6.3.3.3	Alternative 3.....	6-40
6.4	Reach 4	6-42
6.4.1	Fluvial Mine-Waste Deposits.....	6-42
6.4.1.1	Alternative 1.....	6-42
6.4.1.2	Alternative 2.....	6-42
6.4.1.3	Alternative 3.....	6-43

6.4.2	Riparian Areas/Channel Morphology/In-Stream Habitat	6-43
6.4.2.1	Alternative 1.....	6-43
6.4.2.2	Alternative 2.....	6-44
7.0	COMPARATIVE ANALYSIS.....	7-1
7.1	Reach 1	7-2
7.1.1	Fluvial mine-waste Deposits.....	7-2
7.1.2	Riparian Areas/Channel Morphology/ In-Stream Habitat	7-3
7.1.3	Agricultural Lands	7-5
7.2	Reach 2	7-7
7.2.1	Fluvial mine-waste Deposits.....	7-7
7.2.2	Riparian Areas/Channel Morphology/In-Stream Habitat	7-9
7.2.3	Agricultural Lands	7-9
7.3	Reach 3	7-11
7.3.1	Fluvial mine-waste Deposits.....	7-11
7.3.2	Riparian Areas/Channel Morphology/In-Stream Habitat	7-13
7.3.3	Agricultural Lands	7-15
7.4	Reach 4	7-16
7.4.1	Fluvial mine-waste Deposits.....	7-16
7.4.2	Riparian Areas/Channel Morphology/In-Stream Habitat	7-16
7.5	Summary of Comparative Analysis.....	7-17
7.5.1	Fluvial mine-waste Deposits.....	7-17
7.5.2	Riparian Areas/Channel Morphology/In-Stream Habitat	7-19
7.5.3	Agricultural Lands Within the Arkansas River Floodplain (Irrigated Meadows).....	7-20
8.0	REFERENCES/LITERATURE CITED.....	8-1

LIST OF TABLES

<u>Table</u>	<u>Title</u>
3-1	Reach 1 High Priority USEPA Mine-Waste Deposit Treatment Summary
3-2	Reach 1 Moderate Priority USEPA Mine-Waste Deposit Treatment Summary
3-3	Reach 3 High Priority USEPA Mine-Waste Deposit Treatment Summary
3-4	Reach 3 Moderate Priority USEPA Mine-Waste Deposit Treatment Summary
3-5	Reach 3 Low Priority USEPA Mine-Waste Deposit Treatment Summary
3-6	Summary of USEPA Predicted High Phytotoxicity and HQ > 1 Areas in Reach 1
3-7	Summary of USEPA Predicted High Phytotoxicity and HQ > 1 Areas in Reach 2
3-8	Summary of USEPA Predicted High Phytotoxicity and HQ > 1 Areas in Reach 3
4-1	Technology Identification and Screening for Fluvial Mine-Waste Deposits
4-2	Technology Identification and Screening for Agricultural/Floodplain Lands
4-3	Technology Identification and Screening for the Riparian Zone
4-4	Technology Identification and Screening for Channel Morphology/In-Stream Habitat
5-1	Reach 1 Restoration Alternatives
5-2	Reach 1 Fluvial Mine-Waste Deposit Characteristics
5-3	Restoration Alternatives for Fluvial Mine-Waste Deposits by Reach
5-4	Restoration Alternatives for Fluvial Mine-Waste Deposits by Priority
5-5	Restoration Alternatives for Riparian Areas/Channel Morphology/In-Stream Habitat
5-6	Restoration Alternatives for Agricultural Lands
5-7	Reach 2 Restoration Alternatives
5-8	Reach 2 Fluvial Mine-Waste Deposit Characteristics
5-9	Reach 3 Restoration Alternatives
5-10	Reach 3 Fluvial Mine-Waste Deposit Characteristics
5-11	Reach 4 Restoration Alternatives
7-1	Comparative Analysis Summary – Fluvial Mine-Waste Deposits

LIST OF TABLES (continued)

<u>Table</u>	<u>Title</u>
7-2	Comparative Analysis Summary – Riparian Areas/Channel Morphology/In-Stream Habitat
7-3	Comparative Analysis Summary – Agricultural Lands

