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Colorado River Section 206
Aquatic Ecosystem Restoration
Mesa County, Colorado

Appendix B: Engineering Report

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Colorado River Section 206 Aquatic Ecosystem Restoration Mesa County, CO

Appendix B Engineering Report

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List of Acronyms

Acronym	Full Name
APHIS	U.S. Animal and Health Inspection Service
AQI	Air Quality Index
BA	Biological Assessment
Basin	Upper Colorado River Basin
BLM	Bureau of Land Management
BMP	Best Management Practices
BO	Biological Opinion
BOR	Bureau of Reclamation
C	Celsius
CDOT	Colorado Department of Transportation
CDOW	Colorado Department of Natural Resources, Colorado Division of Wildlife
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic feet per second
City	City of Grand Junction
CO	Carbon monoxide
Co	Colorado
CSU	Colorado State University
CWCB	Colorado Water Conservation Board
EA	Environmental Assessment
EPA	U. S. Environmental Protection Agency
ESA	Endangered Species Act
F	Fahrenheit
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
gpm	Gallons per minute
GPS	Global Positioning System
GVIC	Grand Valley Irrigation Company
ha	hectares
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Indices

HU	Habitat Unit
IPM	Integrated Pest Management
LLPMC	Los Lunas Plant Materials Center
m	Meters
MCACES	Micro-Computer Aided Cost Estimating System
MCNCA	McInnis Canyon National Conservation Area
mg/l	milligrams per liter
mi^2	Square miles
mm	Millimeters
NPS	National Park Service
NRCS	National Resource Conservation Service
NWRC	National Wetlands Research Center
O&M	Operations and Maintenance
OHV	Off-highway Vehicle
OMID	Orchard Mesa Irrigation District
OSHA	Occupational Safety and Health Administration
Project	Colorado River Section 206 Aquatic Ecosystem Restoration project
RCRA	Resource Conservation and Recovery Act
Recovery Program	Upper Colorado Fish Recovery Program
RMP	Resource Management Plan
RO	Russian olive
SSS	Special Status Species
SWA	State Wildlife Area
SWFL	Southwestern willow flycatcher
T	Tamarisk
T&E	Special Status Threatened & Endangered
TRO	Tamarisk and Russian olive
U.S.	United States
USACE	U. S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
USGS	United States Geological Survey
VSI	Visibility Standard index
WCHA	Western Colorado Habitat Association
WCWHA	Western Colorado Wildlife Habitat Association

1.0 INTRODUCTION

The purpose of this engineering appendix is to support the U.S. Army Corps of Engineers (USACE) effort for developing and evaluating the Colorado River Ecosystem Restoration project, in accordance with Section 206 of the Water Resources Development Act of 1996. This appendix includes existing conditions information, alternatives analysis and preliminary design and analysis for the recommended alternative.

The sponsor is the City of Grand Junction (City). The city is partnered with a number of organizations to implement this Project, including Mesa County, City of Fruita, Town of Palisade, Colorado Division of Wildlife, Colorado Department of Transportation, Colorado Parks, Colorado Riverfront Commission, Tamarisk Coalition, Audubon Society, Mesa Land Trust, Bureau of Land Management (BLM), National Park Service, and U.S. Fish and Wildlife Service (USFWS). These municipalities and agencies have successfully implemented other aquatic and riverfront improvements that demonstrate their ability to work together in the successful execution of similar, related work. As the sponsor, the City, with assistance from its partners, will be responsible for overseeing implementation of this restoration project, as well as the operations and maintenance efforts.

1.1 General

The Colorado River corridor is renowned for its ecological, recreational, aesthetic, cultural, and vital economic values, including; water supply, livestock production, and agriculture. The project area is concentrated in riparian lands, which are especially integral and fragile aspects of western ecosystems because of their role in maintaining water quality and quantity, providing groundwater recharge, controlling erosion, and dissipating stream energy during floods. Unfortunately, many western rivers and associated riparian lands have been severely degraded over the past 150 years by anthropogenic activities, including water supply development, road building, and the introduction of invasive plant species. This degradation has resulted in reduced water quality, altered river regimes, and reduced ecological systems and habitats (CHIP 2007). Tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus Angustifolia*), both abundantly present within the project footprint, are invasive species of particular interest because of the plants' negative environmental impacts.

The project area includes 15 restoration segments located over a 33-mile reach between the Loma boat launch at Fruita, Colorado and Riverbend Park at Palisade, Colorado. The city of Grand Junction is approximately mid-way between the project limits, and is located at the confluence of the Gunnison River. The project area is outlined on Figure 1.1. Note that the 15 restoration segments are selected based on the presence of infestation of invasive species, primarily tamarisk and Russian olive. The segments are not all contiguous or continuous, however, once restored, these segments will join many other segments which have been or are being restored by other agencies or municipalities, forming a relatively tamarisk-free (and Russian olive-free) 33-mile riparian corridor.

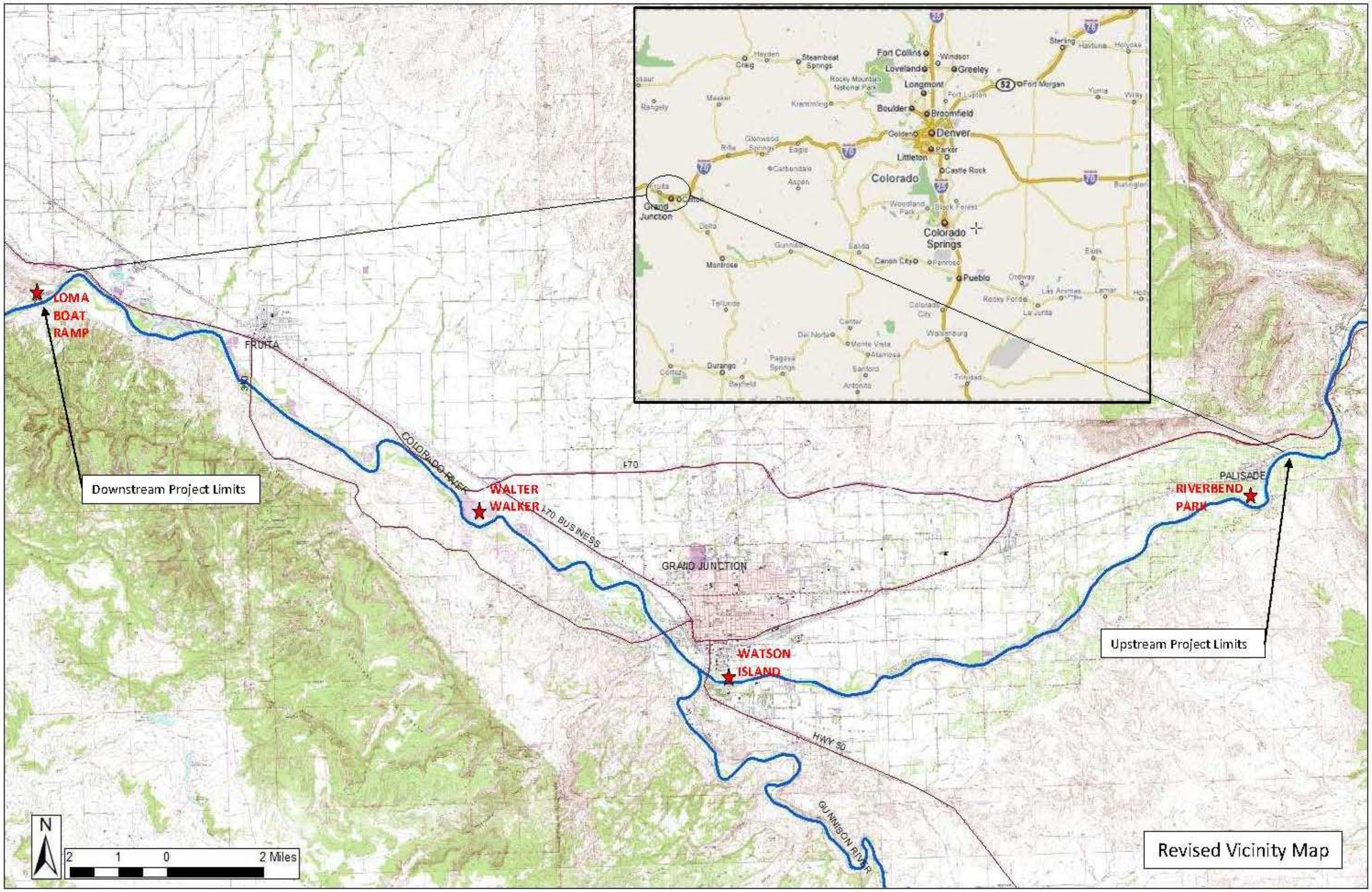

Figure 1.1 **Project vicinity and site location map.**

1.2 Objectives and Goals

The objectives and goals for this Project are as follows:

1. Restore riparian function and wetland and riparian habitat by removing invasive plant species, and replacing them with native vegetation.
2. Restore aquatic function and habitat for the benefit of federally listed and other native fish species, by removing invasive plant species from the aquatic environment.
3. Restore terrestrial habitat in the upper floodplain elevations where contiguous to the riparian and floodplain corridor by removing invasive plant species and replacing them with native vegetation.

1.3 Tamarisk and Russian Olive Overview

Tamarisk (*Tamarix* spp.) is a deciduous shrub or small tree, introduced to the western United States in the early nineteenth century for use as an ornamental, in windbreaks, and for erosion control. Originating in central Asia and the Mediterranean, tamarisk is a facultative phreatophyte with an extensive root system well suited to the hot, arid climates and alkaline soils common in the western U.S. These adaptations have allowed the tamarisk to effectively exploit many of the degraded conditions in southwestern river systems today (such as interrupted flow regimes, reduced flooding, and increased fire). By the mid-twentieth century, tamarisk stands dominated many low-elevation (under 6,500 feet) river, lake, and stream banks from Mexico to Canada and into the plains states. Tamarisk cover estimates range from 1 to 1.5 million acres of land in the western U.S. and may be as high as 2 million acres (Zimmerman 1997; CHIP 2007).

The exact date of introduction is unknown; however, it is generally understood that tamarisk became a problem in western riparian zones in the mid-1900s (Robinson 1965; Howe and Knopf 1991). Genetic analysis suggests that tamarisk species invading the U.S. include Tamarix chinensis, T. ramosissima, T. parviflora, T. gallica, and T. aphylla (Gaskin 2002; Gaskin and Schaal 2002). A hybrid of the first two species appears to be the most successful intruder. Several ornamental varieties of tamarisk are still marketed in the western U.S. Although these species are non-invasive, they contribute to the genetic diversity of invasive populations (CHIP 2007).

Russian olive (*Elaeagnus angustifolia*) was introduced to the U.S. in the late nineteenth century as a small ornamental tree and has since spread from cultivation (Ebinger and Lehnen 1981; Sternberg 1996). Until the 1990s, several State and Federal agencies promoted the distribution of Russian olive for windbreaks and horticulture plantings in the western U.S. and in Canada (Tu 2003; Olson and Knopf 1986; Haber 1999). The seedlings were touted for their use in controlling erosion (Katz and Shafroth 2003), providing wildlife habitat (Borell 1962), and serving as a source of nectar for bees (Hayes 1976).

As a result, Russian olive was distributed widely in the west, and continues to spread through natural sexual and vegetative reproduction (Tu 2003; CHIP 2007).

Originating in southern Europe and central and eastern Asia (Hansen 1901; Shishkin 1949; Little 1961), Russian olive is a long-lived and resilient plant. They are adapted to survive in a variety of soil types and moisture conditions. They can grow between sea level and 8,000 feet, can grow up to 6 feet in one year (Tu 2003), are shade tolerant (Shafroth et al. 1995), and can germinate over a longer time interval than native species (Howe and Knopf 1991; CHIP 2007).

1.4 DESCRIPTION OF PROJECT SITES

The project area includes 15 restoration segments over a 33-mile length of the Colorado River between the Loma boat launch at Fruita and Riverbend Park at the Town of Palisade. Various levels of restoration are proposed within each of these segments. Eleven of these sites are specifically identified by the U.S. Fish and Wildlife Service (USFWS), Upper Colorado Endangered Fish Recovery Program (Recovery Program) as areas that are high priorities for restoration as habitat for the benefit of native and endangered fish species. Endangered fish species found within the project area, include the Bonytail (*Gila elegans*), Colorado pikeminnow (*Ptychocheilus lucius*), Humpback chub (*Gila cypha*), and Razorback sucker (*Xyrauchen texanus*). These high-priority sites are noted in Table 1.1 and identified by an asterisk (*) in the following segment descriptions. All other sites are considered to be important habitat sites, but moderate-priority segments.

The project maps are presented on 11- by 17-inch maps (1 to 500 scale), in Exhibit 1**,** developed from a geographic information system (GIS) format (ArcView). The 15 river segments are divided by common physical features, proposed restoration, and proximity. The maps include river miles consistent with the Bureau of Reclamation (BOR) river miles, and represent the distance upstream from the confluence of the Green River and Colorado River in Utah. The maps also include; land ownership, conservation easements, 100-year floodplain, major roads with access points and staging areas, locations of river cross sections, riverfront trail location, monitoring wells, recreational features, and soil sample locations, all overlaid on 2007 aerial photograph. Table 1.1 and the following paragraphs provide a brief description of each segment.

Segment 4: Loma Boat Launch to Skipper's Island Complex – River Mile 152.7 to 153.9
The Colorado River in this reach transitions from a relatively narrow and confined corridor downstream of Loma, into the broad floodplain of the Grand Valley, typical of the entire project area from Loma to Palisade. Segment 4 is approximately 1.3 miles, and spans both sides of the river bounded by the I-70 highway corridor on the north and the Horsethief State Wildlife Area on the south (see Map 1). The presence of Russian olive is significant, and is typical for the project area. Tamarisk is also present. The south bank is extensively used for hunter training, fishing, and bird watching. The north bank is a popular and highly utilized boat launch site. Removal of both Russian olive and tamarisk will improve riparian habitat throughout this area and the recreational uses.

Table 1.1 Summary of segments.

Moderate and High Priority Segments			
Segment	**Title**	**River Mile**	**Priority**
4	Loma Boat Launch to Skipper's Island Complex	152.5 to 154	Moderate
5	Skipper's Island Complex	154 to 155.5	High
6	Skipper's Island Complex to Old Fruita Bridge	155.5 to 157.8	Moderate
8	OBY Property	159 to 161	High
9	River Segment: DuPont Island Complex	160.8 to 162.5	High
10	Walter Walker State Wildlife Area	162.7 to 166.4	High
11	Connected Lakes State Park Complex	166.5 to 168	High
12	Bananas Island	167.5 to 169	High
13	Broadway Bridge South Bank Island	169 to 170	High
14	Confluence Island and Jarvis	170 to 171	High
16	Watson Island Complex to Orchard Mesa and Colorado River Wildlife Areas	172.6 to 174	Moderate
17	Orchard Mesa and Colorado River Wildlife Areas	174 to 177	High
18A	Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area	177.8 to 182.9	Moderate
18B	Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area	179 to179.8	High
19	Tillie Bishop Wildlife Area	182.9 to 185.2	High

Segment 5: Skipper's Island Complex* – River Mile 153.9 to 155.8
Skipper's Island and the associated secondary channel is owned mostly by the BOR and managed by the Colorado Department of Natural Resources, Colorado Division of Wildlife (CDOW). Other owners include United Sand and Gravel, and an absentee owner (see Maps 2 and 3). USFWS reports that this area was historically been occupied by endangered fish on a year-round basis (Pfister 2007). Portions of this Segment are transitioning from riparian to dry land habitat. There are numerous pockets of tamarisk that may be causing the conversion from riparian to dry land given the tamarisks' tendency to capture sediment as well as to dewater an area. Tamarisk removal is proposed for this Segment to provide the conditions required for native riparian vegetation to recover from being outcompeted by the invasive species.

Segment 6: Skipper's Island Complex to Old Fruita Bridge – River Mile 155.8 to 157.7
This 2-mile segment of river includes a small portion of the Colorado River State Park on the north side of the river, and City of Fruita's open space on the south; both popular recreational sites (see Maps 4 and 5). Tamarisk control will improve riparian habitat throughout this area as well as improve recreational potential because of the reduction in tamarisk.

Segment 8: OBY Property* – River Mile 159.0 to 160.7
This property is owned primarily by Colorado State Parks and has both a secondary and tertiary channel of the Colorado River (see Maps 6 and 7). Tamarisk is encroaching on the banks of these channels as well as on the island between the channels and the Colorado River. Clearing

tamarisk from these areas will improve habitat for endangered fish, and slow channel degradation.

Segment 9: Dupont Island Complex* – River Mile 160.7 to 162.7
The large island in this segment of the Colorado River is owned by several landowners, including two private ownerships and one public, held by Mesa County (see Maps 7 and 8). Mesa County has placed this parcel into a conservation easement. Historically, this island was divided by numerous braided channels. The complex confluence areas with the side channels and Colorado River are believed to ideal spawning habitat for the endangered fish species. Currently, most of these channels are choked by tamarisk and sediment. Removing tamarisk will provide the potential for channel re-braiding through the island, thereby improving vigor to the native plant species and restore habitat for endangered and native fish species. Conservation easements from the additional parcels held by private landowners are a high priority.

Segment 10: Walter Walker Wildlife Area* – River Mile 162.7 to 166.4
This critically important wildlife area extends from the Dupont Island Complex, to the Redlands Parkway Bridge over the Colorado River, and includes the Walter Walker State Wildlife Area along the north and south banks. Walter Walker State Wildlife Area is owned and managed by the CDOW (see Maps 8 through 11). This Segment was once a large gravel pit pond that was captured by the Colorado River in 1983. The captured gravel pit pond has the potential for serving as habitat for native and endangered fish species; however, flows are limited to infrequent, high flows due to a constructed dike. As a result, the pond has filled with sediment, and been colonized by tamarisk and Russian olive. Removing the tamarisk and Russian olive as well as lowering and removing part of the upstream dike will allow the river to naturally restore this area to a more natural bottomland site, providing habitat for endangered and native fish species, and supporting native vegetation. Adjacent to this property on the east are lands owned by the City of Grand Junction and Mesa County, as well as some private lands that are high priority for conservation easements.

Segment 11: Connected Lakes State Park Complex – River Mile 166.4 to 167.8
The Connected Lakes complex is bounded on the north side by the Colorado Riverfront Blue Heron Trail and on the south by Connected Lakes State Park (see Maps 11 through 13). Additionally, the Redlands Power return flow channel abuts the south side of the state park and includes a portion of the riverfront trail system. Tamarisk and Russian olive are relatively dense throughout much of this publicly owned land, restricting recreational use along the trail system, and impairing wildlife habitat. East of Connected Lakes State Park is land owned by the Audubon Society, and a rearing areas for endangered fish. The Audubon property is currently being restored for enhancement of native vegetation. Restoring native vegetation on the Connect Lakes State Park will benefit both properties, and vice versa, by providing contiguous restored sites throughout this important riparian corridor.

Segment 12: Bananas Island* – River Mile 167.8 to 169.0
This island is owned by the city, county, and private landowners (see Map 12). The USFWS has indicated that historically, the backwater channel on the north side of the island was an area where endangered fish commonly occupied. This segment was the site of a historical gravel pit pond that was flooded and captured by the river in 1983. Following this flood event, numerous channels were formed, until tamarisk encroached creating a single primary channel. Restoring

this site will benefit endangered and native fish and provide a more natural river system within the central part of the city of Grand Junction.

Segment 13: Broadway Bridge South Bank Island* – River Mile 169.0 to 169.8
This mile-long island on the south side of the Colorado River below the Broadway Bridge is mostly privately owned (see Map 13). Historically, this braided channel segment was active, but deposition and tamarisk have created a stable island. This segment also contains 'No Thoroughfare Wash', which provides tributary flow to the south side of the island. Restoring this site will benefit endangered and native fish by improving side channels and backwater and provide a more natural river system. An extension to the riverfront trail is proposed (by others) along 'No Thoroughfare Wash'. Thus, removal of the extensive tamarisk and Russian olive infestations in the wash will also improve the recreational experience.

Segment 14: Confluence Island and Jarvis* – River Mile 169.8 to 171.0
Most of the upstream island is owned by either the BOR or the City of Grand Junction. The main river channel flows on the south side of this large island that extends 0.6 miles from the confluence of the Gunnison and Colorado Rivers downstream (see Maps 13 and 14). A second island below this upstream island on the south side of the river is mostly owned by Mesa County with two other private owners. These islands exhibit a mix of mature riparian areas interspersed with tamarisk and Russian olive. Tamarisk and Russian olive have begun to colonize and stabilize the islands. Tamarisk and Russian olive should be removed from both islands to maintain a mobile and active channel. A small constructed backwater is located on the landside (north of) the north bank, in this reach. This backwater is the city-owned Jarvis property, previously reconstructed by the Recovery Program as a backwater habitat for endangered fish. While flows have been periodically captured since its reconstruction, today the site is infested with tamarisk due to lack of maintenance for removal of invasive species. Restoring this site will benefit endangered and native fish and provide a more natural river system within the central part of the city of Grand Junction.

Segment 16: Watson Island Complex to Orchard Mesa and Colorado River Wildlife Areas – River Mile 172.7 to 174.0
This segment includes land owned by the city of Grand Junction, Mesa County School District, Colorado Division of Wildlife, and private individuals. Conservation easements associated with the riverfront trail system have been established for some of the private lands (see Maps 15 and 16). There are no islands or backwaters within this river corridor, but there are quality riparian lands that will benefit from tamarisk control.

Segment 17: Orchard Mesa and Colorado River Wildlife Areas* – River Mile 174.1 to 177.1
This large area (see Maps 16 through 18) was purchased by the BOR and is currently managed by the Western Colorado Habitat Association (WCHA) under the BOR's salinity program. The property on the north side of the river is managed by the CDOW. Historically, the area was occupied by native fish populations, and continues to be important habitat. However, tamarisk now dominates the site, and has reduced or eliminated some of the key backwaters areas used by endangered fish (Pfister 2007). The WCHA has removed some tamarisk and reestablished native vegetation on some areas of the site.

Segment 18A: Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area – River Mile 177.8 to 182.9
The majority of this long stretch of river is privately owned though multiple public landowners and conservation easements are present(see Maps 18 through 21). Sections of the Riverfront Trail system run along areas of the public lands on the north bank. Although this is not a high priority segment, the cobble bars throughout this segment may provide spawning habitat for endangered fish, or may provide source material further downstream for spawning or habitat areas. Thus, it is important to control tamarisk on the islands. Restoring this site will benefit endangered native fish, improve riparian habitat, and provide a more natural river system.

Segment 18B: Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area – River Mile 179 to 179.8
This privately owned riparian complex, composed of riparian terraces, cobble bar islands and secondary channels/backwater, provide spawning habitat for endangered and native fish, and potentially provide source material further downstream for spawning or habitat areas. Thus, it is important to control tamarisk on the islands. Restoring this site will benefit endangered native fish, improve riparian habitat, and provide a more natural river system.

Segment 19: Tillie Bishop Wildlife Area* – River Mile 183.0 to 185.2
This property, owned and operated by the CDOW, includes backwater habitat and historically open braided channel areas (see Maps 21 and 22). Recent tamarisk invasions have choked the backwaters and the open channel areas with newly established thickets. The area has a good mix of native vegetation that will colonize the area once tamarisk is removed. The town of Palisade, Riverbend Park, located on the north bank of the river opposite Segment 19, represents the upstream limits of the project area.

1.5 Change in Conditions

This Colorado River Section 206 Aquatic Ecosystem Restoration project (Project) began in August 2007. Since 2007, there have been several changes in the conditions that are reflected in this appendix. The first and most significant change is impacts to tamarisk related to defoliation from the tamarisk leaf beetle. Since 2005, land managers in and around the Grand Valley have been releasing the Tamarisk leaf beetle (*Diorhabda carinulata)* in efforts not related to this Project, to control the spread of tamarisk. Since their introduction, the leaf beetles have migrated, and are now established in portions of this Project footprint. Based on monitoring data and observations compiled by the Tamarisk Coalition, and the Colorado Department of Agriculture Palisade Insectary, the tamarisk leaf beetle is successfully defoliating and reducing tamarisk densities. Observations and estimations indicate that the density of tamarisk from defoliation will drop and stabilize at or less than nine percent, depending on the specific area. Thus, based on the observations and first-hand experience of the Tamarisk Coalition, estimates used in this report are approximately 0 percent densities on cobble bars, and nine percent on riparian and upper riparian sites.

As the tamarisk defoliates, these areas are being rapidly colonized by other invasive species, primarily Russian olive and Russian knapweed (*Acroptilon repens*). Thus, the objectives and goals of this project remain as initially stated, "to remove invasive plant species, and replace them with native vegetation". However, the composition of invasive species has changed from an extensively dominated tamarisk population, to a tamarisk, Russian olive and Russian knapweed population.

The second change in conditions applies to Segments 7 and 15. Segment 7 is being actively mined for gravel and consequently there is little interest, by the owner, in implementing restoration. On Segment 15, Watson Island Complex, the restoration work proposed for this site has already begun with funding from other sources and therefore has been removed from this project.

The third change in conditions pertains to the elimination of some sites within the Segments. These sites have been eliminated primarily because other agencies and municipalities have stepped in and begin the restoration process with the removal of invasive species as a primary directive. These sites are shown on the maps and noted in the legend as ‘Excluded’.

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2.0 PHYSICAL CHARACTERISTICS OF THE PROJECT AREA

The project area lies in the rain shadow of mountain ranges to the east, west, and north. Precipitation in Grand Junction is about 8 inches per year, with the highest levels occurring in August. Grand Junction is frost-free for approximately 185 days each year (USDA 1989). Temperatures vary as much as 20 degrees with elevation in this diverse terrain, with mean lows in January ranging from 0°F to 16°F, and highs in July from 70°F to 95°F. Summer temperatures over 100°F are common. Humidity is generally 22 percent in midsummer. Prevailing winds are from the southwest, but are influenced by local topography (USDA 1989; CNHP 2002).

Mesa County rests atop diverse geologic formations ranging in age from Precambrian metamorphic and granitic rocks, to Triassic, Jurassic and Cretaceous sedimentary rocks, and the valleys' Quaternary alluvial deposits. These formations influence the distribution of wetland plant communities by directly affecting soil development, groundwater movement, and alluvial processes (CNHP 2002).

Soils of the area may be alluvial; wind deposited, or weathered in place. Some soils at the lowest elevations may contain excess salt or sodium. Wetland plant communities occur on alluvial soils along drainages, in both the higher and lower elevations. There is minimal soil development around many of the seeps and springs in Mesa County, as many of these areas are located on steep hillsides, or atop geologic bedrock. Soils along the Colorado River are highly variable, ranging from very fine silty materials to areas of sand and gravel. Some oxbows and backchannels have organic soil horizons, but the substrate would not be classified as an organic (CNHP 2002).

2.1 Land Use

Land within the project area is owned by the following parties:

- Federal lands under the control of Bureau of Land Management (BLM) and the Bureau of Reclamation (BOR);
- State lands owned by the Colorado State Parks, Colorado Department of Transportation (CDOT), and Colorado Division of Wildlife (CDOW);
- Mesa County;
- Cities of Grand Junction, Fruita, and Palisade;
- Clifton Water District and Clifton Sanitation District;
- Mesa County School District #51;
- Audubon Society; and
- Private property owners.

The project area is entirely within the floodplain of the Colorado River, and largely excludes livestock by means of existing fencing in the valley between Fruita and Palisade. All state wildlife areas, state parks, and riverfront trail systems are also fenced to restrict livestock access. Fencing is also in place for the remaining public lands, and any private lands with a conservation easement. There are no known private lands accessing the project area that support livestock. Thus, restoration efforts will not be impaired by livestock grazing.

The project area does include habitat for large wildlife species, specifically mule deer, and a small herd of desert bighorn sheep. No active controls are proposed to limit browser access to restored lands as the majority of these areas already support mature, native plant populations.

2.2 Soils

Most of the soils in the Grand Valley are either alluvial deposits, or residual soils derived from Mancos Shale. They generally have low permeability levels and high water-holding capacities. Localized areas of high saline-alkaline concentrations are scattered throughout the valley. Poor drainage conditions and high-water tables have resulted in localized accumulations of salts, which adversely affect roughly one-third of the available agricultural acreages in the valley. Soil erosion is a problem in the valley, particularly in uncultivated areas due to low densities of natural vegetation (USDI-BOR 1986). Biological soils crusts (also known as cryptobiotic soils) are common on soil surfaces, and once disturbed require long periods to re-establish (USDI-BLM 2004). National Resource Conservation Service (NRCS) soil maps, in Geographic Information System (GIS) format, have been collected for use during the design phase of the project.

The Colorado River Basin Salinity Control Act (Public Law 93-320) was enacted in June 1974, and then amended in 1984 by Public Law 98-569. This amendment (Public Law 98-569) directs the BLM to develop a comprehensive program for minimizing salt contributions from lands under the BLM's management (USDI-BLM 2004). Colorado's Grand Valley, is recognized as the largest nonpoint source of salinity in the Upper Colorado River Basin. In 1977, the Soil Conservation Service estimated that the Grand Valley annually contributed 2.9 million tons of sediment and 600,000 to 700,000 tons of salt, of which 80,000 tons result from erosion. Studies conducted on Mancos Shale, in the Upper Colorado River Basin, have demonstrated a positive relationship between sediment yield and salt production. Sediment yield increases as a result of either upland erosion, or streambank and gully erosion. Upland erosion is attributed to rill and inter-rill flow. Salt and sediment yield are dependent upon storm period, landform type, and the soluble mineral content of the geologic formation. Badlands are the most erosionally unstable, with sediment yields as high as 15 tons per acre. Rilling accounts for approximately 80 percent of the sediment yield. Because salt production is closely related to sediment yield, and the badland soils have not been leached of their soluble minerals, these soils produce the greatest amount of salt of all the landform types (USDI-BLM 2004).

2.3 Vegetation

Riparian vegetation characterizes the Colorado River corridor in Mesa County. Cottonwood (*Populus acuminata*) galleries, located on the floodplain and on terraces, are interspersed along the river among willow (*Salix,* spp), skunkbush (*Rhus trilobata*), or tamarisk-dominated stream banks. The non-native tamarisk has become a significant component of the riparian community, and either co-dominates or dominates many banks. Changes in river hydrology, mainly dam and irrigation altered flow regimes are thought to be the largest contributing factors to tamarisk invasion. Fires have been another factor in the decline of the native cottonwood community and the increase of tamarisk and other aggressive invaders. Beaver (*Opuntia basilaris* spp) activity, and other recreational impacts have also notably degraded the natural riparian system (USDI-BLM 2004).

The Colorado River floodplain is home to many weed species, and is rapidly being infested. Tamarisk is found along the entire river corridor in varying densities and age classes, and is present in every cottonwood gallery on this stretch of river. Other weed species of particular concern in this area include the following: purple loosestrife (*Lythrum virgatum*), which increased by 400 percent in one year; Russian knapweed (*Acroptilon repens*), which is locally abundant though some infestations exceed 50 acres; and curly dock (*Rumex crispus*), which occurs in scattered areas along the river (USDI-BLM 2004).

Studies of the uncultivated portions of the Grand Valley area revealed 135 plant species including three tree, 20 shrub, 76 forb, and 36 grass and grass-like species. Of these, almost 40 species are exotic vegetation originating outside the North American Continent. The great majority of these species occur exclusively within the riparian corridor due to the arid conditions in the valley. Only sparse stands of vegetation, primarily saltbush, grow in upland areas, or areas with a manmade water supply (USDI-BOR 1986).

Saltbush shrublands dominate the desert vegetation surrounding the irrigated portion of the valley, and consist of shadscale (*Atriplex confertifolia*), Nuttall's (*Atriplex nuttallii*) and mat saltbush (*Atriplex Corrugata*), and occasionally big sagebrush (*Artemisia tridentate*). Greasewood (*Sarcobatus)* stands grow on soils with dependable ground water supplies. This salt-tolerant shrub is associated with alkali seepweed (*Suaeda maritima)* and inland saltgrass (*Distichlis spicata)* and grows along washes, as well as on nonagricultural land within the irrigation systems (USDI-BOR 1986).

Marsh vegetation has developed in low areas within the irrigated portions of the valley, and is supported by seepage from the irrigation systems, or by irrigation wastewater. The species composition of individual marshes varies with soil salinity and other factors. Common plant species include coyote willow, common cattail (*Typha latifolia*), common spikerush (*Eleocharis palustris*), saltgrass *(Spicata*), and common reed (*Phragmites australis*) (USDI-BOR 1986).

Agricultural lands exist adjacent to the project area, but are not part of the project, and will not be restored. These agricultural lands typically include grain crops, hay, and orchards. Relatively narrow rows of natural vegetation along laterals and farm ditches, fencerows, drains, and roadsides are associated with these agricultural lands (USDI-BOR 1986).

2.3.1 **Native Plant Community in the Project Area**

The river typically supports an intermixed community of native species that includes; riparian species of willow and cottonwood; wetland species such as bulrush (*Scirpus*), rush (*Juncus*), sedge (*Carex*), and cattail (*Typha)*; and floodplain terrace species such as three-leaf sumac (*Rhus trilobata*) or skunkbush (*Rhus trilobata*), four-wing saltbush (*Atriplex canescens*), silver buffaloberry (*Shepherdia argentea*), currant (*Ribes*), rabbitbrush (*Chrysothamnus*), desert olive (*Forestiera neomexicana*), wild rose (*Rosa*), salt grass (*Disticichlis stricta*), indian ricegrass (*Oryzopsis hymenoides*), sand dropseed (*Sporabolus cryptandrus*), alkali sacaton (*Sporabolus *airoides*), alkali muhley (*Muhlenbergia asperfolia*), as well as numerous forbs. Depending on individual site characteristics, the abundance of these species may be sufficient to provide natural recruitment or may require more active revegetation action following tamarisk or Russian olive control activities (CHIP 2007).

2.3.1.1 Special Status Threatened & Endangered (T&E) Plant Species in the Project Area

Neither a Federally listed, nor a state-listed plant species has been identified within the area. However, some sensitive plants, specifically Jones' bluestar (*Amsonia jonesii)*, and Osterhout's cryptantha *(Cryptantha osterhoutii)*, are both known to be north of the river, and the latter is found south of the river (USDI-BLM 2004).

2.3.1.2 Special Status Species

BLM (BLM) 6840 Special Status Species Management Policy provides guidance to the BLM in managing all special status species (SSS). The SSS discussed in this section are divided into seven categories. Three categories fall under the Federal Endangered Species Act (ESA) of 1973, as amended—Federal threatened and endangered (T&E) and species ranked as suitable "candidates" for the ESA protection. Two categories fall under regulations from Colorado Revised Statutes as amended—state threatened and endangered. One category includes the Colorado State Director's Sensitive Species List.

2.3.2 Non-native Plants in the Project Area

Non-native plants are found throughout the project area. The noxious weeds identified in the project area, characterized as noxious by the BLM, State Department of Agriculture, or Mesa County are generally invasive in nature. General weed management efforts in the Grand Valley are presented for several of the more abundant species (USDI-BLM 2004):

- Tamarisk and Russian olive constitute a major component of riparian communities. Although eradication of these species in the long-term is unlikely, control using biological and chemical treatments can result in these invasive plants no longer being competitive with native species.
- Russian knapweed is the most abundant of the classic noxious weeds, and is found in the highest percentages along the river corridor. While it is a daunting task, long-term control or containment of this weed is possible. All Russian knapweed infestations inside the wilderness and north of the river have been treated, and BLM continues to treat areas along the river.
- Whitetop (*Lepidium draba*) is abundant valley-wide. Short- and long-term prognosis for control looks good, as long as repeated inventories track and manage this fast spreading weed.
- Purple loosestrife (*Lythrum virgatum*) continues to persist in small, but abundant infestations. This weed is considered to be contained, but not controlled, as a significant seed bank has probably persisted in the soil from past infestations.

- Canada thistle (*Cirsium arvenseis*) rare and both short- and long-term control of this weed look promising.
- Cheatgrass (*Bromus tectorum)*, halogeton (*Halogeton sativus*), Russian thistle, bur buttercup (*Ceratocephala testiculata*), purple mustard (*Sinapis* ssp*)*, tumble mustard, flixweed (*Sisymbrium sophia)*, and redstem filaree (*Erechtites valerianifolia*) are all invasive annuals that mostly occupy polluted sites, or recently disturbed areas such as areas disturbed by fire.

These weeds greatly degrade the function of native ecosystems, but successful plantings of desirable grasses and forbs will out-compete these weeds and keep populations manageable. The long-term prognosis is positive in areas with favorable precipitation and soil conditions for reestablishing native species.

2.3.3 **Tamarisk and Russian Olive State of the Science**

The following discussion on the state-of-the science of tamarisk and Russian olive (TRO) is extracted from the recently published report by the *Tamarisk Coalition, Colorado River Basin Tamarisk and Russian olive Assessment, December 2009.* It reflects the current understanding of the impacts of both tamarisk and Russian olive in the Colorado River watershed with the discussion modified to specifically apply to the Colorado River watershed through the Grand Valley.

Figure 2.1 Tamarisk shrub (left), Tamarisk flowers (right).

In order to assess TRO distribution, the state-of-the-science, and the range of information available on impacts, the Tamarisk Coalition extensively reviewed literature, conducted interviews and compiled information on the following:

- Rate of TRO infestation and mechanisms of spread.
- Extent of TRO infestations including a detailed distribution map based on existing data.
- Wildlife habitat and biodiversity impacts especially as they relate to endangered and threatened species; specifically the Southwestern willow flycatcher and the four endangered Colorado River fish species.
- Sediment deposition and transport impacts.
- Salinity and soil chemistry impacts.

- Wildfire threat.
- Cultural resources impacts.
- Recreation impacts.
- Biomass utilization.

2.3.3.1 Mechanisms of Tamarisk Spread

Tamarisk has many characteristics typical of an early successional species. Because it requires bare, wet ground for colonization, it is dependent on disturbance such as floods; however, heavy rainfall or irrigation water could also create suitable conditions. Seedlings are often found on recently deposited or scoured riparian substrates.

Tamarisk produces many small, lightweight seeds that are dispersed by wind, aided by a hair tuft, or may be carried by water. Larger tamarisk trees can produce as many as 500,000 seeds each year and may bloom across almost the entire growing season, giving it a much broader window of opportunity to colonize available substrates. Seeds are only viable for about 5 weeks, and the site of germination must remain moist for 2 to 4 weeks or seedlings will die. At the same time, seedlings must not be inundated for 4 to 6 weeks following germination, and large floods even two years after germination may lead to plant mortality (Birken and Cooper 2006). Once established, seedlings can grow up to 3 to 4 meters (m) (approximately 10 to 14 feet) per year and may begin reproducing at the end of their first year.

2.3.3.2 Tamarisk's Rate of Spread

A timeline of tamarisk introduction and spread is detailed in Di Tomaso (1998). Tamarisk was introduced on the east coast of North America, where it was sold by plant nurseries in the early 1820s. Western nurseries began selling tamarisk in the mid-1850s and it was planted to prevent erosion, provide shade and windbreaks, as well as for its ornamental value. Tamarisk was found to provide some form of erosion control, bank stability, and sediment deposition; thus, reducing sediment loads to reservoirs (Brotherson and Field 1987; Campbell 1970). Soon tamarisk began escaping cultivation and was recognized as a problem species as early as the 1920s. Tamarisk's spread was rapid—an approximately 3- to 4-percent increase in acreage per year. An estimated 4,000 hectares (ha) (9,900 acres) were covered in the 1920s, compared with approximately 470,000 to 650,000 ha (1.2-1.6 million acres) in 2000 (Zavaleta 2000). Researchers at Colorado State University (CSU) have used data on the pattern of spread of tamarisk, (and Russian olive) to develop a model that predicts where infestation is likely to occur in the future.

The invasion of tamarisk roughly coincided with the advent of major anthropogenic changes in western rivers as well as climatic conditions (i.e., droughts and wet periods) that may have favored the spread of tamarisk (Birken and Cooper 2006). As rivers were dammed and regulated and water was diverted for irrigation and other uses, conditions in riparian areas changed in ways that may have favored tamarisk over native species such as cottonwood and willow. These anthropogenic and climatic conditions generally reduced flows, the frequency and intensity of flood events, and may have increased drought conditions as well as the salinity of riparian soils (Di Tomaso 1998; Glenn and Nagler 2005). Like tamarisk, cottonwoods and willows are dependent on flood events for seedling establishment, so all three species would be negatively impacted if flood events became more infrequent. However, because tamarisk is more tolerant of drought and high salinity than are cottonwood and willow, it would gain a competitive advantage under these conditions (Glenn and Nagler 2005).

However, researchers are not in agreement regarding the conditions under which tamarisk can invade native riparian communities. Some researchers argue that tamarisk is only able to outcompete native riparian species under these stressful conditions (high salinity and drought) because, in part, river regulation conserves water in reservoirs, thus limiting overbank flows that tend to flush away surface salts (Glenn and Nagler 2005). Proponents of this view conclude that restoring more natural flow regimes to western rivers will reduce tamarisk's competitive advantage under stressful conditions, and allow native trees to establish and coexist with tamarisk (Glenn and Nagler 2005). Other researchers point out that tamarisk invaded some rivers before they were dammed (such as the lower Green River), and is invasive on other rivers that have never been regulated (such as the Virgin River) (Birken and Cooper 2006). Proponents of this view argue that river regulation is not the primary force driving tamarisk invasion, and therefore restoring more natural flow regimes will not reduce its spread. In their view, more natural flow regimes, with high-water (flood) years, followed by low water years, may even encourage the establishment of more tamarisk (Birken and Cooper 2006).

Recent research findings by Merritt and Poff (2009) also indicate that tamarisk would be an important component of western riparian ecosystems, even in the absence of water development. Their findings also indicate that without natural hydrograph characteristics downstream of dams, it is unlikely that cottonwood recruitment will occur to decrease the dominance of tamarisk in riparian ecosystems.

Figure 2.2 Tamarisk on the Colorado River overlooking Segment 6, illustrating an infested floodplain.

Figure 2.2 illustrates tamarisk along the Upper Colorado River while Figure 2.3 provides the mapped tamarisk infestations within the Colorado River Basin based on all available mapping and inventory data.

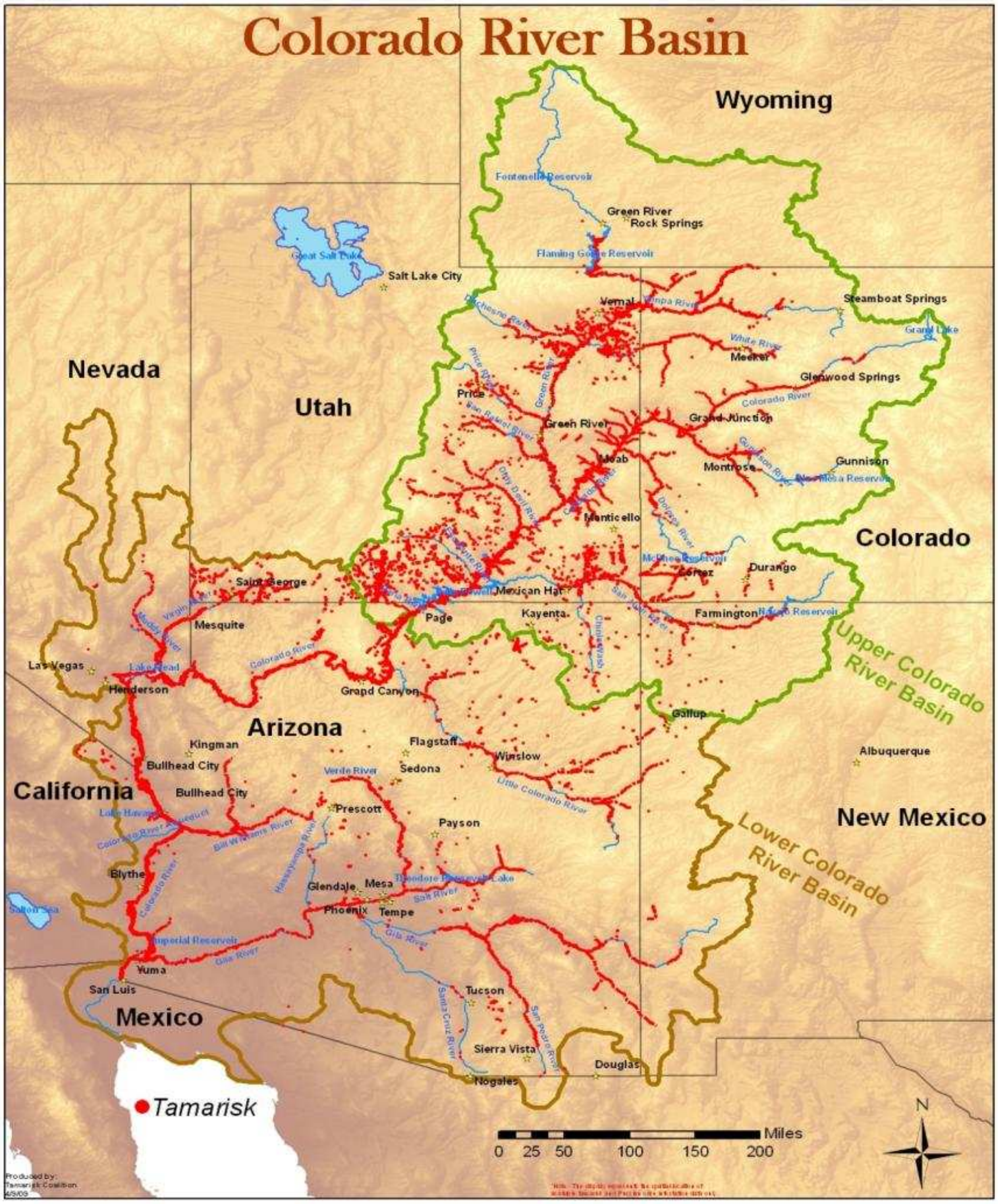

Figure 2.3 Mapped tamarisk infestations in the Colorado River Basin.

2.3.3.3 **Russian olive Reproductive Biology**

Katz and Shafroth (2003) provide a comprehensive review of Russian olive biology, and much of the information summarized here is discussed in more detail in their review. Contrary to tamarisk, Russian olive has the characteristics of a late successional species. The tree produces large seeds contained in a fruit (Figure 2.4) that are 1 to 1.5 centimeters (cm) (approximately 0.4 to 0.6 inches) long and dispersed primarily by birds and other vertebrates. Seed dispersal occurs primarily during the fall and winter with seeds remaining viable for 1 to 3 years. Russian olives do not reach reproductive maturity until approximately 10 years of age. A critically important feature of Russian olive biology is its shade tolerance. Russian olive grows more quickly than cottonwood in shaded conditions (Shafroth et al. 1995) and is able to establish in undisturbed herbaceous vegetation (Katz 2001). This is important because unlike most invasive species, such as tamarisk, Russian olive is not dependent on disturbance to establish.

Figure 2.4 Russian olive tree (left) and seeds (right).

2.3.3.4 **Russian olive's Rate of Spread**

There is far less information available on the rate of spread or invasive characteristics of Russian olive. Compared to tamarisk, Russian olive spreads more slowly, as it is a late successional species that is not adapted for rapid reproduction and dispersal. The species was introduced to the Western U.S. in the early 1900s when it was planted as a shade tree, windbreak, and in hedgerows. Russian olive was not common outside of cultivation until 20 to 50 years following its introduction to the West. Despite the fact that it is now recognized as an invasive species, it was widely promoted, and states subsidized plantings through the 1990s for wildlife habitat and erosion control. It is still sold as a horticultural plant in many states. Russian olive is now invasive in 17 western states, but there is no accurate estimate of the number of infested acres. Within the Colorado River Basin, it is found primarily in the Upper Basin in certain areas such as along Segment 16 (see Figure 2.5), but also occurs in the Little Colorado watershed, as well as the Salt and Gila Rivers in the Sonoran Desert. There are relatively few Russian olive plants in the Dolores River watershed's riparian lands, although there are numerous ornamental plants in the towns of Nucla and Naturita. Figure 2.6 is a map summarizing distribution of Russian olive. The predictive model in development at CSU, referred to in the discussion of tamarisk, will also predict potential future infestations of Russian olive.

Figure 2.5 Russian olive on the Colorado River at Segment 16.

Perhaps because of Russian olive's slow rate of spread, it has generated much less concern than the more aggressive tamarisk. However, the very characteristics that make it slow to spread may make it a more difficult problem in the long run. Its shade-tolerance enables it to invade under woody canopies and a larger seed size conveys a competitive advantage on its seedlings, allowing them to establish within herbaceous groundcover. This means that Russian olive may be able to invade established native riparian communities, whereas tamarisk must wait for physical disturbance to open up bare ground. However if cottonwood forests cannot replenish themselves by recruiting seedlings, Russian olive may continue to invade and eventually come to dominate these riparian forests.

A recent study by Reynolds and Cooper (2010) found that Russian olive could establish in moderate to high shade environments and up to eight feet above ground water. Russian olive is not dependent on flooding like tamarisk and cottonwoods. Due to these characteristics, Russian olive stands can be self-replacing unlike tamarisk and cottonwood allowing it to colonize and persist in areas of defoliated tamarisk. Figure 2.6 provides the mapped Russian olive infestations within the Colorado River Basin based on all available mapping and inventory data.

Figure 2.6 Mapped Russian olive infestations in the Colorado River Basin.

2.3.3.5 Salinity and Soil Chemistry

Soil Salinity and Moisture Stress: As the salinity of soil water around a plant's root system increases, greater osmotic pressure is required on the part of the plant to extract water molecules from the soil (Hem 1967). When a plant cannot generate enough osmotic pressure to separate water molecules from salt and other dissolved solids, it will succumb to drought stress and desiccation. Drought (moisture stress) and elevated levels of soil salinity trigger similar physiological responses in many species of plants; i.e., low soil water potential triggers stomatal closure and reductions in growth, transpiration, photosynthesis, and other metabolic processes (Pataki et al. 2005; Singh et al. 1999).

Competitive Advantages, Salt and Drought Tolerance: Soil salinity has become elevated in the floodplains and bottomlands of southwestern rivers where human activities have resulted in diminished water quality and altered natural flooding regimes (Shafroth et al. 2008). Historically, overbank flooding on unregulated rivers leached salts and other ions from riparian and floodplain soils, but reductions in flooding frequency and magnitude have created drier, more saline soils (Glenn and Nagler 2005). Evaporation of agricultural irrigation runoff has also contributed to elevated soil salinity in these areas. Tamarisk does not require a saline environment for establishment and growth, but can thrive in soils where other types of vegetation are inhibited by elevated salinity (Hem 1967). As a facultative halophyte (salt-tolerant plant), tamarisk has a competitive advantage over many native woody riparian plant species (Wiesenborn 1996; Shafroth et al. 1995), particularly on regulated rivers.

Different studies have reported different ranges of salt tolerance for tamarisk. Collectively, these values range to as high as 30,000 milligrams per liter (mg/l) (DiTomaso 1998; Brotherson and Winkel, 1986; Carmen and Brotherson, 1982; Glenn et al. 1998). Conversely, growth of many native woody plant species, such as willow and cottonwood, is inhibited by saline conditions. In a greenhouse-based study of eight riparian tree and shrub species, salinity tolerances, Jackson et al. (1990) reported that cottonwood and willow did not tolerate salinity over 1,500 mg/l of soil water. In their analysis of seedling growth and survival, Jackson et al. (1990) report that tamarisk and two species of mesquite (*Prosopis* spp.) achieved 100-percent survival up to 36,000 mg/l. Extremely high levels of salinity did eventually impact tamarisk seedlings. Shoot growth and biomass were significantly lower when irrigated with solutions of 36,000 and 60,000 mg/l (Jackson et al. 1990). Glenn et al. (1998) conducted a greenhouse study of tamarisk and five other native tree and shrub seedlings on a salinity gradient. They also reported that tamarisk seedlings had a significant advantage in growth rate and transpiration over cottonwood and willow seedlings at elevated levels of salinity.

Tamarisk is also more salt-tolerant than Russian olive, which occurs on soils with low to medium concentrations of soluble salts (Carman and Brotherson 1982). In a north-central Utah field study of soil and vegetation characteristics on tamarisk-invaded sites versus Russian olive-invaded sites, tamarisk occurred on soils with salt concentrations ranging from 700 to 15,000 mg/l, while salt concentrations at Russian olive sites ranged from 100 to 3,500 mg/l (Carman and Brotherson 1982). Accordingly, plant species associated with Russian olive-invaded sites were described as "typical of mesic meadows", whereas species associated with tamarisk-infested sites were "characteristic of halophytic (plant) communities" (Carman and Brotherson 1982).

Tamarisk's competitive advantage on altered soils extends to post-fire regeneration. Following fire, soils tend to be dryer and more saline. Deposits of ash on the soil surface contain elevated concentrations of phytotoxic boron (see Wildfire Threat—Section 2.3.3.7). Salt glands in tamarisk foliage concentrate and excrete salt, boron, and various other substances, while native riparian plant taxa may be more susceptible to salts and heavy metal toxicity (Busch and Smith 1993).

Tamarisk's Contribution to Soil Salinity: Salts and other elements are absorbed by tamarisk roots from deep within the soil profile, and redistributed to the soil surface via leaf litter. Salt glands occur on tamarisk leaf surfaces and on the stems of new growth. "Collecting cells" accumulate high concentrations of salt, which are then secreted as crystals onto leaf surfaces (DiTomaso 1998; Jackson et al. 1990), along with other ions, such as potassium, nitrate, calcium, magnesium, sulfur, phosphorus, bicarbonate, chloride, molybdenum, boron, copper, manganese, aluminum, zinc, and various additional trace elements, depending on what is present in the root environment (Storey and Thomson 1994; DiTomaso 1998). The diversity of ions secreted by tamarisk glands suggests that the glands as well as the root system have a low level of selectivity to uptake of ions, and that tamarisk can regulate the ionic composition of its cells by secreting a range of elements, allowing it to survive on a wide range of soil types (Storey and Thomson 1994). It is believed that, over time, senescent deciduous tamarisk foliage containing elevated concentrations of salt and other ions accumulates on the soil surface (Figure 2.7), increasing salinity and inhibiting the germination and growth of other species of riparian vegetation (DiTomaso 1998; Wiesenborn 1996). It should be noted that there is some debate over the extent to which tamarisk contributes to soil salinity. Some researchers argue that altered river conditions are largely responsible for elevated soil salinity, and halophytic tamarisk now occupies areas too saline for other native species to survive.

Research indicates that tamarisk stand attributes, such as stand age and density, may be related to levels of soil salinity. Ohrtman et al. (2009) analyzed soil salinity associated with tamarisk stand age and density along a reach of the Middle Rio Grande. The highest soil salinity occurred in middle-aged tamarisk stands (approximately 15 years of age), while lower levels of salinity occurred in older stands (Ohrtman et al. 2009). This may be due in part to greater foliar outputs from mid-aged trees (with branching foliage present across most of their vertical profile) than from mature trees with well-developed trunks and foliage occurring primarily up in the crown (Sher 2009). Ohrtman et al. (2009) further reported that tamarisk density did influence salinity levels, but not heavily; and suggested that surface evaporation, especially in unshaded areas prone to soil capillary action, was also contributing to elevated soil salinity. Study areas subject to overbank flooding had lower levels of soil salinity than areas where flooding was eliminated by a levee (Ohrtman et al. 2009; Sher

Figure 2.7 **Salt accumulation on surface soils Colorado River near Moab, Utah.**

2009). In some riparian and floodplain vegetation communities where tamarisk is the dominant overstory species, salt-tolerant species such as native saltgrass become well-established in the understory (Brotherson and Winkel 1986).

Salinity Remediation and Ecological Restoration: Some researchers believe that tamarisk only has a competitive advantage over native riparian plants under conditions of drought and increased soil salinity (Glenn and Nagler 2005). These researchers advocate overbank flooding as a mechanism for re-establishing native riparian species. Overbank flooding leaches salts out of riparian and floodplain soils and scours away organic litter, preparing the seedbed, providing soil moisture, and reducing soil salinity (Ohrtman et al. 2009; Sher 2009; Bay and Sher 2008). A reduction in soil salinity would negate tamarisk's competitive advantage under high salinity conditions, and flooding would further reduce its advantage because tamarisk is less tolerant of inundation than some native species (Vandersande et al. 2001).