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>
1-1	Drainage Basin, Leadville to Pueblo Reservoir, 500-Year Floodplain, Superfund Site, Airshed, 11-Mile Reach, and Mining Activity
2-1	Subreach Map Showing Main Reaches 1-4 and Reach 0
3-1	Mine-Waste Deposit Priority
3-2	Mine-Waste Deposit Locations California Gulch to Lake Fork (Reach 1)
3-3	Mine-Waste Deposit Locations Lake Fork to Highway 24 Bridge (Reach 2)
3-4	Mine-Waste Deposit Locations Highway 24 Bridge to Narrows Below Kobe (Reach 3)
3-5	Irrigation and Drainage Ditches in the 11-Mile Reach and Vicinity
3-6	Map of Predicted Pattern of Phytotoxicity (Adapted from USEPA 2003b)
5-1	Ownership in 11-Mile Reach and Vicinity

LIST OF APPENDICES

<u>Appendix</u>	<u>Title</u>
A	Cost Analysis Tables

LIST OF ACRONYMS

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

1.0 INTRODUCTION

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

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

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

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

1.1 OVERVIEW OF RAR PROJECT ELEMENTS

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

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

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

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

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

1.2 SCR/RAR RELATIONSHIP

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

- An identification of sources and pathways providing further focus on the fundamental resources (soil, water, sediment) that may cause injuries to biological resources;
- A determination of injury by resource and by geographic area;
- An understanding of the extent and magnitude of the injuries and analysis of the relationship of those injuries to a reduction in the baseline level of services;
- An understanding of the role of non-mining impacts to the UARB resources; and
- An identification of restoration needs.

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

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

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

1.3 REPORT STRUCTURE AND CONTENT

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

- Section 2 summarizes the findings reported in the SCR. This section includes details on the geographic setting and summarizes site conditions. This section also identifies any relevant new information since the release of the SCR and includes an updated summary of SCR findings of injury.
- Section 3 describes the restoration action objectives. An explanation of the CT's approach for identifying restoration needs and a description of how information on injuries was translated to a need for restoration are included in this section. New information since the release of the SCR, identified in Section 2, is considered in terms of restoration needs.
- Section 4 identifies and screens a range of Technologies that may be appropriate for use in the development of comprehensive restoration alternatives. Screening of Technologies

was based on the criteria of: applicability to site conditions and restoration objectives; implementability; and cost effectiveness.

- Section 5 details the comprehensive restoration alternatives developed for Reaches 1-4 of the 11-Mile Reach, from the range of Technologies identified in Section 4. The rationale for each restoration alternative is explained. Due to the differences between reaches in terms of settings, conditions, access, and travel distance, the categories of restoration needs were used as the basis to develop several comprehensive alternatives for each reach. A No Action/Natural Recovery alternative is included for each reach, as a point of comparison.
- Section 6 is a practical analysis of the appropriateness/feasibility of each restoration alternative considering the United States Environmental Protection Agency's (USEPA) guidance on conducting Engineering Evaluation/Cost Analysis (EE/CA) and the U.S. Department of Interior's (DOIs) Restoration Planning Process. The analysis qualitatively explains the expected performance of an alternative (i.e., the extent to which an alternative will likely achieve baseline conditions) as part of the discussion of effectiveness. Additional considerations of feasibility are also discussed in this section.
- Section 7 is a comparative analysis of the alternatives, highlighting the differences between the alternatives for the criteria of implementability, effectiveness, and cost. The summary in this section brings together all of the analyses presented for each set of alternatives across all reaches.