Levels of riparian and floodplain soil salinity vary greatly across the Upper and Lower Basins of the Colorado River watershed. In the context of ecological restoration, soil salinity is an important site factor to evaluate in advance of revegetation (Shafroth et al. 2008). Many native riparian species may not be able to tolerate the elevated salinity levels now present and remediation may be necessary for successful revegetation. Where overbank flooding is not an option, other treatments exist for soil salinity amelioration. Mechanical surface soil treatments may be used to reduce or redistribute salts in leaf litter or surface soils, and commercial soil amendments, which convert salts to neutral or acidic compounds, are available (Shafroth et al. 2008). Caplan et al. (2001) document a soil restoration project in New Mexico that used mechanical soil mixing treatments as well as a gypsum soil amendment. Though this project was successful in restoring native grasses, the technique is quite expensive and may not be practicable in many areas.

Saline conditions on regulated rivers favor the growth and establishment of certain salt-tolerant native species, including saltbush, arrowweed (*Pluchea sericea*) and the extreme halophyte iodinebush (*Allenrolfea occidentalis*), all of which can excrete salt and/or penetrate saline surface soils and utilize less saline groundwater from deeper in the soil profile (Glenn and Nagler 2005). While cottonwood is not generally considered a salt-tolerant species, a study by Rowland et al. (2004) documents genetic variability in salt-tolerance among different families of Rio Grande cottonwood (*Populus deltoides* var. *wislizenii*). This variation could be used to benefit restoration if stock from salt-tolerant families were chosen for revegetation in sites with higher salinity. A summary of the salt tolerances of grass, forb, shrub, and tree species frequently used in revegetation projects is available in Shafroth et al. (2008).

Salinity Conclusions: Levels of riparian and floodplain soil salinity vary greatly across the Upper and Lower Basins of the Colorado River watershed. This is also true for the Dolores River watershed. Tamarisk does not require a saline environment for establishment and growth, but can thrive in soils where other types of vegetation are inhibited by elevated salinity. Research indicates that soil salinity levels may be related to tamarisk stand attributes, such as stand age and density. Although some native plants cannot tolerate high salinity levels, many other native plants can be used for revegetation materials (see for a listing of salt tolerant species).

2.3.3.6 Sedimentation

This review focuses on the role of vegetation in sedimentation, bank stability and erosion processes, and TRO establishment as it relates to channel narrowing. Sedimentation refers to the behavior of particles suspended in river water. How the particles move and settle in the river water, and what external factors affect their behavior. Channel response and potential erosion impacts resulting from TRO management also reviewed.

Braided, meandering and complex channel morphology represents the natural state of river systems in which vegetation and wildlife have adapted. Significant ecological, hydrologic, and geomorphic changes have occurred during the nineteenth and twentieth centuries along many large floodplain rivers in the American Southwest (Birken and Cooper 2006). Many factors that contribute to these changes include climatic factors such as drought, construction of large dams, trans-basin diversions, and non-native vegetation invasion (Allred and Schmidt 1999). Tamarisk now dominates most floodplain ecosystems in the West (Birken and Cooper 2006).

Tamarisk can provide some form of erosion control in riparian areas (Brotherson and Field 1987). The extensive tamarisk root system makes the bank area more stable and resistant to erosion than prior to establishment. The channel stabilization and increased sediment deposition then reduces sedimentation of reservoirs further downstream (Campbell 1970); thus, some reservoirs may not have experienced the anticipated sediment loads that were included in designs. In 1926, tamarisk was introduced to the Rio Puerco, New Mexico to control erosion and slow the amount of sediment filling the Elephant Butte Reservoir (Friedman et al. 2009). A study to investigate causes of channel narrowing and incision in Canyon de Chelly National Monument, found that the effects of root reinforcement provided by TRO had a significant impact on bank stability and bank-failure frequency (Pollen-Bankhead et al. 2009).

The development of heavily vegetated floodplains composed primarily of tamarisk, often within the active channel, has caused many rivers to narrow (Birken and Cooper 2006). Vegetation contributes to channel narrowing by increasing sediment deposition and bank stability (Schumm and Lichty 1963; Friedman et al. 1996). Griffin et al. (2005) present ideas about how channels with and without vegetation impact the hydraulics of the river which in turn impact sedimentation. According to their research, the morphologies of natural stream channels are determined by the interactions of flow, sediment, and riparian vegetation. The establishment of vegetation in the active channel may facilitate the vertical accretion or build-up of sediment and reduce channel capacity by increasing hydraulic roughness and increasing sediment deposition rates (Merritt and Cooper 2000). An example of channel capacity reduction due to tamarisk infestation is documented in a U.S. Geological Survey (USGS) study of a reach of the Arkansas River near the town of Las Animas, Colorado. There, the USGS's hydraulic modeling indicated a potential to increase channel capacity by 55,000 cubic feet per second, a 69-percent increase above existing capacity, through the elimination of a dense stand of tamarisk in a levee-confined reach of the river (USGS, Pueblo, CO 8/7/2006 written communication to CWCB).

The amount of sediment deposited depends on many factors including the rate at which the water is flowing. The higher the flow velocity, the greater the sediment loads being carried. When the water slows, sediments are deposited. Channel narrowing begins (see Figure 2.8) as dense woody vegetation on the floodplain slows the overbank flow, forms drag on the stems and reduces the stream's power or ability to carry sediment on the floodplain to less than the amount of force needed for erosion of the cohesive material on its surface. This results in deposition of fine sediment on the floodplain rather than transport of the sediment back into the river (Griffin et al. 2005).

In a properly functioning river system, the channel form adjusts to handle increases in runoff with minimal disturbance of the channel and associated riparian plant communities. The channel is constantly adjusting itself to the water and sediment load that is present. If a channel is down-cut or incised and flows can no longer access the floodplain, the stream system can no longer provide important hydrologic functions such as sediment disposition and periodic flooding of vegetation. Riparian areas with incised channel conditions with a limited or nonexistent floodplain lack the ability to retain water (Prichard et al. 1998).

Figure 2.8 Accretion from colonizing Tamarisk on a bar, Colorado River Segment 17.

Riparian vegetation has the ability to establish within and near the channel, which increases channel stabilization (Pollen-Bankhead et al. 2009). It has been hypothesized that channel narrowing is initiated by establishment of vegetation on the channel bed during a period of relatively low flows that lasts several years (Friedman et al. 1996). Subsequent higher flows deposit sediment around the vegetation, forming a new stable surface adjacent to a narrower channel (Schumm and Lichty, 1963). Riparian vegetation can only facilitate sediment deposition when flows are high enough to bring the newly established vegetation in contact with flowing sediment, but not so high as to remobilize the channel bars (and hence remove the vegetation itself) (Allred and Schmidt 1999). Similar processes have been proposed to explain channel narrowing following introduction of non-native shrubs (Friedman et al. 1996).

The establishment of tamarisk impacts the channels ability to shift morphology from single-thread meandering to braided. This is attributed to the fact that tamarisk stands have a higher stem density than native vegetation, which allows it to be more resistant to removal, by large floods (Pollen-Bankhead et al. 2009). Tamarisk stems change the landscape properties of gravel and cobble islands and bars, as well as those of adjacent channels, by slowing the flow velocities and increasing the force required to remobilize the channel bed, while woody roots increase the bed resistance to mobilization (Cooper et al. 2003). Figure 2.9 provides a characterization of changes in morphology from a wide braided channel to a narrow, reduced width incised channel as tamarisk is established.

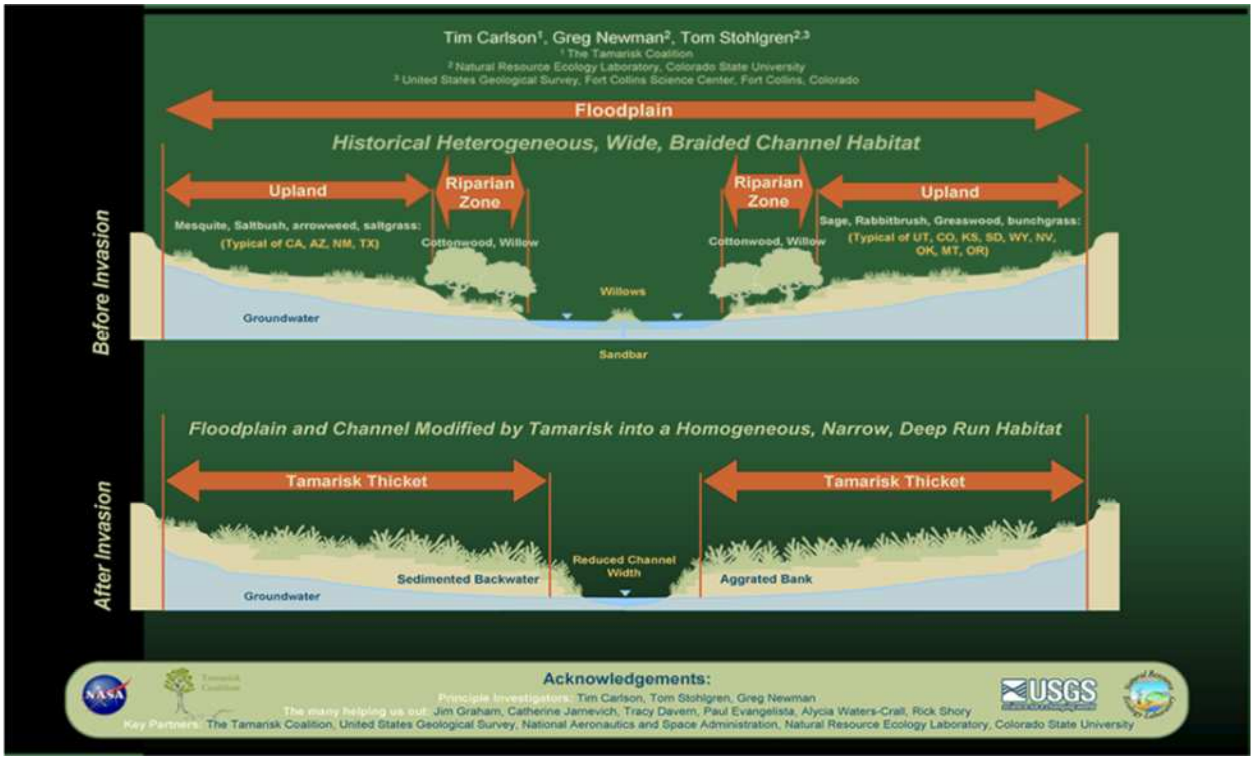

Figure 2.9 Characteristic changes in channel morphology and vegetation as tamarisk is established.

Tamarisk is able to colonize in areas of debris fans and gravel bars exposed at very low flows where no native species are established (Cooper et al. 2003). Tamarisk has facilitated vertical sediment accretion that can lead to bar enlargement, and subsequent channel narrowing (Allred and Schmidt 1999). These processes are evident in both regulated (Lodore Canyon), and unregulated (Yampa Canyon) study areas, showing that tamarisk can change channel and floodplain sediment storage and vegetation patterns along both unregulated and regulated rivers (Cooper et al. 2003).

Channel narrowing along the Green River has been attributed to hydrologic alteration that happened at the same time as the proliferation of tamarisk (Allred and Schmidt 1999). The majority of tamarisk establishment and Green River channel narrowing occurred long before river regulation by Flaming Gorge Dam. Tamarisk initially colonized bare instream sand deposits (e.g., islands and bars), and most channel and floodplain changes followed the establishment of tamarisk (Birken and Cooper 2006).

Another impact of tamarisk establishment related to channel narrowing is the simplification of secondary channels. Allred and Schmidt (1999) found that many of the small islands originally included in their study reach on the Green River became attached to the banks at most discharges because the secondary channels that once surrounded these islands had become constricted, and/or completely filled with sediment. They found that surface area of secondary channels decreased by over 50 percent between 1938 and 1993. Van Steeter and Pitlick (1998) identified similar trends toward channels becoming less complex in some reaches of the Colorado River near Grand Junction, Colorado.

Tamarisk and Russian Olive Management: The specific effects of TRO management on sedimentation and erosion have only been explored by a few. More documentation of erosion following tamarisk management is needed (Hilldale 2007). Specifically, land managers need to understand the impacts of tamarisk management and sedimentation on small reservoirs and other water resources infrastructure (Friedman et al. 2009).

Large-scale TRO eradication has the potential for extreme erosion if revegetation is not accomplished (Friedman et al. 2009). Erosion following tamarisk management should be considered, but not be assumed, because the potential for erosion depends on many factors including soil type, bank height, treatment method and revegetation, morphology of the channel, slope, presence of geologic control, hydrology (controlled or uncontrolled river), and timing of a flood after revegetation (Hilldale 2007). Although TRO management may cause additional sediment load to a river system, the actual impact to a downstream reservoir may be no different over the life of the reservoir; i.e., sediment loads discharged as pulses may be no different than the cumulative sediment loading that would have occurred if TRO had not been established.

Protecting bank vegetation can reduce the risk of erosion in TRO management projects. Erosion following herbicide application is likely to be greatest along flood-prone rivers with sand banks (Friedman et al. 2009). In addition, when TRO mortality is abrupt due to mechanical or chemical control techniques, TRO root stability can decrease quickly (Hilldale 2007). Tamarisk biological control (see Biological Control section) may provide the greatest bank protection. This is because slow mortality of tamarisk in response to beetle defoliation maintains root viability, continuing to provide increased soil strength as other plants colonize under defoliated tamarisk, providing added erosion protection (Hilldale 2007). However, the sediment impacts could be negative if revegetation of the area is not completed (Friedman et al. 2009). Similarly, in New Mexico, the Interstate Stream Commission notes that land disturbance initiated by removal of tamarisk, even while undergoing transition to native plants, can result in significant head-cutting along tributary arroyos. Thus, in areas of sandy/silty soils that occur in much of the Basin, it would seem likely that additional sediment loading will be experienced (Groseclose pers. comm. 2009). When implementing tamarisk management, Friedman suggests avoiding river systems susceptible to erosion, applying herbicide to one small reach at a time, keeping bank vegetation intact, especially willow, and completing quick revegetation of the area.

Sedimentation Conclusions: TRO establishment has played a role in the sedimentation process and morphology of western river systems. TRO management may cause additional sediment load to the Colorado River system. However, over time, this may not be any different from the cumulative sediment loading that would have occurred if TRO had not been established. Methods of TRO management need to be carefully evaluated to determine potential impacts to sedimentation, and inputs to water resources infrastructure prior to implementation (Friedman et al. 2009). A properly designed and implemented project can minimize potential sedimentation impacts.

2.3.3.7 Wildfire Threat

Tamarisk and Wildfire Regimes in Southwestern Riparian Systems: Little information is available on historic fire regimes in southwestern floodplains and riparian areas. No reports of riparian zone fires occur in historical fire accounts of the southwestern U.S. (Zouhar et al. 2008). Dams and diversions, groundwater pumping, agriculture, urban development, and the displacement of native vegetation by invasive exotic vegetation have all contributed to a shift in disturbance regimes on southwestern rivers. Fire has replaced flooding as the major disturbance regime on many southwestern floodplains and riparian corridors (Zouhar 2003; Busch and Smith 1995). Multiple sources report that while fire remains uncommon in tamarisk-free riparian areas, fire frequency has increased in many low-elevation riparian ecosystems where tamarisk has become established (Zouhar 2003; Busch and Smith 1993). Increases in fire frequency have been reported for tamarisk-infested riparian areas across the southwest (DiTomaso 1998), including portions of the Colorado, Little Colorado, Bill Williams, Gila, Virgin Rivers (Busch and Smith 1995), and the Middle Rio Grande Valley (Stuever 1997). Wildfire intensity can be extreme regardless of the time of year (Drus et al. 2009), or greenness of the plant. The costs to fight wildfires can be significant if occurring in urban or other high value areas as experienced near Phoenix in 2008 (see Figure 2.10), and can result in mortality to many native plants such as cottonwoods.

Figure 2.10 Gila River tamarisk wildfire June 2008, Tamarisk adaptations to fire.
(photo credit David Kadlubowski, Arizona Republic)

There is a need for further research on the relationship between tamarisk, Russian olive, and wildfire in southwestern riparian systems. It is unclear whether the presence of tamarisk or Russian olive creates conditions that are conducive to fire, or whether dry conditions and altered disturbance regimes on regulated river systems increase fire risk. In all likelihood, multiple conditions, including flood suppression, water stress, and the replacement of native riparian vegetation by tamarisk and other invasive species, increases the occurrence of fire in southwestern riparian ecosystems (Zouhar 2003). Wildfire impacts include diminished water quality, altered flood regimes, and drier and more saline floodplain environments. Multiple sources note that increased human presence in riparian areas has resulted in increased sources of ignition. Pre-European settlement sources of ignition (i.e., lightning and burning by Native Americans) are now augmented by untended campfires, debris burning, cigarettes, fireworks, equipment, railroads, and fire in surrounding uplands.

Canopy connectivity in dense stands, the growth form of individual trees, and rapid post-fire recovery has been identified as characteristics that make tamarisk a more “fire-adapted” species than native cottonwood or willow. As opposed to open stands of native vegetation, tamarisk can form dense stands of trees with multiple stems, each retaining dry leaf litter and dead branches. This flammable material creates a “fuel ladder” up into the tree crowns of tamarisk (Zouhar 2003), and other tree species present in a mixed stand. It is likely that proximal upper riparian areas (adjacent to river floodplains) also carry an increased risk of fire due to tamarisk, especially those areas where tamarisk has replaced lower-density native vegetation.

While living (fresh) tamarisk foliage contains volatile oils, although it is not considered highly flammable due to its high salt and moisture content (Zouhar et al. 2008; Zouhar 2003; Busch and Smith 1995). However, buildup of dry leaf litter can increase fire frequency along river corridors and floodplains where flow regimes have been altered (Ellis 2001). Natural flooding scours away buildup of dry fuels and debris in riparian areas. Reduced flooding in riparian areas may result in accumulation of a thick layer of combustible material, which can increase wildfire frequency, intensity, and severity (Zouhar 2003; Ellis et al. 1998). Ellis et al. (1998) report that periodic surface moisture from flooding or precipitation increases the rates of decomposition of both cottonwood and tamarisk leaf litter on the soil surface.

Other, highly flammable, exotic, invasive species of vegetation spreading aggressively in southwestern riparian ecosystems include giant reed (*Arundo donax*), red brome (*Bromus madritensis*), and cheatgrass (*Bromus tectorum*).

Response to Fire: Tamarisk vs. Native Vegetation: Data are needed on the responses of both native and exotic plant species to fire in southwestern riparian systems (Ellis 2001). We are unaware of any data available for riparian forests in the Colorado River Basin. However, a study of riparian forest along the Middle Rio Grande Valley is relevant as it addresses similar species. This study (Stuever 1997) revealed high rates of cottonwood mortality in response to fire. Stuever (1997) suggests that Rio Grande cottonwoods evolved in an environment where wildfires were absent or of light intensity, and that traits such as stump sprouting and thick bark evolved in response to stressors other than fire. Native cottonwood (*Populus* spp.) and willow (*Salix* spp.) have the ability to re-sprout from stumps post-fire, but not as quickly as tamarisk recovers by re-sprouting from root crowns (Glenn and Nagler 2005; Zouhar 2003; Ellis 2001). McDaniel and Taylor (2003) reported prolific tamarisk re-sprouting from buried root crowns after a 1986 wildfire in Bosque del Apache National Wildlife Refuge, which resulted in a uniform stand of tamarisk regrowth.

The competitive advantage of tamarisk over cottonwood post-fire is augmented by differences in the timing of seed production. Tamarisk produces large quantities of seed throughout the growing season providing seed source coincident with favorable (moist) germination conditions, over the spring and summer seasons. Cottonwood, on the other hand, produces seed during a relatively brief period in the spring, and is dependent on spring flooding for seedling dispersal and establishment (Zouhar et al. 2008; Glenn and Nagler 2005).

Tamarisk is better adapted to post-fire conditions than many native species. Tamarisk is better able to utilize limited soil moisture, and is more tolerant of elevated levels of salt and mineral nutrients in the soil. Post-fire soil analyses by Busch and Smith (1993) on the Colorado River and Bill Williams River floodplains indicated dryer surface soils, increased soil salinity, as well as elevated levels of phytotoxic boron. While tamarisk can tolerate higher concentrations of boron, other species of vegetation are more sensitive to heavy metal toxicity and elevated soil salinity (Busch and Smith 1993). Predictably, tamarisk and halophytic, drought-tolerant, fire-tolerant shrub species such as saltbush and arrowweed have replaced cottonwood and willow in repeatedly burned, low-elevation riparian plant communities (Zouhar 2003; Busch and Smith 1995). Along the Colorado River, stands of cottonwood which covered over 5,000 acres in the 1600s were reduced to less than 500 acres by 1998 (Zouhar 2003).

Fire as a Management Tool: Tamarisk is one of the only species for which fire has been utilized as a management tool in riparian areas (Zouhar et al. 2008), most often in combination with other control measures. Where tamarisk and native species are present in mixed stands, survival of native species and revegetation are important components of management plans. Due to cottonwood susceptibility to fire, Stuever (1997) argues that where management objectives call for the preservation of cottonwoods, fire should be excluded or carefully managed. As noted earlier, tamarisk can re-sprout vigorously into monotypic stands after fire; thus, fire alone is never recommended, it must be used in combination with either mechanical, chemical, or biological control.

In the context of ecological restoration, dense stands of tamarisk can prevent soil treatments, seedbed preparation, and equipment access (Shafroth et al. 2008). Removal or reduction of woody tamarisk biomass is typically required to facilitate revegetation measures (Shafroth et al. 2008). Prescribed fires are used in the Lake Mead area, for example, in order to reduce aboveground tamarisk biomass and surface litter (Zouhar et al. 2008). Research indicates that tamarisk is most susceptible to fire during periods of moisture stress. Although they are likely to be most effective during the summer months, Lake Mead area burns are typically conducted in the fall to avoid negative impacts to populations of nesting birds (Zouhar et al. 2008). Following controlled burning along the Green River (Ouray National Wildlife Refuge, Utah). Provenza (1982) reported that burning treatments conducted in July prevented 64 percent of tamarisk from re-sprouting, while September/October fires prevented re-sprouting in less than 10 percent of the plants. Ongoing research is underway to determine the optimal phenological stage(s) at which to burn tamarisk to achieve the greatest reductions in canopy, density, and fuel loads (Zouhar 2003).

Controlled burning can be utilized in combination with herbicide, mechanical, and biological control treatments. McDaniel and Taylor (2003) reported that herbicide treatment, followed by a broadcast burn three years later resulted in 93-percent tamarisk mortality six years after the original herbicide application. Comparison treatment, mechanical removal, and burning of slash piles at years one and three, resulted in 97-percent mortality at year six. It is important to note that although both treatments resulted in greater than 90 percent mortality, the costs associated with the mechanical treatment are over five times higher than those of the herbicide-burn treatment (McDaniel and Taylor 2003). Detailed information on fire as a tamarisk control treatment, tamarisk response post-fire, and integrated management combinations of fire, mechanical, and chemical treatments, is available online through the U.S. Department of Agriculture (USDA) Forest Service Fire Effects Information System (Zouhar 2003). Work by Drus et al. (2009) demonstrates that fire following biological control may be an effective way to kill tamarisk and reduce standing biomass. However, timing of this treatment is important. It must be done in the summer when tamarisk are not dormant, otherwise the plant's energy stores are below in the roots, and are not consumed in the fire (Drus pers. comm. 2009).

Russian Olive and Fire in Southwestern Riparian Systems: Russian olive alters the structure of invaded communities by increasing vertical and horizontal canopy density, increasing fuel continuity, and creating volatile fuel ladders (Zouhar et al. 2008; Katz and Shafroth 2003). Russian olive established along the Middle Rio Grande floodplain is described by Caplan (2002) as forming dense, fire-prone thickets that develop into mono-specific stands because of vigorous root-sprout growth following fire.

In the USDA Forest Service Fire Effects Information System, review of Russian olive, Zouhar (2003) states that there is a scarcity of literature addressing Russian olive fire adaptations and post-fire regeneration. Observational evidence, however, indicates re-sprouting from trunk, roots, and root crown in response to dead or damaged aboveground portions of the tree (Zouhar et al. 2008; Zouhar 2003; Katz and Shafroth 2003; Caplan 2002,).

The seeds of Russian olive remain viable longer (up to three years), and germinate under a wider range of conditions than those of cottonwood and other native plant taxa (Katz and Shafroth 2003; Shafroth et al. 1995). In comparison, cottonwood seeds are short-lived, produced in one springtime pulse, and germinate under a narrow range of conditions. Further, Russian olive seeds are bird and animal-dispersed. These characteristics may give Russian olive an advantage in colonizing burned areas.

Wildfire Conclusions: Increased fire frequency and intensity favor tamarisk re-establishment, over less fire-adapted native riparian species, such as willow and cottonwood, which are slower to re-sprout post-fire (Zouhar 2003). Alteration of natural flow regimes (changes in timing, frequency and intensity of overbank flooding) and drier, more saline riparian environments reduce opportunities for recruitment of new cohorts of native cottonwood (Zouhar 2003). It is likely that these factors in combination, favor the replacement of native southwest riparian vegetation by tamarisk.

Russian olive alters the structure of invaded communities by increasing vertical and horizontal canopy density, increasing fuel continuity, and creating volatile fuel ladders (Zouhar et al. 2008; Katz and Shafroth 2003).

Controlled burning can be useful in combination with herbicide, mechanical, and biological control treatments for tamarisk. By itself, fire is a poor management approach for tamarisk because it is better adapted to post-fire conditions than many native species. Although burning may be an effective way to control small Russian olive seedlings, burning alone is not an effective treatment for mature trees, which will vigorously re-sprout following treatment (Tu 2003).

2.3.4 **Wildlife and Sensitive Species**

2.3.5 **Wildlife**

The limited marsh habitat of the Grand Valley is particularly important to species such as the red-winged blackbird *(Agelaius phoeniceus)*, northern oriole (*Icterus galbula)*, song sparrow (*Melospiza melodia)*, and northern harrier *(Circus cyaneus)*. This habitat also provides cover critical for pheasants and other birds but receives limited use by waterfowl because of the limited amount of open water (USDI-BOR 1986).

There are no critical deer and elk winter ranges within the project area. The riparian woodlands, which occur in the floodplains of the Colorado River, occupy less than two percent of the wildlife habitat in the valley, yet they are extremely valuable to wildlife. They support a resident deer herd, and are excellent habitat for furbearers, waterfowl, and numerous non-game birds and mammals. The woodland area is also the most important habitat in the valley for raptors. Songbirds such as the warbling vireo (*Vireo gilvus)* and the black-headed grosbeak (*Pheucticus melanocephalus)* are common in these areas (USDI-BOR 1986).

The river corridor supports a wide variety of wildlife. With improved management, wildlife density and overall biodiversity could be increased. In Colorado, it is estimated that 90 percent of the State's 800 species of fish and wildlife depends on riparian habitat, even though these areas comprise less than two percent of the State (Redelfs 1980; USDI-BOR 1986).

The shrubland habitat in the upper riparian terraces supports homogenous and mixed stands of tamarisk, greasewood, and Russian olive. The shrublands occurring along washes and in small, unfarmed areas near agricultural habitat sustain a local population of deer, particularly in the western end of the valley. This habitat also represents one of the best cover types for Gambel's quail (*Callipepla gambelii*), cottontail rabbit (*Sylvilagus spp*) and pheasant (*Phasianinae*) (particularly during winter periods). Other bird species that commonly use shrublands are the mourning dove (*Zenaida macroura*), western meadowlark (*Sturnella neglecta*), blue grosbeak (*Passerina caerulea)*, lark (*Alaudidae)*, and white-crowned sparrow (*Zonotrichia leucophrys*) (USDI-BOR 1986).

Xeric, upper riparian areas composed mostly of saltbush are of limited value to wildlife due to low food and cover availability and a lack of cover diversity. However, saltbush areas are important to certain species such as the horned lark, prairie dog (*Cynomys*), golden eagle (*Aquila chrysaetos)*, and burrowing owl (*Athene cunicularia*) (USDI-BOR 1986).

Many species of water birds are found along the river, as well as in other areas providing suitable nesting substrate and reliable water. These species include the spotted sandpiper (*Actitis macularia*), mergansers (*Mergus merganser)*, Canada geese (*Branta Canadensis*), mallards (*Anas platyrhynchos*), green-winged teal (*Anas carolinensis*), and others. According to CDOW, late fall and winter inventories in Ruby and Horsethief Canyons find over 500 ducks and fewer geese. Approximately 14 to 20 pairs of geese nest in these areas in the spring, with most nests occurring on the more secluded banks, especially those on islands. Two or more pairs nest on cliffs high above the water (USDI-BLM 2004).

Agricultural habitat is composed of croplands and associated areas of natural vegetation along laterals, drains, and fence lines. This edge habitat is extremely important for species such as Canada geese (*Branta Canadensis*), and mallards (*Anas platyrhynchos*) (USDI-BOR 1986).

2.3.5.1 **Impacts of Invasive Plant Species on Wildlife**

It is commonly assumed that invasive plant species are detrimental to wildlife because they displace native plant species on which animals depend. This is true in many cases, especially when an animal has specialized on a native plant for food or shelter. It is also possible that an invasive will serve as an acceptable substitute for the native plant it displaces and thus have little to no direct or immediate effects on the animal species (however, if an invasive species impacts ecosystem functionality at a landscape level, the animal species may be exposed to indirect effects). Facilitative interactions are also common (Rodriguez 2006) and may occur when the invasive modifies habitat in a manner beneficial to an animal or serves as a food source. Effects of invasive plants on wildlife are diverse and depend on the species considered. There has been considerable debate regarding the wildlife habitat value of tamarisk and Russian olive (Olson and Sferra 2009; Paxton et al. 2007; Dudley et al 2009; and Longland 2009). As with other invasive plants, the habitat value of tamarisk and Russian olive (TRO) will depend on the wildlife species being considered. In addition, the effect of TRO on wildlife will depend on the native plant species that they are replacing. In some areas, TRO may provide better habitat for certain wildlife species than did the native plants that previously occupied the area. However, for many other wildlife species in the same area, replacement of native plants by TRO may prove detrimental (Longland 2009).

Knopf and Olson (1984) have shown that Russian olive stands tend to support less bird species diversity than did stands of native vegetation; however, this effect was not statistically significant. Stoleson and Finch (2001) found that some species of songbirds preferentially placed their nests in Russian olive, however when Southwestern willow flycatchers (*Empidonax trailli extimus*, SWFL) did so, they were more likely to be parasitized by Brown-headed cowbirds (*Molothrus ater*—a brood parasite). Where Russian olive has invaded areas that previously did not support trees, it may provide a nesting substrate for avian nest predators such as magpies (*Cracticus tibicen*). However, Gazda et al. (2002) did not see a significant reduction in duck nest predation rate following Russian olive removal. Given that Russian olive invasion alters the structure of riparian vegetation, and its fruits are a food resource for some animals, it is clear that more research on the interaction between native wildlife and Russian olive is needed.

Tamarisk and Russian olive management will almost always benefit wildlife in the long term when it includes revegetation, either passive or active. Denuded areas rarely support much wildlife, and unless tamarisk and Russian olive is replaced by vegetation of equal or greater habitat value, wildlife will not benefit from control efforts and may in fact be negatively affected. In cases where site characteristics or funding limitations make revegetation impracticable, it may be in the best interest of wildlife to leave tamarisk in place. When control is undertaken, timing control efforts to minimize disturbance to wildlife is an important consideration. In addition, selective removal of patches of tamarisk may afford wildlife some suitable tamarisk habitat while other areas are being restored. Regularly assessing the impact of restoration work on wildlife both during and after a project will allow managers to adjust their current efforts and plan future efforts so as to benefit or minimize detriment to wildlife. If TRO management does not occur, it can be speculated that as infestations expand in the future some species may adapt and do fairly well in a TRO dominated floodplain. Other species, both terrestrial and aquatic, may suffer.

2.3.6 **Fish and Aquatic Life**

Several endangered fish species are found within the project area, including the Bonytail (*Gila elegans*), Colorado Pikeminnow (*Ptychocheilus lucius*), Humpback Chub *(Gila cypha)*, and Razorback Sucker (*Xyrauchen texanus*). These species are discussed in greater detail in the Special Status/Threatened & Endangered Species section below. Tables 2.1 and 2.2 below list the fish species expected to be found within the Colorado River and backwaters, within the project area. Most of the species are categorized as warm- or cool-water fish. Other aquatic life species include frogs, toads, salamanders, and macroinvertebrates (USDI-BLM 2004).

Table 2.1 Native Fishes of the Colorado River that may occur in the project area (USDI-BLM 2004).

Common Name	Family/Scientific Name	Distribution and Abundance
	Catostomidae	
bluehead sucker	Catostomus discobolus	BLM Sensitive Species, widespread, common to abundant
flannelmouth sucker	C. latipinnis	BLM Sensitive Species, widespread, common to abundant
razorback sucker	Xyrauchen texanus	Endangered; incidental
	Cyprinidae	
humpback chub	Gila cypha	Endangered; locally common in Black Rocks and Westwater Canyon
roundtail chub	G. robusta	BLM Sensitive Species, abundant in upper Colorado River; rare in lower Colorado River
bonytail	G. elegans	Endangered; incidental in Colorado River
speckled dace	Rhinichthys osculus	Common and widespread, but not recorded in NCA, needs rocky substrate
Colorado pikeminnow	Ptychocheilus lucius	Endangered; widespread but rare in Colorado River

Table 2.2 Non-native Fishes of the Colorado River that may occur in the project area (USDI-BLM 2004)

Common Name	Family/Scientific Name	Distribution and Abundance
Catostomidae		
white sucker	C. commersoni	Becoming common in many areas
longnose sucker	C. catostomus	Incidental in the Colorado River
white x bluehead	C. discobolus x C. commersoni	Locally common
white x flannelmouth	C. latipinnis x C. commersoni	Locally common
flannelmouth x razorback	C. latipinnis x X. texanus	Rare to incidental
flannelmouth x bluehead	C. latipinnis x C. discobolus	Rare
Cyprinidae		
common carp	Cyprinus carpio	Widespread and abundant
red shiner	Cyprinella lutrensis	Widespread and abundant, especially in low velocity habitats
sand shiner	Notropis stramineus	Widespread and abundant, especially in low velocity habitats
fathead minnow	Pimephales promelas	Widespread and abundant, especially in low velocity habitats
grass carp	Ctenopharyngodon idella	Incidental in Colorado River
Utah chub	G. atraria	Incidental in Colorado River
Centrarchidae		
green sunfish	Lepomis cyanellus	Abundant in riverside ponds; locally common to abundant in parts of river
bluegill	Lepomis machrochirus	Locally common in riverside ponds; also found in river backwaters
largemouth bass	Micropterus salmoides	Common in riverside ponds; locally common in backwaters of CO River
smallmouth bass	M. dolomieui	Incidental in ponds and river
black crappie	Pomoxis nigromaculatus	Locally common in riverside ponds; incidental in Colorado River

Table 2.2 Non-native Fishes of the Colorado River that may occur in the project area (USDI-BLM 2004), cont.

Common Name	Family/Scientific Name	Distribution and Abundance
Ictaluridae		
black bullhead	Ameiurus melas	Abundant in river-side ponds; locally common in river reaches adjacent to ponds
channel catfish	Ictalurus punctatus	Widespread and common to abundant in the Colorado River downstream from diversion dams
Esocidae		
northern pike	Esox lucius	Incidental
Percidae		
Walleye	Stizostedion vitreum	Incidental
Serranidae		
striped bass	Morone saxatilis	Incidental
Cyprinodontidae		
plains killifish	Fundulus kansae	Locally common to abundant in ponds; rare to locally common in river backwaters
Poeciliidae		
western mosquitofish	Gambusia affinis	Locally common to abundant in ponds; rare to locally common in river backwaters

2.3.6.1 Invasive Impacts on Fish

Relative to terrestrial wildlife, much less is known about the impact of tamarisk on aquatic animals. In the upper Colorado River Basin, it has been suggested that tamarisk control may benefit several endangered fish species including the Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*). These species shown in Figure 2.11 may be endangered in part, due to changes in the river's flow regime that have reduced the availability of backwaters, side channels, and bottomlands that are critical habitat (Van Steeter and Pitlick 1998). As discussed elsewhere in this document, these changes in flow regime may promote tamarisk establishment. Tamarisk in turn, further reduces the number of side channels and backwaters by stabilizing banks, and increasing sedimentation and channelization of the river (Graf 1978). Clean gravel and cobble bars, critical for spawning of endangered fish species and other native fish, are stabilizing with tamarisk infestation and the subsequent increase in sedimentation. The results of these studies suggest that removal of tamarisk may improve habitat for the endangered fish species in the Upper Colorado River Basin.

Figure 2.11 Colorado pikeminnow (Ptychocheilus lucius), left Razorback sucker (Xyrauchen texanus), (right). (photos courtesy of U.S. Fish and Wildlife Service)

The river and the riparian vegetation bordering it, are linked via evapotranspiration, nutrient cycling, and leaf litter input (Gregory et al. 1991). Leaf litter is an important source of food and habitat for many aquatic macroinvertebrates, which in turn are an important food source for fish. The Bailey et al. (2001) study comparing macroinvertebrate communities on tamarisk leaf litter to those on native cottonwood leaf litter showed significantly fewer and less diverse macroinvertebrates on tamarisk. The authors suggest that this difference may be due to higher tannin content of tamarisk and the narrow structure of the leaves. How this difference between tamarisk and native leaf litter will scale up the trophic levels is unknown. However, it is possible that if tamarisk is the major source of leaf litter for the river, food resources for fish may be reduced relative to rivers with more native leaf litter. Kennedy et al. (2005) documented an increase in the density of native pupfish in a Nevada desert stream following tamarisk removal. The authors attributed this effect to a reduction in stream shading which promoted growth of algae on which the pupfish feed. These studies demonstrate the cascading effects of tamarisk across trophic levels.

To date, there have been no studies directly examining the impact of tamarisk, and tamarisk management on fish in the Colorado River Basin. The Kennedy et al. (2005) study occurred outside of the Colorado River Basin, and its results may not be able to be generalized as the habitat and fish species studied were unique. To our knowledge, the relationship between tamarisk's ability to alter the structure of stream channels, and its effect on fish has not been studied directly. However as many large scale tamarisk control projects are planned it will be advantageous to examine the impact of these efforts on fish and other aquatic organisms in relationship to the following large-scale endangered fish recovery programs.

2.3.6.2 Special Status Threatened & Endangered (T&E) Fish Species in the Project Area

Established in 1988, the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) is a partnership of public and private organizations working to recover four endangered fish species while allowing continued and future water development. The Recovery Program is coordinated by the USFWS implementing seven major program elements to recover the endangered fish (Valdez and Nelson 2006).The program is working to recover the Colorado pikeminnow**,** razorback sucker, humpback chub (*Gila cypha*) and bonytail (*Gila elegans*) that once thrived in the Colorado River system. Program partners include Federal, state and private organizations and agencies in Colorado, Utah and Wyoming. Recovery strategies include conducting research, improving river habitat, providing adequate stream flows, managing non-native fish, and raising endangered fish in hatcheries for stocking (USFWS 2012).

In the project area Colorado pikeminnow, razorback suckers, bonytail chubs, and humpback chubs occur in numbers well below historic levels. Causal agents include insufficient peak spring runoffs, lack of side channels and backwaters, and the abundance of non-native fish such as channel catfish (USDI-BLM 2004).

Bonytail (*Gila elegans*)

Current Species Status: The bonytail is listed as endangered under the Endangered Species Act of 1973, as amended. The species is endemic to the Colorado River Basin of the southwestern United States. Adults attain a maximum size of about 550 mm total length and 1.1 kg in weight. An unknown, but small number of wild adults exist in Lake Mohave on the mainstem Colorado River of the Lower Colorado River Basin (i.e., downstream of Glen Canyon Dam, Arizona), and there are small numbers of wild individuals in the Green River and upper Colorado River subbasins of the Upper Colorado River Basin (USFWS 2002a).

Habitat Requirements and Limiting Factors: The bonytail was historically common to warm-water reaches of larger rivers from Mexico to Wyoming. Little is known about the specific habitat requirements of bonytail because the species was extirpated from most of its historic range prior to extensive fishery surveys. The bonytail is considered adapted to mainstem rivers where it has been observed in pools and eddies. Similar to other closely related *Gila* spp., bonytail in rivers probably spawn in spring over rocky substrates; spawning in reservoirs has been observed over rocky shoals and shorelines. It is hypothesized, based on available distribution data that flooded bottomland habitats are important growth and conditioning areas for bonytail, particularly as nursery habitats for young. Threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, hybridization, and pesticides and pollutants (USFWS 2002a).

Of five specimens captured recently in the upper basin, four were captured in deep, swift, rocky canyon regions (i.e., Yampa Canyon, Black Rocks, Cataract Canyon, and Coal Creek Rapid), but the fifth was taken in a reservoir (Lake Powell) (USFWS 2002a).

Colorado Pikeminnow (*Ptychocheilus lucius*)

Current Species Status: The Colorado pikeminnow is listed as endangered under the Endangered Species Act of 1973, as amended. The species is endemic to the Colorado River Basin of the southwestern United States. Adults attain a maximum size of about 1.8 m total length and 36 kg in weight. Wild, reproducing populations occur in the Green River and upper Colorado River subbasins of the Upper Colorado River Basin (i.e., upstream of Glen Canyon Dam, Arizona), and there are small numbers of wild individuals (with limited reproduction) in the San Juan River subbasin. The species was extirpated from the Lower Colorado River Basin in the 1970s, but has been reintroduced into the Gila River subbasin, where it exists in small numbers in the Verde River (USFWS 2002b).

Habitat Requirements and Limiting Factors: The Colorado pikeminnow is a long-distance migrator; moving hundreds of kilometers to and from spawning areas. Adults require pools, deep runs, and eddy habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats. Spawning occurs after spring runoff at water temperatures typically between 18°C and 23°C. After hatching and emerging from spawning substrate, larvae drift downstream to nursery backwaters that are restructured by high spring flows and maintained by relatively stable baseflows. Threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, and pesticides and pollutants (USFWS 2002b).

Humpback Chub *(Gila cypha)*

Current Species Status: The humpback chub was listed as an endangered species by the USFWS on March 11, 1967. The humpback chub is endemic to the Colorado River basin. Populations are currently located in the Colorado, Little Colorado, Green, and Yampa Rivers. The largest population is located in the Little Colorado River of the Grand Canyon. The decline of the humpback chub may be due to a combination of factors such as stream alteration (dams, irrigation, dewatering, and channelization); competition with and predation by introduced, non-native fish species; hybridization with other Gila; and other factors. The humpback chub is a medium sized (less than 500 mm in total length), freshwater fish of the minnow family (Cyprinidae), with silvery sides and a brown or olivaceous back (USFWS 1990).

Habitat Requirements and Limiting Factors: Humpback chub in the upper Colorado River (Valdez 1981; Valdez and Clemmer 1982) occupy deep, swift riverine areas. Valdez (1982) and Wick et al. (1979, 1981) found humpback chub in Black Rocks and Westwater Canyons in water averaging 15.2 m in depth with a maximum depth of 28 m. In these localities, humpback chub were associated with large boulders and steep cliffs. Movements of mature-size humpback chub in Black Rocks on the Colorado River were essentially restricted to a 1.6-km reach. These results were based on the recapture of tagged fish and radio telemetry studies conducted from 1979 to 1981 (Valdez et al. 1982) and 1983 to 1985 (Archer et al. 1985; USFWS, 1986) (USFWS 1990).

Adult humpback chub (over 260 mm) were generally captured in water less than 9.1-m deep over silt, sand, boulder, and bedrock substrate and with water velocities usually less than 1,059.6 cubic feet per second (cfs), but use microhabitats with low water velocity, and the young utilize shallow areas (USFWS 1990).

Razorback Sucker (*Xyrauchen texanus*)

Current Species Status: The razorback sucker is listed as endangered under the Endangered Species Act of 1973, as amended. The species is endemic to the Colorado River Basin of the southwestern U.S. Adults attain a maximum size of about 1 m total length and 5 to 6 kg in weight. Remaining wild populations are in serious jeopardy. Razorback sucker are currently found in small numbers in the Green River, upper Colorado River, and San Juan River subbasins; lower Colorado River between Lake Havasu and Davis Dam; reservoirs of Lakes Mead and Mohave; in small tributaries of the Gila River subbasin (Verde River, Salt River, and

Fossil Creek); and in local areas under intensive management such as Cibola High Levee Pond, Achii Hanyo Native Fish Facility, and Parker Strip (USFWS 2002c).

Habitat Requirements and Limiting Factors: Historically, razorback sucker were widely distributed in warm-water reaches of larger rivers of the Colorado River Basin from Mexico to Wyoming. Habitats required by adults in rivers include deep runs, eddies, backwaters, and flooded off-channel environments in spring; runs and pools often in shallow water associated with submerged sandbars in summer and low-velocity runs, pools, and eddies in winter. Spring migrations of adult razorback sucker were associated with spawning in historic accounts and a variety of local and long-distance movements and habitat-use patterns have been documented. Spawning in rivers occurs over bars of cobble, gravel, and sand substrates during spring runoff at widely ranging flows and water temperatures (typically greater than 14˚C). Spawning also occurs in reservoirs over rocky shoals and shorelines. Young require nursery environments with quiet, warm, shallow water such as tributary mouths, backwaters, or inundated floodplain habitats in rivers, and coves or shorelines in reservoirs. Threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, and pesticides and pollutants (USFWS 2002c).

The USFWS enforces endangered fish restrictions require that no work be performed in the active river channel between July 1 and Sept. 30. This would not include riparian restoration activities, only construction work that disturbs the bed of the river (USFWS 2007a).

2.3.7 **Birds**

Riparian habitat is critical for many taxa, including birds. Riparian areas support significantly greater numbers and diversity of birds than do surrounding upper riparians, especially in the arid West. In addition, riparian corridors are critical stopover points during the migration of many birds. Invasive plants, such as tamarisk, are predicted to dominate southwestern riparian ecosystems in 50 to 100 years if they maintain their current rate of spread (Howe and Knopf 1991). This trend has raised concern among wildlife managers and bird researchers that bird populations may be negatively impacted. Because of this concern, there has been more research on the impact of tamarisk on birds than any other wildlife taxa. It is often assumed that tamarisk provides poor habitat for birds. However, research has shown that the impact of tamarisk varies between bird species and depends on the native habitat that is being replaced. Two papers by Sogge et al. (2006) and van Riper et al. (2008) recently addressed this issue.

2.3.8 **Invasive Impacts on Birds**

For many birds, the structure of vegetation is thought to be the most significant characteristic (Hausner et al. 2002; Jones and Bock 2005). Vegetation structure, i.e. height, density, branching patterns, etc. determines in part, its suitability as nesting habitat and foraging habitat. For instance, a cavity nester, like a woodpecker, will not build a nest in a stand of willow shrubs, but will use a dead cottonwood branch. Similarly, a red-tailed hawk (*Buteo jamaicensis*)cannot hunt small mammals concealed beneath a dense tamarisk thicket; rather it hunts over open grassland. When tamarisk structure mirrors that of native vegetation, it may serve as a suitable substitute. For instance, young tamarisk plants are structurally similar to native willow shrubs and are a suitable nesting substrate for many birds that nest in willows. It should be noted, however, that tamarisk structure can vary and thus the quality of habitat it provides will vary. While young tamarisk shrubs resemble willows in having many whip-like stems, older tamarisk are tree-like and may have trunks greater than 12 inches in diameter with a dense canopy of branches. Tamarisk monocultures provide relatively little structural diversity.

Structure is not the only important vegetative characteristic however, and several studies have shown that bird species composition is closely associated with the species composition of the plant community (Walker 2006; Fleishman et al. 2003). Plant species vary in value as a food resource as some produce edible seeds, berries or nectar-rich flowers. Different species of plants may also host different species of insects. The relative importance of plant species composition vs. vegetation structure may depend on the geographical scale being considered (Fleishman et al. 2003).

Many birds are insectivores, thus the insect communities supported by tamarisk will in part determine its ability to support bird populations. Studies comparing insect populations in tamarisk versus native vegetation have yielded varying results in large part due to the collection methods used, vegetation types adjacent to the study area and varying degrees of tamarisk dominance in the tamarisk invaded sites (i.e., monoculture vs. mixed tamarisk-native). In general, tamarisk appears to support an equal, and in some circumstances a greater abundance of insects than native vegetation (Durst et al. 2008). Types of insects supported by the two types of vegetation may vary, but not in a manner expected to affect bird populations. However, Wiesenborn and Heydon (2007) found that tamarisk stands had fewer predaceous insects than did native willow stands. Predaceous insects contain more nitrogen and may have greater nutritional value. Wiesenborn and Heydon's examination of Southwestern willow flycatcher (SWFL) fecal samples suggests that SWFL in tamarisk dominated sites may supplement their diets with insects caught in other vegetation types.

When tamarisk is intermixed with native vegetation and does not form a monoculture, it may be beneficial for many species of birds. On the Lower Colorado River, van Riper et al. (2008) saw a significant increase in the number of birds present as the percentage of native vegetation in these mixed stands increased from 20 to 40 percent. The positive response in bird numbers leveled off at around 60-percent native vegetation. This is described as a "threshold effect" by the authors, who suggest that the most cost effective way to increase bird diversity and abundance in large tamarisk monocultures would be to create a mixed stand by increasing the percentage of native vegetation to 20 to 40 percent. However, mixed native-tamarisk stands (created via natural processes or restoration) may not be climax communities. If tamarisk continues to colonize and out-compete native plants, these mixed stands may become tamarisk monocultures in the future.

The Southwestern willow flycatcher (SWFL)(*Empidonax traillii extimus*, Figure 2.12) was listed as endangered in 1995 primarily due to loss of habitat. The USFWS has identified its critical habitat as that in Figure 2.13. This critical habitat is located in Apache, Cochise, Gila, Graham, Greenlee, Maricopa, Mohave, Pinal, Pima, and Yavapai counties in Arizona; Kern, Santa Barbara, San Bernardino, and San Diego counties in southern California; Clark County in southeastern Nevada; Grant, Hidalgo, Mora, Rio Arriba, Socorro, Taos, and Valencia counties in New Mexico; and Washington County in southwestern Utah (USFWS 2005).

The SWFL breeds in "young" riparian habitat (Paxton et al. 2007) and while historically such habitat was dominated by willow (*Salix* spp.), tamarisk is now extensive in the SWFL's range. Approximately 25 percent of SWFL now breed in mixed native-tamarisk habitat and 25 percent breed in tamarisk dominated habitats (Durst et al. 2006). There is no evidence that SWFL breeding in tamarisk-invaded habitat suffer physiological stress (Owen et al. 2005), reduced productivity or survivorship (Sogge et al. 2008).

Figure 2.12 Southwestern willow flycatcher (Empidonax traillii extimus) (photo USFWS).

Tamarisk provides habitat for the SWFL, and those concerned with the survival of this species fear that tamarisk control efforts will hinder the recovery of the SWFL. Biological control of tamarisk with the tamarisk leaf beetle (*Diorhabda* spp.) has been particularly controversial. In March 2009, the Center for Biological Diversity sued the U.S. Animal and Health Inspection Service (APHIS) and the USFWS for failing to reinitiate Endangered Species Act consultation regarding potential threats to the SWFL resulting from tamarisk biological control (USDCA 2009). When APHIS consulted with USFWS during the tamarisk leaf beetle approval process they assured USFWS that no beetles would be released within 200 miles of SWFL habitat, and that the tamarisk leaf beetle could not become established within the flycatcher's range due to their photo period requirements.

In 2006, the city of St. George, Utah (which is within the range of the SWFL) released tamarisk leaf beetles along the Virgin River and they are now established and spreading in SWFL habitat (Olson and Sferra 2009). There have been anecdotal reports that SWFL nests have already failed as a result of tamarisk defoliation by the tamarisk leaf beetle. The Center for Biological Diversity requests that (1) spread of the tamarisk leaf beetle is monitored, (2) native plants are restored in areas of SWFL habitat where tamarisk has been/may be defoliated, and (3) there be no further introduction of tamarisk leaf beetle within the SWFL's range (Silver 2008). The lawsuit increases the urgency of the need for further research and revegetation efforts. In response to this lawsuit, on June 5, 2009, APHIS at the recommendation of USDA's Office of General Council temporarily suspended current permits and will not issue new permits for interstate beetle distribution. Consultation was reinitiated as of December 2009.

The Tamarisk Coalition is aware of only four bird-monitoring efforts being performed specifically in the context of biological control. One project, in Dinosaur National Monument, is being done by the Rocky Mountain Bird Observatory with funding from the Bureau of Reclamation and the National Parks Service (NPS). At present, three years of data have been gathered. Two other bird monitoring efforts began in Spring 2009, one spanning Western Colorado and Eastern Utah is being performed by the Rocky Mountain Bird Observatory and the Tamarisk Coalition with funding from the Walton Family Foundation. Another study, on the

Figure 2.13 Southwestern willow flycatcher (*Empidonax traillii extimus*) critical habitat(photo USFWS).

Virgin River, is being done by Tom Dudley and Michael Kuehn of the University of California Santa Barbara and collaborators (Dudley and Kuehn, pers. comm. 2009). In 2009, the Utah Division of Wildlife Resources also monitored the SWFL and impacts from biological control on the Virgin River.

Many other riparian bird species besides the SWFL have been observed to nest in tamarisk. Among these is the Yellow-billed cuckoo (*Coccyzus americanus*), which unlike the SWFL, prefers mature riparian woodland and historically nests in cottonwood stands (Hughes 1999). The western U.S. population of this species is a candidate for Federal endangered species listing due to habitat loss. Sogge et al. (2008) lists eleven other species of birds that have been observed to nest in tamarisk-dominated habitats and may experience local declines following tamarisk removal. This list includes several species on the USFWS Birds of Management Concern list and the Partners in Flight Priority Species list such as Summer tanager (*Piranga rubra*), Bell's vireo (*Vireo bellii*) and Lucy's warbler (*Vermivora luciae*).

2.3.8.1 **Special Status Threatened & Endangered (T&E) Bird Species**

Peregrine Falcon *(Falco peregrinus)*

The Federal Endangered Species Act no longer lists this species for protection. This is, in part, due to the perceived success of the species nesting in the McInnis Canyon National Conservation Area (MCNCA). Food quantity has never proven to be a limiting factor for peregrine falcons; thus, human induced disturbance is the management focus for this species. The current level and location of human activity appears to be acceptable (USDI-BLM 2004).

Bald Eagle (*Haliaeetus leucocephalus)*

The slow return of nesting bald eagles (*Haliaeetus leucocephalus)* has been so encouraging that the bald eagle was delisted on July 9, 2007 (Federal Register 2007). The current river recreation and campsite controls are helping bald eagles in Ruby and Westwater Canyons to sustain and expand their population. Protecting the cottonwood riparian areas is integral to the eagle's unremitting recovery. Wildfire is among the biggest threats to that vital habitat. If campfires are controlled, the railroad remains the greatest source of wildfire hazard, abetted by the presence of flammable salt cedars (USDI-BLM 2004).

Other than eagles there are no specific bird nesting dates established, however to avoid nesting activities in riparian areas the USFWS suggests limiting activity from around May 1 until July 30. This should cover most species that would be nesting in riparian areas (USFWS 2007b).

To protect bald eagles, the USFWS suggests using the Colorado Division of Wildlife (CDOW) guidelines that states no activity within one-fourth mile at any time of year and a seasonal closure within one-half mile of nest from November 15 until July 30 (CDOW 2002). There are maybe, two bald eagle nests within the project area. This information is updated annually, and new nest locations may be discovered in the near future as the population continues to expand (USFWS 2007b).

The information below is the official USFWS position. Bald eagles are no longer endangered, though the USFWS suggests that projects avoid disturbance as described below (USFWS 2007b).

Although the bald eagle was removed from the list of Federally listed threatened species, effective August 8, 2007, this species will continue to be protected by the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. Under the Migratory Bird Treaty Act, it is illegal to pursue, hunt, take, capture, kill, possess, sell, barter, purchase, export, or import migratory birds, their parts, nests or eggs, except as permitted by regulation. "Take" is defined under the Migratory Bird Treaty Act as "pursue, hunt, shoot, wound, kill, trap, capture, possess, or collect." The Bald and Golden Eagle Protection Act prohibits the take, possession, sale, purchase, barter, offer to sell, purchase, or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit (16U.S.C 668(a); 50 CFR 22). "Take" is defined as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb" a bald or golden eagle. The term "disturb" under the Bald and Golden Eagle Protection Act was recently defined via a final rule published in the Federal Register on June 5, 2007 (*72 Fed. Reg. 31332*). "Disturb" means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available: (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior (USFWS 2007b).

Southwestern Willow Flycatcher (*Empidonax traillii extimus)*
While the BLM has identified sites along the Colorado River, downstream of the project area as suitable habitat for the southwestern willow flycatcher (*Empidonax traillii extimus)* and has evaluated them with a Biological Assessment (BA) and Biological Opinion (BO), these sites are marginal at best.

The range of the southwestern willow flycatcher in Colorado currently includes the Rio Grande River drainage (San Luis Valley) and the San Juan River drainage. The range boundary used to include the Colorado River and drainages to the south, however, genetic and sonogram analyses determined that willow flycatchers just north of the mainstem Dolores River, and other drainages in the upper Colorado River Basin further north, were the more northerly subspecies *(E. t. adastus)*. Hence, the Southwestern Willow Flycatcher Recovery Team and the USFWS Western Colorado Field Office decided to include drainages only in the San Juan River Basin and Rio Grande River Basin. There is currently no upper elevation limit. Further modifications to the range boundary line and elevation limit may be made upon future scientific information (USFWS 2007c).

Yellow-Billed Cuckoo (*Coccyzus americanus*)
The western population of the yellow-billed cuckoo (*Coccyzus americanus*) is a candidate for Federal Listing. The range of the western yellow-billed cuckoo in Colorado includes all drainages west of the Continental Divide and includes the Rio Grande River drainage (San Luis Valley). Cuckoos inhabit cottonwood galleries with an understory of willows or other shrubs. There is currently no upper elevation limit for the cuckoo in Colorado. The cuckoo has been found at about 7,500 feet in the San Luis Valley. The USFWS Western Colorado Field Office considers cottonwood galleries 10 acres or larger to be suitable for the cuckoo. Cuckoos found in Colorado in the last few years have been in native vegetation. It is unknown if the cuckoo will nest or forage in tamarisk but a cottonwood overstory is necessary for foraging (USFWS 2007).

Thus, the importance of cottonwood galleries within the project area are imperative to support the western yellow-billed cuckoo habitat (USDI-BLM 2004).

Gunnison Sage Grouse (*Centrocercus minimus*)
Range restoration, coordinated with private landowners to the south of the MCNCA, has been very important to the Gunnison sage grouse (*Centrocercus minimus*) on Pinyon Mesa. The grouse species may expand from this range and return to its prior habitat along the northern edge of the MCNCA, at 28-Hole Wash, and the newly acquired sagebrush park to the west. However, The Gunnison Sage-grouse Habitat Assessment conducted in Colorado Canyons National Conservation Area (December 1, 2003, Rocky Mountain Ecological Services, Inc., Redstone, Colo.) found that the understory of sagebrush lands averaged 1 to 3 percent in forb cover and 15 percent in grass cover. This is appropriate for winter habitat but not nesting and chick rearing habitat. Whether livestock grazing or native site potential is responsible for the observed understory was not determined. Only a small percent of the cover was cheatgrass (*Bromus tectorum****))***; but its presence limited the use of prescribed fire, brush beating or chaining as these management activities have a high risk for dramatically increasing cheatgrass. Low slick rock cliffs common around the sagebrush parks provide raptor perch sites and thus reduce the optimum area for wintering sage grouse. The study identified 5,150 acres of potential sage grouse habitat of which 1870 acres (36 percent) met standards for fair to good winter habitat for sage grouse. These standards include at least 15 percent sagebrush cover, an average shrub height of at least 13 inches, a non-severe pinion/juniper invasion and an absence of cliffs in the surrounding vicinity. Sagebrush parks in 28 Hole and the Gore Parcel are large enough to attract sage grouse and now support other sagebrush obligate species. Sagebrush lands on Black Ridge appear large enough but have not proven attractive to sagebrush obligate species. A few sage grouse were recorded in 2003 within a mile of the MCNCA, with acceptable linking habitat between (USDI-BLM 2004).

2.3.9 **Animals and Reptiles**

As discussed above, tamarisk will impact different species of wildlife in different ways depending on their habitat requirements and preferences. The effect of tamarisk replacing native habitat on small mammals and reptiles has not been extensively studied, and conflicting results of existing studies make it difficult to draw general conclusions. A study by Ellis et al. (1997) showed no reduction in species richness of small mammals associated with tamarisk. In contrast, several studies have shown that reptile densities and diversity are lower in tamarisk habitat than in native vegetation (Jackle and Gatz 1985, Jones 1988, Lovich and DeGouvenain 1998). Recent work by Bateman et al. (2008) on the Middle Rio Grande showed that tamarisk control efforts may benefit some lizard species and do not appear to affect snakes or toads. Foraging by bats appeared to increase in areas where tamarisk was controlled, while the abundance of another small mammal, the shrew, was not affected.

2.3.9.1 **Special Status Threatened & Endangered (T&E) Animal Species**

Black-footed Ferret (*Mustela nigripes*)
Following extensive surveys in the 1970s and 1980s, the USFWS determined that no Black-footed ferret (*Mustela nigripes*) population persists in west-central Colorado. While the Black-

footed ferrets have never been documented in the project area, survey records from areas near Meeker, Colorado and Monticello and Vernal, Utah suggest that the species likely occurred in the white-tailed prairie dog (*Cynomys leucurus*)colonies here. Distemper and the plague, epizootic diseases imported by Europeans, could have extinguished the vulnerable population before its presence was recorded. The Cisco population of prairie dogs, located in the MCNCA, has been found suitable for the re-introduction of black-footed ferrets. However, the prairie dog population has since experienced die-offs followed by poor recovery. As a result, the ferret's host species has been labeled as a SSS. The USFWS has been petitioned to list the white-tailed prairie dog as endangered but has not yet acted on this petition (USDI-BLM 2004).

Kit Fox (*Vulpes macrotis*)
A small kit fox (*Vulpes macrotis*) family was found in Rabbit Valley in 1994 and 1995; one of only two sites found in the Grand Valley. Signs were found on 2 Road, immediately north of the MCNCA, by a BLM track-sampling survey. Coyotes (*Canis latrans*) are thought to be this species' primary limiting factor. Kit foxes (*Vulpes macrotis*) need access to a secure food source and optimum den sites to overcome this pressure (USDI-BLM 2004).

2.3.10 **Summary of Special Status Species**

Summary of Special Status Species in the Project Area as of February 2009 (USDI-BLM 2009)
Species Status Occurrence *
Game species have status, but are not included here.
CODES:
FC=Federal candidate for Federal List (ESA)
FE=Federal endangered, Federal Endangered Species Act (ESA)
FT=Federal threatened, under the Federal ESA
S = BLM State Director's sensitive species, Inf. Bull. No. CO-2000-014
sc=Colorado Division of Wildlife Species of Special concern
se = state endangered, protected by Colorado's ESA
st = state threatened, under Colorado's ESA
tr = tracked by the Colorado Natural Heritage Program

MAMMALS
Black-footed Ferret (FE) Re-introducible at prairie dog sites
Gray Wolf (FE,se)
Canada Lynx (FE, se)
Grizzly Bear (FT, se)
Big Free-tailed Bat (FT,se)
Townsend's Big-eared Bat (S,sc)
River Otter (se) Reported above/below the NCA, re-introduced pop.
Kit Fox (se) Rabbit Valley
White-tailed Prairie Dog status pending, colonies struggling with epizootics
Spotted Bat (S) Hypothetical, heard in similar habitat nearby
Fringed Myotis (S) Hypothetical, PJ zone, in similar habitat 24 mi away
Botta's Pocket Gopher (sc)
Northern Pocket Gopher (sc)

Wolverine (se)

BIRDS
California Condor (FE)
Least Tern (FE,se)
Gunnison Sage Grouse (C) Historically present in 28-Hole area
Greater Sage Grouse (FC,S,sc)
Northern Goshawk (S) Especially along Black Ridge in winter
Burrowing Owl (Sst)
Ferruginous Hawk (S) Year-round resident north of Colorado River
W. Snowy Plover (S) Rare migrant, At 6&50 Reservoir May 1 to 4, 2001
Mountain Plover (S) Proposed FT, seen 1 m W of Salt Cr,⅓ m S of I-70
Amer. Peregrine Falcon (S) 6 aeries in the NCA along the Colorado River
Bald Eagle (FT,st) Nest in Ruby Canyon, high winter use from river north
Long-billed Curlew (tr) Scarce migrant, roost in ponds, 6&50 Reservoir
Amer. White Pelican (S)
White-faced Ibis (S) Uncommon migrant, roosts in ponds, 6&50 Reservoir
Brewer Sparrow (S)
Columbine Sharp-tailed Grouse (S,sc)
Gray Vireo (tr) In sparser PJ throughout NCA
Lewis' Woodpecker (P)
Greater Sandhill Crane (sc) Scott's Oriole (P)

HERPETOFAUNA
Boreal Toad (S,se)
Canyon Treefrog (S) All the canyons that have persistent pools
Great Basin Spadefoot Toad (S) Hypothetical, in canyons nearby that are similar
Long-nose Leopard Lizard (S) Especially on greasewood flats
Midget Faded Rattlesnake (S) Throughout NCA except in river and on annual flats
Milk Snake (S) Hypothetical, found just north of M.8 Road
Northern Leopard Frogs (S) May be extirpated

FISH
Colorado Pikeminnow (FE,st) Colo R. is designated Critical Habitat in NCA
Razorback Sucker (FE,se) Colo R. is designated Critical Habitat in NCA
Humpback Chub (FE,st) At Black Rocks in the Colorado River
Bonytail (FE,se) Re-introduced at Black Rocks
Roundtail Chub (S) Colorado River, can be abundant
Flannelmouth Sucker (S) Colorado River and Salt Creek
Bluehead Sucker (S) Colorado River

INSECTS
Minor's Indra Swallowtail (tr) PJ country with Eastwood's lomatium

PLANTS
Colorado hookless cactus(FT)

Parachute beardtongue (FP)
DeBeque phacelia (FP)
Narrow-stem gilia (S)
Jones' bluestar (S)
DeBeque milkvetch (S)
Horseshoe milkvetch (S)
Grand Junction milkvetch (S)
Ferrons' milkvetch (S)
Naturita milkvetch (S)
Fisher milkvetch (S)
San Rafael milkvetch (S)
Grand Junction suncup (S)
Gypsum Valley cateye (S)
Osterhout's cryptantha (S)
Kachina fleabane (S)
Grand buckwheat (S)
Tufted frasera (S)
Piceance bladderpod (S)
Canyonlands biscuitroot (S)
Dolores River skeletonplant (S)
Roan cliffs blazingstar (S)
Eastwood's monkeyflower (S)
Aromatic Indian breadroot (S)
Cathedral Bluff meadow-rue (S)
Adobe thistle(S)

PLANT COMMUNITIES
Cold Desert Shrublands
Gardner's Mat Saltbush Shrublands
Western Slope Grasslands
Western Slope Shrublands
Mesic Western Slope P-J Woodlands
Xeric Western Slope P-J Woodlands
Lower Montane Riparian Shrubland
Montane Riparian Deciduous Forest
Hanging Gardens

The largest Colorado population of the rare plant, Canyonlands Lomatium (*Lomatium latilobum*), which is known only to exist in Mesa County, Colorado and Grand County, Utah clings to the soil around the rock bases at the arches of Rattlesnake Canyon.

2.4 Recreation

Recreation is today's fastest growing use of our public lands. These lands provide an important outlet for our increasingly urban societies and bring tourist dollars to nearby communities. The area has a multitude of uses including: float boating, mountain biking, off road motorized vehicles, hiking/walking/running, horseback riding, rafting/kayaking/canoeing, viewing arches, picnicking, viewing Indian Rock Art, dog-walking, and nature study (USDI-BLM 2004).

Within the Grand Valley, boat launches for rafts, canoes, and kayaks are at the Palisade Riverbend Park, Corn Lake State Park, Broadway Bridge, Connected Lakes State Park, Redlands Parkway Blue Heron Trail, and Fruita State Park. At present, the Loma Boat Launch is under state (CDOW) ownership, and the BLM is authorized to control and manage use of the site through a Cooperative Agreement. The Grand Junction Resource Area Resource Management Plan (RMP) directs the BLM to acquire the Loma Boat Launch should the opportunity arise (USDI-BLM 2004).

Sportsmen account for most of the motorized use, with the highest use occurring during fall waterfowl hunting season with slightly less intensity for deer hunting season and spring/fall fishing. Another emerging motorized activity is the use of personal watercraft (jet skis) (USDI-BLM 2004). Concerns for on-the-river use focus on appropriate motorized use. There are some conflicts that arise with motor craft traveling up-river against the normal traffic. Most of the motorized boats are involved in hunting or fishing activities, making it practical to return to the launch site as opposed to staging 25 miles down-river (USDI-BLM 2004).

Tamarisk is often decried for inhibiting recreational activities in the riparian corridor and degrading aesthetics (Dudley et al. 2000; Haase 1972; Horton and Campbell 1974). However, tamarisk is known to benefit some recreationalists. Russian olive is also known as a physical barrier to many outdoor enthusiasts but is generally thought to be an ornamental that is attractive. Although there is little to no known scientific literature supporting these claims, the experience of many researchers, land managers, river runners, anglers, hunters, hikers, and bird watchers combined define the impacts of TRO, both good and bad, to humans in the outdoors. These impacts are important to consider in restoration projects (Burke pers. comm. 2009).

The most commonly cited benefit of tamarisk to recreationalists is the shade that it provides (Hamilton pers. comm. 2009). Tamarisk's ability to thrive in saline soils (Hem 1967; Wiesenborn 1996; Shafroth 1995); its elevated drought tolerance (Di Tomaso 1998); its ability to quickly resprout following wildfires that remove native species (Glenn and Nagler 2005; Zouhar 2003; Ellis 2001); and its extended seed production (Zouhar 2003) often mean that it is the only plant of shade producing size for miles. In the Southwest, shade can drastically change the quality of any outdoor experience. This benefit seems to be especially important to river runners, who compete to find shaded campsites, tie their boats to tamarisk trunks on the shore, and who travel through areas where rapids force high flows to scour native vegetation to a greater extent.

Many tamarisk removal projects take amount of shade into account when working in high human use areas such as campgrounds or boat launches. Mitigation methods include (1) leaving some tamarisk standing to provide shade, though this increases potential for reinvasion, (2) timing revegetation efforts to allow native vegetation to establish before removing all tamarisk from the area, (3) revegetating with trees, generally cottonwoods, that have larger caliber trunks and that will grow to shade the area more quickly, and (4) building structures to provide shade. Such measures make it possible to thin or control tamarisk stands while maintaining the recreational value of a site. Russian olive trees also provide shade. Monotypic Russian olive stand removal efforts in popular areas should also consider the above options. However, along much of the Colorado River Russian olive growth co-occurs with tamarisk invasion. It has been suggested to remove all tamarisk and leave some larger Russian olives until native vegetation reaches shade producing size as Russian olive are slower invaders than tamarisk.

The negative impacts of TRO to recreationalists are more varied. The dense and widespread growth patterns of tamarisk create physical barriers within the riparian corridor, often completely restricting access to waterways such as rivers, springs, ponds, and lakes. These thickets can also limit access from the water to riverbanks or side canyons, such as those surrounding Lake Powell or along the Colorado River. This limited mobility greatly curtails the activities of recreationalists such as anglers, hunters, river runners, hikers, bird watchers, and boaters (see Figure 2.14).

Figure 2.14 Dense tamarisk and Russian olive infestations on Colorado River, Grand Junction, Colorado.

These bank-invading tendencies have also allowed tamarisk to impede access to or, in some cases, eliminate popular campsites along the river by greatly reducing the number and size of beaches. Many recreationalists have cut camping niches throughout such dense tamarisk stands, in some cases enjoying the extensive shade. However, the area will support fewer campers and presents an alarming risk of wildfire (Invasion on the Colorado [updated 2009]). Dense stands of tamarisk may also facilitate dangerous interactions with wildlife. According to anecdotal reports, dense growth can limit visibility and allow people moving through tamarisk to surprise potentially dangerous animals such as black bears (*Ursus americanus*) (Lauck pers. comm. 2009) or rattlesnakes (*Crotalus spp and Sistrurus spp*) Lair pers. comm. 2008). Hiking through thickets of this dusty and scaly plant can be a difficult and unpleasant experience.

Though not as common throughout the Colorado River system, Russian olive stands can reach densities comparable to tamarisk. These thickets create even more fearsome barriers as their long, sharp thorns make bushwhacking nearly impossible. The trees may create another barrier in the form of irritating allergies. Many locals on the western slope of Colorado complain of strong Russian olive allergies (Swett pers. comm. 2009). The trees are listed by the Allergy Associates of Utah as a springtime allergen (Rogers and Carroll… [updated 2009]).

Though TRO do not universally decrease wildlife abundance and diversity, areas where these species dominate may offer fewer fishing, hiking, camping, hunting, or wildlife viewing opportunities. This is especially true for dense stands where limited visibility inhibits activity and the enjoyment of spectacular western vistas (Dudley et al. 2000; Haase 1972; Horton and Campbell 1974). Though fewer studies have been conducted on the recreational impacts of

Russian olive, it is likely they are capable of similarly degrading riparian areas. For an in-depth discussion of TRO wildlife impacts (see Wildlife and Sensitive Species section).

Aesthetic impacts are more difficult to gauge due to the subjectivity of the topic. Tamarisk were brought to the United States in part to serve as ornamental species (Cronquist et al. 1997, *Tamarix* spp… [updated 2009]). Many people, especially those that have no memory of the river system prior to severe invasions, think these plants are beautiful. Even more popular is Russian olive, a tree many enjoy for its fragrant yellow flowers and sage-like hue. Such realities are especially important for tourism based economies to consider (e.g., Moab, Utah). Tamarisk lines much of the Colorado River that flows by this community and Russian olives line one of its major tributaries, Mill Creek. It is a difficult task for the town to educate a visiting public enjoying the strip of green riverside vegetation about the intricacies of the tamarisk issue. Residents and visitors can be informed of the importance and purpose of TRO management and that negative aesthetic effects can be mediated by planting native species.

The more objective aesthetic realities are the homogenizing, obstructive affects of dense TRO stands. In some areas, these plants are the only species for acres and grow so densely that they can completely hide the Colorado River even when it is flowing yards away. Therefore, it is less a debate of species aesthetics, and more a question of the vegetative composition and viewsheds on a larger scale. In these cases, most people agree that TRO degrade aesthetics.

Recreational Conclusions: TRO do provide some recreational benefit in the form of shade in the absence of native vegetation. However, tamarisk's dense, monotypic growth patterns can block access to waterways, create hazards for river runners, invade popular campsites, and facilitate dangerous wildlife encounters. Likewise, dense Russian olive growth curtails recreationalists' mobility and may exacerbate allergies. Both species impact wildlife, birdlife, fish, and aesthetics directly affecting outdoor enthusiasts as well. The outdoor community and industry provides revenue through tourism and retail outfitters. Additionally, healthy and inviting natural landscapes can create community pride in the river system. Management efforts should consider both potential impacts to recreationalists and potential methods to engage this active community in any management plan.

2.5 Cultural Resources

[this section will be expanded or replaced by the USACE Cultural Resource Survey]

Non-native, invasive plants such as tamarisk and Russian olive alter the vegetative composition of a landscape. This change affects not only ecosystem processes, but also the cultural practices that interact with these processes. Unfortunately, there is little documentation of the impact of invasive species on culture, including impacts of tamarisk and Russian olive. This area of study could greatly benefit from further research that could help define culturally based restoration needs, scope, and goals.

2.5.1 **Background**

The Society for Ecological Restoration's Foundation Documents state that: "A cultural landscape or ecosystem is one that has developed under the joint influence of natural processes and humanimposed organization." They go on to state: "Perhaps all natural ecosystems are culturally influenced in at least some small manner, and this reality merits acknowledgement in the conduct of restoration" (Society 2004 pg 5).

While all landscapes have been impacted by human culture, most contemporary societal practices, ceremonies, and livelihoods in the western United States do not directly depend on their immediate natural surroundings. There is little information describing the cultural impacts that TRO inflict on mainstream culture. For more information on the interactions between people and TRO see the Recreation section of this report. The majority of this discussion will focus on gathering of plant materials (for artistic or practical purposes), as well as Native American, agricultural, or transient populations that are more directly dependent upon or interested in their natural environment.

Little research has been conducted to discover and document any impacts of TRO on culture in part due to the difficulty of assigning quantitative values to cultural practices or to the ease with which they are conducted (Scott-Small pers. comm. 2008). According to Pfeiffer and Voeks (2008), there are three ways that an invasive species can impact cultural practices: a user group is culturally impoverished when native species and their associated cultural practices are reduced or lost; culturally enriched when cultural practices include the invasive species in lexicons, narratives, foods, pharmacopoeias, etc; or culturally facilitated when the invasive species provides continuity and reformulation of traditional ethnobiological practices.

2.5.2 **Gathering of Plant Materials**

The literature and conversations that informed this discussion generally depict TRO as culturally impoverishing species; however, in some cases it may be culturally facilitating. For example, Triassic Stone, an artisan guild in Moab, Utah, that specializes in collecting their own source material in a sustainable way, uses both tamarisk (*Tamarix ramosissima* and *T. chinensis*) and Russian olive in various woodworking projects. Products include bowls, serving trays, chopsticks and tongs. (Figure 2.15) The owner of Triassic Stone finds that while tamarisk wood is beautiful, it is very hard to work with as it cracks significantly when drying during the creation process. He recommends that it only be used for smaller projects such as spoons or cutting boards and even then with caution. Russian olives, being generally larger trees, are easier to work with and can be used for such tasks as flooring, though it is not ideal wood for the task. The wood works easily and is lightweight but strong and durable (Anderson pers. comm. 2009). Other species of tamarisk, *T. aphylla* and *T. gallica*, are listed as plants habitually used by Native Americans. *T. aphylla* serves as fuel wood in the winter and *T. gallica* is an important source of wood and building material (Moerman 1998).

Figure 2.15 Tamarisk Bowl (left), Russian olive tongs (right) *(photos – Triassic Stone).*

2.5.3 **Native American Impacts**

More often, TRO are considered culturally impoverishing species as, "Invasive plants reduce the abundance and health of culturally important native plants by invading sacred landscapes, displacing native plants in traditional gathering sites, and stunting or reducing native plant growth or development" (Pfeiffer and Ortiz 2007 pg 7). Robin Powell, the Nevada Director of Bird Conservation for the Audubon Society who has worked extensively with the Pyramid Lake Paiute Tribe, explains: "the known ecological impacts are transferred to the assumption that invasive plants negatively impact the plant-based cultural resources and cultural practices such as basket making, gathering, medicine, etc." These statements generalize the TRO realities experienced by the Crow, Hopi, and Navajo Nations.

Crow Nation: The Crow Nation is located on the lands surrounding Crow Agency, Montana and is not within the Colorado River Basin but is included here because it is a rare example of documented cultural difficulties with Russian olive. Scott-Small (pers. comm. 2008) is conducting her doctoral research on the cultural impacts of Russian olive growing along the Little Big Horn River within the Crow Nation. She has found that as Russian olive encroaches, locals have to travel further to collect culturally significant native species such as cottonwood (*Populus spp*), willow (*Salix spp*), choke cherry (*Prunus virginiana*), and buffalo berry (*Shepherdia argentea*). Russian olive's hindrance of cottonwood recruitment is especially detrimental to cultural practices as this narrows the range of cottonwood sizes and structures that are required for significant Crow ceremonies (Scott-Small pers. comm. 2008).

Hopi Nation: The Hopi Nation is located in the northeast corner of Arizona and is completely encompassed by the Navajo Reservation. Tamarisk infestations are displacing culturally significant native species on Hopi lands as well. The wetlands of the Hopi Reservation provide water, promote the survival of eagles and hawks, and are necessary for Hopi ceremonial life. However, cottonwoods and willows used in ceremonies are being replaced by tamarisk (Bindell 1996). According to Enrique Salmon, in response to the cultural impacts of tamarisk infestation, Hopi tribal elders are removing stands and revegetating with sand reed (*Calamovila gigantea*), willow, and yucca (*Yucca* spp.). This work is being completed near reservation lands where proximity to the population ensures that the restoration work can be effectively maintained

(Pfeiffer and Ortiz 2007; Pfeiffer and Voeks 2008). Hamann, a graduate student at Northern Arizona University, is exploring similar work in ephemeral and perennial washes on Hopi lands. He is currently studying the ecological and social benefits as well as the economic feasibility of tamarisk removal and biomass utilization (Hamann and Kim 2009).

Navajo Nation: The Navajo Nation is located at the corners of Colorado, Utah, New Mexico, and Arizona, with the majority of its tribal lands lying in Arizona. The Navajo TRO story is very similar to that of the Hopi. These invasive species are choking sources of running water, which exacerbates drought conditions and can affect livestock. The majority of Navajo people keep livestock, and any strain on water resources greatly affects the health of those animals. If water becomes scarce, more time and energy must be spent to haul water to those animals. Additionally, in Canyon de Chelly TRO negatively affect corn, a crop that has great cultural significance for the Navajo. TRO control efforts in Canyon de Chelly have encouraging results as willows are making a strong comeback (Hill pers. comm. 2009). However, while TRO management can improve cultural aspects of the Navajo Nation there is also some concerns about the impact of TRO management on potential increases in bank erosion rates in these areas (Pollen-Bankhead et al. 2009).

There is much discussion throughout the Navajo Nation about how tamarisk removal should be approached. Local tribal chapters are very interested in addressing the invasive weed issue and a Navajo volunteer group is currently working to create a strategic weed management plan to mitigate negative impacts. However, as the Navajo Nation covers a very large area and many diverse environments that require site-specific restoration approaches the plan will not be a simple one. The plan must also strive to work in concert with Hopi TRO removal efforts as Hopi lands are adjacent to Navajo lands. For instance, the Hopi often use cottonwoods in their cultural practices, so the Navajo are considering that in their restoration plans. These restoration efforts must avoid allowing herbicide to contaminate water that Hopi consider sacred. There is interest in tamarisk biological control, *Diorhabda elongata,* as a means of avoiding this issue. Yet, many individuals are seeking herbicide permits to begin control work and the local tribal chapters already have herbicide applicators (Hill pers. comm. 2009).

Other Tribes: Other major tribes and Pueblos in the Colorado River Basin may suffer similar TRO induced cultural impacts. These should be considered in restoration actions and would benefit from additional research.

Ancient Indigenous Art: It is important to note that removing tamarisk may also have culturally impoverishing impacts. Many historically and culturally significant petroglyph and pictograph sites along southwestern river waterways are partially protected from high human traffic by dense stands of tamarisk. Some land managers are concerned that if tamarisk stands are removed in these locations, these sites may suffer damage. However, there are many highly visited, culturally significant river sites that have been well preserved. Interpretive signs and impact education will be necessary at these sites if tamarisk stands are removed to limit potential negative effects.

Another impact of TRO management can be the exposure and/or damage of archeological sites if bank erosion and head-cutting occurs. This could affect the costs for the preservation of these sites.

2.5.4 **Agriculturalists**

Agriculturalists that depend on water quality, quantity, and accessibility for their crops and livestock have a large stake in riparian health. It is apparent that their relationship with TRO is not a simple one as the species alternately impoverish, facilitate, and perhaps enrich their way of life. As such, the impacts to these communities, cultural or otherwise, are important and deserve recognition in the context of restoration needs.

It has been suggested by many that TRO can negatively affect crop cultivation. TRO clog irrigation ditches, decreasing their efficiency and water output. These invasive species also occupy lowland floodplain areas that could be used for crop production.

As mentioned above tamarisk and Russian olive can decrease the availability of water for livestock (Hill pers. comm. 2009). TRO have also been known to form dense barriers limiting livestock access to larger water resources such as rivers or ponds. However, tamarisk stands do provide some cover for livestock (Kearney et al. 1960), and Russian olive are used for windbreaks and erosion control (Christensen 1963; George 1953a, 1953b; Hays 1990). TRO can also serve as browsing material. Though the leaves of tamarisk are generally thought to be unpalatable (Stephenson and Calcarone 1999), cattle and sheep will graze seedlings and mature trees in open stands (Hansen et al. 1995). The nutritional value of tamarisk is not well known and livestock seem to prefer native plants such as cottonwood and willow, giving tamarisk a competitive advantage (Dick-Peddie 1993; Stromberg 1997). Russian olive seedlings can also be browsed by livestock (Borell 1971) and have moderate caloric and protein value (Hansen et al. 1995). Mature Russian olive trees, however, are unpalatable (Katz and Shafroth 2003). TRO are both a source of nectar and pollen for honey bees (*Apis)*. Southwestern beekeepers rely on tamarisk for its nectar and pollen as well as for a refuge from cropland insecticides (Horton 1974). Russian olives are also used for their nectar by honey bees (Katz and Shafroth 2003) but are not as widely known for this use.

2.5.5 **Transient Populations**

In the urbanized areas of Grand Junction some of the dense tamarisk thickets serve as shelter for transient populations. This is somewhat unique to Grand Junction but is considered a phenomenon in urban areas. Often the presence of transients in tamarisk discourages the general public from recreating in and around tamarisk stands due to safety concerns. While these concerns are legitimate and as such should be considered when planning removal activities, consideration must be paid to the transient populations dwelling in tamarisk.

Cultural Resources Conclusions: Cultural impacts of TRO are clearly varied. While TRO generally impede native plant and water related cultural practices, they do provide some benefit in the form of raw wood material, protective barrier, livestock cover, and honey bee nectar/ pollen. These issues deserve consideration in TRO management planning and could benefit from more research.

"What makes ecological restoration especially inspiring is that cultural practices and ecological processes can be mutually reinforcing" (Society 2004 pg 2). In some cases, societies are so closely and reciprocally tied to their landscape that preserving or restoring cultural practices may help to preserve or restore ecological health to the system in a sustainable way (Society 2004). This is a powerful example of approaching restoration work at the level of local partnership and investment to sustain ecosystem health in the long term. As a result, restoration projects that reflect local cultural values could be some of the most effective for sustainable restoration.

2.6 Paleontological Resources

Known fossiliferous formations are located downstream of Loma within the MCNCA and include the Morrison Formation, Burro Canyon Sandstone, and the Dakota Sandstone. The Morrison Formation has consistently yielded dinosaur and other fossils. Fossil locations in the Morrison have yielded many scientifically important fossils, including over 12 varieties of small to large dinosaurs, well preserved varieties of early mammals, eggs, crocodilians, turtles, fish, numerous invertebrates, as well as a variety of fossil wood, pollen and other plant remains. The Burro Canyon Formation in the Wilderness has produced a 115- to 120-million-year-old sycamore, which may be among the world's oldest known plants (USDI-BLM 2004).

2.7 Air Quality

The source of the information on air quality discussed in this section is all derived from USDI-BLM 2004, unless otherwise cited.

The concept of an airshed is similar to that of a watershed, that being a body of air bounded by topographical or meteorological features in which a contaminant, once emitted, is contained. An airshed requires unified management for achieving any air quality goal.

Under the Clean Air Act Amendments of 1990, the U.S. Environmental Protection Agency (EPA) established the National Ambient Air Quality Standard's six criteria pollutants: lead, ozone, sulfur dioxide, oxides of nitrogen, carbon monoxide, and particulate matter smaller than 10 microns in diameter. Mesa County is in attainment with the National Ambient Air Quality Standards.

To protect areas not classified as nonattainment, Congress established a system for the Prevention of Significant Deterioration under the Clean Air Act Amendments of 1977. Areas were classified by the additional amounts of total suspended particles and sulfur dioxide degradation that would be allowed. Class I areas have the greatest limitations; virtually any degradation would be significant. Areas where moderate, controlled growth can occur were designated as Class II areas. Those areas where the greatest degree of impact is allowed are Class III areas. Class I airsheds are geographical areas that Congress defined and designated for special protection from air pollution because of their unique, scenic, or wilderness characteristics. The closest Class I areas to the project area are the Wilderness area of the Black Canyon of the Gunnison National Park located southeast of the planning area; the West Elk Wilderness; and Maroon Bells/Snowmass Wilderness, located east of the planning area.

The state of Colorado established a similar program to the Federal classification system that both limits additional amounts of sulfur dioxide and classifies areas as Category I, Category II, or Category III (corresponding to greater permissible levels of sulfur dioxide).

The Colorado Air Pollution and Prevention Control Act designated all National Parks and National Monuments as Category I. This includes the Colorado National Monument adjacent to the Project planning area. Any Federal activity, either direct or through land-use authorizations, must comply with all local, state, tribal, and Federal air quality laws, statutes, regulations, standards, and implementation plans per the requirements of FLPMA 202(c)(8) and the Clean Air Act 118(a).

Colorado is in the process of pursuing reasonable direction in developing a Regional Haze Implementation Plan for Colorado's twelve Class I areas. In addition to the regulations (40 CFR 51.166) of Prevention of Significant Deterioration of air quality, a State Implementation Plan (SIP) will address the Visibility Standard. (Visibility Standard index [VSI]). The standard for visual air quality is 0.076 per kilometer of atmospheric extinction, which means that 7.6 percent of a light source's intensity is extinguished over a 1-kilometer path. In Denver, a violation occurs when the 4-hour average extinction exceeds the 0.076 standard between 8 a.m. and 4 p.m.

Colorado has three Class 1 areas east of the project area (Flat Tops Wilderness, Maroon Bells-Snowmass Wilderness, and West Elk Wilderness). Four "IMPROVE" air-monitoring sites are located at or near these Class I areas (two at the Flat Tops Wilderness, one at Douglas Pass, and one at the Maroon Bells Wilderness). For viewing data, check out http://vista.cira.colostate.edu/views, see trends, click on "continue," and see the map of IMPROVE sites. Click on any that are of interest and view data through 2002.

The Grand Valley Air Quality Planning Committee, along with the Colorado Department of Public Health and Environment, advises the Mesa County Board of Health. Emissions are regulated by both state and local regulations in Colorado. To protect public health, Mesa County Health Department has a contract with the Colorado Department of Public Health and Environment to enforce state air quality regulations.

The Air Pollution Control Division established two reporting systems to inform the public about air quality conditions. One of those systems, used by the Mesa County Health Department, is the Air Quality Index (AQI) that reports levels of carbon monoxide (CO) and particulate matter smaller than 10 microns (PM-10). Coupled with ozone and particulate matter smaller than 2.5 microns (PM-2.5), these pollutants are of greatest concern in Colorado. Information about individual pollutant concentrations is placed on a scale, known as the AQI scale. The National Ambient Air Quality Standard for each pollutant equals 101 on the AQI scale. AQI reports, greater than 100, exceed a pollutants standard. Hence, condition ratings for the AQI, established by the EPA, are: from 0-50 (Good), 51-100 (Moderate with some visual impacts), 101-150 (Unhealthy for sensitive groups), and 151-200 (Unhealthy for all groups).

Grand Junction has a fully automated air quality-monitoring site at Lincoln Park, located at 12th Street and North Avenue. It is equipped with PM-10 high and low-volume particulate samplers, a CO analyzer, and temperature and wind speed/direction equipment. A Western Slope air watch is in effect during the winter months of November through February. PM-10's include particulate matter smaller than 10 microns and coarse particles dislodged in land disturbance actions such as tilling, development, gravel crushing operations, and dust from roads.

What actually makes air dirty, resulting in visibility impairment, is often caused by fine particles in the 0.1 to 2.5 micrometer size (PM-2.5) range. These particles either scatter or absorb light, impacting a person's view. Sulfate, nitrate, elemental carbon, and organic carbon are the most effective particles at scattering or absorbing light. Geologic dust also decreases visibility in Colorado. Human-made sources of these "PM-2.5's" include wood burning, electric power generation, industrial combustion of coal or oil, agricultural practices, road sanding, and vehicle emissions.

2.7.1 **Clean Air Act Conformity Requirements**

The EPA has promulgated rules that establish conformity analysis procedures for transportation-related actions and for other (general) Federal agency actions. The EPA general conformity rule requires a formal conformity determination document for Federally sponsored or funded actions in nonattainment areas, or in certain designated maintenance areas when the total direct and indirect net emissions of nonattainment pollutants (or their precursors) exceed specified de minimis levels. Since the project area is not within a nonattainment area, Clean Air Act conformity does not apply.

2.8 Water Quality

The source of the information on water quality discussed in this section is all derived from USDI-BLM 2004, unless otherwise cited.

The State of Colorado has established water quality standards for streams in the state-based on existing or potential water uses. The use classifications for the Colorado River mainstem for the reach in the assessment area is Aquatic Life Warm Water 1, Recreation 1a, and Agriculture; while the tributaries to the Colorado River are classified Aquatic Life Warm 2, Recreation 1a, and Agriculture. Aquatic Life Warm Water 1 streams currently are capable of sustaining a wide variety of warm water biota, including sensitive species, or could sustain such biota but for correctable water quality conditions. Class 2 streams are not capable of sustaining a wide variety of warm water biota due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species. The Recreation 1 standard waters are suitable, or intended to become suitable, for recreational activities in or on the water when the ingestion of small quantities of water is likely to occur. The Recreation Class 1a waters are those in which primary contact uses have been documented or are presumed to be present. The agricultural waters are classified for agricultural uses, either livestock watering or crop irrigation. A comprehensive list of standards for physical, biological, inorganic and metals parameters has been established to protect these uses.

This land health assessment is based on water quality collected by USGS at the above mentioned gaging stations. There are limited data available for the Salt Creek station. The data collection period ranges from the mid-1970s to 1998. Generally, data was collected several times each year for pH, hardness, temperature, and the more common ions. Other constituents like heavy metals, pesticides, and herbicides may have as few as one sample. Those data indicate calcium sulfate-type waters. The pH was generally in the 8.1 to 8.3 range, and specific conductance (an indication of the concentration of dissolved solid or salts in the water) ranged between 620 and 9,970 microsiemens. One suspended sediment sample was collected during a high flow event. It had a concentration of 3790 milligrams per liter (mg/l). While these data are limited, they do not reflect violations of water quality standards with the exception of selenium.

The specific conductance ranged between 277 and 1940 microsiemens with sulfate, bicarbonate, sodium and calcium ions comprising most of the dissolved solids. The pH typically ranged between 8.1 and 8.3. Suspended sediment ranged between 10 to over 5,000 mg/L, which equated to 100 to over 180,000 tons per day.

Data comparison, against the standards, indicates compliance with water quality standards, with the exception of selenium. The Colorado 303(d) list identifies those water bodies impaired by one or more pollutants or not attaining assigned use designations. Review of the list substantiates general water quality standard compliance within the project area.

The reach of both the Colorado River and Salt Creek within the planning area is listed for selenium. The Colorado River reach from the Gunnison River to the state line has been sampled 76 times with an ambient level of 5.2 micrograms per liter, while Salt Creek was sampled 37 times with an ambient level of 56 micrograms per liter. The existing chronic for aquatic life standard for selenium is 4.6 micrograms per liter.
While water-use classifications for a portion of the Colorado River Basin are (apparently) being met, there is concern with salinity. The Colorado River Basin Salinity Control Act (Public Law 93-320) was enacted in June 1974. The Act was amended in 1984 by Public Law 98-569. Public Law 98-569 includes directing the BLM to develop a comprehensive program for minimizing salt contributions from lands under its management.

The most important variables influenced by management actions are vegetative cover and compaction. Proper land use, which includes objectives for increasing ground cover, stabilizing stream banks, controlling accelerated gully erosion, and minimizing surface disturbing activities, is the preferred method for achieving salinity control. Effective means of complying with the law include implementing grazing systems, effectively managing off-highway vehicles (OHV) use, controlling recreational activities, managing for properly functioning riparian areas, and restoring degraded areas to improve vegetative cover.

2.9 Groundwater

The source of the information on groundwater discussed in this section is all derived from USDI-BLM 2004, unless otherwise cited.

Groundwater is available in limited quantities in both alluvial and bedrock water zones. The water-bearing formations include, in ascending order, the Wingate Sandstone, Entrada Sandstone, Salt Wash Member of the Morrison Formation, and Dakota Sandstone-Burro Canyon Formations. Except for the Dakota-Burro Canyon, these formations outcrop primarily south of the Colorado River on the Uncompahgre Plateau. The formations subcrop north of the river.

The primary water zone in the project area, based on spring and well data, is the Wingate Sandstone. The Wingate is the cliff-forming sandstone characteristic of the major canyon walls. In the western and southern portion of the Grand Valley, this is the only bedrock water zone present because the younger water-bearing formations are eroded away. The overlying Kayenta is the major outcrop exposure in this area and serves to recharge the underlying Wingate. The unit is recharged through precipitation, streamflow, and snowmelt percolating through overlying formations, as well as along faults cutting the unit. The underlying Chinle forms a relatively impermeable barrier to downward migration of ground water. Ground water in the Wingate may be hydrologically connected with the overlying Entrada Sandstone in areas where both formations are present. The direction of groundwater movement in the Wingate is to the north (downdip), down the slopes of the Uncompahgre and confined by overlying units.

On isolated mesas, the groundwater in the Wingate moves down gradient above the Chinle contact, emerging as seeps or springs where drainages have cut across the contact. The recent spring inventory of the major canyons confirmed that springs emerge from the Wingate, both at the Chinle contact and along bedding planes within the lower part of the Wingate. The spring discharge is generally less than 5 gallons per minute (gpm). Water quality of the springs is excellent (drinking water quality), based on pH and conductivity measurements. Spring data from the adjacent Colorado National Monument also show most of the springs to be discharging from the Wingate Sandstone.

Another regionally important water zone is the Entrada Sandstone, which is exposed in the Glade Park area and along the edge of the mesas above the MCNCA's major canyons. In the eastern portion of the project area, the Entrada underlies surface exposures of the Morrison Formation. In the western and southern portion of the project area, it has been eroded away. Sources of recharge are precipitation, streamflow, and snowmelt, which recharge at the outcrop. Ground water may migrate through the Kayenta, between the Entrada and Wingate. The direction of groundwater movement in the Entrada is to the north (downdip), down the slopes of the Uncompahgre and confined by the overlying Morrison Formation. North of the Colorado River, the Entrada occurs at depths greater than 1,000 feet.

No spring or well data are available for the Entrada water zone within the MCNCA. Most of the Entrada water wells are located on private lands downdip of the Redlands Fault Complex. The few Entrada wells located on the Uncompahgre Plateau have a yield of 2 to 6 gpm, and water quality is excellent.

2.10 Hazardous Materials

The source of the information on hazardous materials discussed in this section is all derived from USDI-BLM 2004, unless otherwise cited.

As defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act of 1986, a hazardous material is a substance, pollutant, or contaminant that, due to its quantity, concentration, or physical or chemical characteristics, poses a potential hazard to human health and safety or to the environment if released into the workplace or the environment.

The Resource Conservation and Recovery Act (RCRA) of 1976, as amended by the Hazardous and Solid Waste Amendments of 1984, defines a hazardous waste as a solid waste or combination of wastes that, due to its quantity, concentration, or physical, chemical, or infectious characteristics, could cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or could pose a substantial present or future hazard to human health or the environment when improperly treated, stored, disposed of, or otherwise managed. A solid waste is a hazardous waste if it is not excluded from regulation as a hazardous waste, if it exhibits any ignitable, corrosive, reactive, or toxic characteristic, or if it is listed in Subpart D of RCRA.

The RCRA requires that hazardous wastes be managed through a recordkeeping system that requires manifesting properly labeled hazardous shipments from point of generation to ultimate disposal. Also required by Federal law are proper labeling, storage, containerization, training, and emergency procedures for hazardous waste.

Materials can leak from improperly closed, improperly removed, or existing storage tanks and can then contaminate ground and surface water. There are no known aboveground or underground storage tanks on public lands in the planning area. No hazardous waste is known to be stored, treated, transferred from, or disposed of on public lands within the planning area. The only hazardous materials that are knowingly used on public lands in the planning area include the occasional use of chemicals for noxious weed control. Occupational Safety and Health Administration (OSHA) regulations for worker safety apply for application of pesticides and herbicides.

2.11 Climate Change

Based on the most recent research and climate modeling, climate change in the Upper Colorado River basin is likely to cause increases in temperatures, reduction in snow pack, earlier snowmelt, and more frequent and longer lasting droughts. Some modeling shows a potential for increases in snow intensity at higher elevations, but shorter winters. The overall result is not entirely clear, however, it is possible that the Colorado River, within the project area, could see increased winter stream-flow, lower and earlier spring run-off, and longer summer and fall low flow conditions. In addition, higher temperatures are anticipated to result in an increase in evapotranspiration (USGCRP). In selecting plant materials to restore the Colorado River through Grand Junction it is important to target plant species that are adapted to the sometimes harsh conditions of the Colorado Plateau ecosystem. These plants must be capable of surviving under many stresses such as drought and high summer temperatures.

2.12 Geomorphic Assessment

This section presents the geomorphic assessment of the Colorado River within the project area based on (1) review of work conducted by others, and (2) a simple analysis of aerial photography dating back to 1937.

2.12.1 **General Overview, Geomorphology**

The project area is divided in two contiguous reaches identified as the 15-mile reach, extending between Palisade and the confluence of the Gunnison River, and the 18-mile reach extending between the confluence of the Gunnison River to the Loma Boat ramp. These segments of the river provide important habitat for endangered fish species and are the focus of many studies, regulations, monitoring and this 206 project. The general pattern of the Colorado River in the 15- and 18-mile reaches is mildly sinuous with minor channel splits and braided like patterns. The 15- and 18-mile reaches are considered geomorphically stable with patterns and position of the channel that are changing relatively slowly (Pitlick 2006). Within the 15-mile reach, the river is confined along the south bank by steep bluffs underlain by Mancos Shale bedrock. In the vicinity of Grand Junction, the channel is also confined in various locations by levees and armored banks as well as Mancos Shale outcrop along the south bank. The north bank is typically low-lying in elevation, and frequently flooded including bottomland sites considered to be important habitats for razorback sucker and Colorado pikeminnow. Along the 18-mile reach the valley is wider although the channel is locally restrained by sections of steep, bedrock underlain bluffs, levees and armored banks.

The floodplain of both reaches is occupied by a mix of urban and rural land uses. The rural areas tend to be agricultural or industrial including gravel mining. Many of these gravel pits have been captured by the river in previous floods (e.g., 1983, 1984). The floodplain and low-lying bar surfaces are covered with a mix of recent and mature vegetation stands, including tamarisk. Sustained low flows during the 2002-2004 drought period may have allowed both native and non-native plants to colonize mid-channel bars and channel banks, areas that would normally be inundated for several weeks during the period of snowmelt, thus normally remaining vegetation free (Pitlick 2006).

The river within the project reach is mostly alluvial in character, although in many places channel banks are formed by either bedrock or artificial revetments (Pitlick 1998b). The average channel width between Palisade and the confluence with the Gunnison River is 440 feet; and from the Gunnison confluence to Ruby-Horsethief Canyon the average width is 574 feet. Depths at bankfull stage range between 8 and 10 feet, respectively (McAda 2003). Pitlick (1998b) provides a number of geomorphic characterizations of the river including: the median grain size of the bed surface material above and below the Gunnison confluence is approximately 2.3 inches (58 mm) and 2.0 inches (51 mm), respectively and typical channel gradients above and below the confluence are 0.00175 (9.2 ft/mile) and 0.0013 (6.9 ft/mile), respectively.

Figures 2.16 and 2.17 present the daily discharge data from two U.S. Geologic Survey (USGS) gages representing the project area. Figure 2.16, Colorado River near Cameo, presents flows in the Colorado River above the Gunnison River confluence for the period from 1933 to 2007 (74 years). Figure 2.17, Colorado River near State Line, presents flows of the Colorado River near the Colorado-Utah state line for the period from 1951 to 2007 (56 years). Figure 2.16 also includes a time line denoting the construction of various upstream dams that potentially affect the reach hydrology.

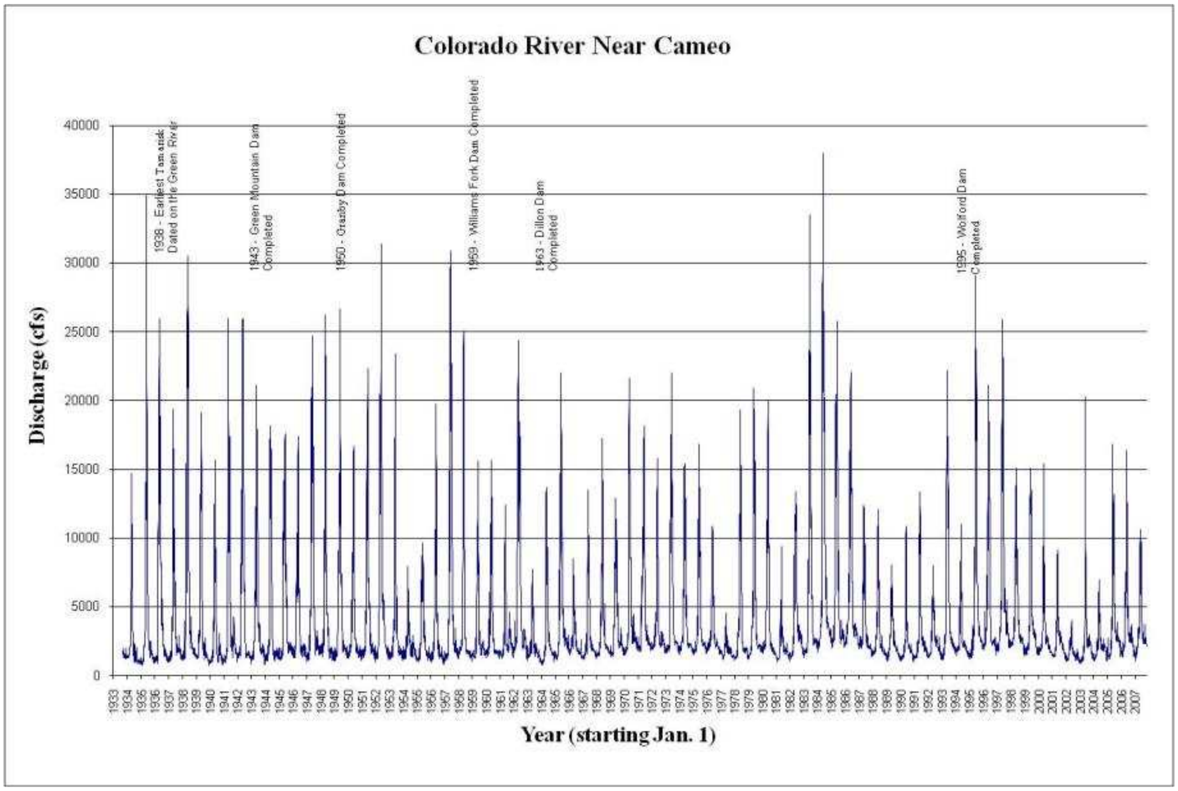

Figure 2.16 Colorado River near Cameo.

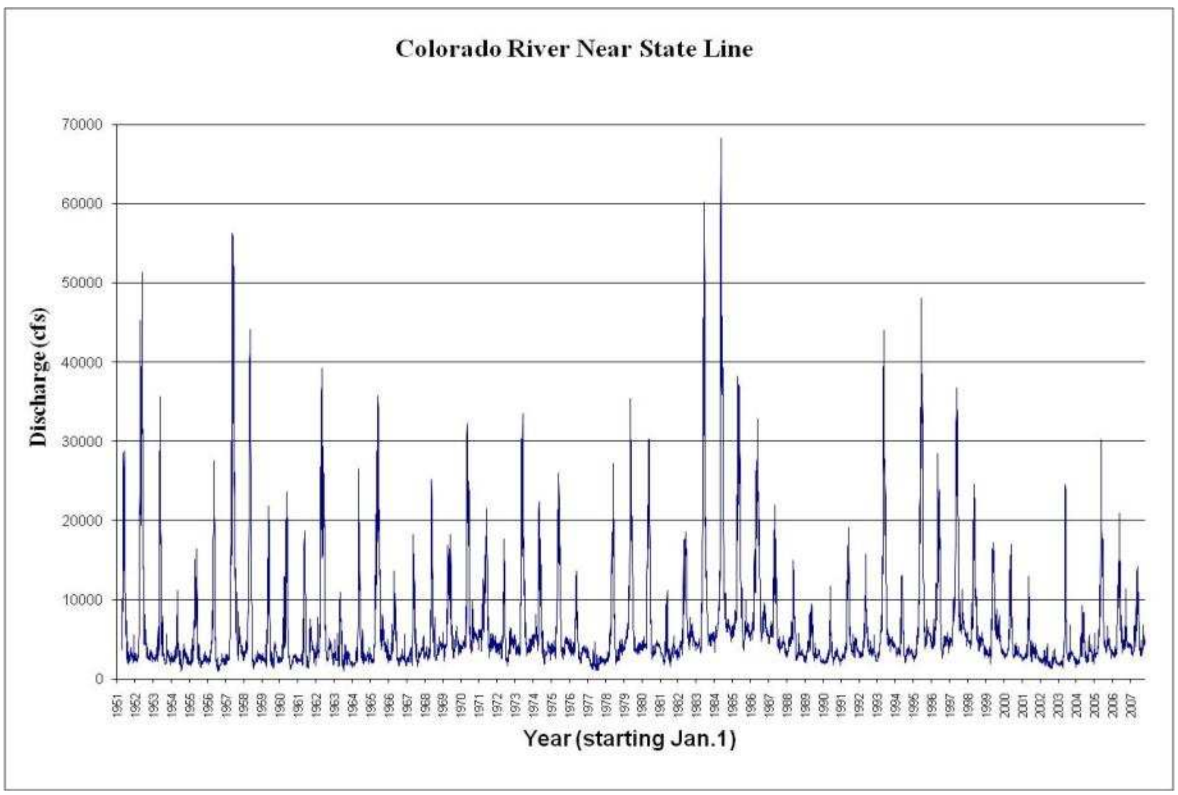

Figure 2.17 Colorado River near State Line.

2.12.2 **Vegetative Changes in Upper Colorado River**

By1950, construction of dams and trans-basin diversions has reduced the annual peak discharges of the Colorado River near Grand Junction by 29 to 38 percent (Pitlick, 1998a). This reduction in peak discharges, has likely been a factor in the colonization by tamarisk of low-lying gravel bars, side channels, and backwater areas. The establishment of this vegetation has stabilized these areas and accelerated sedimentation, resulting in a narrower and less complex channel and the associated loss of valuable fish habitat (Pitlick 2006; Van Steeter and Pitlick 1998).

Channel narrowing and simplification occur through two processes: lateral accretion along the banks, and vertical accretion in side channels. Channel banks and side channels are the most common sites of fine sediment deposition (silt and fine sand), since they are characterized by lower depths and velocities allowing for sediment to build up and vegetation to colonize. Once vegetation is established, it stabilizes the deposits with root systems and further facilitates sedimentation because of the high hydraulic roughness created by the very high stem density. This process is difficult to reverse hydraulically (Pitlick, 1998a). Tamarisk seedling establishment and survival may be facilitated by a large flood followed by three to four sequential low flow years (Cooper 2003).

Most dams that regulate the flows to the area were completed by the 1950s and 1960s. Van Steeter and Pitlick (1998) observed that between 1954 and 1968 the width of the main channel decreased by an average of 29.5 feet (9m) and the width of side channels decreased by an average of 13.1 feet (4m). These changes observed in a little over a decade represent approximately half of the change observed between 1937 and 1993 but occurred in approximately ¼ of the time (Pitlick 1998a). However, narrowing and tamarisk establishment is not limited to regulated rivers (Graf, 1978; Cooper 2006). Cooper dated tamarisk and reviewed aerial images along sections of the Green River between Flaming Gorge Dam and the confluence with the Colorado River. He concluded that the majority of tamarisk establishment and Green River channel narrowing occurred long before the river was regulated by Flaming Gorge Dam (Cooper 2006). He also observed that there was greater post-dam tamarisk establishment on low-lying, in-channel landforms, suggesting that flood peak reductions by Flaming Gorge Dam have likely facilitated establishment of tamarisk on sand and gravel bars and debris fans while curtailing recruitment on higher elevations in the floodplain (Cooper 2006). These observations suggest that channel narrowing and simplification is complex and can occur due to the combined effects of peak flow reduction and tamarisk establishment.