1.3.1 ISSUES BEYOND THE SCOPE OF THE RAR

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

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

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

EXPLANATION

Hydrology

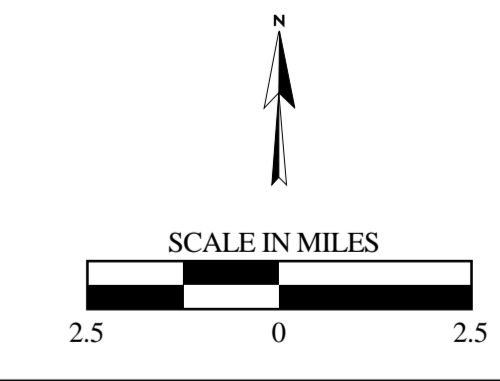
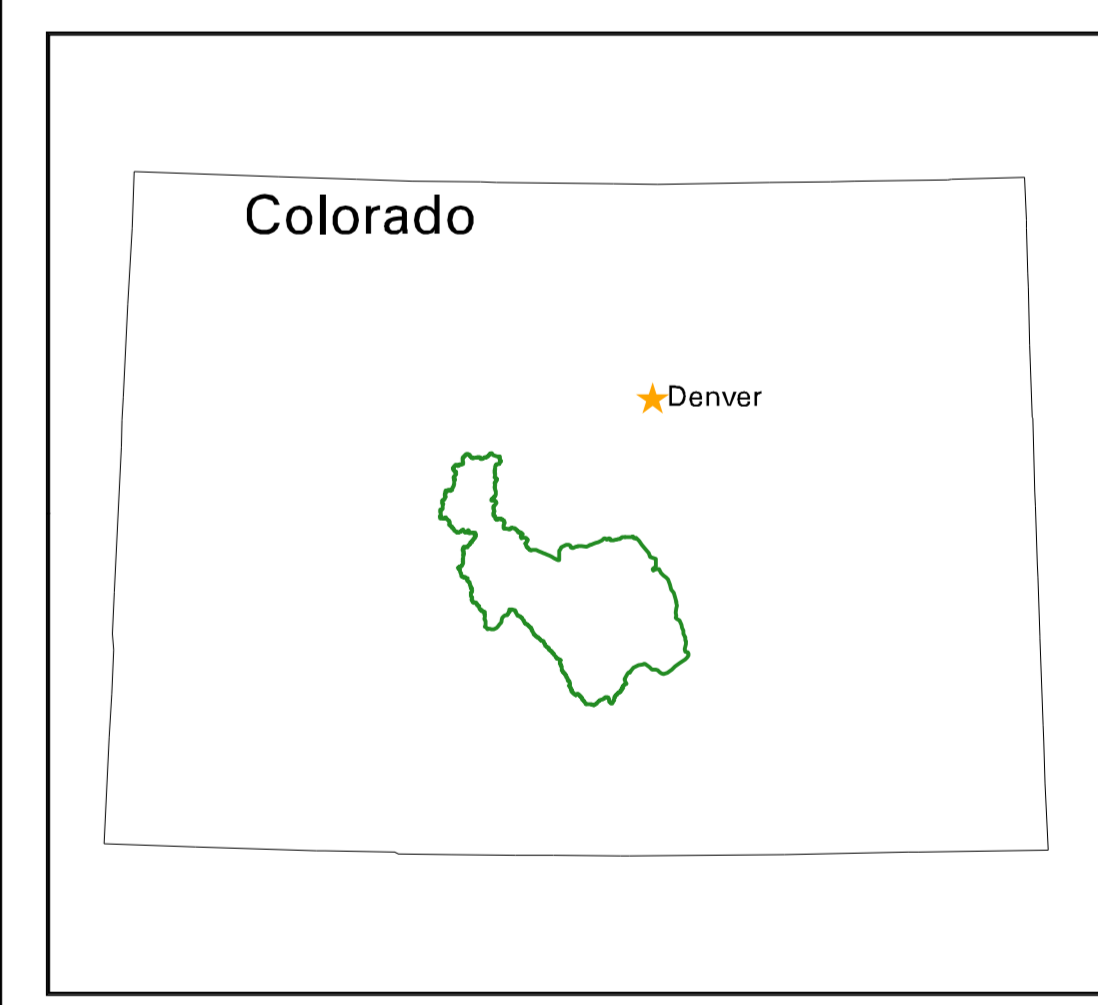
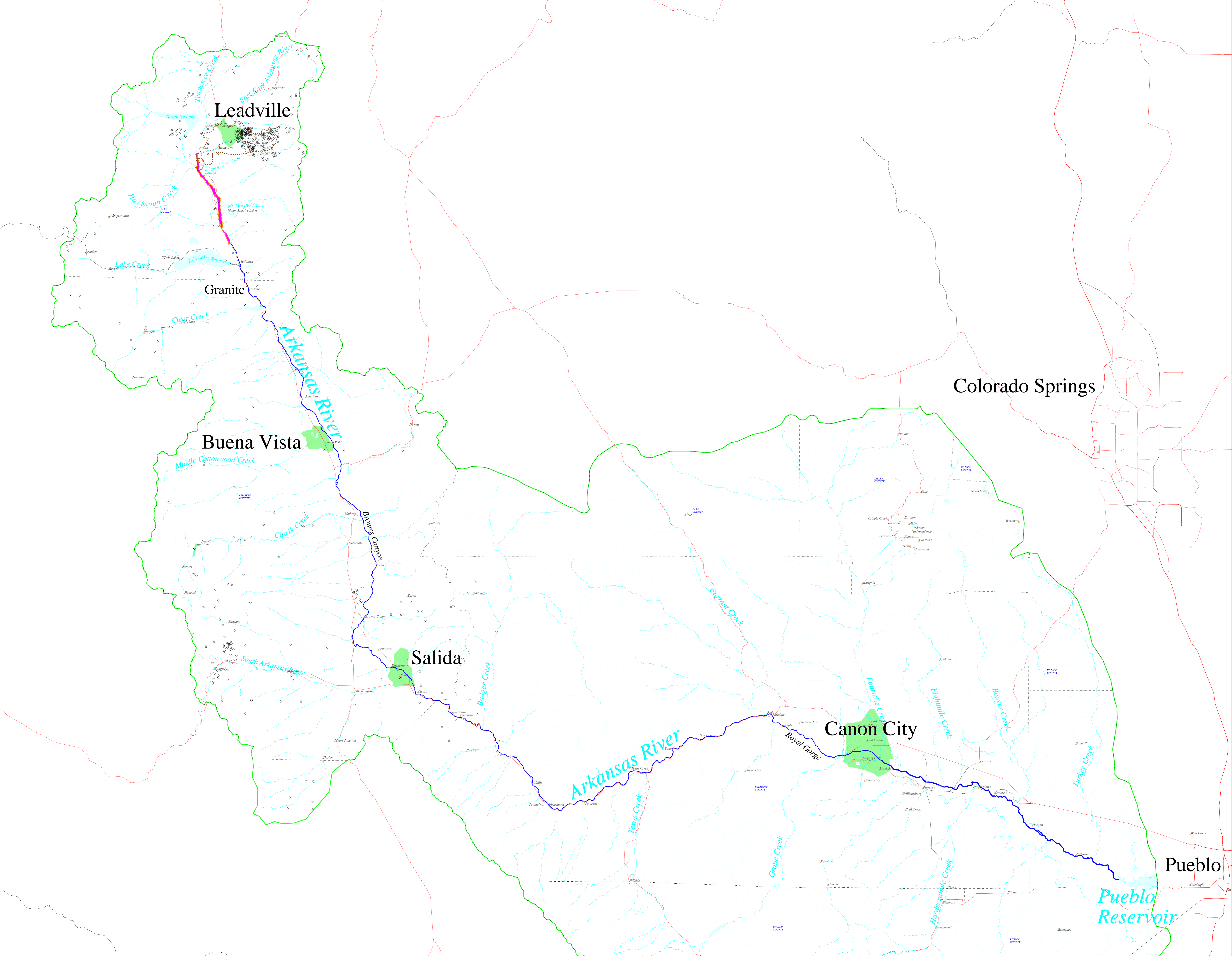
- Arkansas River
- Below 11- Mile Reach
- Watershed Boundary
- River or Stream
- Lake or Open Water
- 11- Mile Reach
- 500- Year Floodplain

Transportation

- Primary Road
- Secondary Road

Other Features

- Mining Activity
- County Boundary
- NPL Site Operable Unit (OU) Boundary/ General Area of Airshed Study
- Town or Landmark



UPPER ARKANSAS RIVER BASIN
RESTORATION ALTERNATIVES REPORT
FIGURE 1-1
DRAINAGE BASIN,
LEADVILLE TO PUEBLO RESERVOIR,
500-YEAR FLOODPLAIN,
SUPERFUND SITE, AIRSHED,
11-MILE REACH, AND MINING ACTIVITY

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

MFG, Inc.
consulting scientists and engineers