The recent severe drought period has only further exacerbated the problem. Between 2000 and 2004, tamarisk colonized many low-lying bars along the Colorado River within the project area. Prior to 2002-2004 these bars were typically inundated by 3 to 6 feet (1 to 2m) of water during spring runoff and were relatively tamarisk-free (Pitlick 2006). However, once tamarisk becomes established it is robust and able to survive large floods Pitlick observed that spring runoff flows in 1993 and 1995 (approximately the 10-year flood event) were higher than bankfull for several weeks, yet bank erosion was relatively localized and little disturbance was observed to the tamarisk. Thus, it now appears that in the absence of a tamarisk removal program, much higher discharges, (in excess of the 10-year flood event), would be needed to initiate widespread changes in channel morphology (Pitlick 1998b) under the stabilizing influence of tamarisk.

2.12.3 **Aerial Overlay Analysis: Cumulative Changes between 1937 and 2007**

A detailed site-by-site analysis is performed at six sites using aerial images collected from Skippers Island to Palisade (approx. mile 153.9-185.2). The purpose of the review is to more closely examine trends in morphologic changes at a smaller scale. Aerial photographs between 1937 and 2007, as well as several years in between, are reviewed. Not all years are available at all sites.

The six sites are considered to be fair representation of the Colorado River within the project area, as well as the high-priority sites. The sites include Tillie Bishop, Orchard Mesa and Colorado River Wildlife Areas, Watson Island Complex, Walter Walker Wildlife Area, OBY Property and Skippers Island Complex. These sites are typically not within the confined canyon sections of the river and include vegetated banks and/or mid-channel cobble bars.

Figures presented in Exhibit 3 provide an overlay comparing the main channel of the Colorado River in 1937 and 2007. The water surface for each of the years are traced from aerial images in ArcMap. U.S. Geologic Survey gage data provides the discharges on the dates the aerial photographs were taken. The flow in the Colorado River above the confluence with the Gunnison when the 1937 aerial photograph was taken was approximately 2000 cubic feet per second (cfs). Gage data below the confluence at the state line do not exist for 1937. The Gunnison River was flowing at approximately 600 cfs when the 1937 aerial photograph was taken. The exact date of the 2007 aerial photograph is not known; however, it is known that the area was flown around mid-March. During this time, flows ranged from approximately 1,600 to 2,700 cfs in the Colorado River above the confluence with the Gunnison and from approximately 1,300 to 1,800 cfs in the Gunnison River. Discharges for each year were also well below bankfull and within the primary channel, so the difference in discharge between the two years would result in a negligible difference of channel width observed. Pitlick undertook a similar analysis and found that differences in discharge produced negligible error (~3 percent) in measured channel width as long as the difference in discharge is less than approximately 30 percent. (Pitlick 1998, 2006).

The year 1937 is selected to represent river conditions prior to tamarisk colonization. Cooper (2007) indicates that tamarisk entered the area by moving up the Green and Colorado Rivers from Utah. Cooper dated tamarisk along several reaches on the Green River and found that by 1938, tamarisk had progressed as far as Gray Canyon, approximately 90 miles from the Colorado River confluence (Cooper 2006). The confluence of the Green River on the Colorado River is 90 miles from the Colorado-Utah state line. Therefore, it is unlikely that tamarisk had spread to or established itself within Colorado along the Colorado River in 1937. Thus for purposes of this aerial analysis, the 1937 aerial photography is utilized to represent “pre-tamarisk” conditions. The year 2007 is used to represent ‘current’ conditions, utilizing available aerial and topographic mapping from Mesa County.

Overall comparison of the the 1937 and 2007 aerial photographs are indicate the majority of the project area appears to have experienced notable changes along the reach between Skippers Island Complex (mile 153.9) to Tillie Bishop Wildlife Area (mile 185.2). Above and below these points, the river is relatively confined with a minimal amount of lateral movement and a relatively narrower corridor of tamarisk colonization. Between miles 154 and 184.5 however, the river has shortened by approximately one-fourth mile due to straightening and loss of sinuosity. In the period between 1937 and 1993, Pitlick (1998a) observed that the river has narrowed by an average of 65.6 feet (20m) and that approximately one-fourth of the area formed by side channels and backwaters had been lost. In other words, the channel has become narrower and less complex (Pitlick 1998a). Based on field observations Pitlick (2006) believes that the overall morphology of the Colorado River has changed little in the last decade, although relatively aggressive infestation of tamarisk was observed between 2000 and 2004 on cobble bars.

Two examples of significant narrowing and reduction in channel complexity in the 1937-2007 period are the Orchard Mesa (miles 174.1 to 177.1) and Skippers Island (miles 153.9 to 155.8) sites. These areas are discussed in greater detail in the site-by-site analysis in the next section. In some areas, bridges, levees, and bank protection have minimized changes in channel alignment. Watson Island (miles 171.1 to 172.2), which is confined on the left bank by bedrock and two bridges on the downstream end, has remained relatively stable for 70 years. This site is discussed in greater detail in the next section as well.

In other areas, gravel pits, such as those at Walter Walker or Orchard Mesa and Colorado River Wildlife Areas (miles 162.7 and 174.1, respectively) have affected the channel planform by either limiting change in channel alignment through the construction of a levee to protect the pit, or have changed significantly the alignment and planform due to pit capture during large floods. The river in the vicinity of the downstream end of Orchard Mesa has experienced these transitions. Other areas have experienced significant bend migration. One example can be seen at approximately mile 167 where the channel is confined on the left bank by bedrock. The bend at this location has migrated downstream approximately 900 feet since 1937, although further migration is unlikely because of the development of the Redlands parkway and bridge at this location.

2.12.4 **Site-by-site Analysis from Review of Aerial Images**

Aerial photography for Tillie Bishop, Orchard Mesa and Colorado River Wildlife Areas, Watson Island Complex, Walter Walker Wildlife Area, OBY Property and Skippers Island Complex are reviewed for observable changes in morphology and vegetation. Tables 2.3 through 2.8 provide a summary of the morphologic changes, organized by dates, observed from the aerial photographs for each of the six sites. The vegetation cover presented in the tables is approximate and is based on visual inspection of all vegetation shown on the aerial imagery. No attempt is made to distinguish the species. Rather it is intended to be used as a relative gauge of trends in vegetation coverage of the area. Copies of the aerial photographs are provided in Exhibit 3.

A major increase in vegetation, realignment, and narrowing of the channel is observed at this site between 1937 and 2007. The realignment of the channel observed in 1977 appears to be caused by a levee or dam constructed to block the main channel in the Labor Camp area. Other shifts in the channel observed after this construction are most likely caused by the channel reacting to this manmade change. Changes in the past decade have primarily been an increase in vegetation density and a narrowing of the channel. Overall, the channel has straightened slightly since 1937 and narrowed from approximately 250 feet in 1937 to approximately 200 feet in 2007 at river mile 183.8. Also in recent years, the backwater area that was formerly the main channel in 1937 has become almost completely filled in and vegetated.

Table 2.3 Tillie Bishop Wildlife Area Geomorphic Observations (miles 183.0 – 185.2).

Year of aerial photograph	Observations
1937	10-15% vegetation cover, relatively straight channel with some small side channels, one bar on upstream end of site
1954	25-35% vegetation cover, main channel relatively unchanged except for downstream end has been straightened a bit, labor camp development visible
1966	no image available
1977	30-40% vegetation cover, channel alignment changed in areas, upstream end of site still resembles 1937 alignment, mid-site has become narrower and moved south, downstream end/labor camp area has been completely re-aligned to the south – old channel has been abandoned and is now a backwater area – appears to have been blocked by manmade construction-levee, labor camp development no longer exists
1982	40-50% vegetation cover, no other significant changes observed
1983	no image available
1986	80-90% vegetation cover, no other significant changes observed
1994	80-90% vegetation cover, upstream end still resembles 1937 alignment, mid-site channel has moved north and new sub-channel has separated a small part of the Tillie bishop area creating a new small island, downstream end/labor camp: original 1937 alignment is filling in and becoming vegetated, new main channel section relatively unchanged
1997	80-90% vegetation cover, old 1937 channel in labor camp area now almost completely filled in
2001	80-90% vegetation cover, labor camp backwater area (org. channel from 1937) filled in and vegetated, some water in this area – appears to be fed from Grand Valley Irrigation Canal irrigation return, no other significant changes
2005	80-90% vegetation cover, vegetation beginning to move in on the banks
2007	80-90% vegetation cover, vegetation becoming denser on the banks

Table 2.4 Orchard Mesa and Colorado River Wildlife Areas Geomorphic Observations (miles 174.1 – 177.1).

Year of aerial photograph	Observations
1937	20-30% vegetation cover, braided channel with some small side channels
1954	50-60% vegetation cover, no major changes in main channel alignment, two new bars on US end of site
1966	60-70% vegetation cover, some more significant changes in main channel alignment observed mid-site, smaller side channels filling in, braids beginning to disappear, beginning of gravel mining operations observed
1977	45-55% vegetation cover, major gravel mining operations observed have removed much of the vegetation, no major shifts in braiding or main channel alignment since 1966
1982	area now dominated by gravel operations, areas not covered by gravel mining have 75-85% vegetation cover, main channel still follows basic alignment observed in 1977 but braids almost non-existent
1983	large flood has washed out gravel operations immediately adjacent to the river and restored some of the braiding on the downstream end of site where gravel operations once were, flood also washed away much of the vegetation, 40-50% vegetation cover remains, main channel alignment has shifted north through the area of former gravel pits
1986	50-60% vegetation cover, north split on upstream end disappearing, no other significant changes
1994	70-80% vegetation cover, north split on upstream end just about gone and beginning to fill with vegetation, no other significant changes
1997	overall vegetation cover unchanged but denser in the middle of islands and away from banks, banks immediately adjacent to the river are relatively bare, most likely because of the large flows in 1995 and early 1997, no significant changes in channel form
2001	75-85% vegetation cover, vegetation is closing in on the banks, no significant changes in channel form
2005	80-90% vegetation cover, new bridge construction observed on downstream end of site, no other significant changes
2007	80-90% vegetation cover, more vegetation is encroaching the banks, no other significant changes

The presence and distribution of vegetation at this site have fluctuated throughout the years, most likely due to of construction of gravels pits and because of major floods and severe droughts. The site is much more vegetated today than in 1937. The channel planform shifted from a relatively braided channel to a fairly straight and narrow channel, with the exception of the downstream end, where the gravel pits were washed out and restored some of the braiding during the 1983 and 1984 floods. Today, the channel is primarily single thread versus 1937. At the middle of the site (approx. mile 175.5), channel width has decreased from approximately 275 feet in 1937 to approximately 200 feet in 2007.

Table 2.5 Watson Island Complex Geomorphic Observations (miles 171.1 – 172.2).

Year of aerial photograph	Observations
1937	20-30% vegetation cover, two major islands on north side and one smaller bar on south side separated by braided channel
1954	30-40% vegetation cover, south bar has grown considerably in size while northwest island has eroded, upstream end of floodplain corridor narrowed by few hundred feet by industrial development
1966	50-60% vegetation cover, south bar has continued to grow in size and has become vegetated, two islands on north side no longer separated by channel and have eroded to accommodate the growth in the south bar, channel between north islands/bar has narrowed, beginning of gravel mining operations observed
1977	no image available
1982	no image available
1983	40-50% vegetation cover, north and south bars have decreased in size with two new smaller bars forming between them, the upstream end of north bar has been divided by small channels into smaller pieces
1986	no image available
1994	50-60% vegetation cover, two new bars observed in 1983 have disappeared, south bar has grown back almost to sized observed in 1966, no other significant changes
1997	70-80% vegetation cover, vegetation encroachment on banks observed, U.S. end of north bar divided farther into one larger bar and several smaller pieces
2001	75-85% vegetation cover, vegetation is closing in on the banks, no significant changes in channel form
2005	80-90% vegetation cover, continued vegetation encroachment on the banks, some tamarisk removal occurred in 2003 on main island, no other significant changes
2007	no significant changes

The most significant change in this site between 1937 and 2007 is the increase in vegetation cover, possibly due to land use changes in this area (industrial to open space). Other changes seen in the aerial include the conversion of the north split flow channel into a small side channel, and a decrease in channel width, from 500 feet to 300 feet at river mile 171.5. Three islands have shifted in size and position within the floodplain over time; otherwise, the basic configuration has remained the same. Some vegetation loss may have occurred as a result of the 1983 and 1984 floods, however, there is no historical documentation or evidence of notable or severe erosion on the Watson Island complex. The relative stability of this site could be attributed to backwater created by both the Highway 50 and Railroad bridge immediately downstream of the site.

Table 2.6 Walter Walker Wildlife Area Geomorphic Observations (miles 162.7 – 166.4).

Year of aerial photograph	Observations
1937	20-30% vegetation cover, banks very bare, gently meandering channel with a few small side channels
1954	30-40% vegetation cover, bar on downstream end has grown significantly in size, increased sinuosity of main channel since 1937
1966	35-45% vegetation cover, slightly increased sinuosity since 1954, large gravel pits observed inside bend on right bank in floodplain
1977	no change in vegetation cover, most of floodplain inside bend covered by gravel pits, some smaller bars have appeared throughout the site, side channel on left side has been replaced by gravel pits
1982	no image available
1983	no change in vegetation cover, gravel pits have be washed out by large flood and main channel appears to split and flow through former gravel pit, banks mostly cleared of vegetation cover, smaller bare bars throughout the site
1986	no image available
1994	70-80% vegetation cover, dike has been rebuilt, much of former gravel pit that was washed out has mostly filled in and vegetated, river has returned to original alignment, bars that remain have become vegetated
1997	80-90% vegetation cover, no other significant changes
2001	80-90% vegetation cover, vegetation is closing in on the banks, no significant changes in channel form
2005	80-90% vegetation cover, continued vegetation encroachment on the banks, no other significant changes
2007	no significant changes

Between 1937 and 2007, the Walter Walker area has changed slightly in spite of the significant footprint of the gravel pit, and subsequent flooding of the gravel pit by the river. Overall changes to the site include an increase in vegetation, the loss of a side channel on the left side at the downstream end, and the addition of a few vegetated bars on the downstream end. All other sites in the project reach show a significant decrease in channel width, yet the width at this site has remained about the same. The relative stability of this site could be a result of the presence of bedrock on the left bank and the construction of a levee on the right bank. This levee was constructed to separate gravel pits in the area from the river. The river re-captured the gravel pit during the 1983 and 1984 floods. By 1994, the river had returned to its original, 1937, alignment and the area behind the levee had mostly filled in and re-vegetated. In the early 2000s, the levee was notched to allow for some flooding of the area.

This site has remained relatively stable since 1937, possibly because of the presence of bedrock on the left bank. Split flow on the right side has been reduced to a side channel but remains connected to the river. This site appears to have increased in width by approximately 100 feet, at river mile 159.7, since 1937.

Table 2.7 OBY Property Geomorphic Observations (miles 159.0 – 160.7).

Year of aerial photograph	Observations
1937	10-15% vegetation cover, banks very bare, relatively straight, braided channel
1954	20-30% vegetation cover, flow split on right side dried out, some braiding upstream of site has been lost
1966	50-60% vegetation cover, flow split on right side almost completely gone
1977	50-60% vegetation cover, no other significant changes
1982	no image available
1983	50-60% vegetation cover, gravel pits observed, no other significant changes
1986	50-60% vegetation cover, gravel pits have been washed out by large flood, no other significant changes
1994	70-80% vegetation cover, former flow split on right side is now a small side channel and at least partially fed from irrigation return
1997	80-90% vegetation cover, no other significant changes
2001	80-90% vegetation cover, vegetation is closing in on the banks, no significant changes in channel form
2005	80-90% vegetation cover, continued vegetation encroachment on the banks, no other significant changes
2007	no significant changes

Table 2.8 Skippers Island Complex Geomorphic Observations (miles 153.9 – 155.8).

Year of aerial photograph	Observations
1937	25-35% vegetation cover, banks very bare, large islands in center of alignment divided by equally sized channels on each side, north channel appears to be the main flow channel
1954	no image available
1966	no image available
1977	60-70% vegetation cover, significant encroachment of vegetation onto banks, I-70 construction completed, some new ponds observed on islands – may be gravel pits; basic layout of area unchanged since 1937, some minor shifts in the channel, north split no longer main channel
1982	no image available
1983	no significant changes observed
1986	no image available
1994	no image available
1997	80-90% vegetation cover, small channel through center of the island completely filled in and vegetated, entrance to channel on north side of island filled in, making the north channel a backwater area
2001	80-90% vegetation cover, vegetation has closed in on the banks to the edge of water, significant sedimentation throughout the site
2005	80-90% vegetation cover, continued vegetation encroachment on the banks, entrance to north channel now filled in and vegetated, north channel continues to grow narrower
2007	no significant changes

Over the last 70 years, only limited development has occurred in the immediate vicinity of this site, with the exception of the construction of Interstate 70 and some agriculture. Before I-70 was built, the right-side channel bend migrated 300 feet downstream. The width of the floodplain corridor decreased from 3,000 to 2,000 feet after I-70 and agricultural development. An active channel within a wide corridor is seem on the 1937 aerials. The most significant changes since 1937 include increased vegetation, the narrowing of the North Channel, and sedimentation at the entrance, effectively turning the North Channel into a backwater area. Other notable changes include the complete sedimentation and vegetation of the small channel that ran through the center of the island. In addition to construction of I-70, tamarisk invasion and river regulation have contributed to the changes observed at this site. Overall channel width at the middle of the site has decreased from approximately 480 feet in 1937 to approximately 300 feet in 2007 at river mile 154.5 due to sedimentation and encroachment of vegetation onto the banks. This site is another good example of channel narrowing and loss of complexity.

2.12.5 Channel Widths from Aerials

Table 2.9 presents approximate channel widths in 1937 versus 2007 based on review of aerial photography and shows a general trend toward channel narrowing. Federal Emergency Management Agency (FEMA) modeled cross sections collected in 1976 were compared to cross sections surveyed in the early 2000s and generally indicate a channel that is relatively stable or in equilibrium. Channel widths estimated from the aerial review are summarized below. These findings are consistent with Pitlick's findings (1998a) that most of the channel narrowing occurred between 1937 and 1993 and that the river has narrowed by an average of 65.6 feet (20m).

Table 2.9 Colorado River Width Changes since 1937.

River Mile	Segment Name	Approx. 1937 Width (ft)	Approx. 2007 Width (ft)	Change	
				Feet	Percent
183.0-185.2	Tillie Bishop	250	200	-50	-20
174.1-177.1	Orchard Mesa	275	200	-75	-27
171.1-172.2	Watson Island	500	300	-200	-40
162.7-166.4	Walter Walker	275	260	-15	-6
159.0-160.7	OBY Property	360	460	+100	+28
153.9-155.8	Skippers Island	480	300	-180	-38

2.13 Hydrology

2.13.1 Overview

The Colorado River watershed originates in the Rocky Mountains along the continental divide, approximately 200 miles east of the project area. The river generally flows southwesterly across the state, exiting the state at the Colorado-Utah state line 30 miles west of Grand Junction. The total drainage area is about 17,873 square miles (mi^2) at the state line (McAda 2003). The Gunnison River has its confluence with the Colorado River in Grand Junction, midway through the project area. The Gunnison is the largest tributary to the Upper Colorado, with a drainage area of 8,753 mi^2 (McAda 2003). Flood flow on the Colorado River is dominated by snowmelt. Severe flooding can occur when flows from rapid snowmelt are augmented by rain. Flooding is generally characterized by moderate peak flows with large volume over extended periods of time (FEMA 1992b). Note that the hydrology presented in this section is based on existing available information collected over the past 10 to 20 years.

Water resource development projects in the Upper Colorado River and Gunnison watersheds have influenced flow patterns of the Colorado River by reducing peak spring runoff and increasing base flows during the remainder of the year (McAda 2003). Altered flow patterns include changes in the frequency, magnitude, and timing of floodplain inundation (Valdez et al. 2006). Since the mid-1950s, upstream reservoirs and diversions have controlled approximately 45 percent of the annual stream flow (Pitlick et al. 1999). Considerable analyses have been carried out by others to evaluate flow conditions in the project reach and, in particular, regulated flow regimes that exist today.

As previously noted, it is possible that the hydrology of the Colorado River, within the project area, could see climate-related changes including increased winter streamflow, lower and earlier spring runoff, and longer summer and fall low flow conditions. For the purposes of this analysis, and based on what is known at this time, it is not anticipated that climate change will alter the hydrology to such an extreme that it would affect the development and comparison of the alternatives presented in this report.

2.13.2 **Peak Flows**

Log-Pearson III methodology was used in a report prepared for the Colorado River Water Conservation District by Miller Ecological Consultants and Mussetter Engineering, Inc. (Miller 2004) to develop flood frequency curves from annual peak flow records at the USGS Palisade gage (No. 090106000) and the USGS Cameo gage (No. 09095500). These flows are presented graphically in the report and summarized in Table 2.10, below. The values listed in Table 2.10 are estimated from a flood frequency plot and are approximate only. Flood flows are also presented in the Flood Insurance Studies prepared by the Federal Emergency Management Agency (FEMA) for various communities along the project reach. Comparison of the FEMA flows with the Miller report shows that FEMA flows are the larger of the two. The FEMA flows are larger probably because the FEMA study was prepared more than 10 years ago and would not have more recent gage data, most of which represent below average and drought conditions of the early 2000s. The FEMA flows for the major flood events (10-year, 50-year, and the 100-year) are used for this study because: 1) they are of higher magnitudes and thus more conservative in terms of flood analyses, and 2) they represent the current, regulatory floodplain in effect as of the time of this analysis. In addition, only FEMA flows are available for the Colorado River below Gunnison and thus use of FEMA flows for above and below the confluence provides consistency. Comparisons of the Miller flows and FEMA are presented in 1.

Table 2.10 Flood-frequency flows, Colorado River, Q, cubic feet per second (cfs).

Return Period	**10-year**	**50-year**	**100-year**
Source	**Above Gunnison River**		
FEMA, FIS Mesa City	32,900	44,400	49,300
Miller Ecological	28,000	38,000	42,000
Source	**Below Gunnison River**		
FEMA, FIS Mesa City	46,600	66,900	76,000

Flood flows in the Colorado River, for frequent events (1.01- to 5-year events) are also available from previous studies. FLO Engineering estimated flows using gage data from 1950 to 1996 to represent and account for flows from post-water development projects (FLO 1996). Higher frequency, lower magnitude flow estimates are also available from the Miller Report (Miller 2004) upstream of the Gunnison confluence. A comparison of FLO and Miller flows appear to be relatively consistent, especially for the 1.11-year through the 5-year as shown in Table 2.11 below. Flows from the FLO reports are used since they provide data for above and below the confluence with the Gunnison, providing consistency with both sets of data.

Table 2.11 Low-frequency flows, Colorado River, Q, cubic feet per second (cfs).

Return Period	1.01-yr	1.11-yr	1.25-yr	2-yr	5-yr
Source	**Above Gunnison River**				
FLO Engineering	5,320	9,010	11,200	16,500	24,000
Miller Ecological	6,400	10,000	12,000	16,000	23,000
	Below Gunnison River				
FLO Engineering	8,080	13,600	16,700	25,300	37,800

2.13.3 **Monthly Mean Flows**

Monthly mean flows for the Colorado River within the project reach are presented below. Much of this information is obtained from several studies prepared for the Recovery Program (FLO 1997). Monthly discharges are calculated for several sites along the project reach, including both downstream and upstream of the confluence with the Gunnison River. Flows for the upstream reach were derived from calculations for the Grand Valley Irrigation Company (GVIC) diversion dam, located on the upstream end of the project reach. Data used in the GVIC analysis are from the following sources: gauging station information obtained from the USGS, flow data provided by the Colorado Division of Water Resources, flow data provided by the Orchard Mesa Irrigation District (OMID), and information from the BOR and the GVIC concerning operation of the various diversions in the area. The flows obtained from these sources were used to estimate the average monthly flows at the upstream end of the project reach.

Flow duration curves for the upstream reach above the confluence with the Gunnison River were developed using mean daily flow data for 30 years from water year 1965-1966 through water year 1995-1996. Data are not available for 1984-1985 because the gage had washed out at Plateau Creek. The mean, minimum, and maximum of the average monthly flows were determined for all 12 months as well as for the 10-, 20-, 50-, 80-, and 90- percent exceedence flows. These values are displayed in Table 2.12.

A flood frequency analysis was performed for the area downstream of the Gunnison River using data from the USGS gage located at the Colorado-Utah State line (No. 09163500) by FLO Engineering for the assessment of the Audubon bottomlands site (FLO 2001). The period of record used in this analysis spans from 1951 to 1998. The highest peak on record for the gage was 69,800 cfs on May 27, 1984 (approximately 50-year flood), and the lowest annual peak was 5,080 cfs recorded on June 10, 1997. The average annual peak for the period of record was 28,000 cfs. Since the record dates back only to 1951, analysis considering pre- and post-water resources development is not possible. Table 2.13 shows the results of the flood frequency analysis.

Table 2.12 Colorado River monthly mean glows, Water Years 1965-1996 Upstream of the Gunnison River Confluence.

Mean Monthly Flows (cfs)				Mean Monthly Flows Exceedence (cfs)				
Month	Mean	Min	Max	10%	20%	50%	80%	90%
October	1,036	442	2,203	1,732	1,382	1,130	580	533
November	2,338	1,510	3,338	3,005	2,849	2,388	1,863	1,767
December	1,955	1,295	2,576	2,414	2,346	2,043	1,612	1,523
January	1,840	1,259	2,434	2,353	2,173	1,851	1,494	1,449
February	1,838	1,263	2,930	2,349	2,132	1,847	1,457	1,383
March	2,069	866	3,559	2,854	2,553	2,154	1,651	1,334
April	2,037	497	5,783	4,036	2,768	1,863	930	841
May	7,104	1,300	19,887	12,417	10,826	5,510	4,765	3,805
June	10,545	1,507	27,150	20,169	14,321	10,662	5,007	3,816
July	4,655	289	16,176	14,533	7,140	3,940	1,396	1,084
August	1,473	250	5,245	4,131	1,965	1,026	631	556
September	1,030	271	2,832	1,931	1,618	853	616	432

*Data for water year 1984 through 1985 not included due to gage wash out at Plateau Creek.

Table 2.13 Monthly flow statistics by day, Colorado River below Gunnison River, near Colorado/Utah State Line, 1951-1998.

Month	Daily Flow (cfs)			Exceedence for Mean Daily Flows (cfs)				
	Minimum	Mean	Maximum	0.1	0.2	0.5	0.8	0.9
January	1,740	3,767	6,710	5,407	4,798	3,750	2,619	2,328
February	1,860	3,897	7,540	5,557	4,949	3,769	2,807	2,513
March	1,650	4,547	10,600	7,236	6,225	4,508	3,204	2,710
April	1,150	6,566	23,200	11,750	9,076	5,638	3,750	2,729
May	1,590	15,298	68,300	27,852	21,554	12,978	6,784	3,741
June	1,240	18,030	60,200	35,583	26,583	16,303	7,250	5,714
July	1,120	9,075	46,500	18,704	13,883	6,412	3,258	2,590
August	1,050	4,462	14,700	8,068	5,740	3,654	2,634	2,198
September	1,750	4,241	11,300	6,288	5,280	3,838	3,087	2,732
October	1,890	4,527	9,930	6,995	5,705	3,983	3,171	2,907
November	2,050	4,504	9,320	6,317	5,756	4,393	3,330	2,976
December	1,590	4,040	6,940	5,673	5,179	4,057	2,917	2,305

2.14 Sediment Transport

2.14.1 General

As with the hydrologic review, the two studies reviewed for trends in sediment transport include the Miller report, specifically sediment transport analyses prepared by Mussetter Engineering, Inc, (Miller 2004) and Pitlick (Pitlick 2006). Based on the Pitlick (2006) report, the Colorado River carries moderately high sediment loads, with an estimated 1.6×10^6 tons per year at the USGS gaging station near Cameo, Colorado, increasing downstream to about 3.7 x 106 tons per year at the USGS gauging station near the Colorado-Utah state line.

These documents discuss the trends in sediment transport when comparing developed (after dam construction) with undeveloped (pre-dam) conditions in the Upper Colorado River basin. The main conclusion in both reports is that a decrease in the total sediment transport can be attributed to the decrease in annual peak discharges. The reduction in peak discharges was noted by both the Miller (2004) and Pitlick (2006) reports.

> *The results of these channel-maintenance studies indicated that, since 1950, there has been about a 30 percent reduction in the annual peak discharges at the Cameo gage on the Colorado River (Miller 2004.)*

This conclusion is substantiated in the Pitlick (2006) report as stated in the following:

> *Reservoir construction and operations have altered the timing and magnitude of peak flows in the 15- and 18-mile reaches significantly. Since 1950, annual peak discharges of the Colorado River, and its major tributary the Gunnison River, have decreased by 30-40 percent.*

Although the total sediment transport decreased with the decrease in peak discharge, there has not been an appreciable corresponding drop in the suspended sediment portion of the total transport, mainly because the suspended sediment found in the project area is derived from the lower elevations of the Upper Colorado River basin, and transported frequently by summer thunderstorms (Miller 2004). The majority of the contributing lower elevations are located downstream of the regulatory dams and reservoirs and therefore, there has not been an obvious reduction in suspended sediment since the 1950s, as discussed in the Miller (2004) report:

> *The fine sediment is derived from the lower elevations of the UCR basin that are underlain by highly erodible sedimentary rocks. Because of the geologic and climatic settings, the suspended sediment loads in the 15-MR have always been high.*

Of the suspended sediment that is transported through the project reach, approximately 80 percent falls in the size range of silts and clays, with 20 percent consisting of sand (Miller 2004).

2.14.2 **Temporal changes of sediment transport**

The temporal fluctuations of discharge lead to a temporal range of sediment transport. The annual peak discharge typically occurs in the spring during snowmelt runoff from the upper watersheds. Depending on the size of the peak and the duration of the hydrograph, the flows have the transport capacity to mobilize the majority of the bed material (silt, sand, gravel, and cobble), as discussed further in the next section. Pitlick (2006) noted the following concerning suspended sediment.

> *Concentrations of suspended sediment at all gauging stations are consistently higher on the rising limb of the hydrograph than they are on the falling limb. Both sediment and water discharge are highest during the late-spring rise in flow, thus the total annual sediment load is dominated by conditions during this period of time (late May-early June).*
>
> *It is evident that sand has the potential to move either in suspension or in contact with the bed, with the threshold in transport mode occurring at flows between 4,400 to 5,300 cfs.*

The spring runoff hydrograph has the largest transport capacity compared with the remainder of flows throughout the year. In general, the dominant discharge or channel-forming flows occur during the spring runoff.

Isolated thunderstorms also contribute to the annual sediment load. These storms typically convey the smaller material, primarily wash load (sand, silts and fines) that tends to deposit on the falling limb of the hydrographs that are driven by small thunderstorms. Extensive information on the suspended sediment concentrations during the summer thunderstorm activity is not available because of the random nature of the isolated storms, which makes sampling difficult. Miller (2004) offers the following on the seasonal nature of suspended sediment.

> *The suspended-sediment data were segregated into three periods for seasonal analysis: 1) from October 1 to the commencement of the snowmelt runoff, 2) during the runoff period, and 3) the post-runoff period. In general, higher concentrations are associated with the snowmelt runoff period, but the highest values are found in the pre- and post-runoff periods. Analysis of the sand fraction by seasonal time periods shows that the highest sand contents occur in the runoff period (average of 28 percent of the sample), and then to be lower in the pre-runoff period (average 18 percent) and post-runoff period (average 12 percent). The sand-fraction data indicated that in the lower flow periods, the suspended-sediment load is dominated by the silt-and-clay fractions that are primarily responsible for the high turbidity values (Kirk 1988; Davies-Colley and others. 1993.*

Similarly, the Miller report notes that muds are introduced to the river by summer thunderstorms, contributing to deposition and described as follows:

> *The muds (about 40 percent sands and 60 percent silt and clay) that are introduced to the river primarily by summer thunderstorms that have little impact on the discharge in the river after the snowmelt-driven peak flows …tend to deposit on and among the gravels and cobble that form the lower banks, and the low-velocity margins of the bed and bars in the river.*

2.14.1 **Project-specific Conclusions Regarding Sediment Transport**

Streamflow regulations and water management within the project reach have resulted in a 30-40 percent reduction in peak flows in the Colorado River, which in turn have resulted in a reduction in sediment transport since the 1950s (Van Steeter and Pitlick 1998). Fine sediments or mud deposition, however, is less affected from streamflow regulations and water management, since these sediments are typically generated from summer rainstorms and runoff from the lower watershed. Accumulated sediments have narrowed the channel by about 15 percent and eliminated side channels and backwaters (25 percent reduction) and reduced channel complexity (Van Steeter and Pitlick, 1998; Pitlick 2006). Tamarisk are colonizing the side channels, backwaters, channel bars and overbanks. Once the vegetation is established, it stabilizes the deposits with root systems and further facilitates sedimentation because of the high hydraulic roughness created by the very high stem density.

2.15 Flood Flow Recommendations for Habitat Maintenance

Pitlick's work for the Recovery Program focused on the success of fish recovery as a function, in part, of maintenance of and improvements in existing habitats along the Colorado River that have been lost or altered as a result of altered flows from water management in the upper Colorado River basin (Pitlick 2006). The study assessed the effects of coordinated reservoir releases and normal snowmelt flows on geomorphic process in the reaches of the Colorado River in the Grand Valley and recommended flows for future coordinated releases. The study includes several recommendations for flows for habitat maintenance, including volumetric flow rates required (1) to suspend sand and remove deposits from cobble bars on bars, (2) to maintain sediment balance through the project reach, (3) to initiate mobilization of the bed material to move and disturb emerging vegetation such as tamarisk (Pitlick 2006). These flows are summarized in Table 2.14. Note that there is no evidence that these flows can remove tamarisk or should be used as a maintenance tool for future tamarisk removal. However, the goal of this Project is to remove the tamarisk using one of several control means (typically biological, hand control and /or mechanical), and maintain these areas vegetation free so as to make the cobble bars and sediment available for mobility should these flows occur.

Table 2.14 Flood flows recommended for habitat maintenance.

Reach	A: Mobilize Cobble Bars Discharge (cfs)	B : Mobilize Coarse Sediment Discharge (cfs)	C: Sand Suspension Discharge (cfs)
Above Gunnison Confluence (15-mile reach)	21,500	9,800	4,400 to 5,300
Below Gunnison Confluence (18-mile reach)	34,600	19,400	9,700 to 11,700

A: Flows required to mobilize coarse material (cobble and gravel) along the majority of the wet channel bed. Widespread mobilization of coarse substrate is required to create and maintain the suite of habitats used by native fishes.
B: Flows required to mobilize coarse sediment on limited portions of the channel bed to improve riffle and run habitats used by native fishes. This flow inundates most low-lying gravel bars, thus limiting the growth of wood plants, especially tamarisk.
C: Flows required to maintain fine to medium sand in suspension over riffles. This prevents sand from accumulating on spawning bars typically used by the Colorado pikeminnow.

Of particular note are the flows recommended for mobilizing coarse sediment (B category). These flows, are roughly equal to one-half the bankfull discharge, and produce limited entrainment of cobble and gravel sized sediment on the channel bed. Pitlick indicated that … "Partial transport of the bed material is necessary for maintaining clean (silt-free) substrates, especially in frequently used habitats such as riffles and runs; removal of interstitial fine sediment from riffles likewise improve habitat for benthic invertebrates and other native fishes….At these flows framework grains start to move and the potential exists to disturb emerging vegetation such as tamarisk."

In 2004, Mussetter Engineering, Inc. performed a detailed two-dimensional analysis between river miles 179.9 and 180.3, referred to as the Clifton Site (Miller 2004). The study focused on the role of peak flows and base flows on bed material mobilization and deposition, and the removal of fine sediment (mud) from gravel and cobbles. Study results generally indicate the following:

1. Fine sediment is composed mainly of fine sands, silts and clays. This material is delivered to the Colorado River during base flow periods from the lower watershed primarily by summer thunderstorms.

2. Velocity and shear stress thresholds for fine sediment (mud) deposition and erosion are identified from field measurement at the study sites. At locations where velocity and shear stress are higher than 2.5 fps and 0.03 lb/ft^2, respectively, mud is not deposited in appreciable quantities.

3. Critical discharge for incipient motion is about 4,800 cfs in the riffles and 13,000 to 15,000 cfs in the run. (Note that Pitlick's recommendation of 9800 cfs for above the Gunnison confluence falls within the range of critical flows identified by MEI of 4,800 to 15,000 cfs).General mobilization of bed material throughout the site occurs at flows in excess of 20,000 cfs.

4. Mud is re-entrained from depositional locations when velocity and shear thresholds of 2.5 fps and 0.03 lb/ft^2 are exceeded. About 85 percent of the study site was mud-free at a flow of 4,800 cfs.

5. Results of the modeling show that the surficial fine sediment can be re-mobilized and flushed by less than the critical flows for the underlying bed material in the Clifton site.

For the purpose of this analysis, including the Habitat Evaluation Procedure described in Section 5, shear and velocities are evaluated for the 'sediment balance/initial motion discharges' of 9,800 and 19,400 cfs (above and below the Gunnison confluence respectively). These flows are selected as being representative of a generalized flow that provides a balance in sediment over the long run by re-mobilizing surficial fine sediment while also potentially limiting the growth of non-native vegetation, primarily tamarisk. Although use of a single flow for representation of these hydraulic conditions is a simplification given that not all cobble bars are represented by these average conditions, it does provide a relatively equitable level of comparison for which to weigh the relative scale of improvements at each segment and between alternatives.

2.15.1 **Flow Recommendations by the Upper Colorado River Endangered Fish Recovery Program**

In February 2006, the Upper Colorado River Endangered Fish Recovery Program released its Floodplain Management Plan (Valdez 2006) which included flow recommendations to be implemented through coordinated reservoir operations. The plan addressed the need for flows, including peaks, duration, and timing, for the benefit of the endangered fish. The recommended flows are for peak spring runoff at the Colorado-Utah state line. Target flows and duration vary from 5,000 to 69,800 cfs, depending on the hydrologic category for the year (wet years and dry years). These flow ranges cover all three categories presented by Pitlick, as well as the flows determined for the 1.01-year through the 5-year events presented above.

One of the fundamental bases of the Upper Colorado River Recovery Implementation Program is that frequent floodplain connectivity provides nursery habitat for the razorback sucker and that restoration of these floodplains and connectivity will assist the recovery of the endangered and native fish species (Valdez et al. 2006). To that end, coordinated reservoir releases are being implemented with target flows as noted, to improve connectivity as well as provide channel bed mobilization and sediment transport that will maintain and improve habitat critical for fish recovery. Releases are also intended to mobilize sediments to prevent colonization of non-native plants, particularly tamarisk.

2.15.2 **Maintenance Issues of Cobble Bars**

The successful long-term benefits from this project rely on the maintenance of tamarisk-free cobble bars. This will require maintenance on a periodic, regular basis for several reasons. First flows of sufficient volumetric rates for partial mobilization (incipient motion) typically occur during the snowmelt runoff period while the majority of fines are introduced during the low-flow summer season by thunderstorms, thereby creating a lag or time period during which tamarisk could potentially initiate colonization. This is of particular concern when associated with multiple dry and below-average spring runoff conditions. Secondly, once tamarisk colonizes it is less likely that the bankfull or annual flows alone will remove new growth. Higher flows (in excess of the 5-year event) are likely required to mobilize bed material and create scoured and undercut banks, to naturally maintain clean cobble bars. Thus, in combination with or in lieu of high flows, maintenance will be required, and is proposed as an integral component of this project. Maintenance will be performed using a variety of techniques including continued biological control, hand control and mechanical removal, all as required and appropriate for various levels of infestation and the particular segment area. See section 5.1.8 for further discussion on the details of operation and maintenance.

2.16 Hydraulics

2.16.1 **Flood Hydraulics**

As tamarisk removal proceeds (either biologically or by hand), some areas will not be revegetated (bars) or other areas will receive replacement vegetation that includes native plants in the understory, wetland species, and riparian species such as willows, cottonwood, sumac, sedges and grasses. None of these species is expected to significantly alter the channel roughness or the hydraulic parameters of the channel banks and overbanks of the specific reaches compared to those seen with light to moderate tamarisk infestation. The presence of tamarisk likely caused some localized increase in roughness, and sediment deposition producing potentially higher flood elevations. However, in terms of the effective, regulatory FEMA floodplain elevations, the original studies were conducted prior to the significant infestation seen following the mid 1980s floods. Thus, regulatory elevations are generally reflective of conditions that are anticipated to be achieved in the restored conditions of this project area.

It is also possible that there may be some temporary elevated levels of sediments that have accumulated in the tamarisk-infested areas, which may be released following tamarisk removal. It is anticipated that this should be somewhat tempered by the non-catastrophic nature of defoliation, extending over a 3- to 5-year period, coupled with the simultaneous revegetation process occurring in concert with the defoliation of tamarisk. Following stabilization the project site is anticipated to more closely resemble the native or non-tamarisk condition which includes an active and dynamic floodplain and high sediment loads for which this river is noted.

Because the 10-, 50-, and 100-year flows are already computed and the 100-year floodplain is delineated by FEMA, they are not repeated in this 2006 study. The FEMA study is available for the entire project reach and includes the 10-, 50-, 100-, and 500-year flood events. Flood profiles and summary tables from the Mesa County FIS are included in Exhibit 4**.** The high-priority sites are superimposed on these profiles. The FEMA cross sections are also shown on the project maps in Exhibit 1.

2.16.2 **Channel Bank Stability**

Removal of tamarisk and Russian olive will likely create some bank instabilities and increase bank retreat rates as compared to current conditions. In some locations, this is desirable and consistent with the objective of this restoration project. Many of these banks have been transformed by tamarisk from a dynamic and highly mobile system to a rigid, vertically accreted bank. There are, however, several locations within the project area with steep and eroding banks that are relatively close to infrastructure, roads, highways or other development. Should the bank regress landward, there is the potential for impacts to these facilities. Based on field observations there are six locations that fit this description. All six of these locations have some existing armoring. No vegetation removal or habitat restoration is proposed for these sites and all six sites are excluded from the project footprint.

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3.0 BASIS OF DESIGN

Proposed restoration elements for the project segments have many common elements and share many of the same technologies. The following section describes technologies and procedures that are generally common to all segments, presented in the following categories: control of invasive species, biomass reduction and revegetation; approaches to habitat restoration; and elements proposed for recreational improvements within the project footprint.

Section 3 also includes a description of proposed restoration at Walter Walker (Segment 10), the only segment with construction proposed for the purpose of providing improved habitat for the Colorado River endangered fish. Elements here include ponds and backwaters to create and improve the bottomlands areas, and reconstruction of the existing dike to increase seasonal flows through the bottomland site. Improvements at Walter Walker also include biomass reduction and revegetation; habitat restoration; and recreational improvements.

3.1 Overview of Technology for Tamarisk Control, Biomass Reduction and Revegetation

Management of non-native phreatophytes consists of four basic components: (1) control work, (2) biomass reduction, (3) revegetation, and (4) long-term monitoring and maintenance. Components 1 through 3 will be discussed in detail below as part of this Project; component four is a long-term responsibility of the project's local sponsor and is addressed in Section 5.. The intent of invasive species management is to ensure that selected approaches are effective and efficient, and that decisions are well-documented. Successful management will also remain open to new or altered approaches based on the latest information, technology, or experiences; i.e., adaptive management.

The following discussion addresses options for the control, biomass reduction, and revegetation management components. All restoration technologies will be implemented within the 100-year floodplain of the Colorado River. All currently available technologies have been evaluated; however, not all are applicable for this section of the Colorado River. For example, biomass reduction and revegetation are not always necessary. In many situations, biomass levels may be very low and natural revegetation can occur.

Tamarisk is the focus of this management plan's control component because it is the principle non-native phreatophytes in the Colorado River watershed. In general, the following discussion applies to Russian olive and other invasive trees but may differ slightly for each (e.g., herbicide used). The definitions used within this project for the three relevant restoration components are:

1. <u>Control</u> refers to the removal of invasive species such as tamarisk, Russian olive, and others, using hand, herbicide, mechanical, or biological methods of removal.
2. <u>Biomass reduction</u> is the removal of dead biomass through mechanical methods, natural decomposition, or controlled fire.

3. Revegetation refers to the reestablishment of native grasses, shrubs, forbs, wetland species, and trees on disturbed areas through seeding, planting, or enabling natural regeneration to occur.

3.2 Tamarisk and Russian Olive Control

Tamarisk and Russian olive can be controlled using single or successional weed management techniques, including chemical, mechanical, and biological techniques. All of the following tamarisk and Russian olive control techniques are viable options, but each must be selected based on local conditions (i.e., "Integrated Pest Management." Integrated Pest Management or IPM) is also known as the "toolbox" from which land managers select control techniques for invasive species management. The IPM process is illustrated in Exhibit 2 and considers community values, prevention, cultural management, land stewardship, mechanical or physical removal, biological control, herbicide treatments, and revegetation techniques. A description of each major control technology is presented below describing effectiveness, impacts, and applicability. Note that there are many hybrids of these technologies and specific applicability may vary for each site.

3.2.1 **Hand Herbicide Application**

There are two types of hand herbicide applications, foliar and basal bark. Foliar sprays are applied directly to vegetation foliage. Basal bark treatment controls seedlings or smaller plants with smooth (basal) bark and a stem that is less than one inch in diameter by spraying herbicide on the bottom 12 to 18 inches of the stem.

Figure 3.1 Horseback herbicide spray application. Wyoming 2004.

Effectiveness: Foliar and basal bark sprays are approximately 85-percent effective and require some level of maintenance to address resprouts. As density increases and access becomes more difficult, this method becomes more expensive and less effective due to limited abilities to spray herbicide onto all exposed basal bark or leaf surfaces. Foliar sprays are best applied during August and September as the plant is hardening up for winter; whereas, basal bark sprays are effective regardless of the time of year unless the temperature exceeds 85^{o}F, at which point the triclopyr herbicide used for basal bark application volatizes and can be potentially harmful to workers and surrounding vegetation. If temperatures are anticipated to be above 85^{o}F, other herbicides are required. Freezing conditions may also limit its use.

Pros of Hand Herbicide Application:

1. Inexpensive and effective for light infestations.
2. For inaccessible and remote areas, hand application using backpack, horses, or off-road vehicles is effective.
3. Generally, there is no need to remove dead biomass or revegetate in light infestations where this approach is typically used.

Cons of Hand Herbicide Application:

1. Not feasible for large infestations.
2. Not appropriate above 85^{o} F or in freezing temperatures due to triclopyr herbicide.
3. May require leaving tamarisk and Russian olive standing in an area for a period of years.

Applicability: When density of infestations are light, the use of a foliar or basal bark spray can be effective using backpack sprayers, horseback sprayers (see Figure 3.1), or vehicle mounted equipment. Thus, hand herbicide application is appropriate for controlling light tamarisk or Russian olive infestations, especially in areas that are difficult to access such as canyons, washes, irrigation ditches, and steep embankments. This approach is especially appropriate for controlling resprouts and other noxious weed control efforts.

3.2.2 **Hand Cutting with Herbicide Application**

This method is referred to as the "cut-stump" approach in which the tree is cut with chainsaws, handsaws, or loppers, and the stump is treated with an herbicide within a few minutes of cutting. Within approximately 15 minutes, a solution of triclopyr systemic herbicide (Garlon 4 ® mixed in vegetable crop oil) must be applied to tamarisk cut stumps. For Russian olive, the preferred herbicide is glyphosate applied at full strength. Stumps must be treated with herbicide in order to kill root crowns. If viable root crowns remain in the soil, both tamarisk and Russian olive will vigorously resprout. Cut materials are chipped, piled and burned, or piled for wildlife habitat depending on site-specific circumstances. This method of tamarisk and Russian olive removal (see Figures 3.2 and 3.3) is probably the most widely used method. **Training and use of safety equipment, as shown in Figure 3.2, are critically important when using chainsaws.**

Pros of Hand Cutting:

1. Hand cutting effectively removes tamarisk and Russian olive in mixed vegetation without damaging other valuable plants.
2. Hand cutting is appropriate for rough terrain that is not accessible by mechanical equipment.
3. Soil disturbance is minimal which can limit secondary weed infestation.

Cons of Hand Cutting:

1. Cut material must be stacked and burned, chipped, or left in piles for wildlife habitat.
2. Resprouts will require herbicide re-application.

Figure 3.2 Chainsaw removal of tamarisk in Colorado with proper safety equipment.

3. Hand clearing is labor-intensive and can be expensive.

Applicability: Hand-clearing tamarisk and Russian olive is appropriate for canyons, washes, irrigation ditches, and along steep riverbanks, which have a high level of access difficulty. For moderate levels of access difficulty, hand removal will be appropriate for some areas of a work site, such as steep slopes. For volunteer projects, hand control measures using handsaws and loppers to reduce liability issues is an appropriate approach (Figure 3.3).

Figure 3.3 **McInnis Canyons Volunteer Project western Colorado using the cut-stump removal technique near Grand Junction, 2007.**

3.2.3 Mechanical Removal

This approach uses heavy equipment to physically remove tamarisk and Russian olive. The use of mechanical equipment is preferred for large areas of infestations offset transport and equipment costs. Mechanical removal is typical cost effective compared to hand removal. Four basic mechanical equipment control techniques are available: root crown extraction without herbicide, root plowing and raking without herbicide, mulching with herbicide application, and cut-stump with herbicide.

Root crown extraction – Extraction is a root crown removal technique, which uses a large excavator (such as a CAT 320 or larger) to, pluck individual trees from the ground (see Figure 3.4). This approach has been used successfully in mixed stands of tamarisk, Russian olive, Siberian elm (*Ulmus pumila*), and native cottonwood (*Populus deltoids*). This mechanical process completely removes target trees and their root balls from the soil, along with a significant amount of their lateral roots. This approach provides an advantage for projects working to clear ditches and step riverbanks where other mechanical equipment cannot gain access. With a skilled operator, this approach can also remove only the target species and does not require herbicide. The rate of removal with an experienced operator can be as high as 3 to 8 acres per day in moderate to dense infestations. The removed trees are stacked for future mulching, burning, or are left in place (Boss Personal Communication 2006). This approach can result in a significant level of soil disturbance and may require substantial revegetation efforts.

Note: For Russian olive infestations, extraction should only be used for saplings with a trunk diameter less than 3 inches since larger trees can leave behind root fragments that may resprout.

Figure 3.4 Root crown extraction using tracked excavator.

Root plowing and raking – This approach uses large bulldozers (Caterpillar D-7 or D-8 size) equipped with brush bars to remove the above ground vegetation (see Figure 3.5), root plows to cut the root system below the crown, and root rakes to remove the root crown (Taylor et al. 2003).

This approach is extremely disruptive to the soil, destroys any native plants present, and can support weed viability. It removes vegetation in a manner similar to intense agricultural production preparation. For land managers with access to water rights, and who intend to use agricultural reseeding practices, this approach can work well (e.g. the Bosque del Apache National Wildlife Refuge, NM). This approach is not appropriate for areas with a lack of water and a significant presence of native plant species.

Mulching equipment – Tamarisk and Russian olive can be effectively controlled with specialized equipment to mulch the trees, followed by herbicide application to the cut stumps (see Figure 3.6) within a few minutes, or a foliar herbicide can be applied the following year to resprouts. Additionally, mulching equipment simultaneously addresses biomass removal. There are two categories of mulching equipment: excavator mulching head attachments and skid-steer mounted mulchers.

Excavator mulching head attachments can mulch a 3- to 6-inch tamarisk or Russian olive in a few seconds and a tree up to 10 inches in diameter in about 3 minutes. The boom arm on the excavator can typically clear a swath with up to 50-foot radius from a single point, enabling work on overhangs and steeper terrain. Excavators with rubber tracks keep disturbance to a minimum and greatly reducing soil impaction. The mulch generated by the mulching head is finer than mulch typically produced by other attachments, which may help facilitate restoration efforts by producing a thin layer of mulch to inhibit secondary weed growth. The mulcher could be effective when used in concert with biological control efforts (i.e., removal of standing dead tamarisk biomass).

Figure 3.5 Large equipment (Caterpillar D-8) incorporating a deep root rake, Bosque del Apache National Wildlife Refuge, NM, 2007.

Figure 3.6 Mechanical mulching equipment.

When using a skid-steer mounted mulcher, the trees are typically mulched in a six-foot wide path at a rate of 0.25 to 1.5 acres per hour depending on density, terrain, and equipment. The resulting mulched materials can reduce soil disturbance, and provide a good seed bed for native plant recruitment if the mulched material recruitment if the mulched materials are not too thick while discouraging establishment of secondary weeds. The carrier equipment can run on track or rubber tire systems and typically range from 100 to 225 horsepower. Larger diameter trees (greater than 12 inches) occasionally require 500 horsepower equipment. Tracked mulching equipment provides a lighter footprint pressure than those with wheels and thus causes less soil disturbance.

Mechanical mulching is appropriate technology for areas with good access and relative level ground. When using herbicide on the cut stump, mulching equipment should have cutting heads that have knife blades to cut stumps cleanly instead of carbide teeth cutting heads that shred the trunks. This is an important consideration, as shredded cut stumps require significantly more herbicide. Additionally, cutting head rotation is critical to limit soil disturbance and incorporation of cut material into the soil. When using herbicide, flailing heads should not be used as they are unsafe to work around (require a 100-yard safety zone), leave large wood chunks, and obliterate stumps making it nearly impossible to efficiently apply herbicide.

However, if no herbicide is used on the cut stump and resprouts are treated in the subsequent year, both flaying heads and mulching heads using carbide teeth can be used successfully. Since tamarisk leaf beetles are established at defoliating populations in the project area, they can be used as an alternative resprout treatment method.

Grab and cut-stump – Equipment developed for the forest products industry combines a grabbing or holding device that attaches to a tree while a shear or circular saw blade cuts the tree near ground level (see Figure 3.7). Herbicide is then applied to the cut stump. This equipment is commonly called a "feller buncher" and is produced by several manufactures as a tracked or rubber tired vehicle and can be equipped with a self-leveling capability to work in rough terrain. Recent work in Nebraska has shown this equipment's usefulness in clearing ditches and step stream banks where other mechanical equipment could not gain access (Beyer 2007). As with extraction equipment, valuable native vegetation can be avoided. Removed trees are stacked for future mulching, burning, or are left in place. Unlike the extraction technology, this approach can be used to remove Russian olive.

Figure 3.7 Grab and cut-stump equipment.

Effectiveness: The efficiency of these mechanical tamarisk and Russian olive removal methods is approximately 85 percent. The use of this equipment is principally limited to areas with good to moderate access. Their use would not be suitable for long, steep embankments, canyons, or other remote locations. Those mechanical techniques requiring herbicide applications are effective regardless of the time of year unless the temperature exceeds 85°F, at which point the triclopyr herbicide volatizes and can be potentially harmful to workers and surrounding vegetation. If temperatures are anticipated to be above 85°F, other herbicides are required. Freezing conditions may also limit its use.

Pros of Mechanical Removal Techniques:

1. Extraction, excavator mulching head attachments and grab and cut-stump equipment can very effectively remove tamarisk and Russian olive in a mixed vegetation stand without killing other valuable plants. Extraction can effectively remove Russian olive less than 3 inches in diameter. Skid-steer mounting mulching equipment is a little less forgiving, but still effective in mixed stands of natives.
2. Extraction, excavator mulching head attachments and grab and cut-stump equipment can be used in more difficult terrain and for clearing ditches and riverbanks. Grab and cut-stump works best on trees greater than 4 inches in diameter.

3. Mulched materials provide a suitable seedbed for revegetation. Care must be taken to prevent re-incorporating viable stems into moist soil, as these can resprout. Fall, winter, and early spring are the best times of year for mechanical mulching.
4. Removing root crowns with root rakes greatly disturbs the soil but can benefit revegetation efforts if irrigation water is available.

Cons of Mechanical Removal Techniques:

1. Skid-steer mounted mulchers and root plowing requires relatively level and accessible terrain.
2. Root crown removal using an excavator or root rake creates significant soil disturbance, which can promote secondary weed growth and could destabilize embankments.
3. Herbicide re-application will be necessary to control resprouts following initial removal or during the following year for all of these methods and will increase costs by approximately 20 percent.

Applicability: Root crown extraction works especially well in areas with steep embankments that other mechanical equipment cannot access. It should not be used for Russian olive control. Grab & cut-stump is also best used on steep embankments and is effective for Russian olive. Mulching equipment can be used wherever access is available. Root crown removal using a root rake is highly disruptive and should not be used in areas with significant numbers of native species or areas that are limited in revegetation by the lack of available water. An excavator with mulching head attachments are preferred methods where access is available because they simultaneously addresses biomass reduction and mulch can inhibit secondary weed growth.

3.2.4 Aerial Herbicide Application

Aerial herbicide application (see Figure 3.8) now uses precision agricultural spraying techniques controlled by GPS coordinates and specific flight plans to ensure that herbicide is only delivered to desired locations. Additionally, nozzle design improvements minimize herbicide drift. Herbicide can be delivered by helicopter or fixed wing aircraft. The herbicide typically used is imazapyr (Arsenal®) which has been approved for use near water (sold under the Habitat® label) in some southwestern states.

Figure 3.8 Aerial herbicide application technique being demonstrated with dyed water at 2003 Tamarisk Symposium, Grand Junction, Colorado.

In monotypic stands of tamarisk and/or Russian olive, such as those found in many parts of the Southwest, this may be an appropriate approach. For areas with a significant mix of native vegetation, this approach is not recommended.

Effectiveness: Recent foliar herbicide helicopter applications in New Mexico and Texas have demonstrated a tamarisk and Russian olive kill rate in a range of 85 to 95 percent. Many river corridors have large expanses of tamarisk and/or Russian olive monocultures and over the past several years large control efforts have taken place. To effectively kill tamarisk and/or Russian olive, treated trees must be left undisturbed for a minimum of two years for the herbicide to work properly. The rate of application is several hundred acres per day (Hart 2003, Lee Personal Communication 2003).

Pros of Aerial Herbicide Application:

1. The use of computer aided precision herbicide application allows the helicopter pilot to spray only tamarisk and/or Russian olive stands and to avoid previously identified native plants, if tamarisk and/or Russian olive and native are growing in discrete patches.
2. Aerial herbicide spray is extremely effective in killing tamarisk as well as Russian olive.

Cons of Aerial Herbicide Application:

1. Aerial herbicide will often kill most other vegetation, including valuable natives that are mixed in with or near to the target vegetation. Some species, such as Baccharis *(baccharises*) and Mesquite (*Nahuatl mizquitl*), appear to be unharmed; and saltgrass may recover within one year (Tanzy Personal Communication 2004).
2. Some spot herbicide re-application will be necessary.
3. If large, contiguous areas of tamarisk and/or Russian olive are killed using aerial herbicide application, there will be impacts to wildlife habitat. This is an important consideration when selecting this approach.

Applicability: This approach is most suitable for areas with broad monotypic infestations with very limited native vegetation present. Along the Colorado River and within this project area the densities of invasive species are relatively low and well mixed with native plants. Thus, aerial herbicide is not recommended for this project.

3.2.5 **Biological Control**

Biological control is the use of living organisms, such as predators, parasitoids, and pathogens, to control pest insects, weeds, or diseases. For tamarisk, two biological control agents have been identified—goats (*Capra aegagrus hircus*), and the tamarisk leaf beetle (*Diorhabda* spp.). Both organisms work to control tamarisk by repeated defoliation of the plant over several years. No biological control agents are available for Russian olive.

Goats – will feed on tamarisk shrubs if fencing limits other food sources (Figure 3.9). Typically, a guard dog, herding dog, and goat herder are required. Several private goat herds are available throughout the West but there is limited cost and success information. It is too early to provide good information on the effectiveness, applicability, and pros and cons of using goats as a viable means of controlling tamarisk. To date, goats have been used in a few situations but have not received widespread acceptance primarily because of cost and long-term effectiveness. A large project is currently underway on the Rio Grande in New Mexico to provide this information.

Figure 3.9 Goats eating tamarisk leaves and small branches.

Both the adults and the larvae of the tamarisk leaf beetle (Figure 3.10) feed on foliage. Larvae are most effective with 90-percent defoliation, damaging tamarisk directly through predation or indirectly by drying out foliage beyond the feeding point. The most promising characteristic of the tamarisk beetle is that it inflicts no damage to native plant populations (Figure 3.11).

The tamarisk leaf beetle (*Diorhabda* spp.) was identified during investigations for an insect tamarisk biological control in the 1980s by the U.S. Department of Agriculture (USDA) under the direction of Dr. C. Jack DeLoach. A beetle from Fukang, in Xianjiang Province of northwest China, was then tested extensively in quarantine to ensure safety with respect to non-target impacts. In 1995, release permits for this beetle were about to be granted when the USFWS listed the Southwestern subspecies of the willow flycatcher (SWFL) (*Empidonax traillii extimus*) as a Federal endangered species. This bird was found to nest in tamarisk in New Mexico, Arizona, and southern parts of California, Nevada, Utah, and Colorado. Permission for widespread insect bio-control releases was withheld pending further investigations of potential effects on the flycatcher. However, a number of research sites isolated from the southwestern willow flycatcher nesting areas were allowed and research began at these

Figure 3.10 Bio-control (Diorhabda spp. adult beetle, actual size ~3/16 inch).

sites in 1996. Research was conducted at these sites to determine the insect's life cycle, reproductive and dispersal rates; its impacts on tamarisk and surrounding vegetation; and impacts on wildlife (DeLoach et al. 2002; Eberts et al. 2001; Lewis et al. 2003). USDA APHIS Environmental Assessment of June 2005 outlined an agreement with U.S. Fish and Wildlife Service that all release sites "would be located more than 200 miles from where the SWFL nested in salt cedar" (APHIS EA, 2005, Pg. 7).

Figure 3.11 Tamarisk defoliated (brown) by tamarisk leaf beetle and non-damaged native vegetation (green), Colorado River in Canyonlands National Park, Utah 2008.

There are no SWFL nesting sites within 200 miles of this Project footprint therefore beetle establishment and releases within the area do not violate APHIS (*Diorhabda* spp.) release requirements. On June 15, 2010, USDA APHIS released a moratorium discontinuing and cancelling all interstate movement and release of *Diorhabda* spp. (APHIS Moratorium, 2010). The moratorium does not apply to releases within the Project footprint.

Releases of the tamarisk leaf beetle not associated with this project have been conducted by land managers in and around the Grand Valley since 2005. Based on monitoring data compiled by the Tamarisk Coalition and the Colorado Department of Agriculture Palisade Insectary for 2007-2010, the tamarisk leaf beetle (*Diorhabda* spp.) is now established in the project footprint (Figure 3.12) and will continue to be active.

Preliminary evidence of effectiveness shows great potential. If this is the case, the advantages over other approaches can be significant (i.e., limited use of herbicides and a cost effective, long-term solution). Another observation is that native plant species seem to be flourishing as tamarisk are stressed by the beetle, possibly due to increased light penetration to the understory and/or reduced competition for water and nutrients.

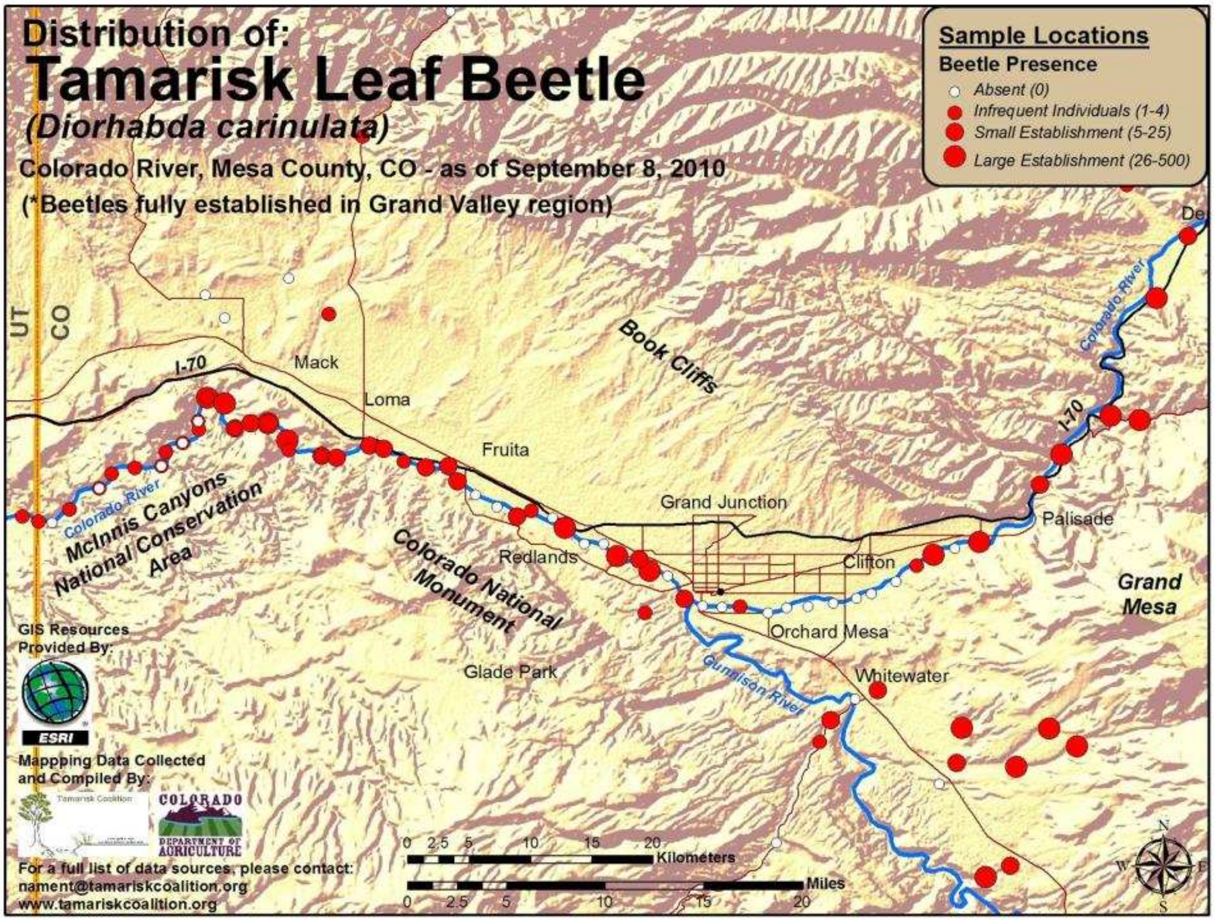

Figure 3.12 **Establishment of Diorhabda carinulata within the Colorado River Section 206 Aquatic Ecosystem Restoration.**

Monitoring will be instrumental in determining the rate of beetle spread, rate of defoliation, rate of tamarisk mortality, native plant recruitment, other weed infestations to be addressed, biomass accumulation, and biomass removal approaches. Once the trees are killed, skeleton trees will require removal in moderately to heavily infested areas and revegetation must take place. Removal of dead trees, if needed, can be accomplished using fire or mechanical mulching equipment.

Note: The reader is advised to review Exhibit 2 of this document, which contains a much broader and detailed discussion on the tamarisk leaf beetle and potential impacts.

Effectiveness: At the Nevada, Utah, and Colorado research sites, tamarisk plants died after three to ten successive years of defoliation by *Diorhabda* spp. It is not absolutely certain whether the insects, once established in a given area, will be more effective at killing large numbers of tamarisk or at acting as a control mechanism to prevent further spread. However, all indications show that they will perform both tasks to some degree. Studies continue at various universities and the USDA to determine the effectiveness of this insect in greater detail. Combining the beetle with other Integrated Pest Management methods will probably be necessary to achieve the best tamarisk control.

Pros of Biological Control:

1. Biological control is cost effective, is more targeted and less polluting than herbicide and minimizes disturbance to native plants.
2. *Diorhabda* spp. research has been more extensive than any other bio-control agent previously investigated. All indications show that there is no threat to other plant species.

Cons of Biological Control:

1. There is the potential for risk associated with the introduction of a new species including impacts to wildlife, wildfire, sedimentation, and soil chemistry that are unknown.
2. Monitoring efforts are critically important for current biological control actions within the Colorado River through the Grand Valley.
3. A significant short-term impact of bio-control is the tamarisk vegetation browning that residents and visitors to the area may consider unsightly. In response to this reaction education is important for gaining public support.
4. The use of goats as a bio-control agent is expensive, especially as a maintenance technique. Unless carefully managed, goats will cause extensive damage to non-target vegetation. Ongoing research in New Mexico should provide important effectiveness information in the near future.
5. Removal of dead trees and revegetation may be required.
6. It may take 3 to 10 years of repeated defoliation for *Diorhabda* spp. to kill tamarisk plants and the beetle's effectiveness is not entirely known. Observations show that tamarisk mortality from *Diorhabda* spp. is often impacted by the tree's resource availability.
7. Biocontrol insects are in development for Russian olive; however these are years away from being used by land managers.

Applicability: The use of the bio-control agent *Diorhabda* spp. is applicable to all levels of infestation, is not constrained by access conditions, and can be used in both riparian and floodplain terrace zones. Currently, the tamarisk leaf beetle is established throughout the project area and is now considered an instrumental component of the tamarisk control program. Monitoring is an extremely important component of biological control.

3.3 Dead Tamarisk and Russian Olive Biomass Reduction

Biomass Reduction is the removal of dead biomass through natural decomposition, or controlled fire. Typically areas receiving mechanical control will also receive mechanical mulching, and thus not require biomass reduction. In hand cut areas however, biomass reduction could beperformed by mechanical mulching, fire and/or stacking for natural decomposition. Details are presented below.

3.3.1 Mechanically Mulched Biomass

Mulching head attachments used in combination with excavators make control/removal and mulching a single-stepped process. Mechanical mulching can also be used in areas that are accessible to construction equipment and have combined tamarisk and Russian olive density is greater than 50 percent. Mechanical mulching as shown in Figure 3.13, manages the dead material by transforming it into mulch (e.g., using a chipper). Care must be taken to limit the thickness of the mulch layer to avoid impeding or preventing revegetation.

3.3.2 Fire Biomass Reduction

Reducing biomass with fire may require the construction of adequate fire breaks in sensitive riparian areas to safely burn the invasive plants. In addition, air quality may be a concern for large-scale burns as carbon sequestered in the tamarisk will be released instantly. Fire is an option that must be carefully coordinated with land managers and county air quality personnel. It should only be used for biomass reduction on dead or hand cut biomass because live tamarisk will flourish after fire. Fire breaks and professional fire fighting staff are critical because of the intensity that tamarisk fires exhibit (see Figure 3.14). Fire is recommended to reduce hand cut biomass on cobble bars and islands where mulching equipment is not appropriate.

3.3.3 Natural Decomposition

For other areas where hand control is used, cut materials can be stacked in loose piles for wildlife habitat or cut into lengths for firewood near campsites. Stacking piles for wildlife is recommended for sites where the combined tamarisk and Russian olive density is less than 50 percent and on cobble bars and islands where mulching equipment is not appropriate (Table 3.1).

3.3.4 Hand Cut Biomass

It is important to address the biomass created as a result of hand cutting tamarisk and Russian olive. Biomass from hand cutting can be reduced by mechanical mulching, burning or stacking for wildlife/natural decomposition.

Mechanical mulching manages the dead material by transforming it into mulch (e.g., using a chipper). Mechanical mulching of hand cut biomass is recommended for sites where the combined tamarisk and Russian olive density is greater than 50 percent and the site is accessible to mechanical equipment. Fire biomass reduction is recommended where the combined tamarisk and Russian olive density is greater than 50 percent, or to reduce hand cut biomass on cobble bars and islands where mulching equipment is not appropriate (see Table 3.1).

Figure 3.13 Large mulching equipment.

Figure 3.14 Controlled fire for dead tamarisk.

3.3.5 **Standing Dead Biomass**

Removing tamarisk tree skeletons may be important after mechanical root crown removal, biological control, or foliar herbicide control if densities are moderate to heavy. Biomass reduction under these conditions assists planned revegetation efforts, restores aesthetic values, and reduces the wildfire potential of leaf litter in moderately to highly infested areas. Standing dead biomass in lightly infested areas does not significantly impede natural or planned revegetation, affect aesthetics, or support high wildfire potential. Therefore, such stands could be allowed to naturally decompose. Removal of standing dead biomass can be accomplished by mechanical mulching equipment or fire.

Table 3.1 Biomass reduction methods for sites lacking access for mechanical equipment.

Percent Density of Tamarisk and Russian olive	Percent of Biomass to Burn	Percent of Biomass to Stack for Wildlife Habitat
10	0	100
20	50	50
30	65	35
40	75	25
50	80	20
60	82	18
70	84	16
80	86	14
90	88	12
100	90	10

3.4 Revegetation

One of the most positive aspects of tamarisk and Russian olive control is the natural recruitment of native plants that often occurs following removal of these two invasive species. The river corridor typically supports an intermixed community of native species that includes:

- Wetland species such as hard-stem bulrush (*Schoenoplectus acutus*), alkali bulrush (*Scirpus maritimus*), three-square bulrush (*Scirpus americanus*), swordleaf rush (*Juncus ensifolius*), baltic rush (*Juncus balticus*), creeping spikerush (*Eleocharis fallax*), beaked sedge (*Carex rostrata*), Nebraska sedge (*Carex nebrascensis*), inland saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), and scratchgrass (*Muhlenbergia asperifolia*).

- Riparian species such as sandbar or coyote willow (*Salix exigua*), whiplash willow (*Salix lucida*), Fremont cottonwood (*Populus fremontii*), three-leaf sumac or skunkbush (*Rhus trilobata*), inland saltgrass (*Distichlis spicata*), hard-stem bulrush (*Schoenoplectus acutus*), alkali bulrush (*Scirpus maritimus*), three-square bulrush (*Scirpus americanus*), swordleaf rush (*Juncus ensifolius*), baltic rush (*Juncus balticus*), creeping spikerush (*Eleocharis fallax*), alkali sacaton (*Sporobolus airoides*), beaked sedge (*Carex rostrata*), Nebraska sedge (*Carex nebrascensis*), New Mexico privet (*Forestiera neomexicana*), false willow (*Baccharis* spp.), basin wild rye (*Leymus cinereus*), Canada wild rye (*Elymus canadensis*), thickspike wheatgrass (*Elymus lanceolatus*), Lewis flax (*Linum lewisii*), scratchgrass (*Muhlenbergia asperifolia*), silver buffaloberry (*Shepherdia argentea*), Wood's rose (*Rosa woodsii*), and golden currant (*Ribes aureum*).

- Upper terraces species or upper riparian species that exist within the project area (within the 100-year floodplain) include black greasewood (*Sarcobatus vermiculatus*), basin big sagebrush (*Artemisia tridentata* . ssp. *tridentata*), galleta (*Pleuraphis* spp.), western wheatgrass (*Pascopyrum smithii*), snakeweed (*Gutierrezia*spp.), scarlet globemallow (*Sphaeralcea coccinea*), bottlebrush squirreltail (*Elymus elymoides*), blue grama (*Bouteloua gracilis*), red threeawn (*Aristida purpurea*), needle and thread (*Hesperostipa comata*), shadscale (*Atriplex confertifolia*), fourwing saltbush (*Atriplex canescens*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), rubber rabbitbrush (*Ericameria nauseosa*), indian ricegrass (*Achnatherum hymenoides*), sand dropseed (*Sporobolus cryptandrus*), as well as numerous forbs.

Depending on individual site characteristics, the abundance of these species may provide natural recruitment or may require more active revegetation (e.g., pole plantings or seeding) following tamarisk or Russian olive control activities. The native plants listed above are good candidates for active revegetation. Site-specific characteristics will be identified during the design phase to determine which plants should be used in a given location.

Revegetation considerations may influence the selected control option. To minimize costs and water resources associated with revegetation, removal should account for the ecological potential of each site. When there are many native species interspersed within tamarisk and Russian olive stands invasive removal must be executed in a manner that protects native seed sources for natural revegetation. Manual control, root extraction, grab and cut-stump, and mechanical mulching are methods capable of sparing interspersed natives, even 1-inch caliper saplings.

The least intensive/disruptive removal and revegetation treatments are preferred when possible. This means avoiding the extensive costs associated with irrigated projects—and relying on the natural regenerative capabilities of most areas. Revegetation may not be necessary where native trees, shrubs, grasses and forbs are present within 25 to 50 feet of removal centers. Revegetation is also not desirable on cobble bars or islands that are frequently inundated in both riparian and floodplain terrace settings (Hart 2003). For broader areas, active revegetation may be required. Currently, monitoring activities on the Rio Grande and Pecos River in New Mexico are attempting to determine what circumstances require active revegetation.

In broad areas of infestation, such as Walter Walker Wildlife Refuge or the Tillie Bishop Wildlife Area, it is important to pace removal efforts to allow, and encourage, natural native plant regeneration. In such large, dense stands of tamarisk it may be advisable to create vegetative islands and paths within the tamarisk to help speed native regeneration process and to provide fire breaks.

In some higher value areas, such as wildlife habitats or high profile/high human use areas, pole plantings, shrub and tubing plantings, and seeding may be desirable to aid in the regeneration process. However, when these kinds of revegetation projects are appropriate, land managers should understand that they can be expensive and require long-term maintenance commitments.

Recommended riparian and upper riparian plant species are listed in Table 3.2. These species are recommended, as they are typically available from commercial nurseries and as long stem products from the National Resource Conservation Service (NRCS). Furthermore, these species have successfully been planted in numerous restoration efforts. Revegetation efforts may require labor, seed, plant materials, amendments such as fertilizer and mycorrhizal inoculants, equipment rental, weed control, and water. Equally important is the technique used for planting. Some planting approaches developed by NRCS are shown in Figure 3.15.

Table 3.2 Recommended revegetation trees and shrubs.

	Common Name	***Scientific Name***
Riparian Species	Cottonwood	*Populus fremontii*
	Box Elder	*Acer negundo*
	Three-Leaf Sumac	*Rhus triobata*
	Golden Current	*Ribes aureum*
	Wood's Rose	*Rosa woodsii*
	Sliver Buffaloberry	*Shepherdia argentea*
Upper Riparian Species	Rubber Rabbitbrush	*Ericameria nauseosa*
	Fourwing Saltbrush	*Atriplex canescens*
	Big Sagebrush	*Artemisia tridentata*
	Winterfat	*Kraschenninnikovi lanata*

Special considerations for wildlife are important in revegetation efforts. Just as the impact of tamarisk invasion will vary with the wildlife species and the area considered, so too will the impact of tamarisk management. For instance, a recent study found that birds nesting in mid-story vegetation are negatively affected by tamarisk control, but other bird species are not affected (Bateman et al. 2009). In some areas, especially those with light tamarisk infestations, active revegetation may not be necessary, as pre-existing native plants will be able to colonize patches where tamarisk has been removed. In other areas, such as tamarisk monocultures, intensive revegetation will be necessary.

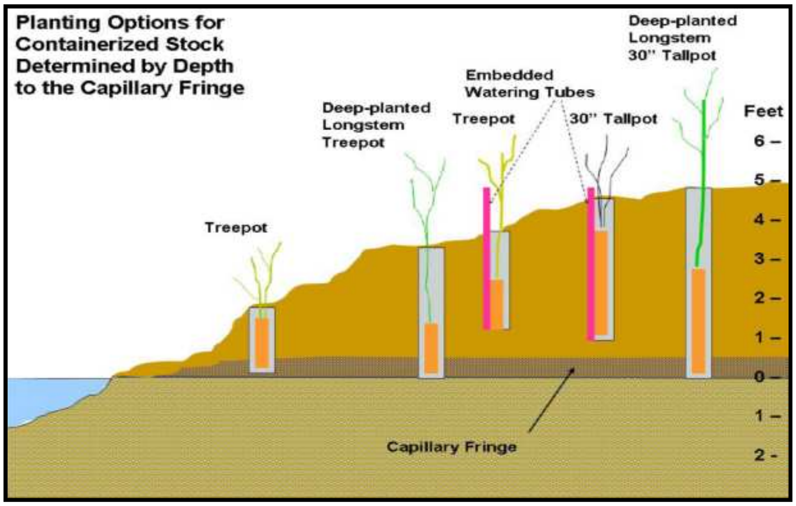

Figure 3.15 Techniques for revegetation of riparian areas (NRCS).

The net effect of tamarisk management on wildlife will depend on what species replace tamarisk once it is removed. If active revegetation does not occur, the disturbance caused by tamarisk control may favor the establishment of other invasive species such as Russian knapweed. In some areas, revegetation with the plant species that historically occupied the site may be impossible.

The process by which control and revegetation occur will also affect birds. Timing is important for all aspects of tamarisk management. Bird populations may be most vulnerable if reproduction is disrupted. If tamarisk control can occur outside of the breeding or nesting season, it may be less disruptive. Similarly, the timing of revegetation must also be considered. In most cases, plants used in revegetation will take several years to establish, mature and provide suitable habitat. There will be a considerable lag time between tamarisk removal and when the habitat is again suitable for many species, leading to a short-term loss of habitat. This short-term loss may still have significant negative effects on bird populations. In some situations, such as a large tamarisk monoculture, it may be advisable to control tamarisk and revegetate in patches (i.e., staged revegetation). When this strategy is used, birds will still have tamarisk habitat available to them while replacement vegetation is establishing in the areas where tamarisk was removed.

Successful revegetation is a complex undertaking. As a result, implementing revegetation projects following the removal of invasive species is an inherently site-specific task. To develop the proposed revegetation approach for the project area, specialists with the Colorado Division of Wildlife, the NRCS, and comprehensive revegetation and restoration texts are consulted. NRCS's Los Lunas Plant Material Center in New Mexico recently compiled an excellent reference guide for riparian restoration/revegetation (USDA 2007). Also, the University of Denver has prepared a "Best Management Practices for Revegetation after Tamarisk Removal" handbook (Sher et al. 2010). Both are used for the project's design phase. While the specifics of revegetation will be determined during the design phase, some of the resources used include:

- **Society for Ecological Restoration**
  Summary: This site provides a reading list for ecological restoration practices, links for many example projects and other resources and support. www.ser.org/reading_resources.asp

- **Riparian Restoration in the Southwest – Species Selection, Propagation, Planting Methods, and Case Studies**
  Summary: This document identifies the natural processes and managed activities that cause the degradation of riparian lands and provides general guidelines to restore the natural system. It describes methods of selecting appropriate revegetation species, processes for producing riparian plants, details planting techniques, and provides case studies of past projects. www.nm.nrcs.usda.gov/programs/pmc/symposium/nmpmcsy03852.pdf

- **Stream Corridor Restoration: Principles, Processes, and Practices**
  Summary: This large and detailed document has a three-tiered design. The first section provides background information describing the basics of stream corridor systems. The second section describes the steps to produce an effective restoration plan. The final section provides guidelines to implement restoration projects.
  www.nrcs.usda.gov/technical/stream_restoration/

- **Guidelines for Planning Riparian Restoration in the Southwest**
  Summary: This restoration guide is intended to address considerations for developing riparian restoration projects and to provide a number of responses or solutions to potential problems. www.nm.nrcs.usda.gov/news/publications/riparian.pdf

- **Guidelines for Planting Longstem Transplants for Riparian Restoration in the Southwest: Deep Planting**
  Summary: This site describes a good technique for revegetating a riparian site that lacks overbank flooding and has a deep water table.
  http://www.nm.nrcs.usda.gov/news/publications/deep-planting.pdf

- **The Pole Cutting Solution**
  Summary: Guidelines for planting dormant pole cuttings in riparian areas of the Southwest. Planting dormant pole cuttings has proven to be a successful technique for establishing many riparian trees and shrub species. www.nm.nrcs.usda.gov/news/publications/polecutting.pdf

- **Plant Technology Fact Sheet: Tall-Pots**
  Summary: This fact sheet describes the use of tall-pots to establish plants in areas lacking sufficient soil moisture or irrigation availability to revegetate using more traditional means. A discussion of the structure, usefulness, benefits, and limitations of the tall-pot revegetation method is included. www.nm.nrcs.usda.gov/programs/pmc/factsheets/tall-pot.pdf

Figure 3.16 Revegetation at the Matheson Wetlands Preserve in Moab, Utah, 2006.

Successful revegetation requires a level of post-planting commitment to ensure plants are well established and capable of persisting in the future. This includes monitoring plant survival, replacing failed plants, and weed control. These elements typically occur over a three-year period following initial control and revegetation activities. Costs for this post-planting component of restoration are a function of infestation levels and control technologies. Light infestations are calculated at 20 percent of the control and revegetation combined costs. For moderate infestations the post-planting costs are estimated at 25 percent, while heavy infestations are estimated at 30 percent.

3.4.1 **Revegetation Strategies and Climate Change**

In selecting plant materials to restore the Colorado River through Grand Junction it is important to target plant species that are adapted to the sometimes harsh conditions of the Colorado Plateau ecosystem. These plants must be capable of surviving under many stresses such as drought and high summer temperatures. The plant materials identified below meet these criteria and therefore exist, and thrive in the Grand Junction project area and throughout the Colorado Plateau. Acknowledging that climate change may have a variety of impacts on temperature and moisture conditions within the region, this selection of plant materials will tolerate extreme stresses and will increase the likelihood of long-term planting success.

Eliminating the tamarisk dominated floodplain area and restoring a healthy diverse riparian ecosystem will increase the system's capacity to react to the uncertainty that is inevitable in any climate-shifting scenario. By providing a richer seed bank from highly stress tolerant plants, restoration efforts will greatly increase the ability of the riparian corridor to withstand climate change.

Wetland species such as hard-stem bulrush (*Schoenoplectus acutus*), alkali bulrush (*Scirpus maritimus*), three-square bulrush (*Scirpus americanus*), swordleaf rush (*Juncus ensifolius*), baltic rush (*Juncus balticus*), creeping spikerush (*Eleocharis fallax*), beaked sedge (*Carex rostrata*), Nebraska sedge (*Carex nebrascensis*), inland saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), and scratchgrass (*Muhlenbergia asperifolia*).

Riparian species such as sandbar or coyote willow (*Salix exigual*), whiplash willow (*Salix lucida*), Fremont cottonwood (*Populus fremontii*), three-leaf sumac or skunkbush (*Rhus trilobata*), inland saltgrass (*Distichlis spicata*), hard-stem bulrush (*Schoenoplectus acutus*), alkali bulrush (*Scirpus maritimus*), three-square bulrush (*Scirpus americanus*), swordleaf rush (*Juncus ensifolius*), baltic rush (*Juncus balticus*), creeping spikerush (*Eleocharis fallax*), alkali sacaton (*Sporobolus airoides*), beaked sedge (*Carex rostrata*), Nebraska sedge (*Carex nebrascensis*), New Mexico privet (*Forestiera neomexicana*), false willow (*Baccharis* spp.), basin wildrye (*Leymus cinereus*), Canada wildrye (*Elymus* canadensis), thickspike wheatgrass (*Elymus lanceolatus*), Lewis flax (*Linum lewisii*), scratchgrass (*Muhlenbergia asperifolia*), silver buffaloberry (*Shepherdia argentea*), Wood's rose (*Rosa woodsii*), and Golden currant (*Ribes aureum*).

Upper terraces species such as black greasewood (*Sarcobatus vermiculatus*), basin big sagebrush (*Artemisia tridentata* Nutt. spp. *Tridentata*), galleta (*Pleuraphis*), western wheatgrass (*Pascopyrum smithii*), snakeweed (*Gutierrezia* Lag.), scarlet globemallow (*Sphaeralcea coccinea*), bottlebrush squirreltail (*Elymus elymoides*), blue grama (*Bouteloua gracilis*), red threeawn (*Aristida*), needle and thread (*Hesperostipa comata*), shadscale (*Atriplex confertifolia*), fourwing saltbush (*Atriplex canescens*), douglas rabbitbrush (*Chrysothamnus viscidiflorus*), rubber rabbitbrush (*Ericameria nauseosa*), indian ricegrass (*Achnatherum hymenoides*), sand dropseed (*Sporobolus cryptandrus*), as well as numerous forbs.

3.4.2 Vegetation Methods and Establishment

3.4.2.1 Grass and Forbs Establishment Recommendations

Using native grass species for revegetation after tamarisk and Russian olive control is important as they can provide ground cover after weed control, which is essential for site stabilization and erosion control. In addition, once established, native grasses will out-complete invasive weeds (Sher 2010). Three mixes have been identified and are recommended and include consideration of salt content of the soils and proximity to the ground water (Table 3.3).

Drill seeding methods are recommended in areas where high levels of disturbance have resulted from control methods. Broadcast seeding is recommended in areas where ground disturbance is minimized. Seeding methods are identified in the written descriptions for each segment. Seed amount estimates are slight inflated from typical application rates in order to achieve a higher success rate for establishment. This information is developed from recommendations made by Pawnee Butte Seed Inc.

Table 3.3 Native grass/forbs mix information.

Mix	Type	Number of Seeds*	PLS# Lbs	PLS lbs/acre Broadcast	PLS lbs/acre Drilled@
Upper riparian	Alkali sacaton *(Sporobolus airoides)*	700,000	0.4	13.2	6.6
	Slender wheatgrass *(Elymus trachycaulus)*	1.1 mil	7.0		
	Indian ricegrass *(Achnatherum hymenoides)*	1.1 mil	4.8		
	Scarlet globemallow *(Sphaeralcea coccinea)*	250,000	0.5		
	Evening primrose *(Oenothera* spp.)	430,000	0.5		
	seeds/square foot&	**82**			
Upper riparian Salty	Alkali sacaton *(Sporobolus airoides)*	1.1 mil	0.65	18.65	9.33
	Slender wheatgrass *(Elymus trachycaulus)*	1.0 mil	8.4		
	Western wheatgrass *(Pascopyrum smithii)*	1.3 mil	9.6		
	seeds/square foot	**78**			
Riparian	Alkali sacaton *(Sporobolus airoides)*	1.5 mil	0.85	11.25	5.625
	Slender wheatgrass *(Elymus trachycaulus)*	1.4 mil	8.8		
	Inland saltgrass *(Distichlis spicata)*	830,000	1.6		
	seeds/square foot	**86**			

* Number of seeds per acre.
# PLS is Pure Live Seed.
@ Drill seed application is calculated to use approximately half of the seed as broadcast application.
& Based on one acre, seeds per square foot = total number of seeds / 43,560 ft^2.

3.4.2.2 Tree and Shrub Planting Recommendations

The long-stem/deep-planting technique (Figure 3.17) pioneered by the Los Lunas Plant Materials Center (LLPMC) in New Mexico is the recommended planting method for trees and shrubs. Plants are developed using a particular grow-out method to allow rapid root access to the capillary fringe of the water table and to minimize irrigation requirements (Dressen 2010). Special mechanical equipment will be required to accomplish the deep-planting techniques. The Colorado River terrace composition is dominated by cobble, thus, provides challenges to revegetation. A rotary stinger bar tool (Figures. 3.18 through 3.20) developed by the Aberdeen Plant Materials Center in Idaho could prove successful in this application while minimizing disturbance to existing vegetation.

Figure 3.17 Example of long-stem plant in container.

Figure 3.18 Rotary Stinger used for deep planting from Los Lunas Plant Materials Center.

Figure 3.19 Rotary Stinger used for deep planting.

Figure 3.20 Plant container portion of Rotary Stinger.

Recommended trees and shrubs for revegetation include cottonwood (*Populus fremontii*), box elder (*Acer negundo*), three-leaf or skunkbush sumac (*Rhus triobata*), golden currant (*Ribes aureum*), Woods' rose (*Rosa woodsii*), silver buffaloberry (*Shepherdia argentea*), rubber rabbitbrush (*Ericameria nauseosa*), four-wing saltbrush (*Atriplex canescens*), big sagebrush (*Artemisia tridentata*), and winterfat (*Krascheninnikovi lanata*). Note that the cottonwood trees will be harvested dormant pole cuttings that are deep-planted, rather than grown out in the long-stem method like the other listed species. Trees and shrubs are determined based on successful long-stem grow outs by LLPMC, local knowledge of species native to the project area and benefits to wildlife.

The LLPMC expects a 90-percent survival rate using this method of planting. In order to account for this, and have some room for error, an 85-percent plant survival rate is used in all tree and shrub calculations. The revegetation calculations are based on the percent canopy cover of Russian olive, and tamarisk estimated in the field. Tables 3.4 and 3.5 provide number of replacement vegetation for each acre of Russian olive and tamarisk removed. Tamarisk provides less wildlife habitat than an equivalent Russian olive therefore the calculation for replacement vegetation is 50 percent of the Russian olive rate.

Table 3.4 Number and species of proposed replacement begetation per acre of Russian olive removed.

Site Type	Riparian Replacement Species				Upper Riparian Replacement Species			
	Three-Leaf Sumac	Golden Currant	Woods Rose	Silver Buffalo berry	Rubber Rabbit brush	Fourwing Saltbrush	Big Sagebrush	Winterfat
Riparian	50	50	50	25	0	0	0	0
Upper Riparian	0	0	0	0	25	25	25	25
Wetland	0	0	0	0	0	0	0	0

Table 3.5 Number and species of proposed replacement vegetation per acre of tamarisk removed.

Site Type	Riparian Replacement Species				Upper Riparian Replacement Species			
	Three-Leaf Sumac	Golden Currant	Woods Rose	Silver Buffalo berry	Rubber Rabbit brush	Fourwing Saltbrush	Big Sagebrush	Winterfat
Riparian	25	25	25	12.5	0	0	0	0
Upper Riparian	0	0	0	0	12.5	12.5	12.5	12.5
Wetland	0	0	0	0	0	0	0	0

Cottonwood and boxelder plantings will be located in wetland and riparian areas as noted in Section 4, on a segment by segment basis. A total of 15 trees per acre is proposed with mix of 11 cottonwoods, and four boxelders to increase the biodiversity of the river system. These planting rates are based on observations in natural cottonwood galleries in the Orchard Mesa Wildlife Area in Grand Junction, CO and Upper Colorado River near Silt, CO (Figure 3.21). These same areas provided information for shrub community diversity and density that are calculated above.

Figure 3.21 Orchard Mesa Wildlife Area, Grand Junction (left), State Wildlife Area, Silt (right).

3.4.2.3 **Time Distribution of Restoration Activities**

Timing of restoration activities is an important consideration for this project. Table 3.6 is based on a 5-year construction timeframe and is divided up in to four seasons: fall, winter, spring and summer. The timeframe is flexible, the importance of this discussion is to demonstrate the ordering and sequence for restoration activities to achieve success. A few points to note include:

- Due to the high number of plant materials required for this project, it is recommended that development of plant materials begin as soon as possible. Three years is needed for plants to grow-out to the maturity needed for planting pole cuttings and long-stem materials.
- Monitoring wells should be installed at the beginning of construction so that an adequate amount of data is recorded to inform planting efforts.
- As described in the segment narratives, there is a moderate cover of secondary invasive weeds, which tend to colonize following tamarisk and Russian olive control without proper

weed management. Thus, follow-up weed management of secondary invasive species is an important component of this schedule and occurs during spring and fall (depending on the target weed) immediately following tamarisk and Russian olive removal.

- As previously mentioned, revegetation will have a higher chance of success if native grasses can be established to compete with secondary invasive weeds. Native grass establishment should be used in concert with secondary weed treatments, which usually occur in the spring (kochia and whitetop) and the fall (Russian knapweed).
- Tree and shrub plantings are not recommended until after the secondary weed population is suppressed.
- Ongoing monitoring and maintenance of each site will be required throughout the construction process in order to make management decisions. These decisions will be based on the site's response to weed treatments and the success of revegetation treatments.

Table 3.6 Time distribution of restoration activities.

Restoration Activity	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Year 5**			
	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su
Development of tree and shrub plant materials	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tamarisk and Russian olive removal (Mechanical and hand cutting methods)	■	■	■		■	■	■		■	■	■									
Tamarisk and Russian olive re-sprout treatments					■	■	■		■	■	■		■	■	■					
Monitoring wells installed	■	■	■	■																
Secondary invasive weed treatments					■		■		■		■		■		■		■		■	
Native grass seeding						■				■				■				■		
Planting of tree and shrub materials									■	■	■		■	■	■		■	■	■	
Monitoring and Maintenance	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

F = fall months of September, October and November; **W** = winter months of December, January and February; **Sp** = spring months of March, April and May; **Su** = summer months of June, July and August.

3.5 Habitat Restoration of Cobble Bars and Side Channels

3.5.1 Channel Cobble Bars

Habitat restoration is proposed for cobble bars, including islands dominated by cobble and gravels, through the removal of tamarisk. Tamarisk is stabilizing the bars and reducing the otherwise natural dynamic nature of these mid-channel areas. The USFWS has indicated that the cobble bars, in the natural dynamic state provide spawning habitat for native fish, including the endangered fish. Both the pikeminnow and razorback sucker spawn over bars of cobble, gravel, and coarse sand substrates during spring runoff. Spawning success is dependent on clean inter-gravel environment, relatively free from fine sediment. The emergence of tamarisk on cobble bars has resulted in sediment accumulation in and around the base of the tree as it blocks and slows flows, resulting in excessive sediment deposition on top of the cobbles, and loss of spawning habitat. Further, the dynamic nature of these bars result in the movement and continued passage of sediments that, rather than being unnaturally collected on these bars, continue to move downstream providing source material for spawning and/or habitat areas (McAda 2003).

Stabilization of these cobble bars are believed to be linked to reduced flows as seen over the past 5 years of drought, as well as altered flow regimes from water development in the Colorado River basin. Based on the Recovery Program's extensive work addressing flow regimes, coordinated flow operations are currently being implemented to simulate historic flow conditions that mimic a more natural, dynamic process (McAda 2003). This Project seeks to aid in the development of a more natural, dynamic system with the removal of invasive species that are currently occupying and stabilizing the channel cobble bars. The removal of these invasive plants, in combination with flow operations, should help simulate a more natural and dynamic river system, particularly a more dynamic system associated with the sediment transport and bed mobilization. Sites selected for proposed restoration of tamarisk removal on cobble bars are listed in section 5.3 of this report.

3.5.2 Side Channels and Backwater Areas

Restoration is proposed for side channels and associated backwater areas through the removal of tamarisk and Russian olive. These invasive species are stabilizing the side channels, reducing flows and sediment transport resulting in a disconnection between the side channels and backwaters from flows in the main channel. USFWS has indicated that backwater and side channels provide necessary habitat for rearing fish, and reconnection of these side channels and backwaters would likely improve survival of endangered and other native fish.

As previously noted the Recovery Program is currently implementing flow regimes to mimic a more natural, dynamic process (McAda 2003). The removal of tamarisk and Russian olive along the banks and within the confluence areas of these backwater areas, in combination with changes in flow operations, should help increase flooding to these important habitat and rearing areas.

3.5.3 **Walter Walker (Site #10)**

The Walter Walker Wildlife Area is located at River Segment 10. Modifications to Walter Walker Wildlife area are being proposed as part of this Project for the purpose of restoring habitat for the benefit of fish species by removing invasive plant species from the aquatic environment. The following discussion proposes a conceptual plan for site modifications. During the upcoming design phase, this work must be carefully reviewed and coordinated with the USFWS and CPAW prior to implementation.

Site Description and Proposed Improvements: The Walter Walker Wildlife Area is located approximately 7 miles downstream of the Gunnison River confluence. In the 1960s and 1970s, the Walter Walker site was home to extensive gravel mining operations until the large floods of 1983 and 1984 breached a levee and filled much of it with sediment. Since then the segment has been colonized primarily by tamarisk. Removing tamarisk and improving hydraulic connectivity of the site with the river would allow the river to restore natural braided channels throughout this portion of Walter Walker. In particular, a side channel exists along the north end of the site, which is fed by a gated culvert that extends through an existing levee. Note that the levee is not a flood control structure. This levee, is a man-made dike, likely constructed to reduce flooding into the bottomland and/or gravel pitarea. The side channel has limited connectivity to the main stem of the Colorado River due to the limited capacity of the culvert. Groundwater seeps also fed this side channel in years past, bringing with it naturally occurring selenium. Note that the existing gated culvert was installed over 20 years ago, along with partial removal of the levee, for purposes of providing fresh water into the side channel to dilute and increase the transport of selenium-laden water through the side channel and back into the main stem. However, condition have changed since then, in several ways. First, adjacent to Walter Walker, gravel mining efforts have resulted in deep open pits which have been intercepting the groundwater, thereby reducing groundwater seeps and selenium laden flows into the Water Walker side channel (USFWS 2011). Secondly, flows into the side channel have been relatively infrequent and somewhat low in magnitude, possibly due to low runoff flows, with the exception of 2011, from recent years of drought and the relatively high elevation of the culvert.

To improve the conditions within the side channels and backwaters at Walter Walker several site modifications are proposed. First, improve the hydraulic connectivity of the site to the main stem of the Colorado River so that the endangered fish will have greater access to this floodplain habitat and to dilute and transport selenium out of the side channel. This will be accomplished by constructing an opening in the levee to increase the quantity and frequency of flows entering the bottomland site. USFWS has indicated that a minimum of 200 cfs flowing through the existing side channel would be ideal. The second modification is to regrade one pond to create a backwater area for spawning habitat adjacent to the side channel. This will require the removal of sediment that has filled this existing pond to allow springtime flows to back-up and flood this site. The establishment of exotic fish populations in the backwaters is a concern so this backwater areas should only be inundated during spring runoff and must drain completely under base flow conditions. The backwater area does not necessarily need to flood every year, but should drain completely when not flooded. The proposed site modifications are depicted on Figure 3.22 including inlet elevations and pond grades.

Hydraulic Modeling: A HEC-RAS model for this area was developed in July 2000 (Tetra Tech 2002) using a combination of bathymetric and field surveys at each of the noted cross sections and two-foot contour aerial mapping for areas without field surveys. Additional surveying may be required for construction drawings.

The HECRAS model is slightly modified to include the side channel in this analysis. Survey information from the July 2000 study is used to build the side channel in HEC-RAS. The side channel is added as a separate reach and connected to the main channel via a lateral structure from the main channel discharging into the side channel. The 'flow optimization' option in HEC-RAS is used to reconcile flows and elevations between the two channels. This allows for the calculation of flows in the side channel for various return periods, as well as elevations in the main channel. Based on the side channel flows and main channel elevations, the hydraulic characteristics are established for use in the design recommendations for site modifications. Calculations are presented in Exhibit 4.

Seven different discharges are modeled. These flows include the minimum base flow of 1,800 cfs, the annual peak flows for the 1.01- and 1.11-year return periods, and four additional flows in between these values.

Design Considerations for Levee Opening: The proposed levee opening is modeled as a trapezoidal notch or short channel, located between the existing notch and the gated culvert. The opening would be unprotected and is expected to erode and widen over time when floods access the overbank. This option requires removal of approximately 4100 cubic yards of the existing levee, all of which is at or above the ordinary high water mark, and should be done in late fall or winter when flows are low and work 'in-the-dry' is possible. The levee removal footprint will not be revegetated as it will re-connect with the existing downstream cobble bankline and point bar.

The HEC-RAS models the initial trapezoidal opening in the levee as a lateral 'weir' in the main channel supplying flow into the side channel. The proposed cut is 10 feet wide on the bottom at an elevation of 4508.5 and 3:1 side slopes up to existing grade. The model is unable to converge on to a solution at the lowest two flows. Therefore, side channel flows, for the lowest two main stem flows, are estimated through use of a regression line that is fit to the HEC-RAS data produced for the higher flows. Results indicate that the trapezoidal cut allows for the desired 200 cfs lateral flow into the side channel is achieved when the Colorado River is between 5000 and 8080 cfs, as shown in Table 3.7. As the levee erodes, these flows could increase. This option also requires the removal (excavation) of two small berms in the side channel as shown on Figure 3.22. This work will also be done in late fall or winter when flows are low and work 'in-the-dry' is possible.

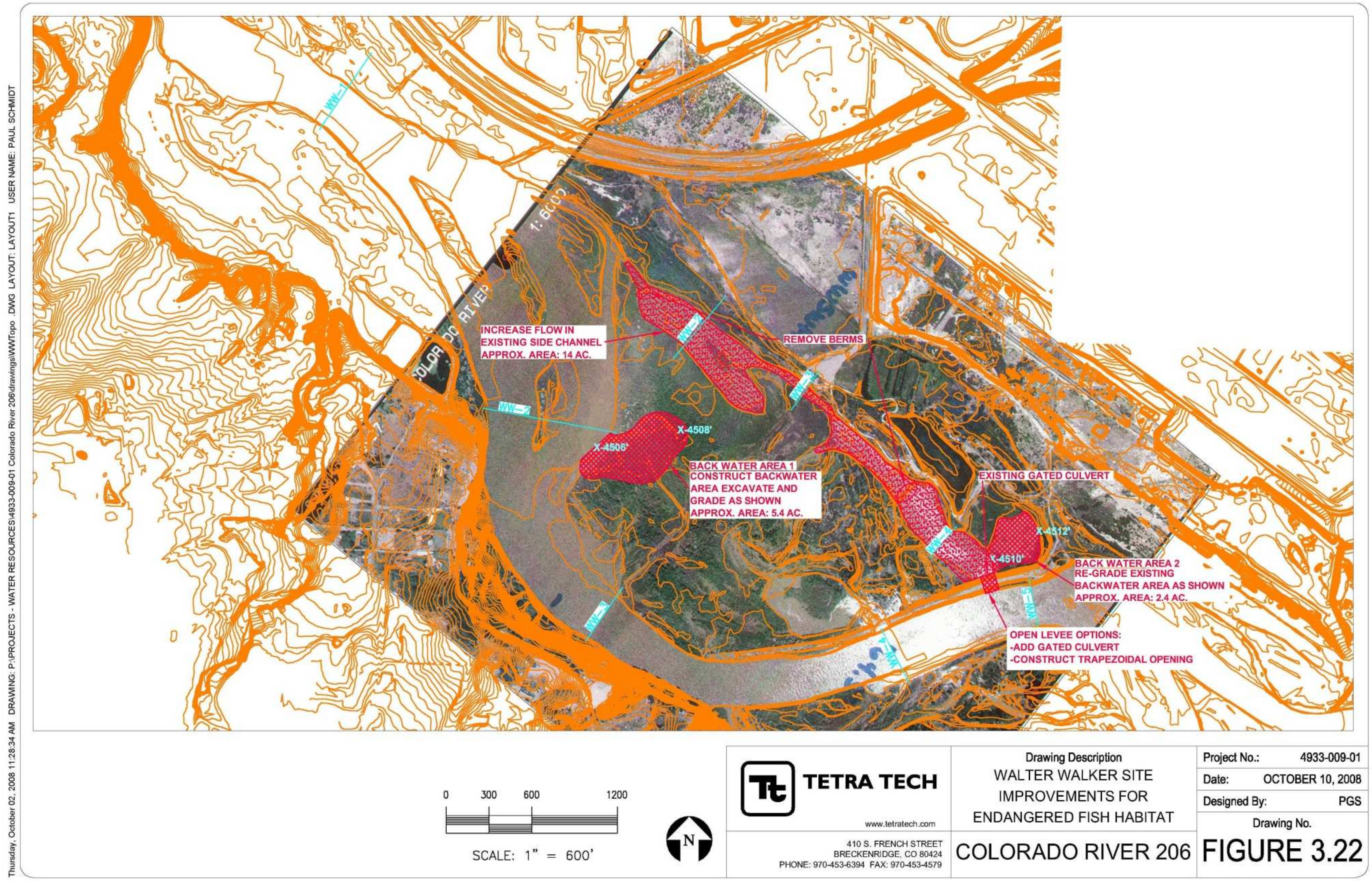

Figure 3.22 Walter Walker site.

Table 3.7 Side Channel flows – Trapezoidal opening option.

Return Period	Main Channel *Q* (cfs)	Side Channel *Q* (cfs)
min USFWS flow	1800	6
-	2000	8
-	3000	15
-	4000	62
-	5000	140
$Q_{1.01}$	8080	400
$Q_{1.11}$	13600	917

Proposed Site Modifications, Backwater Area: The criteria for the backwater area is to be inundated during spring runoff flows and completely drain during base flow conditions. The proposed grading shown on Figure 3.22 is based on the elevations estimated in the HEC-RAS models, which are presented in Table 3.8. The lowest elevation at the pond outlet (to the side channel) is elevation 4509, placing the outlet and pond above base flow conditions, based on 1800 cfs in the Colorado River main stem. The bottom of the pond will be sloped from 4509 to 4512, which represents the water level from backwater of the Colorado River at the 1.01-year frequency level, thus insuring the pond will, on the average, fill with water during peak runoff and drain by late summer.

Table 3.8 Flood elevations for proposed backwater area at Walter Walker.

(Cross Section WW-5)	
Main Stem Flow (cfs)	Elevation (ft)
1800	
minimum USFWS flow	4509.4
2000	4509.5
3000	4509.9
4000	4510.6
5000	4511.2
8080	
$Q_{1.01}$	4512.3
13600	
$Q_{1.11}$	4513.1

Geomorphic and site stability of side channel reconnection: As discussed in Section 2.13 of this report, Geomorphic Assessment for Walter Walker, the area has undergone significant changes over the last 70 years, but has since returned to a planform that is relatively consistent with the planform observed on the 1937 aerial photo. The channel width and location of the channel banks, both left and right, have remained relatively stable. The stability of this site could be a result of the bed rock present on the left bank and, possibly the existing levee on the right bank. The levee was initially constructed to separate the gravel pits. The river breached this levee and flooded the gravel pits during the 1983 and 1984 floods. However, by or before 1994 the river returned to its original, 1937, alignment leaving the pits behind the levee mostly filled in and naturally re-vegetated. Again, the channel bank alignments and widths were, and continue to be, relatively the same size even after these floods. Based on the historic trend of this site, it is likely that the trapezoidal opening will not significantly alter the geomorphic configuration of the Walter Walker site except to increase flooding in the side channel.

3.6 Recreation Opportunities

In general, tamarisk and Russian olive control will improve recreational opportunities throughout this area, including improvements to camping sites, hiking trails and wildlife viewing areas.

Many of the river segments within the project area already include wildlife viewing areas, soft and paved trails, park areas, and camping sites. The dense stands of tamarisk and Russian olive restrict and diminish these recreational uses. Tamarisk and Russian olive removal will compensate for these negative impacts and improve the recreational experience.

Additional wildlife viewing areas are proposed at some of the river segments, to enhance the recreational experience of trails. Each wildlife viewing area includes an interpretive sign, and a bench set on a 10- by 20-foot pad, graded level and set with 6 inches of base coarse. These areas are intended to be handicap accessible where connected to paths that are also handicap accessible. Section 4 of this report discusses these recreational opportunities on a site-by-site basis.

3.7 Representative Cross Sections

Representative cross-sections are chosen in three segments (see Figures 3.23 through 3.25) to demonstrate different conditions found throughout the project area. The horizontal scales are based on topography while the vertical scale is exaggerated to enhance details. Each cross-section is drawn for the present condition based on June 2010 field work. The mature restored condition is based on project objectives and represents a projection of the landscape after the fifty-year monitoring and maintenance period.

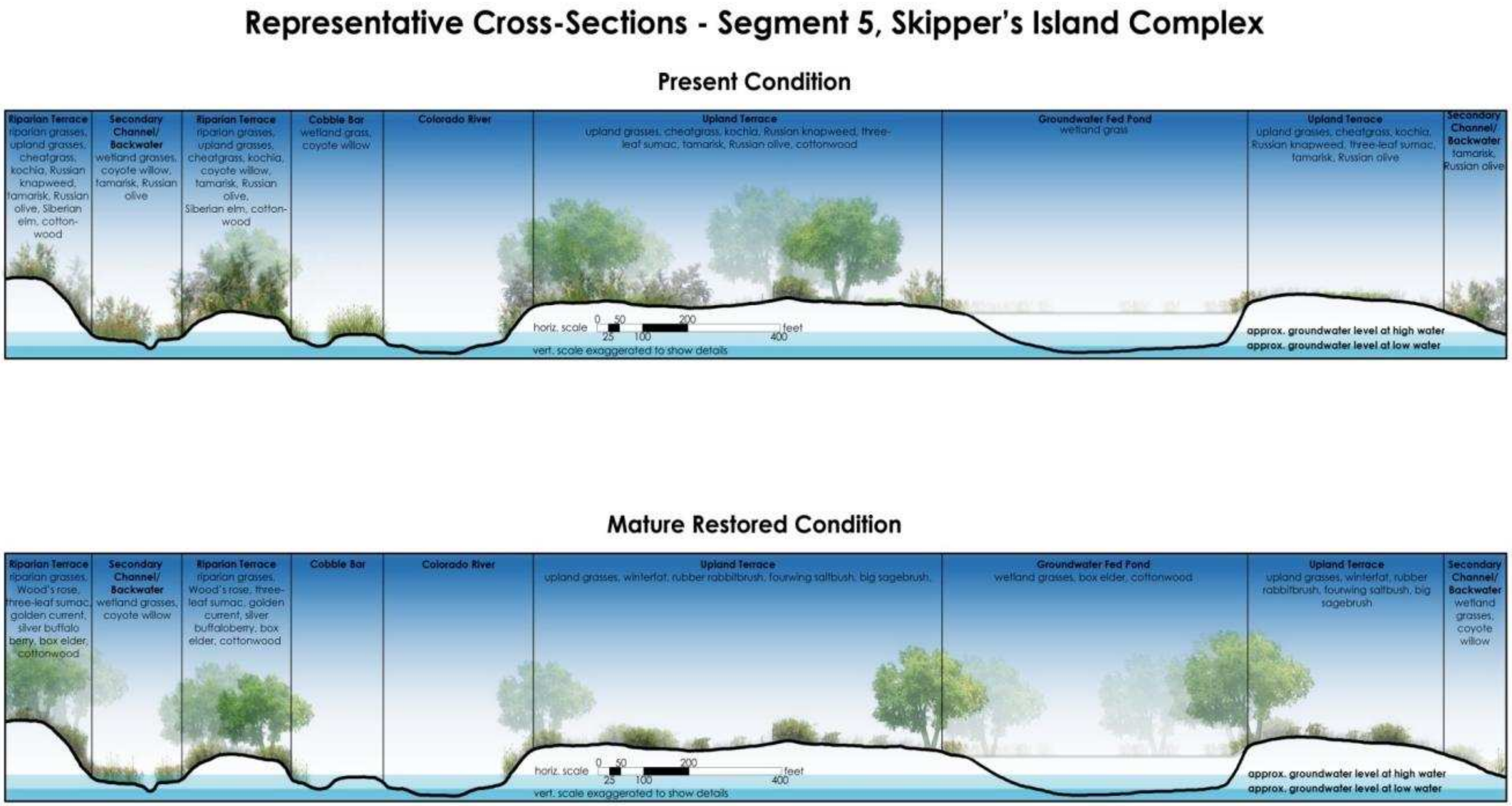

Figure 3.23 Representative cross sections-Segment 5, Skippers Island.

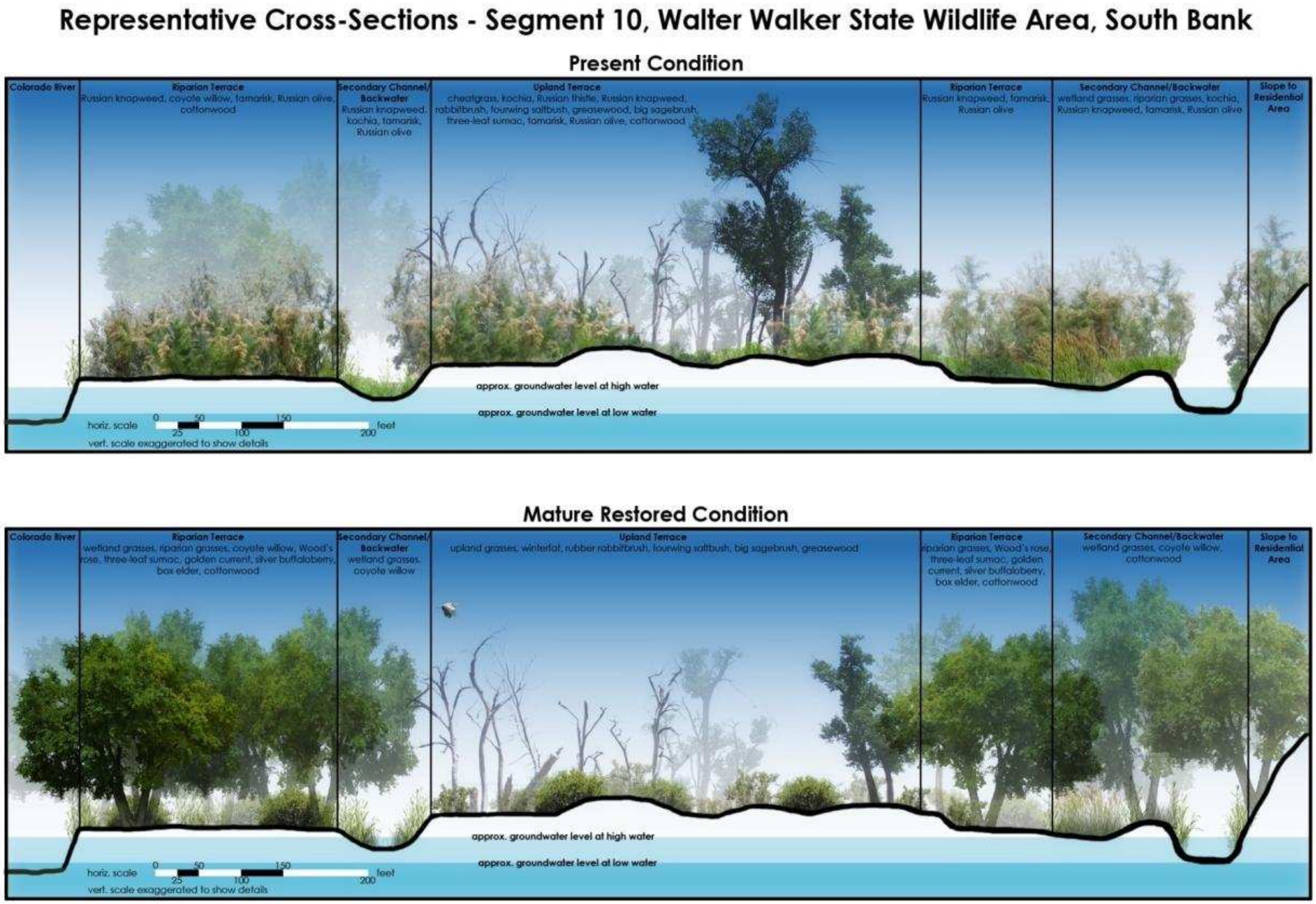

Figure 3.24 Representative cross sections- Segment 10, Walter Walker South Bank.

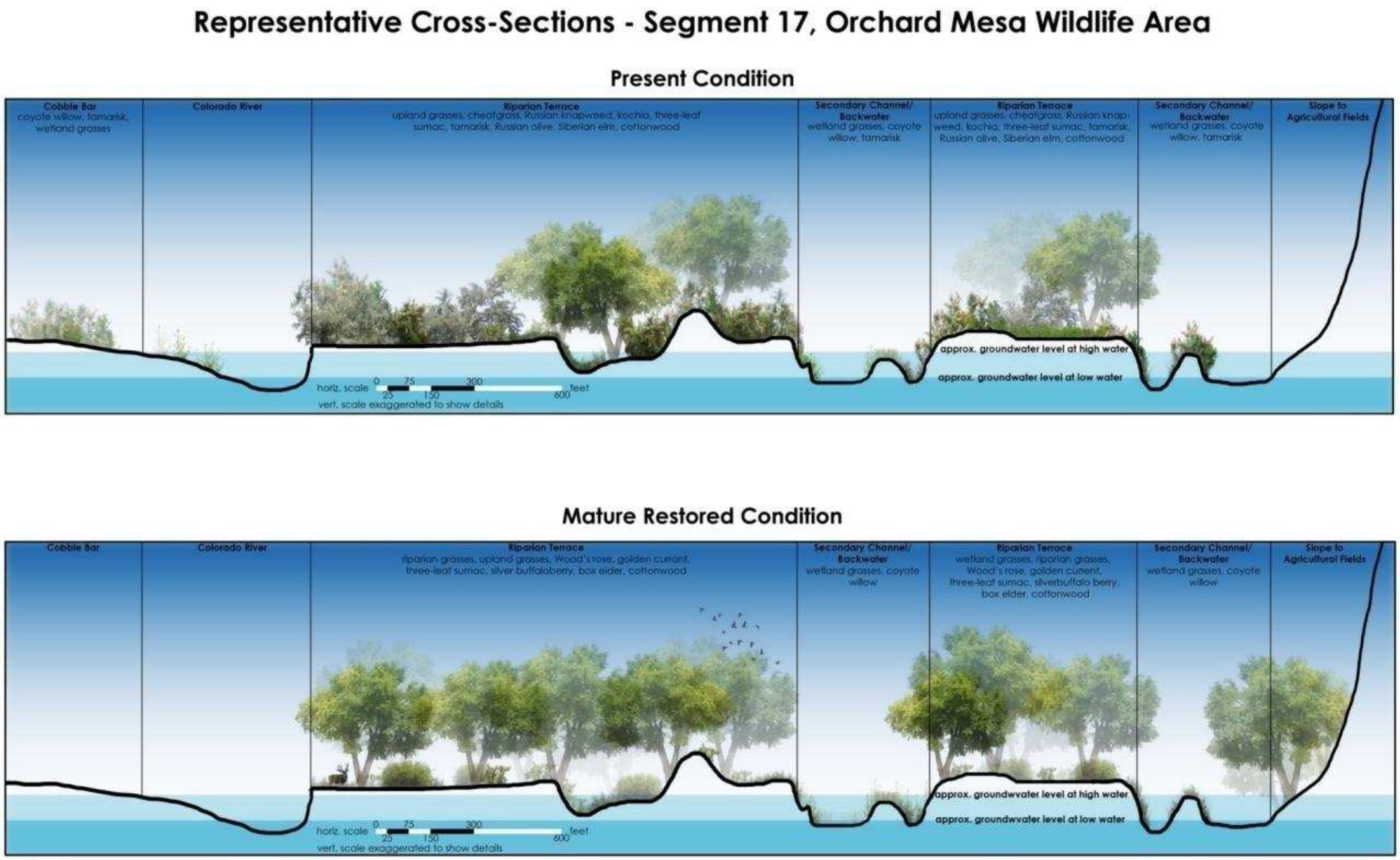

Figure 3.25 Representative cross sections- Segment 17, Orchard Mesa Wildlife Area.

4.0 PRELIMINARY DESIGN OF COLORADO RIVER SEGMENTS

4.1 Drawing Descriptions and Format (Map Book under Separate Cover)

Reconnaissance level plans have been developed for each of the segments and are appended under separate cover. All information was developed based on Phase 1 information and additional vegetation field surveys completed by the Tamarisk Coalition between June and July 2010. The corresponding map book provides index sheets which include an overview of segment locations and names, one sample map that describes labeling, and 22 maps which cover the project length. The maps are labeled according to the Map Number and the Segment Number. The maps contain the following information:

- Segment Boundaries: Segment boundaries are revised from Phase 1 based on a refined inventory of tamarisk, Russian olive and secondary invasive weeds.
- Site Designations (SD): Each segment is divided into sites which are represented by polygons. These sites are labeled according to their site designation. An example is 04R01. "04" represents the Segment Number, "R" indicates that the site type is designated as riparian, and "01" is the site number within the designation. The site types, all located within the floodplain, were determined according to the following descriptions.

  - *Upper Riparian (U)* – Sites estimated to be over 6 feet above the water table, and encompassing vegetation typical of upper riparian areas . The depth of the water table was determined using 2 ft contour shapefiles provided by the City of Grand Junction, and field observations of vegetation that can help approximate ground water depth. Monitoring wells are recommended to confirm depth to ground water.
  - *Riparian (R)* – The site is 0-6 feet above the water table and includes riparian terraces and cobble bars.
  - *Wetland (W)* – The site has standing water (i.e. is wet). Includes backwaters, secondary channels, sloughs and ponds.

- Cobble Bars: Where possible and practical cobble bars have been delineated as a single riparian site and designated as a cobble bar. However, not all bars are delineated as such and in some cases the bars are included with a larger riparian area. These are discussed on a site by site basis.
- Conservation Easements: Represents current conservation easements currently held by Mesa Land Trust or the Colorado Wildlife Heritage Foundation.
- Land Ownership: Shows landownership within each segment. Note: The Interstate 70 corridor is owned by the Colorado Department of Transportation and is not marked on each map.
- 100-year Floodplain: This information is based on floodplain delineations prepared by the Federal Emergency Management Agency (FEMA).
- Staging Area: Shows the location and extent of staging areas required for restoration work.
- Hydraulic Cross Sections: Shows the location and name of available hydraulic cross sections from both FEMA and Tetra Tech, previously developed for other purposes.

- Riverfront Trail: Shows existing and proposed sections of the Mesa County recreational trail system.
- Access Roads: Indicates access easements that will be required to access a given segment. Public roads, where available for accessing a segment are also noted by labels.
- Site Access Point: Shows recommended access points for the segment.
- Monitoring Wells: Shows recommended locations for groundwater monitoring wells (see Exhibit 2).
- Recreational Features: Shows location of recreational features. 12 wildlife viewing areas with educational interpretive signs are propsed.
- Soil Samples: Location of samples sites. Samples were taken in June and July of 2010 and represent areas where planting is recommended. See Exhibit 2 for a discussion on sample sites, methods and individual segment reports for a discussion of results.
- River Miles: The river miles shown on the Maps are those established by the Bureau of Reclamation prior to the 1984 flood event and represent miles upstream of the Green River confluence in Utah. The 1984 flood event changed the course of the river in some areas thereby altering the corridor. Thus in some cases the river miles do not always follow the current river corridor. The river miles for this project start and end at approximately river mile 152.5 and 185.2, respectively.

4.2 Project Narrative

Each of the river segments in the Project are described in the Narratives found in Sections 4.3 through 4.17. Eleven of these river segments are identified by the U.S. Fish and Wildlife Service (USFWS) as high priority sites for tamarisk control to restore endangered fish habitat. These high priority sites are identified in the discussion below by an asterisk. It is important to note that the 100-year floodplain of the Colorado River throughout the entire project area is designated by the USFWS as critical habitat for the endangered Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*). The high priority sites however, are specific areas that have had known occupation by one or more endangered fish species, or are considered to be unique and highly valued habitat with potential for occupation. Table 4.1 provides a summary of sites and priority rating.

Narratives include the following information:

- Segment Information: Each write up includes the segment number, name, river mile range covered, numbers of corresponding maps, a listing of all applicable site designations and corresponding photos by file name.
- Land ownership: The total acres of the segment are described along with the percentages of land ownership. The landownership categories are Federal, Non-Federal Public, and Private under Conservation Easement, Private Lands, and Unclassified. Non-Federal Public refers to land owned by the county, state, water and sanitation districts, and municipalities. Unclassified lands refer to lands that do not have any official ownership based on Mesa County Assessor’s records, according to parcel maps and surveys, and are thus, designated by default to fall under the control of BLM (Mesa County). These parcels were typically created when parcel lines were established as being defined by the riverbanks.

Table 4.1 Summary of segments.

MODERATE AND HIGH PRIORITY LISTINGS			
SEGMENT	**TITLE**	**RIVER MILE**	**PRIORITY**
4	Loma Boat Launch to Skipper's Island Complex	152.5 to 154	Moderate
5	Skipper's Island Complex	154 to 155.5	High
6	Skipper's Island Complex to Old Fruita Bridge	155.5 to 157.8	Moderate
8	OBY Property	159 to 161	High
9	River Segment: DuPont Island Complex	160.8 to 162.5	High
10	Walter Walker State Wildlife Area	162.7 to 166.4	High
11	Connected Lakes State Park Complex	166.5 to 168	High
12	Bananas Island	167.5 to 169	High
13	Broadway Bridge South Bank Island	169 to 170	High
14	Confluence Island and Jarvis	170 to 171	High
16	Watson Island Complex to Orchard Mesa and Colorado River Wildlife Areas	172.6 to 174	Moderate
17	Orchard Mesa and Colorado River Wildlife Areas	174 to 177	High
18A	Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area	177.8 to 182.9	Moderate
18B	Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area	179 to179.8	High
19	Tillie Bishop Wildlife Area	182.9 to 185.2	High

- Estimated tamarisk canopy coverage: Includes total acres and percent canopy cover of tamarisk for the whole segment. Polygons are drawn in the field using ArcPad 8.0 and percent canopy cover of tamarisk is estimated for each polygon. The polygons are digitized in ArcMap 9.3 and tamarisk acreages are calculated based on total acres in each polygon and associated estimated canopy coverage. The tamarisk acreages from each polygon are then summed to estimate total tamarisk canopy coverage for each segment.
- Estimated Russian olive canopy coverage: Includes total acres and percent canopy cover of Russian olive for the whole segment. Polygons are drawn in the field using ArcPad 8.0 and percent canopy cover of Russian olive estimated for each polygon. The polygons are digitized in ArcMap 9.3 and Russian olive acreages are calculated based on total acres in each polygon and associated estimated canopy coverage. The Russian olive acreages from each polygon are summed to estimate total Russian olive canopy coverage for each segment.
- Narrative description of the segment and recommendations: Indication of high priority site as designated by the USFWS if applicable.
- Recreation Features: Recreational features, location and type.
- Photo #s: Photos are labeled with the segment name, site designation, GPS coordinates, datum, direction the photo is taken, and date. The photo numbers are four digit numbers and correspond to the photo file names.
- Tables: Include details of all restoration recommendations for each segment. Tables provide information that corresponds to each site designation indicated on the maps.

Tables include site description and restoration action, grass seed mix type and method of application by site, acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site, areas identified and number of cottonwood pole and box elder plantings, access and staging area requirements

By way of summary, the proposed methods (presented in Section 3) are outlined below. Note that each Segment will utilize multiple options within each of the proposed methods of restoration. The proposed management approaches portray the most suitable combinations of control, biomass reduction, revegetation, habitat restoration and recreational elements for each segment within the project area. The recommended approaches also reflect the desires of public and private land managers (State Parks, Division of Wildlife, Colorado Department of Transportation, BLM, BOR, the Audubon Society, and the Cities of Grand Junction, Palisade, and Fruita) as identified through interviews in December 2007 and January 2008; and the recommendations, where appropriate, made in the *Colorado Headwaters Woody Invasive Species Management Plan for the Colorado River* (CHIP).

Control
- ✓ Hand Herbicide Application
- ✓ Hand Cutting with Herbicide Application
- ✓ Mechanical Removal
- ✓ Biological Control

Biomass Reduction
- ✓ Naturally Decompose/Standing Dead
- ✓ Mechanical Mulch
- ✓ Stack and Burn
- ✓ Stack and Pile for Habitat

Revegetation
- ✓ Leave Unvegetated
- ✓ Natural Recruitment
- ✓ Grass and Forbs
- ✓ Tree and Shrub Planting

Habitat Restoration
- ✓ Mid-channel bars: remove invasive species
- ✓ Side channels: remove invasive species
- ✓ Channel banks: remove invasive species, replace with native shrubs, grasses
- ✓ Walter Walker (Segment 10): construct site modifications

Recreation facilities
- ✓ Interpretive Signs, benches and viewing pad

4.3 River Segment 4: Loma Boat Launch to Skipper's Island Complex

<u>River Mile</u>: 152.7 to 153.9
<u>Maps</u>: Map 1 to Map 2
<u>Site Designations (SD)</u>: 04R02 and 04R04
<u>Photo #</u>: 1125, 1128
<u>Land Ownership</u>: 15.0 acres = 96% Federal, 0% Non-Federal Public, 0% Private, 0% Private under Conservation Easement, and 4% Unclassified.
<u>Estimated Tamarisk Canopy Coverage</u>: 15% of total or 2.2 acres
<u>Estimated Russian olive Canopy Coverage</u>: 1% of total or 0.1 acres

At the Loma boat launch the Colorado River transitions from the narrow canyon floodplain, downstream, to the broad Grand Valley floodplain, upstream. The Colorado River is immediately south of the Interstate 70 and north of Horsethief State Wildlife Area (SWA). Two cobble bars dominated by willows with 15 percent tamarisk and 1 percent Russian olive boarder the Interstate 70 corridor and the mid-channel island (SD: 04R02, 04R04; Photo 1125 and 1128). Tamarisk and Russian olive will be removed from these sites and the cobble bars will be left unvegetated.

Any work adjacent to Interstate 70 will require permits from CDOT for work within the right-of-way or for access to adjacent property. CDOT has indicated support for permitting this effort.

Recreational Features: One wildlife viewing area and educational interpretive sign will be installed at the Loma boat launch.

Photo 1125

Photo 1128

Maps 1 and 2 provide site designations; tree planting areas, land ownership, conservation easements, 100 year flood plain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds, and sloughs are abbreviated by "SC", "BW", "P", and "SL" respectively.

Table 4.2 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Cobble Bars	04R02, 04R04	15 acres with 15% T, 1% RO and no RK. These sites are cobble bars and islands dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	<u>Control</u>: Biological control for T, hand cut RO. <u>Biomass</u>: Leave RO to naturally decompose. <u>Revegetation</u>: No revegetation.

Table 4.3 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Cobble Bar	04R02	8	None	-	-
	04R04	7	None	-	-

*Type of Grass Seed Mix:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.4 Acres of Tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive										
	Site	**Acres**	**Veg Const***	**%**	**Acres**	**%**	**Acres**	**Three-Leaf Sumac**	**Golden Current**	**Woods Rose**	**Silver Buffaloberry**	**Rubber Rabbitbrush**	**Fourwing Saltbrush**	**Big Sagebrush**	**Winterfat**	**Total**
Cobble Bar	04R02	8.2	Cobble	10	0.8	1	0.1	0	0	0	0	0	0	0	0	**0**
	04R04	6.8	Island	20	1.4	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**15.0**			**2.2**		**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**15.0**			**2.2**		**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

* **Veg Const (Vegetation Constraints): Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.5 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
None	0	0	0	**0**
Total	**0**	**0**	**0**	**0**

Table 4.6 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
04-B	N 39.168573° W 108.793404°	04R02, 04R04	**River Access Only:** Put-In at James M. Robb Colorado River State Park Fruita Section; take-out Loma Boat Ramp in Loma, CO	None required

Table 4.7 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.8 Overview of control and restoration acreages.

Site	Total Site Acrage	Acres with Control: Mechanical: Tamarisk	Acres with Control: Mechanical: Russian olive	Acres with Control: Mechanical: Subtotal Mechanical	Acres with Control: Hand: Tamarisk	Acres with Control: Hand: Russian olive	Acres with Control: Hand: Subtotal Hand	Acres with Control: Biocontrol: Tamarisk	Acres with Control: Total: Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Revegetation: Recommended Shrub Planting Area (Acres)	Revegetation: Number of Shrub Plantings	Revegetation: RecommendedTree Planting Area (Acres)	Revegetation: Number of Tree Plantings	Biomass Reduction of Hand: Mulching	Biomass Reduction of Hand: Fire	Biomass Reduction of Hand: Natural Decomposition
04R02	8.2	0.0	0.0	0.0	0.0	0.1	0.1	0.8	0.9	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.08
04R04	6.8	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.4	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	15.0	0.0	0.0	0.0	0.0	0.1	0.1	2.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08

4.4 River Segment 5: Skipper's Island Complex*

River Mile: 153.9 to 155.8
Maps: Map 2 to Map 3
Site Designations (SD): 05U04, 05R04 and 05R07 to 05R09
Photo #: 1119-1121
Land Ownership: 89.8 acres = 100% Federal, 0% Non-Federal Public, 0% Private, 0% Private under Conservation Easement, and 0% Unclassified.
Estimated Tamarisk Canopy Coverage: 45% of total or 40.1 acres
Estimated Russian olive Canopy Coverage: 11% of total or 9.7 acres

**The USFWS has identified this segment a high priority for restoring habitat for endangered fish species.*

Ownership of Skipper's Island Complex is split between private and public (mostly BOR) parties. On the north side of the river, the complex contains a large upper riparian terrace (SD: 05U04), and a historic cobble bar (SD: 05R09) infested with tamarisk. Currently, the island vegetation is transitioning from riparian to upper riparian. Tamarisk may be exacerbating this habitat conversion because of its sediment capturing root systems. Overall, the upper riparian terrace on the north side of the river has 50 percent tamarisk, 10 percent Russian olive and 80 percent Russian knapweed therefore, removal and active revegetation is necessary (Photo 1120). The riparian cobble bar (Photo 1121) will be addressed with biological control of tamarisk, and hand-cutting Russian olive.

A narrow riparian terrace (SD: 05R04) dominated by 30 percent tamarisk and 30 percent Russian olive runs along the south bank upstream of riparian complex. Two cobble bar islands (SD: 05R07, 05R08) dominated by coyote willow and 20 percent tamarisk are located in the east end of the segment. Tamarisk will be addressed with biological control while Russian olive will be removed by hand.

Historically, Skipper's Island Complex has been used by endangered fish species throughout the year. However, if the upper riparian terrace transition continues the backwater could be compromised, impairing the aquatic habitat. Removing tamarisk and Russian olive from this area will allow native riparian vegetation to recover and could potentially protect the backwater by preserving water and by capturing less sediment. In addition the cobble bars are being colonized by tamarisk reducing the surface to be utilized during spawning.

Any work adjacent to Interstate 70 will require permits from the Colorado Department of Transportation (CDOT) for work within the right-of-way or for access to adjacent property. CDOT has indicated support for permitting this effort.

Recreational Features: No recreational features are planned for this segment.

Photo 1120

Photo 1121

Maps 2 and 3 provide site designations; tree planting areas, land ownership, conservation easements, 100 year flood plain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds, and sloughs are abbreviated as "SC", "BW", "P", and "SL" respectively.

Table 4.9 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Upper Riparian Terrace	05U04	71.2 acres with 50% T, 10% RO and 80% RK. This site is an upper riparian terrace dominated by upland grasses, cheatgrass, RK and sparse shrubs.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting of RO; treat secondary weed with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant upland shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Lower Riparian Terrace	05R04	8 acres with 30% T, 30% RO and 40% RK. This site is lower riparian terrace dominated by coyote willows and wetland grasses with few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control for T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	05R07, 05R08, 05R09	36 acres with 20% T, 1% RO and 1% RK. These sites are cobble bars dominated by coyote willows and wetland grasses with few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control for T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.

Table 4.10 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Upper Riparian Terrace	05U04	71.2	RK and cheatgrass infestation	Upland Salty	Broadcast
Lower Riparian Terrace	05R04	8.2	RK, kochia, Russian thistle and cheatgrass infestation	Riparian	Broadcast
Cobble Bar	05R07	0.9	Kochia and perennial pepperweed	Riparian	Broadcast
	05R08	8.0	None	-	-
	05R09	1.5	None	-	-
Totals		89.8			

*Type of Grass Seed Mix:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.11 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive										
	Site	Acres	Veg Const*	%	Acres	%	Acres	Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Upper Riparian Terrace	05U04	71.2	None	50	35.6	10	7.1	0	0	0	0	733	733	733	733	**2932**
	Sub-Total	**71.2**			**35.6**		**7.1**	**0**	**0**	**0**	**0**	**733**	**733**	**733**	**733**	**2932**
Lower Riparian Terrace	05R04	8.2	Veg	30	2.5	30	2.5	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**8.2**			**2.5**		**2.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cobble Bars	05R07	0.9	Island	10	0.1	5	0	0	0	0	0	0	0	0	0	**0**
	05R08	8.0	Island	20	1.6	0	0	0	0	0	0	0	0	0	0	**0**
	05R09	1.5	Cobble	20	0.3	5	0.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**10.4**			**2.0**		**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**89.8**			**40.1**		**9.7**	**0**	**0**	**0**	**0**	**733**	**733**	**733**	**733**	**2932**

* **Veg Const (Vegetation Constraints): Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

#: Replacement revegetation numbers are calculated based on acres of tree plantings from Table 5-4 due to area available for plantings.

Table 4.12 Areas identified and number of vottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
None	0	0	0	**0**
Total	**0**	**0**	**0**	**0**

Table 4.13 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
05-B	N 39.163876° W 108.78164°	05U04, 05R09	I-70 west to Loma Exit #15; turn around to head I-70 east, access point is a gravel turn-off on the south side of the interstate 1000 ft before mile marker 24	0.74 acres
05-D	N 39.157141° W 108.762596°	05R04, 05R07, 05R08	**River Access Only:** Put-in at James M. Robb State Park Fruita Section; take-out at Loma Boat Ramp in Loma, CO	None required

Table 4.14 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.15 Overview of control and restoration acreages.

Site	Total Site Acrage	Acres with Control								Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
		Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control			Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
05U04	71.2	10.7	6.4	17.1	0.0	0.7	0.7	24.9	42.7	57.0	71.2	71.2	2931.6	0.0	0.0	0.0	0.0	0.7
05R04	8.2	0.0	0.0	0.0	0.0	2.5	2.5	2.5	4.9	3.3	8.2	0	0.0	0.0	0.0	0.0	1.6	0.9
05R07	0.9	0.0	0.0	0.0	0.0	0.04	0.0	0.1	0.1	0.1	0.9	0	0.0	0.0	0.0	0.0	0.0	0.05
05R08	8.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
05R09	1.5	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.4	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.08
Totals	89.8	10.7	6.4	17.1	0.0	3.3	3.3	29.4	49.8	60.3	80.3	71.2	2931.6	0.0	0.0	0.0	1.6	1.7

4.5 River Segment 6: Skipper's Island Complex to Old Fruita Bridge

River Mile: 155.8 to 157.7
Maps: Map 4 to Map 5
Site Designations (SD): 06U03 to 06U04, 06R05 to 06R10 and 06W01
Photo #: 0604-0608, 0612, 3208-3209
Land Ownership: 44.3 acres = 0% Federal, 55.9% Non-Federal Public, 0% Private, 0% Private under Conservation Easement, and 44.1% Unclassified.
Estimated Tamarisk Canopy Coverage: 20% of total or 8.9 acres
Estimated Russion olive Canopy Coverage: 7% of total or 3.2 acres

This two-mile river section is bordered to the north by the James M. Robb Colorado River State Park. To the south is the City of Fruita's Kingsview Open Space Park near the CO Hwy 340 Bridge and Snook's Bottom, which is a park also owned by the City of Fruita with BLM land intermixed.

The Snooks Bottom park is an old gravel pit lake adjacent to an upper riparian terrace (SD: 06U03), lower riparian terraces (SD: 06R07, 06R08), secondary channel/backwater (SD: 06W01), and cobble bar (SD: 06R06). Active revegetation will be done on the upper and lower riparian terrace after the removal of approximately 20 percent tamarisk and 20 percent Russian olive (Photo 0606). Tamarisk and Russian olive have been removed around the lake, but no secondary weed control or revegetation has occurred (Photo 0605). In order to improve habitat and recreational value, active revegetation around the lake is recommended. Restoration in this complex will increase aquatic habitat by opening up a backwater area (SD: 06W01) for endangered fish rearing and mobilize a cobble bar (SD: 07R06) to be used as spawning habitat.

A thin riparian terrace (SD: 06R05) runs between the Snooks bottom park and the City of Fruita's Kingsview Open Space Park. It is dominated by 40 percent tamarisk and 10 percent Russian olive. Here, the Russian olive will be cut by hand and biological control will be used on the tamarisk.

The upper riparian terrace (SD: 06U04) on the north side of the river has 70 percent tamarisk and 10 percent Russian olive (Photo 0609). Invasive removal and subsequent active revegetation is recommended for SD: 06U04.

Two low lying mid-channel cobble bar islands just downstream of the CO Hwy 340 bridge are being colonized and stabilized by 20 percent tamarisk (SD: 06R09, 06R10; Photo 0607). Using biological control to remove these plants is proposed to help restore the natural dynamic nature of such islands and increase available surfaces for spawning.

Recreational Features: Two wildlife viewing areas and educational interpretive signs will be installed. One will be located on the north side of the river by the boat launch in the James M. Robb Colorado River State Park, Fruita Section. The other will be located near the Snooks Bottom Lake.

Photo 0606

Photo 0605

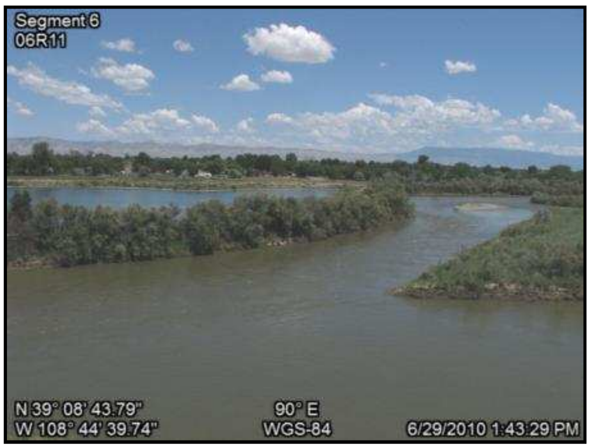

Photo 0609

Photo 0607

Maps 4 and 5 provide site designations; tree planting areas, land ownership, conservation easements, 100 year flood plain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC", "BW", "P", and "SL" respectively.

Table 4.16 Site description and restoration action.

	Sites	Description	Restoration Approach
Upper RiparianTerraces	06U03, 06U04	9 acres with 40% T, 10% RO and 40% RK. These sites are upper riparian terraces dominated by upland grasses, cheatgrass, RK and sparse shrubs.	Control: Mechanical removal and biological control T. Mechanical removal and hand cutting of RO and T; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant upland shrubs and seed appropriate grass mix to outcompete secondary weeds.
Lower Riparian Terraces	06R08	2.6 acres with 40% T, 40% RO and 20% RK. These sites are lower riparian terraces dominated by old cottonwood galleries, upland grasses and sparse shrubs.	Control: Mechanical removal and biological control T. Mechanical removal and hand cutting of RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds to outcompete secondary weeds.
	06R07	11 acres with no T, RO or RK. This site is Snook's Bottom lake. T has been removed from the perimeter but no revegetation has occurred therefore it is mostly bare ground with kochia, cheatgrass and other upland grasses.	Control: None Biomass: None Revegetation: Plantings of CW &BE in designated areas, plant upland shrubs on outside edges and riparian shrubs next to the lake and seed appropriate grass mix to outcompete secondary weeds.
	06R05	0.4 acres with 40% T, 10% RO and no RK. This site is a lower riparian terrace dominated by T, riparian shrubs with some RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for wildlife habitat. Revegetation: Natural recruitment, seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	06R06, 06R09, 06R10	17.8 acres with 20% T, 5% RO and no RK. These sites are cobble bars and islands dominated by coyote willows and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for wildlife habitat. Revegetation: No revegetation, seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
SC, BW, P, SL	06W01	3 acres with no T, RO or RK. This site is a wetland dominated by wetland grasses and willows. RO and T hang over the bank, but are addressed in adjacent sites. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: None. Biomass: None. Revegetation: No revegetation.

Table 4.17 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Upper Riparian Terraces	06U03	5	RK, cheatgrass and kochia infestation	Upland	Broadcast
	06U04	4	Cheatgrass and RK infestation	Upland Salty	Drill
Lower Riparian Terraces	06R08	3	RK infestation	Riparian	Broadcast
	06R07	11	Kochia and cheatgrass infestation	Riparian/Upland	Broadcast
	06R05	0.4	Natural recruitment is adequate	-	-
Cobble Bars	06R06	6	None	-	-
	06R09	9	None	-	-
	06R10	3	None	-	-
SC, BW, P, SL	06W01	3	None	-	-

***Type of Grass Seed Mix**:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.18 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species by site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

	Site	Acres	Veg Const*	Woody Invasives: Tamarisk %	Tamarisk Acres	Russian Olive %	Russian Olive Acres	No. Riparian Replacement Shrubs Species: Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	No. Upland Replacement Shrubs Species: Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Upper Riparian Terraces	06U03	5.3	None	10	0.5	10	0.5	0	0	0	0	23	23	23	23	**93**
	06U04	3.9	None	70	2.8	10	0.4	0	0	0	0	52	52	52	52	**208**
	Sub-Total	**9.2**			**3.3**		**0.9**	**0**	**0**	**0**	**0**	**75**	**75**	**75**	**75**	**302**
Lower Riparian Terrace	06R08	2.6	None	40	1.1	40	1.1	93	93	93	47	0	0	0	0	**326**
	Sub-Total	**2.6**			**1.1**		**1.1**	**93**	**93**	**93**	**47**	**0**	**0**	**0**	**0**	**326**
Lower Riparian Terrace	06R07[#]	10.8	None	0	0	0	0	319	319	319	160	160	160	160	160	**1755**
	Sub-Total	**10.8**			**0**		**0**	**319**	**319**	**319**	**160**	**160**	**160**	**160**	**160**	**1755**
Lower Riparian Terrace	06R05	0.4	Veg	40	0.2	10	0.04	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**0.4**			**0.2**		**0.04**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cobble Bars	06R06	6.5	Veg	20	1.3	10	0.6	0	0	0	0	0	0	0	0	**0**
	06R09	8.6	Island	30	2.6	5	0.4	0	0	0	0	0	0	0	0	**0**
	06R10	2.8	Island	20	0.6	5	0.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**17.8**			**4.4**		**1.2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	06W01	3.4	Veg	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**3.4**			**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**44.3**			**8.9**		**3.2**	**412**	**412**	**412**	**206**	**235**	**235**	**235**	**235**	**2383**

*__Veg Const (Vegetation Constraints): Veg__ - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to the site.

#: Replacement revegetation numbers are calculated based on the total acres of this site due to the lack of T and RO and desire to improve habitat and recreational values.

Table 4.19 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calcualtions.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
06R08, 06W01	3	36	13	**49**
06R07	10	136	49	**185**
Total	**13**	**172**	**63**	**235**

Table 4.20 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
06-B	N 39.148077° W 108.747335°	06U03, 06R06, 06R07, 06R08, 06W01	Take CO Hwy 340 south from Fruita, cross the river and turn west (R) on Kingsveiw Rd, when it turns to dirt vear right towards Snooks Bottom.	2.71 acres
06-C	N 39.143226° W 108.741538°	06R09, 06R10,	**River access only**: Put-in at Blue Heron Boat Launch, take-out at James M. Robb Colorado River State Park	None Required
06-D	N 39.145102° W 108.739718°	06U04	Take CO Hwy 340 south from Fruita, turn Right into the James M. Robb Colorado River State Park	1.05 acres
06-E	N 39.139502° W 108.738512°	06R05	Take CO Hwy 340 south from Fruita, cross the bridge and turn west (R) into small dirt access area south of the river.	0.65 acres

Table 4.21 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.22 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
06U03	5.3	0.1	0.5	0.6	0.0	0.1	0.1	0.4	1.1	2.1	5.3	5.3	93	0.0	0	0.0	0.0	0.05
06U04	3.9	0.8	0.4	1.2	0.0	0.04	0.04	1.9	3.1	2.0	3.9	3.9	208	0.0	0	0.0	0.0	0.04
06R05	0.4	0.0	0.0	0.0	0.0	0.04	0.04	0.2	0.2	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.04
06R06	6.5	0.0	0.0	0.0	0.0	0.6	0.6	1.3	1.9	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.7
06R07	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	10.8	10.8	1755	10.5	185	0.0	0.0	0.0
06R08	2.6	0.3	1.0	1.3	0.0	0.1	0.1	0.7	2.1	0.5	2.6	2.6	326	2.8	49	0.0	0.0	0.1
06R09	8.6	0.0	0.0	0.0	0.0	0.4	0.4	1.6	2.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.4
06R10	2.8	0.0	0.0	0.0	0.0	0.1	0.1	0.8	0.9	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.1
06W01	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
Totals	44.3	1.2	1.8	3.0	0.0	1.4	1.4	7.0	11.4	6.8	22.7	22.7	2383	13.3	235	0.0	0.0	1.5

4.6 River Segment 8: Oby Property*

River Mile: 159.0 to 160.7
Maps: Map 6 to Map 7
Site Designations (SD): 08R01 to 08R08, and 08W01 to 08W03
Photo #: 1098, 1100-1111
Land Ownership: 144.9 acres = 2% Federal, 18% Non-Federal Public, 74% Private, 0% Private under Conservation Easement, and 6% Unclassified.
Estimated Tamarisk Canopy Coverage: 36% of total or 52.2 acres
Estimated Russian olive Canopy Coverage: 22% of total or 32.4 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species.*

The majority of this property is divided among several private owners; however, a significant portion is owned by the State of Colorado and managed by Colorado State Parks. The northern bank complex contains a lower riparian terrace (SD: 08R01, 08R03), a secondary and historic tertiary channel of the Colorado River (SD: 08W03), an island (SD: 08R04, 08R06; Photo 1107), a pond/slough (SD: 08W02) and an overflow channel from a gravel pit lake (SD: 08W01). A portion of 08W01 is being encroached upon by tamarisk (Photo 1106). Overall the north bank has 40 percent tamarisk, 20 percent Russian olive and 30 percent Russian knapweed in the riparian sites and 20 percent tamarisk and 10 percent Russian olive in the wetland sites. Removal of tamarisk using biological control is appropriate. Russian olive will be removed by mechanical equipment. Active revegetation with shrubs is proposed for all the riparian sites while tree plantings should only be done in selected areas for improving cottonwood populations. The secondary channel, pond/slough and overflow channel will be left unvegetated.

The southern bank supports a few small cobble bar islands (SD: 08R05, 08R07, 08R08) and a thin lower riparian terrace with 30 percent tamarisk, 20 percent Russian olive and 10 percent Russian knapweed (SD: 08R02; Photo 1110). Russian olive will be removed by hand in these areas, tamarisk will be controlled with biological control and revegetation will be by natural recruitment, with the exception of 08R07, which will be left unvegetated.

Controlling tamarisk and Russian olive in these areas will improve habitat for endangered fish and slow the degradation of secondary channels. Riparian habitat would also be improved.

Recreational Features: No recreational features are planned for this segment.

Photo 1107

Photo 1106

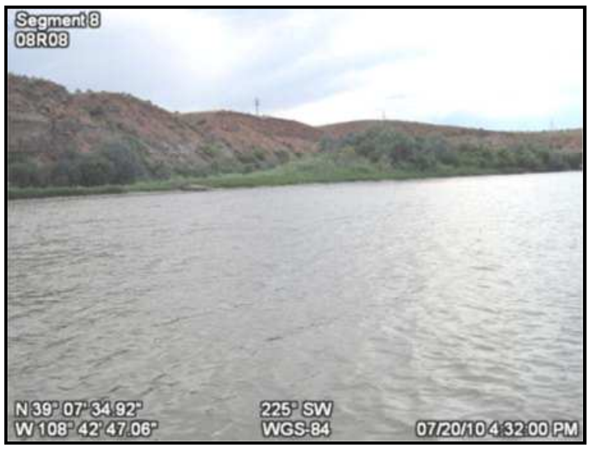

Photo 1110

Maps 6 and 7 provide site designations, tree planting areas, land ownership, conservation easements, 100-year flood plain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as “T”, “RO”, “RK”, “CW”, and “BE” respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as “SC”, “BW”, “P”, and “SL” respectively.

Table 4.23 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
LowerRiparian Terraces	08R01, 08R03, 08R04, 08R06	111 acres with 40% T, 20% RO and 30% RK. These sites are lower riparian terraces dominated by T and RO with some old cottonwood galleries, upland grasses, secondary weeds and sparse shrubs. Some areas have been cleared by landowners for unknown reasons.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to outcompete secondary weeds.
	08R02	6 acres with 30% T, 30% RO and 20% RK. This site is lower riparian terrace dominated by coyote willows and wetland grasses with moderate T and RO and sparse riparian shrubs. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Islands	08R05, 08R08	7 acres with 30% T, 10% RO and 10% RK. These sites are islands dominated by coyote willows and wetland grasses with moderate T and RO and sparse riparian shrubs. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bar	08R07	1 acre with no T, RO or RK. This site is a cobble bar dominated by coyote willows and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: None. Biomass: None. Revegetation: No revegetation.
SC, BW, P, SL	08W01, 08W02, 08W03	19 acres with 20% T, 10% RO and no RK. These sites are wetlands dominated by wetland grasses and willows. RO and T hang over the bank, but are addressed in adjacent sites. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation.

Table 4.24 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Lower Riparian Terraces	08R01	38	Perennial pepperweed, RK and kochia infestation	Upland Salty	Broadcast
	08R03	35	RK, whitetop, perennial pepperweed and kochia infestation	Upland Salty	Broadcast
	08R04	15	Whitetop and RK infestation	Upland	Broadcast
	08R06	24	RK infestation	Upland	Broadcast
	08R02	6	RK infestation	Riparian	Broadcast
Islands	08R05	4	Natural recruitment is adequate	-	-
	08R08	3	RK and cheatgrass infestation	Riparian	Broadcast
Cobble Bar	08R07	1	Natural recruitment is adequate	-	-
SC, BW, P, SL	08W01	3	Natural recruitment is adequate	-	-
	08W02	5	Natural recruitment is adequate	-	-
	08W03	11	Natural recruitment is adequate	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.25 Acres of tamarisk and Russian olive to treate and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive		Three-Leaf	Golden	Woods	Silver	Rubber	Fourwing	Big		
	Site	**Acres**	**Veg Const***	**%**	**Acres**	**%**	**Acres**	**Sumac**	**Current**	**Rose**	**Buffaloberry**	**Rabbitbrush**	**Saltbrush**	**Sagebrush**	**Winterfat**	**Total**
Lower Riparian Terraces	08R01	37.7	None	30	11.3	10	3.8	554	554	554	277	0	0	0	0	**1939**
	08R03	34.7	None	60	20.8	30	10.4	1225	1225	1225	613	0	0	0	0	**4289**
	08R04	14.6	None	30	4.4	50	7.3	558	558	558	279	0	0	0	0	**1952**
	08R06	24.0	None	30	7.2	20	4.8	495	495	495	248	0	0	0	0	**1733**
	Sub-Total	**111.0**			**43.7**		**26.3**	**2832**	**2832**	**2832**	**1416**	**0**	**0**	**0**	**0**	**9912**
Lower Riparian Terrace	08R02	6.3	Veg	30	1.9	30	1.9	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**6.3**			**1.9**		**1.9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Islands	08R05	4.3	Island	40	1.7	20	0.9	0	0	0	0	0	0	0	0	**0**
	08R08	3.0	Island	20	0.6	20	0.6	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**7.2**			**2.3**		**1.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cobble Bar	08R07	1.1	Island	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**1.1**			**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	08W01	3.2	Veg	5	0.2	5	0.2	0	0	0	0	0	0	0	0	**0**
	08W02	5.1	Veg	60	3.1	30	1.5	0	0	0	0	0	0	0	0	**0**
	08W03	10.9	Veg	10	1.1	10	1.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**19.3**			**4.3**		**2.8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**144.9**			**52.2**		**32.4**	**2832**	**2832**	**2832**	**1416**	**0**	**0**	**0**	**0**	**9912**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.26 Areas identified and number of cottowood pole and boxelder planting.

NOTE: Refer to revegetation recommendations section or the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
08R01, 08W01	27	349	127	**476**
08R03, 08W02, 08W03	20	256	93	**349**
08R04	15	188	68	**256**
Total	**61**	**793**	**288**	**1081**

Table 4.27 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
08-A	N 39.128902° W 108.710209°	08R03, 08R04, 08R06, 08W03	Take Frontage Road east from Fruita, turn south on 18.5 Rd, access through Adobe Creek Golf Course on private road for 0.05	0.81 acres
08-B	N 39.123129° W 108.701239°	08R01, 08R03, 08W01, 08W02	Take Frontage Road east from Fruita, turn south on 19 Rd	1.87 acres
08-C	N 39.116262° W 108.694446°	08R02, 08R05, 08R07, 08R08	**River access only:** Put-in at Blue Heron Boat Launch and take-out at James M. Robb Colorado River State Park Fruita Section	None required

Table 4.28 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Sat Paste mmhos/cm
08R01	4"	8.51	0.79	1.97
	10"	7.97	3.53	8.83

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.29 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
08R01	37.7	2.3	0.1	2.4	0.0	0.4	0.4	9.0	11.8	13.2	37.7	37.7	1939	27.0	476	0.0	0.0	0.0
08R02	6.3	0.0	0.0	0.0	0.0	1.9	1.9	1.9	3.8	1.3	6.3	0.0	0	0.0	0	0.0	1.2	0.7
08R03	34.7	6.2	9.4	15.6	0.0	1.0	1.0	14.6	31.2	29.5	34.7	34.7	4289	19.8	349	0.0	0.0	1.0
08R04	14.6	1.3	6.6	7.9	0.0	0.7	0.7	3.1	11.7	7.3	14.6	14.6	1952	14.5	256	0.0	0.0	0.7
08R05	4.3	0.0	0.0	0.0	0.0	0.9	0.9	1.7	2.6	0.0	0.0	0.0	0	0.0	0	0.0	0.4	0.4
08R06	24.0	1.4	4.3	5.8	0.0	0.5	0.5	5.8	12.0	9.6	24.0	24.0	1733	0.0	0	0.0	0.0	0.5
08R07	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
08R08	3.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	1.2	0.6	3.0	0.0	0	0.0	0	0.0	0.3	0.3
08W01	3.2	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.3	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.2
08W02	5.1	0.0	0.0	0.0	0.0	1.5	1.5	3.1	4.6	0.0	0.0	0.0	0	0.0	0	0.0	1.0	0.5
08W03	10.9	0.0	0.0	0.0	0.0	1.1	1.1	1.1	2.2	0.0	0.0	0.0	0	0.0	0	0.0	0.0	1.1
Totals	144.9	11.3	20.4	31.6	0.0	8.8	8.8	41.0	81.3	61.5	120.3	111.0	9912	61.2	1081	0.0	3.0	5.4

4.7 River Segment 9: Dupont Island Complex*

River Mile: 160.7 to 162.7
Maps: Map 7 to Map 8
Site Designations (SD): 09U01, 09R01 to 09R06, and 09W01.
Photo #: 1089, 1091-1096, 1099
Land Ownership: 237.5 acres = 0% Federal, 7% Non-Federal Public, 67% Private, 11% Private under Conservation Easement, and 15% Unclassified.
Estimated Tamarisk Canopy Coverage: 26% of total or 61.5 acres
Estimated Russian olive Canopy Coverage: 24% of total or 57.8 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

Mesa County owns a relatively small parcel of this land. The remainder of this large island and river bank complex is owned by several private parties. The island complex contains one large island, Dupont Island, and two small islands. Historically, this large island was divided by numerous braided channels that are currently choked by tamarisk and sediment. The riparian sites on the islands have 30 percent tamarisk, 30 percent Russian olive and 50 percent Russian knapweed (SD: 09R03, 09R04, 09R05, 09R06; Photo 1095) while the upper riparian terrace (SD: 09U01) and wetland (SD: 09W01) sites have 10 percent tamarisk and 10 percent Russian olive (Photo 1094). All control actions on the islands will be done through a combination of biological and hand approaches. The area supports a variety of native vegetation, which is anticipated to provide seed material for natural recruitment to colonize most areas once the tamarisk and secondary weeds are removed, thereby reducing the effort required to revegetate this site. Removing tamarisk and Russian olive in the island complex will improve the vigor of native plant species, facilitate the natural channel braiding through the island, and provide habitat for endangered and native fish as well as terrestrial species. US Fish and Wildlife Service (USFWS) believes the downstream cobble bar complex (portions of 09R01, 09R03 and 09R06) southwest tip of the island near mile 160.8) was once used for spawning by endangered fish, in particular, the Colorado pikeminnow (Photo 1099). Thus, removing tamarisk from the low lying cobble bar will improve the bar dynamics and potential habitat for fish spawning. The cobble bars within each of these riparian sites will remain unvegetated after tamarisk removal.

The lower riparian terrace on the southern bank is bordered to the south by a gravel pit operation (SD: 09R01). The site is dominated by old cottonwood galleries, 40 percent tamarisk, 30 percent Russian olive and 20 percent Russian knapweed (Photo 1089). Active removal and revegetation are proposed to improve wildlife habitat at this site.

Recreational Features: No recreational features are planned for this segment.

Photo 1095

Photo 1094

Photo 1099

Photo 1089

Maps 7 and 8 provide site designations, tree planting areas, land ownership, conservation easements, 100-year flood plain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as “T”, “RO”, “RK”, “CW”, and “BE” respectively. Secondary channels, backwaters, ponds, and sloughs are abbreviated as “SC”, “BW”, “P”, and “SL” respectively.

Table 4.30 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Upper Riparian Terrace	09U01	21 acres with 10% T, 10% RO and 20% RK. This site is an upper riparian terrace on an island, dominated by upland grasses, cheatgrass, RK and sparse shrubs.	Control: Biological control T, hand cut RO; treat secondary weeds with herbicide. Biomass: Stack piles for wildlife habitat. Revegetation: Natural recruitment, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Lower Riparian Terraces	09R01	56 acres with 40% T, 30% RO and 10% RK. This site is a lower riparian terrace dominated by T and RO with some old cottonwood galleries, upland grasses and sparse shrubs.	Control: Mechanical removal of T and RO, biological control for T, hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
	09R03, 09R04, 09R05, 09R06,	140 acres with 30% T, 30% RO and 50% RK. These sites are lower riparian terraces on islands, dominated by T and RO and secondary weeds, and some CW, upland grasses and sparse shrubs.	Control: Biological control T, hand cut RO; treat secondary weeds with herbicide. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
SC, BW, P, SL	09W01	21 acres with 10% T, 10% RO and no RK. This site is a wetland dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for wildlife habitat. Revegetation: No revegetation.

Table 4.31 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Upper Riparian Terrace	09U01	21	RK and cheatgrass infestation	Upland	Broadcast
Lower Riparian Terraces	09R01	56	Cheatgrass and RK infestation	Riparian	Broadcast
	09R03	50	RK, cheatgrass and perennial pepperweed infestation	Riparian	Broadcast
	09R04	5	Natural recruitment is adequate	-	-
	09R05	7	RK infestation	Riparian	Broadcast
	09R06	77	RK and cheatgrass infestation	Riparian	Broadcast
SC, BW, P, SL	09W01	21	None	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.32 Acres of tamarisk and Russian olive to treat and number of replacmement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive										
	Site	Acres	Veg Const*	%	Acres	%	Acres	Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Upper Riparian Terrace	09U01	21.0	Island	10	2.1	10	2.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**21.0**			**2.1**		**2.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lower Riparian Terrace	09R01	55.5	None	40	22.2	30	16.7	1632	1632	1632	816	0	0	0	0	**5713**
	Sub-Total	**55.5**			**22.2**		**16.7**	**1632**	**1632**	**1632**	**816**	**0**	**0**	**0**	**0**	**5713**
Lower Riparian Terraces	09R03	50.3	Island	30	15.1	20	10.1	0	0	0	0	0	0	0	0	**0**
	09R04	5.4	Island	20	1.1	30	1.6	0	0	0	0	0	0	0	0	**0**
	09R05	6.9	Island	50	3.4	30	2.1	0	0	0	0	0	0	0	0	**0**
	09R06	77.1	Island	20	15.4	30	23.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**139.7**			**35.0**		**36.9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	09W01	21.2	Veg	10	2.1	10	2.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**21.2**			**2.1**		**2.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**237.5**			**61.5**		**57.8**	**1632**	**1632**	**1632**	**816**	**0**	**0**	**0**	**0**	**5713**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to the site.

Table 4.33 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
None	0	0	0	0
Total	**0**	**0**	**0**	**0**

Table 4.34 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
09-B	N 39.115466° W 108.685147°	09R01	Take CO Hwy 340 south from Fruita, at S. Broadway Intersection turn north onto private road for approximately 1.6 miles	0.33 acres
09-C	N 39.120530° W 108.677827°	09U01, 09R03, 09R04, 09R05, 09R06, 09W01	**River access only:** Put-in at Blue Heron Boat Launch; take-out at James M. Robb Colorado State Park Fruita Section.	None required

Table 4.35 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.36 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
09U01	21.0	0.0	0.0	0.0	0.0	2.1	2.1	2.1	4.2	4.2	21.0	0.0	0	0.0	0	0.0	0.0	2.1
09R01	55.5	6.7	15.0	21.6	0.0	1.7	1.7	15.5	38.9	5.6	55.5	55.5	5713	0.0	0	0.0	0.0	1.7
09R03	50.3	0.0	0.0	0.0	0.0	10.1	10.1	15.1	25.2	27.7	50.3	0.0	0	0.0	0	0.0	5.0	5.0
09R04	5.4	0.0	0.0	0.0	0.0	1.6	1.6	1.1	2.7	0.0	5.4	0.0	0	0.0	0	0.0	1.0	0.6
09R05	6.9	0.0	0.0	0.0	0.0	2.1	2.1	3.4	5.5	1.4	6.9	0.0	0	0.0	0	0.0	1.3	0.7
09R06	77.1	0.0	0.0	0.0	0.0	23.1	23.1	15.4	38.6	38.6	77.1	0.0	0	0.0	0	0.0	15.0	8.1
09W01	21.2	0.0	0.0	0.0	0.0	2.1	2.1	2.1	4.2	0.0	0.0	0.0	0	0.0	0	0.0	0.0	2.1
Totals	237.5	6.7	15.0	21.6	0.0	42.8	42.8	54.8	119.2	77.4	216.3	55.5	5713	0.0	0	0.0	22.5	20.3

4.8 River Segment 10: Walter Walker Wildlife Area*

River Mile: 162.7 to 166.4
Maps: Map 8 to Map 11
Site Designations (SD): 10U01 to 10U10, 10R01 to 10R18, 10R20 to 10R21, and 10W01 to 10W10
Photo #: 0782-0784, 0816-0819, 1069-1088, 1197-1201, 3237-3242
Land Ownership: 497.3 acres = 2% Federal, 74% Non-Federal Public, 19% Private, 0% Private under Conservation Easement, and 5% Unclassified.
Estimated Tamarisk Canopy Coverage: 31% of total or 155.1 acres
Estimated Russian olive Canopy Coverage: 10% of total or 50.9 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

This vital wildlife habitat area extends from the DuPont Island Complex to the Redlands Parkway Bridge. The Walter Walker State Wildlife Area, on the north bank, and Leatha Jean Stassen, located on the south banks are owned and managed by the Colorado Division of Wildlife (CDOW). Lands adjacent to this property to the east are owned by the City of Grand Junction, Mesa County, BOR, and private landowners. This meandering section of the Colorado River includes secondary channels, backwaters, sloughs, low-lying cobble bars, islands, a gravel pit pond, and broad, low-lying floodplains.

The north section of the Walter Walker State Wildlife Area (SWA) was once a large gravel pit pond. In 1983, the dike surrounding the pit was overtopped and breached. Since then, the pond has filled with sediment and is being colonized primarily by tamarisk. An interpretive trail meanders through this section of Walter Walker, which will eventually connect to the Riverfront Trail system. The western end of this area is dominated braided secondary channels/backwaters (SD: 10W09), and cobble bars (SD: 10R20; Photo 1088). The vegetation community is dominated by 50 percent tamarisk, 20 percent Russian olive and 20 percent Russian knapweed. Biological control of tamarisk, hand cutting Russian olive and natural revegetation are proposed, except for the cobble area on 10R20. Biological control of tamarisk and hand cutting Russian olive are also proposed for the secondary channels/backwaters (SD: 10W09).

The invasive species on the main Walter Walker complex south of the large secondary channel/backwater (SD: 10U08, 10R05, 10R06, 10R09, 10R13,) will be controlled with biological control and hand cutting while allowing the native vegetation to naturally recruit. A small portion of 10R09 is cobble and will be left unvegetated. Invasive species in the large secondary channel backwaters 10W05 and 10W06 will be removed with biological control and hand cutting and will be left unvegetated.

A 95 percent thick band of tamarisk in SD: 10R07will be removed by mechanical mulching equipment and actively revegetated. The upper riparian terraces (SD: 10U05, 10U06, 10U07), lower riparian terraces (SD: 10R04; Photo 3238), and two ponds/sloughs (SD: 10W03, 10W04; Photo 3239) to the north of the large secondary channel mechanical removal of Russian olive is proposed. Active revegetation is proposed for 10W03.

Through discussions and coordination with the USFWS, for this segment. The first is to improve the hydraulic connectivity of the site to the main stem of the Colorado River so that the endangered fish will have greater access to this floodplain habitat and to dilute and transport selenium out of the side channel. USFWS has indicated that a minimum of 200 cfs flowing through the existing side channel would be ideal. The potential for improving endangered fish habitat in the area behind the levee has been recognized in the past and minor modifications to the levee have been made to provide hydraulic connection of the mainstem to the Walter Walker side channel. These efforts included the installation of a gated culvert located at the upstream end of the levee and a notch cut in the levee at cross section WW-4. Past efforts have provided some flow through the culvert and notch, but generally flows have been relatively low possibly due to low flows from subsequent years of drought and the relatively high elevations of both the culvert and notch. Thus as part of this Project, construction of a new trapezoidal opening is proposed at this upstream levee to increase flows into the floodplain.

The second goal for this site is to create a backwater area for Colorado pikeminnow and other native fish spawning habitat. This will be done by dredging a pond that has filled in over the years since the initial gravel pit capture. The establishment of exotic fish populations in the backwaters is a concern so this backwater areas will only be inundated during spring runoff, and must drain completely during base flow. The backwater area does not necessarily need to flood every year, but should drain completely when not flooded. The backwater area is depicted on the map. An extension of the Riverfront trail is proposed along the northern edge of Segment 10. Removing invasive species along this trail corridor will enhance the habitat conditions, improve the recreational experience, and provide opportunity for natural recruitment of native species.

A small tract of land owned by CDOW is proposed for cultivation as a nursery for ecotype-specific plant materials native to the project area. This will augment a similar facility that may be established at River Segment 19 – the CDOW Tillie Bishop Wildlife Area.

Leatha Jean Stassen SWA is located on the south bank west of the main Walter Walker area. Restoring the large secondary channel/backwater is proposed (SD: 10R18, 10W08, Photo 1085). Just upstream from Leatha Jean Stassen SWA on the south bank is a lower riparian terrace (SD: 10R14) with 30 percent Russian olive, 10 percent tamarisk and 50 percent Siberian elm that will be removed by hand cutting, and allowed to revegetated with a natural recruitment in combination with reseeding.

On the south side of the river Walter Walker SWA and adjacent private land contains the largest upper riparian terrace (SD: 10U01, 10U02, 10U03, 10U04, 10U09) in the project area as well as multiple lower riparian terraces (SD: 10R01, 10R02, 10R03, 10R08, 10R12, 10R18), and secondary channels/backwaters (SD: 10W01, 10W02, 10W07). Fires within this area have burned twice in the past ten years, resulting in the deaths of numerous mature cottonwoods and a small reduction in tamarisk (Photo 0817). Many of these dead cottonwoods are now occupied by a large great blue heron rookery. Overall, this area has 40 percent tamarisk, 20 percent Russian olive and 40 percent Russian knapweed that will all be removed with mechanical equipment. Most of the remnant backwater areas in this area are disconnected, as evidenced by 1997 aerial flood photos (approximately 5-year flood), with the exception of 10W02. Thus, all but a small portion of 10W02 will be actively revegetated.

The eastern end of the segment is an upper riparian terrace (SD: 10U10), lower riparian terrace (SD: 10R21), and gravel pit pond (SD: 10W10) owned by Mesa County (Photo 1199). Tamarisk removal around the pond will extend to the river and active revegetation with salt tolerant grasses and shrubs will replace the 60 percent tamarisk infestation.

The cobble bar islands throughout the segment have experienced some stabilization due to colonization of tamarisk, currently estimated at 50 percent (SD: 10R10, 10R11, 10R15, 10R16, 10R17). Tamarisk removal using biological control is proposed to enhance the dynamic state of these cobble bars increasing spawning habitat. These bars, along with portions of 10R08, 10R13 and 10R20 will be left unvegetated following tamarisk removal. .

Recreational Features: A wildlife viewing area and educational interpretive sign will be installed on the northern bank of the Walter Walker SWA on the remaining portion of the dike.

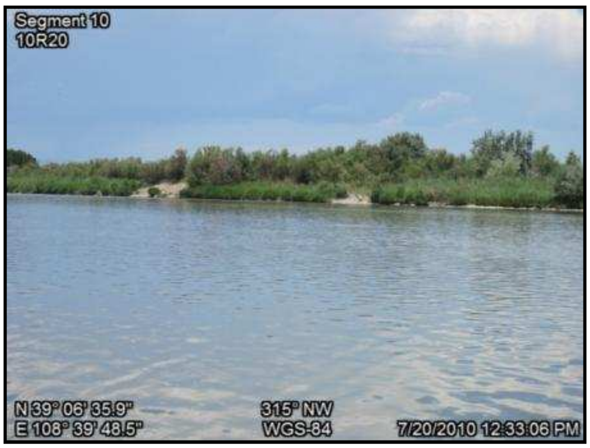

Photo 1088

Photo 3238

Photo 3239

Photo 1085

Photo 0817

Photo 1199

Maps 8 through 11 provide site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as “T”, “RO”, “RK”, “CW”, and “BE” respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as “SC”, “BW”, “P”, and “SL” respectively.

Table 4.37 Site descriptions restoration action.

	Sites	Description	Restoration Approach
Upper Riparian Terraces	10U01, 10U02, 10U03, 10U04, 10U05, 10U06 10U07, 10U08, 10U09, 10U10	153 acres with 20% T, 10% RO and 20% RK. These sites are upper riparian terraces dominated by upland grasses, cheatgrass, RK, kochia and moderate shrubs.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting of RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant upland shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Lower Riparian Terraces	10R01, 10R02, 10R03, 10R04, 10R07, 10R12, 10R18, 10R21	83 acres with 50% T, 10% RO and 20% RK. These sites are lower riparian terraces dominated by T and RO with some old cottonwood galleries, upland grasses and sparse shrubs. T has been removed on part of 10R21.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting of RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Lower Riparian Terraces	10R05, 10R06, 10R14	67 acres with 20% T, 10% RO and 5% RK. These sites are riparian terraces dominated by cottonwoods, coyote willow with some T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control for T, hand cut RO; treat secondary weeds with herbicide. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment mostly, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Island	10R10	29 acres with 40% T, 20% RO and no RK. This site is an islands dominated by coyote willows, T and wetland grasses with low RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control for T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment.
Cobble Bars	10R08, 10R09, 10R11, 10R13, 10R15, 10R16, 10R17, 10R20	58 acres with 40% T, 20% RO and 5% RK. These sites are cobble bars and islands dominated by coyote willows, T and wetland grasses with low RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control for T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
SC, BW, P, SL	10W01, 10W02, 10W03, 10W04, 10W05, 10W06, 10W07, 10W08, 10W09, 10W10	108 acres with 20% T, 10% RO and 5% RK. This site is a wetland dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control for T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation, but plantings of CW and BE in designated areas and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.

Table 4.38 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Upper Riparian Terraces	10U01	33.8	Kochia and Russian thistle infestation	Upland	Broadcast
	10U02	9.2	Kochia infestation	Upland	Broadcast
	10U03	11.8	RK infestation	Upland	Broadcast
	10U04	11.3	RK infestation	Upland	Broadcast
	10U05	26.0	Halogeton, kochia, Russian thistle and cheatgrass infestation	Upland Salty	Broadcast
	10U06	5.3	RK and kochia infestation	Upland Salty	Broadcast
	10U07	5.5	Kochia infestation	Upland Salty	Broadcast
	10U08	11.2	Kochia, cheatgrass and RK infestation	Upland Salty	Broadcast
	10U09	24.0	Cheatgrass infestation	Upland	Broadcast
	10U10	15.2	RK, kochia and cheatgrass infestation	Upland Salty	Broadcast
Lower Riparian Terraces	10R01	9.0	RK infestation	Riparian	Broadcast
	10R02	9.3	RK infestation	Riparian	Broadcast
	10R03	6.2	RK infestation	Riparian	Broadcast
	10R04	10.8	Kochia, RK and cheatgrass infestation	Riparian	Broadcast
	10R07	12.8	RK infestation	Riparian	Broadcast
	10R12	4.1	Natural recruitment is adequate	-	-
	10R18	8.4	RK infestation	Riparian	Broadcast
	10R21	21.9	Kochia infestation	Riparian	Broadcast

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.38. Grass seed mix type and method of application by site, cont.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Lower Riparian Terraces	10R05	48.1	RK infestation	Riparian	Broadcast
	10R06	9.4	RK infestation	Riparian	Broadcast
	10R14	9.4	RK and cheatgrass infestation	Riparian	Broadcast
Islands	10R10	29.2	Natural recruitment is adequate	-	-
Cobble Bars	10R08	7.3	None	-	-
	10R09	9.5	RK infestation	Riparian	Broadcast
	10R11	3.3	None	-	-
	10R13	5.8	None	-	-
	10R15	4.9	None	-	-
	10R16	2.6	None	-	-
	10R17	3.1	None	-	-
	10R20	21.0	RK infestation	Riparian	Broadcast
SC, BW, P, SL	10W01	3.4	Kochia infestation	Riparian	Broadcast
	10W02	5.3	RK infestation	Riparian	Broadcast
	10W03	4.1	None	-	-
	10W04	5.6	None	-	-
	10W05	22.0	None	-	-
	10W06	7.7	RK infestation	Riparian	Broadcast
	10W07	12.8	None	-	-
	10W08	23.3	None	-	-
	10W09	17.0	None	-	-
	10W10	6.6	None	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.39 Acres of tamarisk and Russian olive to treat and number of replacement of shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
			Veg	Tamarisk		Russian Olive		Three-Leaf	Golden	Woods	Silver	Rubber	Fourwing	Big		
	Site	Acres	Const*	%	Acres	%	Acres	Sumac	Current	Rose	Buffaloberry	Rabbitbrush	Saltbrush	Sagebrush	Winterfat	Total
Upper Riparian Terraces	10U01	33.8	None	20	6.8	10	3.4	0	0	0	0	199	199	199	199	**796**
	10U02	9.2	None	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	10U03	11.8	None	40	4.7	20	2.4	0	0	0	0	139	139	139	139	**555**
	10U04	11.3	None	60	6.8	20	2.3	0	0	0	0	166	166	166	166	**666**
	10U05	26.0	None	10	2.6	0	0	0	0	0	0	38	38	38	38	**153**
	10U06	5.3	None	5	0.3	10	0.5	0	0	0	0	19	19	19	19	**78**
	10U07	5.5	None	60	3.3	0	0	0	0	0	0	48	48	48	48	**193**
	10U08	11.2	Veg	30	3.4	0	0	0	0	0	0	0	0	0	0	**0**
	10U09	24.0	None	5	1.2	5	1.2	0	0	0	0	53	53	53	53	**212**
	10U10	15.2	None	30	4.6	10	1.5	0	0	0	0	112	112	112	112	**447**
	Sub-Total	**153.3**			**33.6**		**11.3**	**0**	**0**	**0**	**0**	**775**	**775**	**775**	**775**	**3099**
Lower Riparian Terraces	10R01	9.0	None	80	7.2	10	0.9	265	265	265	133	0	0	0	0	**929**
	10R02	9.3	None	50	4.7	0	0	137	137	137	69	0	0	0	0	**480**
	10R03	6.2	None	70	4.4	10	0.6	165	165	165	82	0	0	0	0	**577**
	10R04	10.8	None	40	4.3	0	0	127	127	127	64	0	0	0	0	**445**
	10R07	12.8	None	80	10.3	10	1.3	378	378	378	189	0	0	0	0	**1322**
	10R12	4.1	None	30	1.2	40	1.6	132	132	132	66	0	0	0	0	**464**
	10R18	8.4	None	30	2.5	40	3.4	271	271	271	136	0	0	0	0	**949**
	10R21	21.9	None	60	13.1	0	0	386	386	386	193	0	0	0	0	**1350**
	Sub-Total	**82.6**			**47.7**		**7.8**	**1862**	**1862**	**1862**	**931**	**0**	**0**	**0**	**0**	**6516**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

+: The site is not an island, but is only accessible by boat because there is no road access.

Table 4.39 Acres of Tamarisk and Russian olive to Treat and Number of Replacement Shrubs by Species per Site, continued.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
	Site	Acres	Veg Const*	Tamarisk %	Tamarisk Acres	Russian Olive %	Russian Olive Acres	Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Lower Riparian Terraces	10R05	48.1	Veg	30	14.4	10	4.8	0	0	0	0	0	0	0	0	**0**
	10R06	9.4	Veg	1	0.1	5	0.5	0	0	0	0	0	0	0	0	**0**
	10R14	9.4	Island+	10	0.9	30	2.8	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**67.0**			**15.5**		**8.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Islands	10R10	29.2	Island	40	11.7	20	5.8	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**29.2**			**11.7**		**5.8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cobble Bars	10R08	7.3	Cobble	0	0	5	0.4	0	0	0	0	0	0	0	0	**0**
	10R09	9.5	Veg	60	5.7	20	1.9	0	0	0	0	0	0	0	0	**0**
	10R11	3.3	Island	50	1.7	10	0.3	0	0	0	0	0	0	0	0	**0**
	10R13	5.8	Cobble	10	0.6	0	0	0	0	0	0	0	0	0	0	**0**
	10R15	4.9	Island	40	2.0	20	1.0	0	0	0	0	0	0	0	0	**0**
	10R16	2.6	Island	40	1.0	20	0.5	0	0	0	0	0	0	0	0	**0**
	10R17	3.1	Island	40	1.2	20	0.6	0	0	0	0	0	0	0	0	**0**
	10R20	21.0	Veg	60	12.6	30	6.3	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**57.5**			**24.8**		**11.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	10W01	3.4	Veg	10	0.3	10	0.3	0	0	0	0	0	0	0	0	**0**
	10W02	5.3	Veg	10	0.5	10	0.5	0	0	0	0	0	0	0	0	**0**
	10W03	4.1	Veg	40	1.6	0	0	0	0	0	0	0	0	0	0	**0**
	10W04	5.6	Veg	50	2.8	5	0.3	0	0	0	0	0	0	0	0	**0**
	10W05	22.0	Veg	10	2.2	0	0	0	0	0	0	0	0	0	0	**0**
	10W06	7.7	Veg	10	0.8	5	0.4	0	0	0	0	0	0	0	0	**0**
	10W07	12.8	Veg	10	1.3	5	0.6	0	0	0	0	0	0	0	0	**0**
	10W08	23.3	Veg	40	9.3	20	4.7	0	0	0	0	0	0	0	0	**0**
	10W09	17.0	Veg	10	1.7	0	0	0	0	0	0	0	0	0	0	**0**
	10W10	6.6	Veg	20	1.3	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**107.7**			**21.9**		**6.8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**497.3**			**155.1**		**50.9**	**1862**	**1862**	**1862**	**931**	**775**	**775**	**775**	**775**	**9615**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

+: The site is not an island, but is only accessible by boat because there is no road access.

Table 4.40 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres	No. Replacement Tree Species Cottonwood	Box Elder	Total
10U09, 10R12	3	41	15	**56**
10R01, 10R02, 10R03, 10W01, 10W02, 10W07	44	569	207	**776**
10R04, 10W03, 10W04	18	235	86	**321**
10R07	13	167	61	**227**
10R18, 10W08	27	350	127	**478**
Total	**105**	**1362**	**495**	**1857**

Table 4.41 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
10-A	N 39.106095° W 108.664901°	10R18, 10W08	Take CO Hwy 340 South from Fruita, turn north on 20.5 Rd, turn east (R) on F 3/4 Rd, turn N (L) on Round-up Dr, turn east (R) on Spur Cross Rd. Parking Area for Leatha Jean Stassen SWA is directly east of T in road.	0.73 acres
10-B	N 39.105663° W 108.65066°	10U05, 10U06, 10U07, 10U08, 10R04, 10R05, 10R06, 10R07, 10R09, 10R13, 10R20, 10W03, 10W04, 10W05, 10W06, 10W09	From Fruita take I-70E Exit 26 for Business Loop 70 (US Hwy 6&50), turn south (R) on G Rd, cross railroad tracks, turn northwest (R) on Riverside Pkwy, turn southwest (L) on Railroad Ave, continue south to Walter Walker SWA Parking Lot	0.70 acres
10-C	N 39.095166° W 108.645099°	10U01, 10U02, 10U03, 10U04, 10U09, 10R01, 10R02, 10R03, 10R08, 10R12, 10W01, 10W02, 10W07	From CO Hwy 340, take 22.5 Rd north, turn west (L) on Saddlehorn Rd, turn north (R) on Wagon Trail Dr, turn north (R) on Canyon Creek Rd, at intersection with Sand Castle Ln proceed down gated road approximately 0.15	0.79 acres
10-D	N 39.095991° W 108.634781°	10R10, 10R11, 10R14, 10R15, 10R16, 10R17	**River access only:** Put-in at Blue Heron Boat Launch; take-out at James M. Robb Colorado River State Park Fruita Section	None required
10-E	N 39.092975° W 108.633394°	10U02, 10U09, 10R12, 10W07	From CO Hwy 340 go north on 22.5 Rd, at intersection with Saddlehorn Dr go northeast (R) onto gated private road for approximately 0.3	0.32 acres
10-F	N 39.092153° W 108.626549°	10U10, 10R21, 10W10	From Riverside Pkwy, turn south on 23 Rd, continue on private road for 0.04 miles	1.98 acres

Table 4.42 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.43 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
10U01	33.8	1.4	3.0	4.4	0.0	0.3	0.3	5.4	10.2	8.5	33.8	33.8	796	0.0	0	0.0	0.0	0.3
10U02	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	9.2	0.0	0	0.0	0	0.0	0.0	0.0
10U03	11.8	1.4	2.1	3.5	0.0	0.2	0.2	3.3	7.1	9.4	11.8	11.8	555	0.0	0	0.0	0.0	0.2
10U04	11.3	2.0	2.0	4.1	0.0	0.2	0.2	4.8	9.1	7.9	11.3	11.3	666	0.0	0	0.0	0.0	0.2
10U05	26.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	20.8	26.0	26.0	153	0.0	0	0.0	0.0	0.0
10U06	5.3	0.1	0.5	0.5	0.0	0.1	0.1	0.2	0.8	0.5	5.3	5.3	78	0.0	0	0.0	0.0	0.05
10U07	5.5	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.3	4.4	5.5	5.5	193	0.0	0	0.0	0.0	0.0
10U08	11.2	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	5.1	11.2	0.0	0	0.0	0	0.0	0.0	0.0
10U09	24.0	0.2	1.1	1.3	0.0	0.1	0.1	1.0	2.4	1.2	24.0	24.0	212	0.0	0	0.0	0.0	0.1
10U10	15.2	0.9	1.4	2.3	0.0	0.2	0.2	3.6	6.1	6.1	15.2	15.2	447	0.0	0	0.0	0.0	0.2
10R01	9.0	2.2	0.8	3.0	0.0	0.1	0.1	5.1	8.1	5.4	9.0	9.0	929			0.0	0.0	0.1
10R02	9.3	0.0	0.0	0.0	0.0	0.0	0.0	4.7	4.7	6.5	9.3	9.3	480	44.0	776	0.0	0.0	0.0
10R03	6.2	1.3	0.6	1.9	0.0	0.1	0.1	3.1	5.0	6.2	6.2	6.2	577			0.0	0.0	0.1
10R04	10.8	0.0	0.0	0.0	0.0	0.0	0.0	4.3	4.3	5.4	10.8	10.8	445	18.2	321	0.0	0.0	0.0
10R05	48.1	0.0	0.0	0.0	0.0	4.8	4.8	14.4	19.2	2.4	48.1	0.0	0	0.0	0	0.0	0.0	4.8
10R06	9.4	0.0	0.0	0.0	0.0	0.5	0.5	0.1	0.6	0.5	9.4	0.0	0	0.0	0	0.0	0.0	0.5
10R07	12.8	3.1	1.2	4.2	0.0	0.1	0.1	7.2	11.6	0.6	12.8	12.8	1322	12.9	227	0.0	0.0	0.1
10R08	7.3	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.4	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.4
10R09	9.5	0.0	0.0	0.0	0.0	1.9	1.9	5.7	7.6	0.9	9.5	0.0	0	0.0	0	0.0	1.0	1.0
10R10	29.2	0.0	0.0	0.0	0.0	5.8	5.8	11.7	17.5	0.0	0.0	0.0	0	0.0	0	0.0	2.9	2.9
10R11	3.3	0.0	0.0	0.0	0.0	0.3	0.3	1.7	2.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.3
10R12	4.1	0.4	1.5	1.8	0.0	0.2	0.2	0.9	2.9	0.0	0.0	4.1	464	3.2	56	0.0	0.0	0.2
10R13	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
10R14	9.4	0.0	0.0	0.0	0.0	2.8	2.8	0.9	3.8	0.9	9.4	0.0	0	0.0	0	0.0	1.8	1.0
10R15	4.9	0.0	0.0	0.0	0.0	1.0	1.0	2.0	3.0	0.0	0.0	0.0	0	0.0	0	0.0	0.5	0.5

Table 4.43 Overview of Control and Restoration Acreages, cont.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
10R16	2.6	0.0	0.0	0.0	0.0	0.5	0.5	1.0	1.6	0.0	0.0	0.0	0	0.0	0	0.0	0.3	0.3
10R17	3.1	0.0	0.0	0.0	0.0	0.6	0.6	1.2	1.9	0.0	0.0	0.0	0	0.0	0	0.0	0.3	0.3
10R18	8.4	0.8	3.0	3.8	0.0	0.3	0.3	1.8	5.9	0.8	8.4	8.4	949	27.1	478	0.0	0.0	0.3
10R20	21.0	0.0	0.0	0.0	0.0	6.3	6.3	12.6	18.9	0.0	21.0	0.0	0	0.0	0	0.0	4.1	2.2
10R21	21.9	0.0	0.0	0.0	0.0	0.0	0.0	13.1	13.1	13.1	21.9	21.9	1350	0.0	0	0.0	0.0	0.0
10W01	3.4	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.7	0.2	3.4	0.0	0	0.0	0	0.0	0.0	0.3
10W02	5.3	0.0	0.0	0.0	0.0	0.5	0.5	0.5	1.1	2.6	5.3	0.0	0	0.0	0	0.0	0.0	0.5
10W03	4.1	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
10W04	5.6	0.0	0.0	0.0	0.0	0.3	0.3	2.8	3.1	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.3
10W05	22.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.2	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
10W06	7.7	0.0	0.0	0.0	0.0	0.4	0.4	0.8	1.2	0.4	7.7	0.0	0	0.0	0	0.0	0.0	0.4
10W07	12.8	0.0	0.0	0.0	0.0	0.6	0.6	1.3	1.9	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.6
10W08	23.3	0.0	0.0	0.0	0.0	4.7	4.7	9.3	14.0	0.0	0.0	0.0	0	0.0	0	0.0	2.3	2.3
10W09	17.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
10W10	6.6	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
Totals	497.3	13.7	17.1	30.8	0.0	33.7	33.7	141.4	205.9	115.5	345.6	215.5	9615	105.3	1857	0.0	13.2	20.5

4.9 River Segment 11: Connected Lakes State Park Complex

River Mile: 166.4 to 167.8
Maps: Map 11 to Map 13
Site Designations (SD): 11U01, 11R01 and 11R03 to 11R08, 11W01 to 11W03
Photo #: 0991-1003
Land Ownership: 226.8 acres = 0% Federal, 77% Non-Federal Public, 11% Private, 0% Private under Conservation Easement, and 12% Unclassified.
Estimated Tamarisk Canopy Coverage: 22% of total or 48.9 acres
Estimated Russian olive Canopy Coverage: 21% of total or 48.3 acres

The Connected Lakes State Park it is bounded to the north by the Grand Junction City owned Colorado Riverfront Blue Heron Trail, as well as a Mesa County owned wetland restoration and tamarisk removal project. The north bank consists of an upper riparian terrace (SD: 11U01), two ponds (SD: 11W01, 11W02), a lower riparian terrace (SD: 11R07), and a cobble bar (SD: 11R08). Tamarisk has been removed from around one of the pond/sloughs (Photo 1002) and grass has been established, but 5-percent tamarisk, 10-percent Russian olive, and 200percent Russian knapweed still remain. The western lower riparian terrace, upper riparian terrace and associated pond has 40-percent tamarisk, 10-percent Russian olive and 70-percent secondary weeds, therefore removal of Russian olive and active revegetation is necessary (Photo 1000). The cobble bar to the west of the lower riparian terrace has 5-percent tamarisk that will be addressed with biological control. Natural recruitment of native species will be adequate for the lower riparian terrace while the cobble bar will be left unvegetated (Photo 0998). The soils and groundwater along the north bank are highly alkaline therefore, all planted revegetation species will be salt tolerant.

To the south, the river is bordered by Connected Lakes State Park. The Redlands Power return flow channel abuts the State Park to the south and runs alongside a section of the Riverfront Trail system. The Connected Lakes State Park area is dominated by a large lower riparian terrace surrounding the lakes (SD: 11R03, 11R04; Photo 0995), the lower riparian terrace surrounding the Redlands Power return flow channel (SD: 11R01; Photo 0991), a pond in the Audubon Society property (SD: 11W03; Photo 0992) and a cobble bar to the north (SD: 11R05, 11R06; Photo 0993). Overall the Connected Lakes State Park area contains 20 percent tamarisk, 20 percent Russian olive and 20 percent Russian knapweed. Mechanical removal of Russian olive, biological control of tamarisk and active revegetation is recommended to enhance wildlife habitat along the Riverfront trail and throughout the State Park (SD: 11R01, 11R03, 11R04). Tamarisk and Russian olive has already been removed from the lands owned by the Audubon Society adjacent (east) of the State Park (SD: 11W03). The Audubon site also contains endangered fish rearing ponds and backwaters that will benefit from restoration activities. A master plan for the Audubon property has been developed that includes a picnic structure, trails, and various ponds and bird viewing areas. Thus restoration recommendations for this Project would be coordinated with the Audubon Society for implementation in concert with Master Plan improvements. Mesa State College also uses the Connected Lakes State Park as a living laboratory for students in the environmental restoration program. As such, their interaction in the project is being encouraged to provide input on monitoring, revegetation, wildlife habitat, etc.

The cobble bar to the north of the Connected Lakes State Park (SD: 11R05, 11R06) are colonized by tamarisk, currently covering 20 percent of the cobble. Recommendations for this cobble bar include biological control of the tamarisk and no revegetation. The cobble bar on 11R06 will be beneficial to endangered fish populations as potential spawning areas. 11R05 is a land-locked cobble bar that is currently not accessible to fish.

Recreational Features: A wildlife viewing area and educational interpretive sign will be installed in 11R03, near the existing boat launch just west of the Audubon property.

Photo 1002

Photo 1000

Photo 0998

Photo 0995

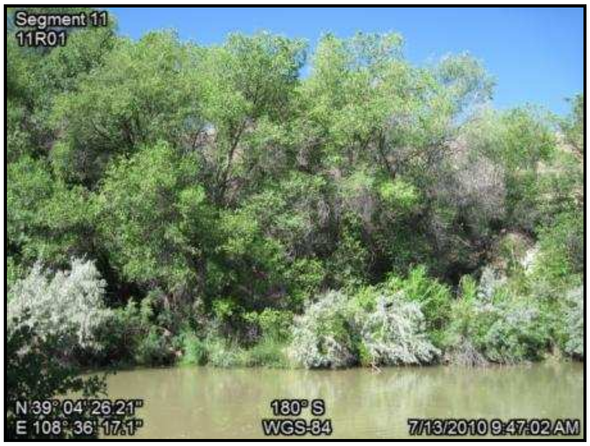

Photo 0991

Photo 0992

Photo 0993

Maps 11 through 13 provide site designations; tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC", "BW", "P", and "SL" respectively.

Table 4.44 Site description and restoration action.

	Sites	Description	Restoration Approach
Upper Riparian Terraces	11U01	20 acres with 50% T, 20% RO and 50% RK. These sites are upper riparian terraces dominated by T and RO, upland grasses and secondary weeds, T has been removed from 11U02.	Control: Mechanical removal and biological control for T, mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant upland shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Lower Riparian Terraces	11R01, 11R03, 11R04, 11R07	145 acres with 20% T, 30% RO and 10% RK. These sites are riparian terraces dominated by T and RO, old cottonwood galleries, riparian shrubs, upland grasses and secondary weeds.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	11R05, 11R06, 11R08	41 acres with 20% T, 1% RO and 10% RK. These sites are cobble bars and islands dominated by coyote willows and wetland grasses with moderate T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for wildlife habitat. Revegetation: No revegetation, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
SC, BW, P, SL	11W01, 11W02, 11W03	21 acres with no T, RO or RK. These sites are wetlands dominated by wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: None Biomass: None Revegetation: No revegetation.

Table 4.45 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Upper Riparian Terraces	11U01	20	RK, cheatgrass and whitetop infestation	Upland Salty	Broadcast
Lower Riparian Terraces	11R01	59	Cheatgrass, kochia, RK, Russian thistle infestation	Riparian	Broadcast
	11R03	56	Cheatgrass, RK, kochia infestation	Riparian	Broadcast
	11R04	20	RK and cheatgrass infestation	Riparian	Broadcast
	11R07	8	Kochia and cheatgrass infestation	Riparian	Broadcast
Cobble Bars	11R05	20	RK and cheatgrass infestation	Riparian	Broadcast
	11R06	18	None	-	-
	11R08	3	None	-	-
SC, BW, P, SL	11W01	5	None	-	-
	11W02	3	None	-	-
	11W03	13	None	-	-

***Type of Grass Seed Mix**:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.46 Areas of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive										
	Site	Acres	Veg Const*	%	Acres	%	Acres	Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Upper Riparian Terraces	11U01	19.9	None	50	10.0	20	4.0	0	0	0	0	264	264	264	264	**1055**
	Sub-Total	**19.9**			**10.0**		**4.0**	**0**	**0**	**0**	**0**	**264**	**264**	**264**	**264**	**1055**
Lower Riparian Terraces	11R01	59.3	None	10	5.9	30	17.8	1221	1221	1221	611	0	0	0	0	**4275**
	11R03	56.5	None	20	11.3	40	22.6	1661	1661	1661	831	0	0	0	0	**5814**
	11R04	20.5	None	50	10.2	10	2.0	422	422	422	211	0	0	0	0	**1476**
	11R07	8.4	None	40	3.4	10	0.8	149	149	149	75	0	0	0	0	**522**
	Sub-Total	**144.7**			**30.8**		**43.3**	**3453**	**3453**	**3453**	**1727**	**0**	**0**	**0**	**0**	**12087**
Cobble Bars	11R05	20.3	Veg	30	6.1	5	1.0	0	0	0	0	0	0	0	0	**0**
	11R06	18.4	Cobble	5	0.9	0	0	0	0	0	0	0	0	0	0	**0**
	11R08	2.8	Cobble	5	0.1	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**41.5**			**7.1**		**1.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	11W01	4.5	Veg	5	0	0	0	0	0	0	0	0	0	0	0	**0**
	11W02	2.7	Veg	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	11W03	13.4	Veg	5	1	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**20.7**		**4**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**226.8**			**48.9**		**48.3**	**3453**	**3453**	**3453**	**1727**	**264**	**264**	**264**	**264**	**13142**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.47 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
11W02	3	32	12	**44**
11R01, 11R03, 11R04	84	1084	399	**1483**
Total	**86**	**1117**	**411**	**1527**

Table 4.48 Access for tamarisk and Russian olive control and revegetation**.**

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
11-A	N 39.089232° W 108.618985°	11U01,11W01	From I-70 Business Loop take Redlands Parkway east, before the river turn left into Blue Heron Boat Launch	1.59 acres
11-B	N 39.08463° W 108.607892°	11R07, 11R08, 11W02	From Riverside Pkwy turn south on 24.25 Rd, turn west (R) on Blue Heron Rd, Continue onto Riverfront Trail	1.67 acres
11-C	N 39.077497° W 108.607488°	11R01, 11R03, 11R04, 11R05, 11R06, 11W03	Take CO Hwy 340 south from Grand Junction, turn west (R) on Dike Rd/Power Rd to James M. Robb State Park Connected Lakes	0.45 acres

Table 4.49 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
11R04	4"	8.68	0.33	0.83
	10"	8.82	0.24	0.59
11R05	4"	8.62	0.40	1.01
	10"	8.66	0.21	0.52

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.50 Overview of control and restoration acreages.

Site	Total Site Acrage	Acres with Control								Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
		Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control			Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
11U01	19.9	3.0	3.6	6.6	0.0	0.4	0.4	7.0	14.0	10.0	19.9	19.9	1055	0.0	0	0.0	0.0	0.4
11R01	59.3	1.2	16.0	17.2	0.0	1.8	1.8	4.7	23.7	24.3	59.3	59.3	4275	83.8	1483	0.0	0.0	1.8
11R03	56.5	3.4	20.3	23.7	0.0	2.3	2.3	7.9	33.9	22.6	56.5	56.5	5814			0.0	0.0	2.3
11R04	20.5	3.1	1.8	4.9	0.0	0.2	0.2	7.2	12.3	8.2	20.5	20.5	1476	0.0	0	0.0	0.0	0.2
11R05	20.3	0.0	0.0	0.0	0.0	1.0	1.0	6.1	7.1	4.1	20.3	0.0	0	0.0	0	0.0	0.0	1.0
11R06	18.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
11R07	8.4	0.7	0.8	1.4	0.0	0.1	0.1	2.7	4.2	2.5	8.4	8.4	522	0.0	0	0.0	0.0	0.1
11R08	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
11W01	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0	2.5	44	0.0	0.0	0.0
11W02	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
11W03	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
Totals	226.8	11.3	42.5	53.9	0.0	5.7	5.7	37.5	97.1	71.7	184.9	164.7	13142	86.3	1527	0.0	0.0	5.8

4.10 River Segment 12: Bananas Island*

River Mile: 167.8 to 169.0
Maps: Map 12
Site Designations (SD): 12R01 to 12R06 and 12W01
Photo #: 1004-1011, 1164-1165
Land Ownership: 105.5 acres = 0% Federal, 48% Non-Federal Public, 43% Private, 0% Private under Conservation Easement, and 9% Unclassified.
Estimated Tamarisk Canopy Coverage: 42% of total or 43.8 acres
Estimated Russian olive Canopy Coverage: 13% of total or 13.3 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

The Bananas Island complex is owned by the city of Grand Junction, Mesa County, and various private landowners. This area was the site of a historic gravel pit pond which was captured in the 1983 flood. This segment's accessibility provides an opportunity to use the area as a public restoration demonstration site. Numerous tamarisk and Russian olive removal projects along its length have already greatly improved the recreational value of Bananas Island section of the Riverfront Trail, which runs along the riparian terrace on the north bank (SD: 12R01, 12R03). Recommendations for 12R01 and 12R03 include maintenance of existing restored sites, removal of remaining tamarisk, treatment of the secondary weed infestation, and actively revegetating along the Riverfront trail (Photo 1010).

The large island known as Bananas Island supports riparian terraces, secondary channels/backwaters (SD: 12R02; Photo 1007 & 1165). Overall the area has 60-percent tamarisk, 20-percent Russian olive and 20-percent Russian knapweed. The high concentration of tamarisk and Russian olive and the possibility to use the site for demonstration purposes support the recommendation to mechanically remove both tamarisk and Russian olive and actively revegetate the island with riparian shrubs and tree plantings. Access to the island with mechanical equipment shall be scheduled to coincide with the low flows of the winter months.

Historic backwater channels exist adjacent to the Riverfront trail and throughout the island (SD: 12R06, 12W01). The riparian areas have been invaded by tamarisk and Russian olive reducing the habitat value of the segment, and immediately adjacent to the backwater (Photo 1106). Therefore, removing tamarisk and Russian olive and leaving the areas unvegetated will improve habitat and provide a healthier river system in central Grand Junction. The backwater areas themselves are currently open and wet areas relatively vegetation-free.

The mid-channel islands in this river section have been colonized by 30 percent tamarisk which are stabilizing the cobble bars and reducing the otherwise dynamic nature of these mid-channel areas (SD: 12R04, 12R05; Photo 1164). Recommendations include the removal of tamarisk and the cobble bars will be left unvegetated.

Recreational Features: A wildlife viewing area and educational interpretive sign will be installed on the north bank adjacent to the Riverfront Trail at the southeastern end of the Bananas Island segment.

Photo 1010

Photo 1007

Photo 1165

Photo 1006

Photo 1164

Map 12 provides site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC", "BW", "P", and "SL" respectively.

Table 4.51 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Riparian Terraces	12R01, 12R02, 12R03, 12R06	70 acres with 50% T, 20% RO and 20% RK. These sites are riparian terraces dominated by T, RO cheatgrass and secondary weeds, with a few old cottonwood galleries.	Control: Mechanical removal and hand cutting of T and RO, biocontrol of T; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	12R04, 12R05	22 acres with 30% T, no RO and no RK. These sites are cobble bars and islands dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T. Biomass: None. Revegetation: No revegetation.
SC, BW, P, SL	12W01	13 acres with no 1% T and RO and no RK. These sites are wetlands dominated by wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cutting of RO. Biomass: Leave RO to naturally decompose. Revegetation: No revegetation.

Table 4.52 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Riparian Terraces	12R01	11	Kochia, RK, and cheatgrass infestation	Riparian	Broadcast
	12R02	49	RK and perennial pepperweed infestation	Riparian	Broadcast
	12R03	4	RK, kochia, cheatgrass and Russian thistle infestation	Riparian	Broadcast
	12R06	6	RK infestation	Riparian	Broadcast
Cobble Bars	12R04	4	None	-	-
	12R05	19	None	-	-
SC, BW, P, SL	12W01	13	None	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.53 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

	Site	Acres	Veg Const*	Woody Invasives: Tamarisk %	Tamarisk Acres	Russian Olive %	Russian Olive Acres	No. Riparian Replacement Shrub Species: Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	No. Upland Replacement Shrub Species: Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Riparian Terraces	12R01	10.7	None	50	5.3	10	1.1	220	220	220	110	0	0	0	0	**769**
	12R02	48.5	None	60	29.1	20	9.7	1426	1426	1426	713	0	0	0	0	**4993**
	12R03#	4.3	None	10	0.4	0	0	126	126	126	63	0	0	0	0	**443**
	12R06	6.3	None	50	3.2	40	3	185	185	185	93	0	0	0	0	**649**
	Sub-Total	**69.8**			**38.0**		**13.3**	**1958**	**1958**	**1958**	**979**	**0**	**0**	**0**	**0**	**6853**
Cobble Bars	12R04	3.8	Island	1	0.04	0	0	0	0	0	0	0	0	0	0	**0**
	12R05	18.6	Island	30	5.6	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**22.3**			**5.6**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	12W01	13.4	Island	1	0.1	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**13.4**			**0.1**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**105.5**			**43.8**		**13.3**	**1958**	**1958**	**1958**	**979**	**0**	**0**	**0**	**0**	**6853**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

#: Replacement revegetation numbers are calculated based on the total acres of this site due to the lack of T and RO and desire to improve habitat and recreational values.

Table 4.54 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
12R01, 12R03	22	280	102	**381**
Total	**22**	**280**	**102**	**381**

Table 4.55 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum:WGS84	Sites Accessed	Description of Access Route	Staging
12-A	N 39.082001° W 108.603414°	12R01, 12W01	From Riverside Pkwy turn south on 24.25 Rd, turn west (R) on Blue Heron Rd, continue onto Riverfront Trail	0.99 acres
12-B	N 39.075504° W 108.590328°	12R04, 12R05	**River access only:** Put-in at Watson Island or James M. Robb State Park Corn Lake; take-out at James M. Robb Colorado River State Park Connected Lakes	None required
12-C	N 39. 075698° W 108.587865°	12R02, 12R03, 12R06	From I-70 Business Loop take Redlands Pwky/24 Rd west, then access the Riverfront Trail and travel South to access point	1.32 acres

Table 4.56 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Sat Paste mmhos/cm
12R03	4"	8.55	1.37	3.42
	10"	8.25	5.39	13.48

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.57 Overview of control and restoration acreages.

Site	Total Site Acrage	Acres with Control – Mechanical – Tamarisk	Acres with Control – Mechanical – Russian olive	Acres with Control – Mechanical – Subtotal Mechanical	Acres with Control – Hand – Tamarisk	Acres with Control – Hand – Russian olive	Acres with Control – Hand – Subtotal Hand	Acres with Control – Biocontrol – Tamarisk	Acres with Control – Total – Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Revegetation – Recommended Shrub Planting Area (Acres)	Revegetation – Number of Shrub Plantings	Revegetation – RecommendedTree Planting Area (Acres)	Revegetation – Number of Tree Plantings	Biomass Reduction of Hand Control Work – Mulching	Biomass Reduction of Hand Control Work – Fire	Biomass Reduction of Hand Control Work – Natural Decomposition
12R01	10.7	1.6	1.0	2.6	0.0	0.1	0.1	3.7	6.4	5.3	10.7	10.7	769	21.6	381	0.0	0.0	0.1
12R02	48.5	8.7	8.7	17.5	0.0	1.0	1.0	20.4	38.8	12.1	48.5	48.5	4993	0.0	0	0.0	0.0	1.0
12R03	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.04	3.0	4.3	4.3	443	0.0	0	0.0	0.0	0.0
12R04	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
12R05	18.6	0.0	0.0	0.0	0.0	0.0	0.0	5.6	5.6	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
12R06	6.3	0.0	0.0	0.0	0.0	2.5	2.5	3.2	5.7	0.0	6.3	6.3	649	0.0	0	0.0	1.9	0.6
12W01	13.4	0.0	0.0	0.0	0.0	0.13	0.1	0.13	0.3	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.03
Totals	105.5	10.3	9.7	20.0	0.0	3.7	3.7	33.4	57.1	20.5	69.8	69.8	6853	21.6	381	0.0	1.9	1.7

4.11 River Segment 13: Broadway Bridge South Bank Island*

River Mile: 169.0 to 169.8
Maps: Map 13
Site Designations (SD): 13R01 to 13R03, and 13W01
Photo #: 1012-1014, 1024-1026, 1163
Land Ownership: 57 acres = 0% Federal, 2% Non-Federal Public, 56% Private, 0% Private under Conservation Easement, and 42% Unclassified.
Estimated Tamarisk Canopy Coverage: 23% of total or 13 acres
Estimated Russian olive Canopy Coverage: 16% of total or 9 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

This mile long property on the south side of the Colorado River downstream of the CO Hwy 340/Broadway bridge is primarily privately owned. Historically, this land was an island that supported many active braided channels, but tamarisk sediment capture greatly stabilized the area and transformed it into the new south bank of the Colorado River. While the area no longer functions as an island, it supports a lower riparian terrace (SD: 13R02; Photo 1025), and secondary channel/backwater (SD: 13W01; Photo 1013). Despite the 30 percent tamarisk and 20 percent Russian olive and 20 percent Russian knapweed, this area has an existing healthy native vegetation community. Therefore, Russian olive will be removed by hand and tamarisk by biological control. Revegetation will be achieved by natural recruitment.

A mid-channel cobble bar on the downstream end of the island has been colonized by 5 percent tamarisk that is stabilizing it and reducing its otherwise dynamic nature (SD: 13R03; Photo 1163). Removing tamarisk from this site will benefit endangered native fish, and provide a more natural river system.

A perennial stream, No Thoroughfare, empties into the river by running through the south bank (SD: 13R01; Photo 1014). The Riverfront trail runs parallel to this stream. Removal of tamarisk and Russian olive infestations (10 percent and 30 percent respectively) and revegetation will benefit the aquatic habitat and improve the recreational experience along the Riverfront trail.

Recreational Features: A wildlife viewing area and educational interpretive sign will be installed on the north bank downstream from the Broadway Bridge.

Photo 1025

Photo 1013

Photo 1163

Photo 1014

Map 13 provides site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as “T”, “RO”, “RK”, “CW”, and “BE” respectively. Secondary channels backwaters, ponds and sloughs are abbreviated as “SC”, “BW”, “P”, and “SL” respectively.

Table 4.58 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Lower Riparian Terraces	13R01	3 acres with 10% T, 30% RO and no RK. This site is a lower riparian terrace surrounding No Thoroughfare and is dominated by old cottonwood galleries, T, RO, upland grasses, secondary weeds and sparse coyote willows.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
	13R02	38 acres with 30% T, 20% RO and 20% RK. This site is a cobble bar terrace dominated by coyote willows, cottonwoods, T, RO and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO; treat secondary weeds. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bar	13R03	8 acres with 5% T and no RO or RK. This site is a cobble bar dominated by coyote willows and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T. Biomass: None. Revegetation: No revegetation.
SC, BW, P, SL	13W01	8 acres with 10% T, 10% RO and no RK. This site is a wetland dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for wildlife habitat. Revegetation: No revegetation.

Table 4.59 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Lower Riparian Terraces	13R01	3	Kochia and cheatgrass infestation	Riparian	Broadcast
	13R02	38	RK and cheatgrass infestation	Riparian	Broadcast
Cobble Bar	13R03	8	None	-	-
SC, BW, P, SL	13W01	8	None	-	-

***Type of Grass Seed Mix**:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.60 Acres of tamarisk and russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive		Three-Leaf	Golden	Woods	Silver	Rubber	Fourwing	Big		
	Site	Acres	Veg Const*	%	Acres	%	Acres	Sumac	Current	Rose	Buffaloberry	Rabbitbrush	Saltbrush	Sagebrush	Winterfat	Total
Lower Riparian Terrace	13R01	2.9	None	10	0.3	30	0.9	59	59	59	30	0	0	0	0	**208**
	Sub-Total	**2.9**			**0.3**		**0.9**	**59**	**59**	**59**	**30**	**0**	**0**	**0**	**0**	**208**
Lower Riparian Terrace	13R02	38.3	Veg	30	11.5	20	7.7	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**38.3**			**11.5**		**7.7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cobble Bar	13R03	7.5	Island	5	0.4	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**7.5**			**0.4**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	13W01	8.2	Veg	10	0.8	10	0.8	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**8.2**			**0.8**		**0.8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**56.9**			**13.0**		**9.4**	**59**	**59**	**59**	**30**	**0**	**0**	**0**	**0**	**208**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.61 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
13R01	3	38	14	**51**
Total	**3**	**38**	**14**	**51**

Table 4.62 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
13-A	N 39.072549° W 108.58593°	13R03	**River access only:** Put-in at Watson Island or James M. Robb State Park Corn Lake, take-out at James M. Robb Colorado River State Park Connected Lakes	None required
13-B	N 39.066993° W 108.584211°	13R02, 13W01	From Grand Junction take CO Hwy 340 southwest, pass the Colorado River, turn-off on the north of CO Hwy 340 which is next to Riverfront Trail access	0.36 acres
13-C	N 39. 063737° W 108.58584°	13R01	From Grand Junction take CO Hwy 340 southwest, turn south (L) on Monument Rd, turn-out on left by Riverfront Trail access	0.28 acres

Table 4.63 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.64 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
13R01	2.9	0.1	0.8	0.8	0.0	0.1	0.1	0.2	1.2	0.9	2.9	2.9	208	2.9	51	0.0	0.0	0.1
13R02	38.3	0.0	0.0	0.0	0.0	7.7	7.7	11.5	19.2	7.7	38.3	0.0	0	0.0	0	0.0	3.8	3.8
13R03	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.38	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
13W01	8.2	0.0	0.0	0.0	0.0	0.8	0.8	0.8	1.6	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.8
Totals	56.9	0.1	0.8	0.8	0.0	8.6	8.6	12.9	22.3	8.5	41.2	2.9	208	2.9	51	0.0	3.8	4.7

4.12 River Segment 14: Confluence Island and Jarvis*

River Mile: 169.8 to 171.0
Maps: Map 13 to Map 14
Site Designations (SD): 14R01 to 14R04, 14W01
Photo #: 1021-1023, 1162
Land Ownership: 68.1 acres = 11% Federal, 28% Non-Federal Public, 3% Private, 0% Private under Conservation Easement, and 58% Unclassified.
Estimated Tamarisk Canopy Coverage: 35% of total or 23.6 acres
Estimated Russian olive Canopy Coverage: 23% of total or 15.6 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species.*

River segment 14 is located immediately downstream of the confluence of the Colorado and Gunnison Rivers. This segment is composed of two large islands with riparian terraces and cobble bars, and the north bank riparian terrace/cobble bar. This segment is easily accessible which provides an opportunity to use the area as a public restoration demonstration site. Most of the northern, downstream island is owned by Mesa County and BOR, along with a private owner. The second island is in the southern, upstream side of the segment and is mostly owned by BOR or the City of Grand Junction. These islands support mature, native riparian communities interspersed with tamarisk and Russian olive.

The downstream island is composed of a lower riparian terrace surrounded by cobble bars (SD: 14R04; Photo 1162). The 30 percent tamarisk, 30 percent Russian olive and 20 percent Russian knapweed are colonizing and stabilizing this island. This island is best accessed by hand crews. Proposed enhancements for 14R04 include hand removal of Russian olive, biological control for tamarisk reduction and revegetation by natural recruitment. Portions of 14R04 will be reseeded in areas with potential for, or already have existing riparian growth. The exposed cobble bar portions of this island will be left unvegetated. Treatment of secondary weeds with herbicide and establishment of native grasses is essential to the natural recruitment of shrubs and trees on this site.

The larger, upstream island, commonly referred to as Confluence Island (SD: 14R01), supports a number of old growth cottonwoods along with 30 percent tamarisk, 30 percent Russian olive and 10 percent Russian knapweed. There are numerous cobble bars along its outer edges dominated by willows and wetland grasses (Photo 1022). These areas will be left unaltered. The use of mechanical equipment to remove tamarisk and Russian olive within the interior of the island is proposed. Scheduling of heavy equipment during low flows will be required to insure work and access in the dry. This island will be revegetated including tree plantings in select areas as shown.

The riparian terrace (SD: 14R03) thin cobble bar (SD: 14R02) and backwater (SD: 14W01) on the north bank is dominated by 70 percent tamarisk, 10 percent Russian olive and 10 percent Russian knapweed. This area is commonly referred to as the Jarvis property due to a historical designation and includes a portion of the Riverfront trail. The Jarvis property was reconstructed by the Recovery Program as a backwater habitat for endangered fish with the construction of a low-flow notch. While the project has been successful with the diversion of flows captured in this backwater area, today the site is infested with tamarisk due to lack of maintenance for removal of invasive species. Restoring this site will benefit endangered and native fish and provide a more natural river system within the central part of the City of Grand Junction.

14R02 is a cobble bar and will be left unvegetated. A portion of 14R03 is also a cobble bar and will also be left unvegetated to increase available spawning habitat for the endangered fish species. Plantings are proposed along the inland side of this site as shown on the map.

Recreational Features: A wildlife viewing area and educational interpretive sign will be installed along the Riverfront Trail overlooking the large upstream island.

Photo 1162

Photo 1022

Maps 13 and 14 provide site designations; tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as “T”, “RO”, “RK”, “CW”, and “BE” respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as “SC”, “BW”, “P”, and “SL” respectively.

Table 4.65 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Lower Riparian Terrace	14R03	12 acres with 70% T, 10% RO and 10% RK. This site is a riparian terrace dominated by T, RO, old cottonwood galleries, grasses and sparse coyote willow.	Control: Mechanical removal and hand cutting of T and RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Islands	14R01, 14R04	48 acres with 30% T, 30% RO and 10% RK. These sites are islands dominated by T, RO, coyote willows and wetland grasses.	Control: Mechanical removal and hand cutting of T and RO (14R01), biological control T, hand cut RO (14R04); treat secondary weeds with herbicide. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Plant riparian shrubs (14R01), natural recruitment (14R04), and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bar	14R02	1 acre with no T, RO or RK. This site is a cobble bar dominated by coyote willows and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: None. Biomass: None. Revegetation: No revegetation.
SC, BW, P, SL	14W01	7 acres with no 10% T and RO and no RK. These sites are wetlands dominated by wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biocontrol of T. Biomass: None. Revegetation: No revegetation.

Table 4.66 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Lower Riparian Terrace	14R03	12	Cheatgrass, RK, kochia and Russian thistle infestation	Riparian	Broadcast
Islands	14R01	33	RK, kochia and cheatgrass infestation	Riparian	Broadcast
	14R04	15	RK and cheatgrass infestation	Riparian	Broadcast
Cobble Bar	14R02	1	None	-	-
SC, BW, P, SL	14W01	7	None	-	-

***Type of Grass Seed Mix**:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.67 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive		Three-Leaf	Golden	Woods	Silver	Rubber	Fourwing	Big		
	Site	Acres	Veg Const*	%	Acres	%	Acres	Sumac	Current	Rose	Buffaloberry	Rabbitbrush	Saltbrush	Sagebrush	Winterfat	Total
Lower Riparian Terrace	14R03	12.2	None	70	8.5	10	1.2	323	323	323	161	0	0	0	0	**1129**
	Sub-Total	**12.2**			**8.5**		**1.2**	**323**	**323**	**323**	**161**	**0**	**0**	**0**	**0**	**1129**
Islands	14R01	32.9	None	30	9.9	30	9.9	872	872	872	436	0	0	0	0	**3052**
	14R04	14.9	Island	30	4.5	30	4.5	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**47.8**			**14.3**		**14.3**	**872**	**872**	**872**	**436**	**0**	**0**	**0**	**0**	**3052**
Cobble Bar	14R02	1.0	Island	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**1.0**			**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	14W01	7.1	Island	10	1	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**7.1**			**1**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**68.1**			**23.6**		**15.6**	**1195**	**1195**	**1195**	**597**	**0**	**0**	**0**	**0**	**4181**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.68 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
14R01	12	158	57	**215**
14R03	6	82	30	**111**
Total	**19**	**240**	**87**	**327**

Table 4.69 Access for tamarisk and Russian olive control and Revegetation.

Access Label	GPS Coordinates	Sites Accessed	Description of Access Route	Staging
14-A	N 39.059308° W 108.57274°	14R01, 14R02, 14R03, 14W01	From Grand Junction take 7th St south, turn west (R) on Struthers Ave, at end of Struthers Ave access the Riverfront Trail and travel west to access point	1 acre
14-B	N 39.05513° W 108.567193°	14R01, 14R04	**River access only:** Put-in at Watson Island or James M. Robb State Park Corn Lake; take-out at James M. Robb Colorado River State Park Connected Lakes	None required

Table 4.70 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.71 Overview of control and restoration acreages.

Site	Total Site Acrage	Acres with Control								Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
		Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control			Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
14R01	32.9	3.0	8.9	11.9	0.0	1.0	1.0	6.9	19.8	9.9	32.9	32.9	3052	12.2	215	0.0	0.0	1.0
14R02	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
14R03	12.2	2.6	1.1	3.7	0.0	0.1	0.1	5.97	9.75	3.0	12.2	12.2	1129	6.3	111	0.0	0.0	0.1
14R04	14.9	0.0	0.0	0.0	0.0	4.5	4.5	4.5	8.9	3.0	14.9	0.0	0	0.0	0	0.0	2.9	1.6
14W01	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
Totals	68.1	5.5	10.0	15.5	0.0	5.6	5.6	18.1	39.2	15.9	60.0	45.1	4181	18.5	327	0.0	2.9	2.7

4.13 River Segment 16: Watson Island Compex to Orchard Mesa and Colorado River Wildife Areas

River Mile: 172.7 to 174.0
Maps: Map 15 to Map 16
Site Designations (SD): 16R01 to 16R04
Photo #: 1158-1161
Land Ownership: 65.1 acres = 0% Federal, 38% Non-Federal Public, 26% Private, 0% Private under Conservation Easement, and 36% Unclassified.
Estimated Tamarisk Canopy Coverage: 37% of total or 24.1 acres
Estimated Russian olive Canopy Coverage: 33% of total or 21.6 acres

This section of river includes land owned by the Colorado Department of Natural Resources, State of Colorado, and by private individuals. The two riparian terraces on the north side of the river have 40 percent tamarisk, 20 percent Russian olive and 30 percent Russian knapweed infestations (SD: 16R02, 16R04; Photo 1159). While there are no backwaters within these sites, there is quality riparian land that will benefit from tamarisk control. Active revegetation of shrubs and grasses is necessary, but tree species are present and will naturally recruit on these sites.

The southern riparian terrace (SD: 16R01, 16R03; Photo 1160) and portions of the cobble bar island have 40 percent tamarisk, 50 percent Russian olive and 20 percent Russian knapweed that will be removed by hand. Revegetation will be accomplished by natural recruitment. Cobble bars are to remain unvegetated after treatment.

Recreational Features: No recreational features are planned for this segment.

Photo 1159

Photo 1160

Maps 15 and 16 provide site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC', 'BW', 'P', and "SL" respectively.

Table 4.72 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Lower Riparian Terraces	16R02, 16R03, 16R04	63 acres with 40% T, 30% RO and 30% RK. These sites are lower riparian terraces dominated by T, RO, old cottonwood galleries, upland grasses, secondary weeds and sparse shrubs.	Control: Mechanical removal and biological control for T, mechanical removal and hand cutting for RO (16R02, 16R04) and biological control of T and hand cutting of RO only (16R03). Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Plant riparian shrubs (16R02, 16R04) and seed appropriate grass mix to enhance habitat and outcompete secondary weeds (16R02, 16R03, 16R04).
Cobble Bar	16R01	2 acres with 40% T, 10% RO and no RK. This site is a riparian terrace dominated by T, RO, old cottonwood galleries, upland grasses, secondary weeds and sparse shrubs.	Control: Biological control T, hand cut RO. Biomass: Stack piles for wildlife habitat. Revegetation: No revegetation.

Table 4.73 Grass seed mix type and method of application.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Lower Riparian Terraces	16R02	26	RK and cheatgrass infestation	Riparian	Broadcast
	16R04	20	Natural recruitment is adequate	-	-
	16R03	17	RK and cheatgrass infestation	Riparian	Broadcast
Cobble Bar	16R01	2	None	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.74 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

	Site	Acres	Veg Const*	Woody Invasives: Tamarisk %	Tamarisk Acres	Russian Olive %	Russian Olive Acres	No. Riparian Replacement Shrub Species: Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	No. Upland Replacement Shrub Species: Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Lower Riparian Terraces	16R02	26.2	None	40	10.5	20	5.2	617	617	617	309	0	0	0	0	**2161**
	16R03	17.0	Island+	40	6.8	60	10.2	0	0	0	0	0	0	0	0	**0**
	16R04	19.7	None	30	5.9	30	5.9	521	521	521	261	0	0	0	0	**1825**
	Sub-Total	**63.0**			**23.2**		**21.4**	**1139**	**1139**	**1139**	**569**	**0**	**0**	**0**	**0**	**3986**
Cobble Bar	16R01	2.1	Island	40	0.8	10	0.2	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**2.1**			**0.8**		**0.2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**65.1**			**24.1**		**21.6**	**1139**	**1139**	**1139**	**569**	**0**	**0**	**0**	**0**	**3986**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

+: The site is not an island, but is only accessible by boat because it there is no road access.

Table 4.75 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species: Cottonwood	Box Elder	Total
None	0	0	0	**0**
Total	**0**	**0**	**0**	**0**

Table 4.76 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
16-A	N 39.053953° W 108.533869°	16R04	From Grand Junction, take Riverside Pkwy east, turn east (L) on D Rd, turn south onto 28 Rd, then continue onto private road for 0.1	1.34 acres
16-B	N 39.052376° W 108.520959°	16R02	From Grand Junction, take Riverside Pkwy east, turn east (R) on D Rd, turn south onto 28 Rd, turn east onto C1/2 Rd, turn south on private road for approximately 0.2 miles	2.06 acres
16-C	N 39.048479° W 108.516741°	16R01, 16R03	**River access only:** Put-in at James M. Robb Colorado River State Park Corn Lake; take-out at James M. Robb Colorado State Park Connected Lakes or Watson Island	None required

Table 4.77 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.78 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
16R01	2.1	0.0	0.0	0.0	0.0	0.2	0.2	0.8	1.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.2
16R02	26.2	3.1	4.7	7.9	0.0	0.5	0.5	7.3	15.7	15.7	26.2	26.2	2161	0.0	0	0.0	0.0	0.5
16R03	17.0	0.0	0.0	0.0	0.0	10.2	10.2	6.82	17.05	3.4	17.0	0.0	0	0.0	0	0.0	8.4	1.8
16R04	19.7	1.8	5.3	7.1	0.0	0.6	0.6	4.1	11.8	0.0	19.7	19.7	1825	0.0	0	0.0	0.0	0.6
Totals	65.1	4.9	10.0	15.0	0.0	11.6	11.6	19.1	45.7	19.2	63.0	45.9	3986	0.0	0	0.0	8.4	3.2

4.14 River Segment 17: Orchard Mesa and Colorado River Wildlife Areas*

River Mile: 174.1 to 177.1
Maps: Map 16 to Map 18
Site Designations (SD): 17R18 to 17R20, 17R22 and 17W06
Photo #: 1151, 1152
Land Ownership: 59.4 acres = 7% Federal, 44% Non-Federal Public, 16% Private, 0% Private under Conservation Easement, and 33% Unclassified.
Estimated Tamarisk Canopy Coverage: 35% of total or 125.9 acres
Estimated Russian olive Canopy Coverage: 21% of total or 75.7 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

This segment's channel complexity including numerous braided channels, cobble bars, and a few healthy stands of native plants make this an important restoration site. Historically, the area has supported heavy use by fish populations and continues to be an important habitat. However, tamarisk now dominates the segment and has reduced or eliminated some of the key areas used by endangered fish. Recent tamarisk thicket invasions are choking the side channels.

Mid-channel cobble bars and backwater areas (SD: 17W06) are being colonized with tamarisk, (SD: 17R19, 17R22; Photo 1152) and Russian olive with evidence of sediment aggradation (SD: 17R18, 17R20; Photo 1151). This is stabilizing the bars and reducing the otherwise natural dynamic nature of these mid-channel areas. It is a priority for the Fish and Wildlife Service to reclaim these mid-channel cobble bars to a more natural state without vegetation. Thus, Russian olive and tamarisk will be removed by hand and the left unvegetated.

Recreational Features: Two wildlife viewing areas and educational interpretive signs will be installed. One will be on the north side of the river, at the junction of the D Road access to the Riverfront Trail, near access point 17-F. The second will be on the south side of the river near the public access trail to the Orchard Mesa Wildlife Area, near access point 17-E.

Photo1152

Photo 1151

Maps 16 through 18 provide site designations; tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features, soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as “T”, “RO”, “RK”, “CW”, and “BE” respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as “SC”, “BW”, “P”, and “SL” respectively.

Table 4.79 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Islands	17R18, 17R20	39 acres with 50% T, 25% RO and 20% RK. These sites are islands dominated by T, RO, coyote willows and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO; treat secondary weeds with herbicide. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: Natural recruitment, seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	17R19, 17R22	6 acres with 20% T, 10% RO and no RK. These sites are cobble bars and islands dominated by T, RO, coyote willows and wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation.
SC, BW, P, SL	17W06	13 acres with no 1% T and RO and no RK. These sites are wetlands dominated by wetland grasses. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cutting of RO. Biomass: Leave RO to naturally decompose. Revegetation: No revegetation.

Table 4.80 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Islands	17R18	22	Cheatgrass, RK and Russian thistle infestation	Riparian	Broadcast
	17R20	18	RK and cheatgrass infestation	Riparian	Broadcast
Cobble Bars	17R19	5	None	-	-
	17R22	2	None	-	-
SC, BW, P, SL	17W06	13	None	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.81 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

	Site	Acres	Veg Const*	Woody Invasives: Tamarisk %	Tamarisk Acres	Russian Olive %	Russian Olive Acres	No. Riparian Replacement Shrub Species: Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	No. Upland Replacement Shrub Species: Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Island	17R18	21.6	Island	30	6.5	30	6.5	0	0	0	0	0	0	0	0	**0**
	17R20	17.8	Island	70	12.5	20	3.6	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**39.4**			**19.0**		**10.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cobble Bar	17R19	5.0	Island	20	1.0	10	0.5	0	0	0	0	0	0	0	0	**0**
	17R22	1.9	Island	5	0.1	0	0.0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**6.8**			**1.1**		**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	17W06	13.1	Island	5	0.7	5	0.7	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**13.1**			**0.7**		**0.7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**59.4**			**20.7**		**11.2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.82 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species: Cottonwood	Box Elder	Total
None	0	0	0	**0**
Total	**0**	**0**	**0**	**0**

Table 4.83 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
17-H	N 39.056627° W 108.474225°	17R18, 17R19, 17R20, 17R22, 17W06	**River access only:** Put-in at James M. Robb Colorado River State Park Corn Lake; take-out at Watson Island or James M. Robb Colorado River State Park Connected Lakes	None required

Table 4.84 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.85 Overview of control and restoration acreages.

Site	Total Site Acrage	Acres with Control								Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
		Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control			Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
17R18	21.6	0.0	0.0	0.0	0.0	6.5	6.5	6.5	13.0	4.3	21.6	0.0	0.0	0.0	0.0	0.0	4.2	2.3
17R19	5.0	0.0	0.0	0.0	0.0	0.5	0.5	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
17R20	17.8	0.0	0.0	0.0	0.0	3.6	3.6	12.5	16.0	3.6	17.8	0.0	0.0	0.0	0.0	0.0	1.8	1.8
17R22	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.09	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17W06	13.1	0.0	0.0	0.0	0.0	0.7	0.7	0.7	1.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Totals	59.4	0.0	0.0	0.0	0.0	11.2	11.2	20.7	31.9	7.9	39.4	0.0	0	0.0	0	0.0	6.0	5.2

4.15 River Segment 18A: Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area

River Mile: 177.8 to 182.9
Maps: Map 18 to Map 21
Site Designations (SD): 18AR01 to 18AR07, 18AR09, 18AR13, and 18AW01 to 18AW03
Photo #: 1131-1140, 1142-1146
Land Ownership: 163.8 acres = 0% Federal, 0% Non-Federal Public, 34% Private, 17% Private under Conservation Easement, and 49% Unclassified.
Estimated Tamarisk Canopy Coverage: 15% of total or 24.8 acres
Estimated Russian olive Canopy Coverage: 21% of total or 34.7 acres

The majority of this seven mile long stretch of river is privately owned though multiple public landowners and conservation easements are present. Sections of the Riverfront Trail system run along areas of the public lands on the north bank.

Upstream (east) from the Clifton Nature Park, between river miles 178.5 and 179.5, there are two riparian terraces (SD: 18AR07, 18AR09) and a secondary channel/backwater (SD: 18AW02) on the south bank. These sites are dominated by 40 percent tamarisk, 20 percent Russian olive, 10 percent Russian knapweed and old cottonwood galleries, which will be addressed with biological control of tamarisk and hand-cutting Russian olive. Revegetation on the south side will be accomplished by natural recruitment.

The privately owned riparian complex around river mile 181 is a diverse site with riparian terraces (SD: 18AR13), cobble bars (SD: 18AR05, 18AR06), secondary channel and multiple pond/sloughs (SD: 18AW03; Photo 1188). The land owner has worked with NRCS to remove tamarisk, but Russian olive still remains at about 20 percent canopy cover and there is around 10 percent scattered wispy tamarisk. Removal of the remaining Russian olive is proposed. The existing various riparian shrubs, wetland grass and willow communities and cottonwood galleries contribute to the existing diverse habitat at this site. This area is a good example/reference site for removal and revegetation projects throughout the river system and could be used as an example of a successfully restored riparian habitat after removal and restoration efforts.

The upstream end of the segment around river mile 182.5 consists of an abandoned oxbow riparian terrace on the north side of the river (SD: 18AR03; Photo 1132), and a riparian complex with a lower riparian terrace (SD: 18AR02), cobble bars (SD: 18AR01, 18AR04), disconnected secondary channels/backwaters, and pond/sloughs on the south bank (SD: 18AW01; Photo 1133). The southern site is similar to the riparian complex directly downstream, and would benefit from removal and revegetation projects similar to those downstream. Both the north and south side of the river has 20 percent tamarisk and 30 percent Russian olive, therefore active removal and revegetation is proposed.

Even though this is not a high priority segment, the cobble bars throughout this segment may provide spawning habitat for endangered fish, or may provide source material further downstream for spawning or habitat areas. Thus, it is important to control tamarisk on the islands. Restoring this site will benefit endangered native fish, improve riparian habitat, and provide a more natural river system.

Recreational Features: No recreational features are planned for this segment.

Photo 1193

Photo 1145

Photo 1188

Photo 1132

Photo 1133

Maps 18 through 21 provide site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC", "BW", "P", and "SL" respectively.

Table 4.86 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Riparian Terraces	18AR02, 18AR03, 18AR13	88 acres with 20% T, 30% RO and 10% RK. These sites are riparian terraces dominated by T, RO, old cottonwood galleries, upland grasses, secondary weeds, coyote willow and sparse shrubs.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs, seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	18AR01, 18AR04, 18AR05, 18AR06, 18AR07, 18AR09	37 acres with 20% T, 20% RO and 5% RK. These sites are cobble bars and islands dominated by T, RO, coyote willows and wetland grasses with very few. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO; treat secondary weeds in 18R09 with herbicide. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
SC, BW, P, SL	18AW01, 18AW02, 18AW03	40 acres with no T, 20% RO and no RK. These sites are wetlands dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation, but plantings of cottonwoods in designated areas.

Table 4.87 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Riparian Terraces	18AR02	35	RK and cheatgrass infestation	Riparian	Broadcast
	18AR03	24	RK infestation	Riparian	Broadcast
	18AR13	29	Cheatgrass and kochia infestation	Riparian	Broadcast
Cobble Bars	18AR01	5	None	-	-
	18AR04	9	None	-	-
	18AR05	4	None	-	-
	18AR06	3	None	-	-
	18AR07	8	None	-	-
	18AR09	8	RK infestation	Riparian	Broadcast
SC, BW, P, SL	18AW01	14	None	-	-
	18AW02	2	None	-	-
	18AW03	23	None	-	-

***Type of Grass Seed Mix**:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.88 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive										
	Site	Acres	Veg Const*	%	Acres	%	Acres	Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Riparian Terraces	18AR02	35.3	None	30	10.6	40	14.1	1143	1143	1143	572	0	0	0	0	**4002**
	18AR03	23.6	None	20	4.7	10	2.4	278	278	278	139	0	0	0	0	**974**
	18AR13	28.6	None	10	2.9	20	5.7	420	420	420	210	0	0	0	0	**1471**
	Sub-Total	**87.6**			**18.2**		**22.2**	**1842**	**1842**	**1842**	**921**	**0**	**0**	**0**	**0**	**6446**
Cobble Bars	18AR01	5.1	Cobble	0	0	10	0.5	0	0	0	0	0	0	0	0	**0**
	18AR04	8.9	Cobble	10	0.9	20	1.8	0	0	0	0	0	0	0	0	**0**
	18AR05	4.3	Island	20	0.9	0	0	0	0	0	0	0	0	0	0	**0**
	18AR06	2.6	Cobble	50	1.3	5	0.1	0	0	0	0	0	0	0	0	**0**
	18AR07	7.9	Island[+]	40	3.2	20	1.6	0	0	0	0	0	0	0	0	**0**
	18AR09	8.2	Island[+]	5	0.4	30	2.5	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**37.1**			**6.6**		**6.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	18AW01	14.0	Veg	0	0	30	4.2	0	0	0	0	0	0	0	0	**0**
	18AW02	2.3	Veg	0	0	30	0.7	0	0	0	0	0	0	0	0	**0**
	18AW03	22.9	Veg	0	0	5	1.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**39.3**			**0.0**		**6.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**163.9**			**24.8**		**34.7**	**1842**	**1842**	**1842**	**921**	**0**	**0**	**0**	**0**	**6446**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

+: The site is not an island, but is only accessible by boat because there is no road access.

#: Replacement revegetation numbers are calculated based on the total acres of this site due previous removal of T and RO and desire to improve habitat and recreational values.

Table 4.89 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species		Total
		Cottonwood	Box Elder	
None	0	0	0	**0**
Total	**0**	**0**	**0**	**0**

Table 4.90 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
18-C	N 39.078501° W 108.41158°	18AR06, 18AR13, 18AW03	From CO Hwy 141 south, turn northeast (L) on C 1/2 Rd, turn north on 34.5 Rd, turn east on D Rd, follow as it curves north and turns into 35 Rd, turn west on E Rd, before 34.75 Rd turn north (R) into private drive for approximately 0.4 miles	0.31 acres
18-D	N 39.084039° W 108.4028°	18AR05, 18AR07, 18AR09, 18AW02	**River access only:** Put-in at Palisade Riverbend Park; take-out at James M. Robb Colorado River State Park Corn Lake	None required
18-E	N 39.089319° W 108.392009°	18AR01, 18AR02, 18AR04, 18AW01	From CO Hwy 141 south, turn northeast (L) on C 1/2 Rd, turn north on 34.5 Rd, turn east on D Rd, follow as it curves to the north and turns into 35 Rd, turn east on E Rd, turn north on 35.5 Rd, east on E 1/2, north on 36 Rd, after a quarter mile turn west (L) onto private drive and go approximately 0.4 miles	0.57 acres
18-F	N 39.096866° W 108.394533°	18AR03	From Grand Junction, go east on F Rd, continue on Front St through Palisade, turn south (R) on 35.5 Rd to intersection with Grand Valley Canal Rd	1.11 acres

Table 4.91 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.92 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
18AR01	5.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.5
18AR02	35.3	3.2	12.7	15.9	0.0	1.4	1.4	7.4	24.7	3.5	35.3	35.3	4002	0.0	0	0.0	0.0	1.4
18AR03	23.6	0.9	2.1	3.1	0.0	0.2	0.2	3.8	7.1	2.4	23.6	23.6	974	0.0	0	0.0	0.0	0.2
18AR04	8.9	0.0	0.0	0.0	0.0	1.8	1.8	0.9	2.7	0.0	0.0	0.0	0	0.0	0	0.0	0.9	0.9
18AR05	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
18AR06	2.6	0.0	0.0	0.0	0.0	0.1	0.1	1.3	1.4	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.1
18AR07	7.9	0.0	0.0	0.0	0.0	1.6	1.6	3.2	4.8	0.0	0.0	0.0	0	0.0	0	0.0	0.8	0.8
18AR09	8.2	0.0	0.0	0.0	0.0	2.5	2.5	0.4	2.9	1.6	8.2	0.0	0	0.0	0	0.0	1.6	0.9
18AR13	28.6	0.6	5.1	5.7	0.0	0.6	0.6	2.3	8.6	0.3	28.6	28.6	1471	0.0	0	0.0	0.0	0.6
18AW01	14.0	0.0	0.0	0.0	0.0	4.2	4.2	0.0	4.2	0.0	0.0	0.0	0	0.0	0	0.0	2.7	1.5
18AW02	2.3	0.0	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.0	0.0	0.0	0	0.0	0	0.0	0.4	0.2
18AW03	22.9	0.0	0.0	0.0	0.0	1.1	1.1	0.0	1.1	0.0	0.0	0.0	0	0.0	0	0.0	0.0	1.1
Totals	163.8	4.7	20.0	24.7	0.0	14.7	14.7	20.1	59.5	7.8	95.8	87.6	6446	0.0	0	0.0	6.4	8.2

4.16 River Segment 18B: Orchard Mesa and Colorado River Wildlife Areas to Tillie Bishop Wildlife Area

River Mile: 179 to 179.8
Maps: Map 19
Site Designations (SD): 18BR01 to 18BR04, 18BW01
Photo #: 1141
Land Ownership: 51.6 acres = 0% Federal, 0% Non-Federal Public, 21% Private, % Private under Conservation Easement, and 79% Unclassified.
Estimated Tamarisk Canopy Coverage: 27% of total or 13.7 acres
Estimated Russian olive Canopy Coverage: 6% of total or 2.9 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

Upstream (east) from the Clifton Nature Park, between river miles 178.5 and 179.5, there is riparian complex composed of riparian terraces (SD: 18BR01, 18BR02), cobble bar islands (SD: 18BR03, 18BR04); and secondary channels/backwater (SD: 18BW01). These sites are dominated by 30 percent tamarisk, 10 percent Russian olive, 10 percent Russian knapweed and old cottonwood galleries, which will be addressed with biological control of tamarisk and hand-cutting Russian olive. The riparian complex on the north side of the river requires active revegetation of riparian shrubs. The cobble bars and secondary channels/backwaters will be left unvegetated. These cobble bars provide spawning habitat for endangered fish, and potentially provide source material further downstream for spawning or habitat areas. Thus, it is important to control tamarisk on the islands. Restoring this site will benefit endangered native fish, improve riparian habitat, and provide a more natural river system.

Recreational Features: No recreational features are planned for this segment.

Map 19 provides site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC", "BW", "P", and "SL" respectively.

Table 4.93 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Riparian Terraces	18BR01, 18BR02	28 acres with 30% T, 10% RO and 10% RK. These sites are riparian terraces dominated by T, RO, old cottonwood galleries, upland grasses, secondary weeds, coyote willow and sparse shrubs.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant riparian shrubs, seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	18BR03, 18BR04	17 acres with 30% T, no RO and no RK. These sites are cobble bars and islands dominated by T, RO, coyote willows and wetland grasses with very few. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation.
SC, BW, P, SL	18BW01	7 acres with 5% T, 1% RO and no RK. These sites are wetlands dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO. Biomass: Stack piles for burning and/or wildlife habitat. Revegetation: No revegetation.

Table 4.94 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Riparian Terraces	18BR01	22.1	RK and cheatgrass infestation	Riparian	Broadcast
	18BR02	5.8	None	-	-
Cobble Bars	18BR03	3.5	None	-	-
	18BR04	13.6	None	-	-
SC, BW, P, SL	18BW01	6.6	None	-	-

***Type of Grass Seed Mix**:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*)

Table 4.95 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

	Site	Acres	Veg Const*	Woody Invasives: Tamarisk %	Tamarisk Acres	Russian Olive %	Russian Olive Acres	No. Riparian Replacement Shrub Species: Three-Leaf Sumac	Golden Current	Woods Rose	Silver Buffaloberry	No. Upland Replacement Shrub Species: Rubber Rabbitbrush	Fourwing Saltbrush	Big Sagebrush	Winterfat	Total
Lower Riparian Terraces	18BR01	22.1	None	30	6.6	10	2.2	324	324	324	162	0	0	0	0	**1135**
	18BR02	5.8	None	40	2.3	10	0.6	103	103	103	51	0	0	0	0	**360**
	Sub-Total	**27.9**			**8.9**		**2.8**	**427**	**427**	**427**	**214**	**0**	**0**	**0**	**0**	**1495**
Cobble Bars	18BR03	3.5	Cobble	10	0	0	0.0	0	0	0	0	0	0	0	0	**0**
	18BR04	13.6	Cobble	30	4.1	0	0.0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**17.1**		**26**	**4.4**		**0.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	18BW01	6.6	Veg	5	0	1	0.1	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**6.6**			**0.3**		**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**51.6**		**27**	**13.7**	**6**	**2.9**	**427**	**427**	**427**	**214**	**0**	**0**	**0**	**0**	**1495**

* **Veg Const** (**Vegetation Constraints**): **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

+: The site is not an island, but is only accessible by boat because there is no road access.

#: Replacement revegetation numbers are calculated based on the total acres of this site due previous removal of T and RO and desire to improve habitat and recreational values.

Table 4.96 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
None	0	0	0	**0**
Total	**0**	**0**	**0**	**0**

Table 4.97 Access for tamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
18-B	N 39.071527° W 108.42385°	18BR01, 18BR02, 18BR03, 18BR04, 18BW01	From Grand Junction, take F Rd east, turn south on 34 Rd, to Clifton Water District property, then drive private drive for approximately 1 mile to access point	1.12 acres

Table 4.98 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
None				

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.99 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
18BR01	22.1	1.3	2.0	3.3	0.0	0.2	0.2	5.3	8.8	2.2	22.1	22.1	1135	0.0	0	0.0	0.0	0.2
18BR02	5.8	0.5	0.5	1.0	0.0	0.1	0.1	1.9	2.9	0.0	0.0	5.8	360	0.0	0	0.0	0.0	0.06
18BR03	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
18BR04	13.6	0.0	0.0	0.0	0.0	0.0	0.0	4.1	4.08	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
18BW01	6.6	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.40	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.07
Totals	51.6	1.8	2.5	4.3	0.0	0.3	0.3	11.9	16.6	2.2	22.1	27.9	1495	0.0	0	0.0	0.0	0.3

4.17 River Segment 19: Tillie Bishop Wildlife Area*

River Mile: 183.0 to 185.2
Maps: Map 21 to Map 22
Site Designations (SD): 19U04 to 19U05, 19R01 to 19R09, and 19W01 to 19W04
Photo #: 0821-0825; 0974-0987
Land Ownership: 133.8 acres = 0% Federal, 64% Non-Federal Public, 31% Private, 0% Private under Conservation Easement, and 5% Unclassified.
Estimated Tamarisk Canopy Coverage: 16% of total or 21.6 acres
Estimated Russian olive Canopy Coverage: 23% of total or 30.8 acres

** The USFWS has identified this segment a high priority for restoring habitat for endangered fish species..*

The privately owned area at the downstream, west end of the north bank is a riparian complex with riparian terraces (SD: 19R01, 19R02, 19R03), secondary channels/backwaters (SD: 19W02) and cobble bars (SD: 19R04, 10R05). This area is commonly known as the Labor Camp as it is a historic site where migrant workers camped. The existing side channel (SD: 19W02) has experienced aggradation and vegetation encroachment and is an important spawning habitat for endangered fish (Photo 0979). Overall the Labor Camp has 20 percent tamarisk and 10 percent Russian olive which will be removed. The overbanks will be actively revegetated, including the overbank areas of the active side channel, SD: 19W02 (outside of and above the wet channel). The wet channel of 19W02 and the cobble bar (SD: 19R05) will be left unvegetated to provide enhanced habitat for the endangered fish.

The Tillie Bishop State Wildlife Area (SWA) on the south side of the river is owned and managed by the Colorado Division of Wildlife (CDOW). The area contains upper riparian terraces (SD: 19U04, 19U05), riparian terraces (SD: 19R06, 19R08), cobble bars (SD: 19R07), disconnected secondary channels (SD: 19W03, 19W04) and pond/sloughs (SD: 19W01). The eastern upper riparian terrace has been revegetated with wildlife shrubs by the CDOW (Photo 0825). The western upper riparian terrace, riparian terraces, secondary channels/backwaters and pond/sloughs have 20 percent tamarisk, and 50 percent Russian olive (Photo 0985). Removal and active revegetation in designated sites will improve habitat. Backwater areas and the open channels will be left unvegetated for endangered fish spawning and rearing habitat. A nursery is proposed in the adjacent, irrigated field for cultivating ecotype-specific plant materials for the project area. This will augment a similar facility to be established at the CDOW Walter Walker SWA.

Cobble bars (SD: 19R05, 19R07, 19R09) are currently colonized with tamarisk. This is stabilizing the bars and reducing the otherwise natural dynamic nature of these mid-channel areas. Tamarisk will be removed and the cobble bars left unvegetated.

Recreational Features: No recreational features are planned for this segment.

Photo 0979

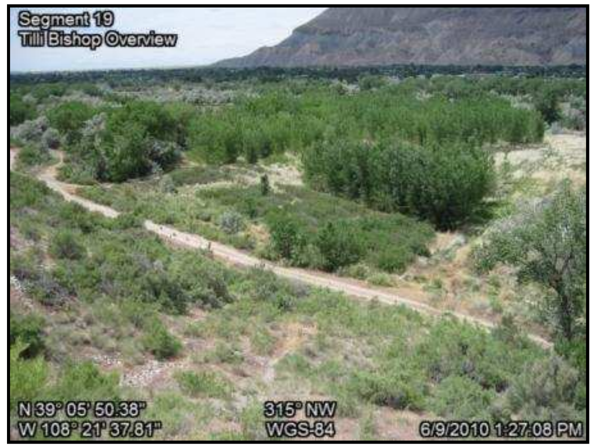

Photo 0825

Photo 0985

Maps 21 and 22 provide site designations, tree planting areas, land ownership, conservation easements, 100-year floodplain, staging areas, hydraulic cross sections, River Front Trail, access roads/points, monitoring wells, recreational features soil samples and river miles.

The following tables, maps and descriptions provide recommendations that are appropriate for this segment with tamarisk, Russian olive, Russian knapweed, cottonwood, and box elder abbreviated as "T", "RO", "RK", "CW", and "BE" respectively. Secondary channels, backwaters, ponds and sloughs are abbreviated as "SC", "BW", "P" and "SL" respectively.

Table 4.100 Site descriptions and restoration action.

	Sites	Description	Restoration Approach
Upper Riparian Terraces	19U04, 19U05	38 acres with 10% T, 40% RO and 1% RK. These sites are upper riparian terraces dominated by upland grasses, secondary weeds and sparse shrubs.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plant upland shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Lower Riparian Terraces	19R01, 19R02, 19R03, 19R06, 19R08	37 acres with 20% T, 40% RO and 20% RK. These sites are lower riparian terraces dominated T, RO, by old cottonwood galleries, upland grasses, secondary weeds and sparse shrubs.	Control: Mechanical removal and biological control for T. Mechanical removal and hand cutting for RO; treat secondary weeds with herbicide. Biomass: Leave T and RO to naturally decompose. Revegetation: Plantings of CW & BE in designated areas, plant riparian shrubs and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
Cobble Bars	19R04, 19R05, 19R07, 19R09	36 acres with 20% T, 5% RO and 1% RK. These sites are cobble bars and islands dominated by coyote willows and wetland grasses with some T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO; treat secondary weeds with herbicide. Biomass: Stack piles for burning and/or wildlife. Revegetation: No revegetation, but seed appropriate grass mix to enhance habitat and outcompete secondary weeds.
SC, BW, P, SL	19W01, 19W02, 19W03, 19W04	23 acres with 5% T, 5% RO and no RK. These sites are wetlands dominated by coyote willows and wetland grasses with very few T and RO. Given the need to minimize impacts to the existing vegetation, restoration will be accomplished by hand and without the use of heavy equipment.	Control: Biological control T, hand cut RO; treat secondary weeds with herbicide. Biomass: Stack piles for burning and/or wildlife. Revegetation: No revegetation, but plantings of CW and BE in designated areas and seed appropriate grass mix to enhance habitat and outcompete secondary weeds.

Table 4.101 Grass seed mix type and method of application by site.

NOTE: Refer to revegetation recommendations section of the introduction for application rates, ratios of seed mixes and discussion of application methods.

	Site	Acres	Site Considerations	Type of Grass Seed Mix*	Method of Application
Upland Terraces	19U04	23	RK and cheatgrass infestation	Upland	Broadcast
	19U05	15	Kochia and whitetop infestation	Upland	Broadcast
Riparian Terraces	19R01	6	Cheatgrass infestation	Riparian	Broadcast
	19R02	10	RK and cheatgrass infestation	Riparian	Broadcast
	19R03	4	RK infestation	Riparian	Broadcast
	19R06	7	RK and kochia infestation	Riparian	Broadcast
	19R08	10	RK and kochia infestation	Riparian	Broadcast
Cobble Bars	19R04	4	RK infestation	Riparian	Broadcast
	19R05	7	None	-	-
	19R07	16	None	-	-
	19R09	9	None	-	-
SC, BW, P, SL	19W01	7	Kochia infestation	Riparian	Broadcast
	19W02	11	None	-	-
	19W03	2	None	-	-
	19W04	3	None	-	-

*__Type of Grass Seed Mix__:

Upland - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), Indian ricegrass (*Achnatherum hymenoides*), scarlet globemallow (*Sphaeralcea coccinea*), evening primrose (*Oenothera* spp.)

Upland Salty - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*)

Riparian - Alkali sacaton (*Sporobolus airoides*), slender wheatgrass (*Elymus trachycaulus*), inland saltgrass (*Distichlis spicata*).

Table 4.102 Acres of tamarisk and Russian olive to treat and number of replacement shrubs by species per site.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

				Woody Invasives				No. Riparian Replacement Shrub Species				No. Upland Replacement Shrub Species				
				Tamarisk		Russian Olive		Three-Leaf	Golden	Woods	Silver	Rubber	Fourwing	Big		
	Site	**Acres**	**Veg Const***	**%**	**Acres**	**%**	**Acres**	**Sumac**	**Current**	**Rose**	**Buffaloberry**	**Rabbitbrush**	**Saltbrush**	**Sagebrush**	**Winterfat**	**Total**
Upland Terraces	19U04	23.2	None	10	2.3	20	4.6	0	0	0	0	171	171	171	171	**683**
	19U05	15.1	None	20	3.0	60	9.1	0	0	0	0	311	311	311	311	**1244**
	Sub-Total	**38.3**			**5.3**		**13.7**	**0**	**0**	**0**	**0**	**482**	**482**	**482**	**482**	**1926**
Riparian Terrac	19R01	5.9	None	20	1.2	10	0.6	70	70	70	35	0	0	0	0	**244**
	19R02	9.8	None	30	2.9	20	2.0	202	202	202	101	0	0	0	0	**708**
	19R03	4.4	None	30	1.3	20	0.9	90	90	90	45	0	0	0	0	**316**
	19R06	6.9	None	30	2.1	50	3.4	262	262	262	131	0	0	0	0	**918**
	19R08	9.7	None	10	1.0	70	6.8	430	430	430	215	0	0	0	0	**1504**
	Sub-Total	**36.7**			**8.5**		**13.7**	**1054**	**1054**	**1054**	**527**	**0**	**0**	**0**	**0**	**3690**
Cobble Bars	19R04	3.9	Veg	10	0.4	10	0.4	0	0	0	0	0	0	0	0	**0**
	19R05	6.6	Cobble	20	1.3	0	0	0	0	0	0	0	0	0	0	**0**
	19R07	16.4	Cobble	20	3.3	0	0	0	0	0	0	0	0	0	0	**0**
	19R09	9.1	Island	20	1.8	20	1.8	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**36.1**			**6.8**		**2.2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SC, BW, P, SL	19W01	6.6	Veg	5	0.3	5	0.3	0	0	0	0	0	0	0	0	**0**
	19W02	10.6	Veg	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	19W03	2.2	Veg	30	0.7	40	0.9	0	0	0	0	0	0	0	0	**0**
	19W04	3.3	Veg	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Sub-Total	**22.7**			**1.0**		**1.2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL	**133.8**			**21.6**		**30.8**	**1054**	**1054**	**1054**	**527**	**482**	**482**	**482**	**482**	**5616**

* **Veg Const (Vegetation Constraints)**: **Veg** - The site either contains adequate native vegetation or heavy equipment should not be used because damage to existing native vegetation would occur; **Cobble** - The site functions as a cobble bar which is scoured annually by seasonal high flows and does not require revegetation; **Island** - The site is on an island and therefore is best accessed by hand crews; **None** - Site issues not applicable to this site.

Table 4.103 Areas identified and number of cottonwood pole and boxelder plantings.

NOTE: Refer to revegetation recommendations section of the introduction for explanation of revegetation calculations.

Sites	Recommended Tree Planting Area (Acres)	No. Replacement Tree Species Cottonwood	Box Elder	Total
19R01, 19R02, 19R03, 19W02	23	294	107	**401**
19R06, 19R08, 19W01, 19W04	19	250	91	**341**
Total	**42**	**544**	**198**	**742**

Table 4.104 Access for yamarisk and Russian olive control and revegetation.

Access Label	GPS Coordinates Datum: WGS84	Sites Accessed	Description of Access Route	Staging
19-A	N 39.096915° W 108.360718°	19U04, 19U05, 19R06, 19R07, 19R08, 19W01, 19W03, 19W04	Drive east on F Rd, follow as it turns into Front St. then G Rd, continue on G Rd., cross the Colorado then turn south (R) on 38 Rd which turns into F 1/4 Rd, follow F 1/4 Rd till dead end and vear north (R) on dirt road to dirt parking lot	0.29 acres
19-B	N 39.10164° W 108.358076°	19R01, 19R02, 19R03, 19R04, 19R05, 19W02	Drive east on F Rd, follow as it turns into Front St. then G Rd, continue on G Rd., turn south (R) on Logan St	0.43 acres
19-C	N 39.104803° W 108.349975°	19R09	**River access only**: Put-in at I-70; take-out at Palisade Riverbend Park	None required

Table 4.105 Soil samples.

Location	Depth	pH	Salinity Measured mmhos/cm	Salinity Sat Paste mmhos/cm
19R01	4"	8.95	0.21	0.53
	10"	9.03	0.15	0.37
19R03	4"	8.26	1.66	4.14
	10"	8.13	1.52	3.80

Note: Measured values were converted to saturated paste using Tri-River Area Colorado State University Extension office's protocols.

Table 4.106 Overview of control and restoration acreages.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Site	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
19U04	23.2	0.5	4.2	4.6	0.0	0.5	0.5	1.9	7.0	1.2	23.2	23.2	683	0.0	0	0.0	0.0	0.5
19U05	15.1	0.9	8.2	9.1	0.0	0.9	0.9	2.1	12.1	15.1	15.1	15.1	1244	0.0	0	0.0	0.0	0.9
19R01	5.9	0.2	0.5	0.8	0.0	0.1	0.1	0.9	1.8	0.3	5.9	5.9	244			0.0	0.0	0.1
19R02	9.8	0.6	1.8	2.4	0.0	0.2	0.2	2.4	4.9	3.9	9.8	9.8	708	22.7	401	0.0	0.0	0.2
19R03	4.4	0.3	0.8	1.1	0.0	0.1	0.1	1.1	2.2	1.8	4.4	4.4	316			0.0	0.0	0.1
19R04	3.9	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.8	0.2	3.9	0.0	0	0.0	0	0.0	0.0	0.4
19R05	6.6	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
19R06	6.9	0.6	3.1	3.7	0.0	0.3	0.3	1.4	5.5	0.0	6.9	6.9	918	19.3	341	0.0	0.0	0.3
19R07	16.4	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.3	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
19R08	9.7	0.3	6.1	6.4	0.0	0.7	0.7	0.7	7.8	1.9	9.7	9.7	1504	0.0	0	0.0	0.0	0.7
19R09	9.1	0.0	0.0	0.0	0.0	1.8	1.8	1.8	3.7	0.5	0.0	0.0	0	0.0	0	0.0	0.9	0.9
19W01	6.6	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.7	1.0	6.6	0.0	0	0.0	0	0.0	0.0	0.3
19W02	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
19W03	2.2	0.0	0.0	0.0	0.0	0.9	0.9	0.7	1.5	0.0	0.0	0.0	0	0.0	0	0.0	0.7	0.2
19W04	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0.0	0.0
Totals	133.8	3.4	24.6	28.0	0.0	6.2	6.2	18.3	52.4	25.8	85.6	75.1	5616	42.0	742	0.0	1.6	4.6

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5.0 ASSESSMENT OF SEGMENTS

5.1 Opinion of Probable Costs

In this section of the engineering appendix, each of the Segments are assessed, individually, for both costs and environmental benefits. Costs, or 'opinion of probable costs' are generally estimated in four general categories: (1) mobilization, demobilization and BMPs, (2) control and biomass reduction, (3) revegetation, and (4) recreational facilities. For Segment 10, Walter Walker there is also a cost category for habitat restoration, which, unlike the other segments, requires earthwork. Earthwork is calculated using exiswting and proposed contours and CAD software. Areas are calculated using GIS shape files. Existing contours are available as shown on the conceptual site plan, Shown in Figure 3.22. A 10-percent contingency is added for the construction total. Total preliminary Segment costs also include the cost for plans, specifications and engineering during construction (EDC); supervision and administration; and land, easements, rights-of-way and disposal sites (LEERDs). A template is developed for each Segment, as demonstrated in Figure 5.1.

Benefits are estimated using the Habitat Evaluation Procedure (HEP) developed by the USFWS (1980), and modified with USFWS guidance, to facilitate identification of impacts from various Federal actions on fish and wildlife habitat for the species of concern. Details of these assessments are presented in the following sections.

Summaries on a segment-by-segment are included in Exhibit 4. All associated backup is included on the CD contained in this report and. Elements of each item are described below.

	SEGMENT 6			UNIT	SUB TOT
	ITEM DESCRIPTION	UNIT	QTY	COST	COST
1	Mobilization/Demobilization/BMPs	LS	1	$3,500	$ 3,500
2	Control and biomass reduction	LS	1	$ 22,692	$ 22,692
3	Revegetation	LS	1	$ 52,160	$ 52,160
	Subtotal				$78,352
	Ccontingency (10%)				$7,835
	CONSTRUCTION SUBTOTAL				**$86,187**
	Plans, specifications, EDC				$2,586
	Supervision and Administration (10%)				$8,619
	LERRDs				$46,540
	SUBTOTAL PRELIMINARY PROJECT COST				**$143,932**
4	Recreational facilities	LS	1	$ 17,180	$ 17,180
	PRELIMINARY PROJECT COST				**$161,111**

Figure 5.1 Template for segment cost estimates.

5.1.1 Mobilization/Demobilization/BMPs

Each Segment is comprised of multiple sites. Some sites are accessible by land, while others can only be reached by boat. In general sites that are accessible only by boat will be restored using biocontrol and hand-methods eliminating the need for equipment. Land accessible sites may be treated by hand and/or using equipment as previously described in Section 4 of this appendix. For the purpose of developing an opinon of probably cost, mobilization/demobilization costs include equipment rental and transport, boat rental to transport labor to islands, toilet and permit fees and BMPs. In the case of Walter Walker, trailer and temporary utilities are also included. The cost of labor to access the sites is a function of the size of restoration and types of treatment. Thus these hours are included under the 'Control, Biomass Reduction' and 'Revegetation.'

5.1.2 Control, Biomass Reduction and Revegetation

Site-specific conditions and restoration approaches for each segment have been identified and used to develop an opinion of probable costs. Field surveys conducted June through August 2010 provide on-the-ground determination of vegetation densities and site conditions. This detailed information is for the cost estimate calculations. Costs are based on specific recommendations by site, including: type of control for removal of tamarisk (T) and Russian olive (RO), method for reduction of biomass, specific amount of secondary weed control based on present densities, amount and type of grass seeding, and amount and type of shrub and tree plantings. Control costs and biomass mulching costs vary by the amount (or density) of the tamarisk and Russian olive. Unit cost information is based on the extensive experience of regional efforts and the Tamarisk Coalition in similar projects near and adjacent to this Project area. Costs for each Site within each Segment is estimated for control, biomass reduction and plant establishment (revegetation). The following example is one of the 16 Sites within Segment 6 demonstrating the cost estimate procedure. Copies of all the sites for each segment are presented in Exhibit 5 along with the detailed cost algorithms and unit price back-up information.

5.1.3 Habitat Restoration (Walter Walker, Segment 10)

The opinion of probable cost for Walter Walker (Segment 10) includes the costs for Habitat Restoration, and grading portions of the site to create a backwater area, and reconstruction of the levee to increase flow into the floodplain bottomlands area as discussed in previous Sections of this report. The final configuration for Walter Walker will consist of a trapezoidal cut in the levee construction of a backwater area and the removal of the two small berms in the side channel, estimated at $491,000. Details are included in Exhibit 4.

Habitat restoration at Walter Walker also is comprised of the removal of invasive species from mid-channel cobble bars, side channels and overbanks. Revegetation is proposed for channel bank and overbank restoration, all which is covered in the control, biomass reduction and revegetation elements.

Segment 6: Skipper's Island Complex to Old Fruita Bridge			
Site Designation: 06U03			
	Tamarisk Average Canopy Cover (%)	10%	
	Russian Olive Average Canopy Cover (%)	10%	
	Total Site Acreage	5.3	
	Technologies for Control & Biomass Reduction	**Percentage of Each Technology Recommended**	**Restoration Costs**
Control & Biomass Reduction	T Hand control	0%	$0
	T Mechanical removal	20%	$172
	T Biological control	80%	$47
	RO Hand control	10%	$415
	RO Mechanical removal	90%	$773
	TRO Biomass reduction of hand controlled work by mulching	0%	$0
	TRO Biomass reduction of hand controlled work by fire	0%	$0
	TRO Biomass reduction of hand controlled work by natural decomposition	100%	$0
	Secondary weed control - Percent area infested	40%	$424
	Subtotal Control & Biomass Reduction Costs for Site =		$1,829
	TRO Resprout control	20%	$366
	Control & Biomass Reduction Costs for Site =		***$2,195***
	Technologies for Revegetation	**Unit**	**Restoration Costs**
Revegetation	Upland grass mix - Broadcast seeding	5.3 acres	$1,086
	Upland grass mix - Drill seeding	0 acres	$0
	Upland salty grass mix - Broadcast seeding	0 acres	$0
	Upland salty grass mix - Drill seeding	0 acres	$0
	Riparian grass mix - Broadcast seeding	0 acres	$0
	Riparian grass mix - Drill seeding	0 acres	$0
	Riparian shrubs	0 plants	$0
	Upland shrubs	93 plants	$1,402
	Subtotal Revegetation Costs for Site =		$2,488
	Revegetation establishment	20%	$498
	Revegetation Costs for Site =		***$2,985***
	Total Control, Biomass Reduction, & Revegetation Costs for 06U03 =		**$5,180**

Figure 5.2 Template for cost estimates of Control, biomass reduction and revegetation.

5.1.4 Cost of Recreational Features

In compliance with the scope of work a Micro-Computer Aided Cost Estimating System (MCACES) cost estimate for recreational features has been prepared and is appended in Exhibit 7. Recreational features include including interpretive signs, and wildlife viewing areas.

5.1.5 Plans, Specification and EDC Costs

Plans, specification and engineering during construction (EDC) costs are estimated based on 3 percent of the construction costs for all sites except Walter Walker. Walter Walker costs are based on 10 percent of the construction costs, a slightly higher percentage to account for the grading and earthmoving activities required to complete restoration. The overall cost for plans and specifications are relatively low as compared to conventional civil plans and specifications due to the fact that there is minimal amount of actual construction. Most of the effort will require specifications to set standards and guidelines for the control, biomass reduction and revegetation. This can be accomplished in one document and used for all segments. Walter Walker will also require drawings and details for site improvements, but again the overall construction is minor and relatively simple.

5.1.6 Lands, Easements, Rights-of-way and Disposal Sites (LEERDs)

Acreages for each Segment are identified by land ownership for purposes of determining real estate costs. The landownership categories are Federal, Non-Federal Public, Private under Conservation Easement, Private Lands, and Unclassified. Non-Federal Public refers to land owned by the county, state, water and sanitation districts, and municipalities. Unclassified lands refer to lands that do not have any official ownership based on Mesa County Assessor's records, according to parcel maps and surveys, and are thus designated by default to fall under the control of BLM. These parcels were typically created when parcel lines were established as being defined by the riverbanks. The LEERDs calculations also include temporary easements for access and staging areas.

5.1.7 Other Costs

In addition to the costs noted above, a 10-percent contingency is included for construction. The Detailed Project Report and EA costs are estimated based on input from the USACE staff and is $1,200,000 total for all 15 sites.

5.1.8 Monitoring, Operations and Maintenance

The objective of the operations and maintenance (O&M) procedures is to maintain project features to "as-built conditions or conditions that provide for acceptable project performance consistent with project objectives. Of note, is the maintenance of cobble bars. Once the tamarisk is removed, it is critical the bars remain relatively free from further infestation. This will require maintenance on a periodic, regular basis for several reasons. First flows of sufficient volumetric rates for partial mobilization (incipient motion) typically occur during the snowmelt runoff period while the majority of fines are introduced during the low-flow summer season by thunderstorms, thereby creating a lag or time period during which tamarisk could potentially initiate colonization. This is particularly of concern when associated with multiple dry and below-average spring runoff conditions. Once tamarisk colonize, it is less likely that the bankfull or annual flows alone will remove new growth. Higher flows (such as the 5-year event) are required to mobilize bed material and create scoured and undercut banks, to naturally maintain clean cobble bars. Thus, in combination with or in lieu of high flows, maintenance will be required, and is proposed as an integral component of this project. Maintenance will be performed using a variety of techniques including continued biological control, hand control and mechanical removal, all as required and appropriate for various levels of infestation.

Annual O&M costs are based on a detailed cost estimate prepared by the Tamarisk Coalition, projected to be approximately 2 percent of the total present day construction costs. Implementation of O&M requirements is the responsibility of the project sponsor. Maintenance activities to be implemented by the Sponsor will include any or all of the following:

- Perform once per year for years 1 through 5 and then once every 5 years to assess requirements for maintenance,
- Periodic tamarisk and Russian olive resprout control, and
- Herbaceous weed control.

Monitoring procedures are in addition to O&M costs. The goal of the monitoring plan is to evaluate the Project's success in establishing plantings and geomorphic improvements. Procedures are outlined in Section 6.

5.1.9 **Summary of Opinion of Probable Costs**

Table 5.1 summarizes the construction costs for each river segment discussed herein. Cost estimates are conceptual, based on 2010 price level. Note that the construction cost estimate for Segment 10 was originally prepared in 2008, however, unit prices since 2008 have not changed significantly. Thus for purposes of this alternative cost analysis all Segment costs can be considered as prepared at the 2010 price level.

5.2 Habitat Evaluation Procedure (HEP)

A quantitative or numeric scoring method is a useful tool to facilitate comparisons of the potential habitat impacts and benefits between alternatives. The Habitat Evaluation Procedure (HEP) was developed by the USFWS (1980) to facilitate identification of impacts from various Federal actions on fish and wildlife habitat. A HEP can provide numeric scores for existing conditions at a project site, potential future without-project conditions, and various with-project alternatives.

Table 5.1 Opinion of probable costs for all segments.

Item	Segment 4	Segment 5	Segment 6	Segment 8	Segment 9	Segment 10	Segment 11	Segment 12	Segment 13	Segment 14	Segment 16	Segment 17	Segment 18A	Segment 18B	Segment 19
Restoration	$ 2,082	$ 159,096	$ 76,352	$ 405,399	$ 633,128	$ 846,291	$ 499,507	$ 261,198	$ 102,888	$ 192,785	$ 229,304	$ 125,321	$ 339,339	$ 24,001	$ 258,930
Contingency	$ 208	$ 15,910	$ 7,635	$ 40,540	$ 63,313	$ 84,629	$ 49,951	$ 26,120	$ 10,289	$ 19,279	$ 22,930	$ 12,532	$ 33,934	$ 2,400	$ 25,893
DPR/EA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Plans, Specs, EDC	$ 69	$ 5,250	$ 2,520	$ 13,378	$ 20,893	$ 93,092	$ 16,484	$ 8,620	$ 3,395	$ 6,362	$ 7,567	$ 4,136	$ 11,198	$ 792	$ 8,545
Supervision & Admin	$ 229	$ 17,501	$ 8,399	$ 44,594	$ 69,644	$ 93,092	$ 54,946	$ 28,732	$ 11,318	$ 21,206	$ 25,223	$ 13,785	$ 37,327	$ 2,640	$ 28,482
LERRDs	$ 1,875	$ 1,068	$ 46,540	$ 88,505	$ 147,222	$ 444,229	$ 216,774	$ 83,499	$ 41,255	$ 59,933	$ 57,082	$ 53,340	$ 98,724	$ 46,173	$ 113,645
Subtotal	$ 4,463	$ 198,824	$ 141,446	$ 592,416	$ 934,200	$ 1,561,333	$ 837,661	$ 408,169	$ 169,145	$ 299,565	$ 342,107	$ 209,114	$ 520,522	$ 76,006	$ 435,496
Recreation	$ 17,180	$ -	$ 17,180	$ -	$ -	$ 8,590	$ 8,590	$ 8,590	$ 8,590	$ 8,590	$ -	$ 17,180	$ -	$ -	$ -
Total First Cost	$ 21,643	$ 198,824	$ 158,625	$ 592,416	$ 934,200	$ 1,569,923	$ 846,251	$ 416,758	$ 177,735	$ 308,155	$ 342,107	$ 226,293	$ 520,522	$ 76,006	$ 435,496

A HEP is composed of one or more Habitat Suitability Indices (HSI), which are models for calculating the habitat suitability of an area for an individual or assemblage of species. The HSIs are comprised of a set of variables that represents the life requisites for the species (such as percent cover, water depth, and tree height). The variables are measured in the field, and their corresponding index values are inserted into the HSI model to produce a score that describes existing habitat suitability. The index value is a score between 0 and 1. HSI models may be designed to evaluate habitat suitability for the entire life cycle of a species or for a specific season or life history stage (especially for migratory species). Most of the HSI models used for this HEP are derived from existing models, which are available at the National Wetlands Research Center website (NWRC 2002) and developed through the review of literature on the species' habitat requirements and preferences for species where existing models apply. Other models are site specific and, with the assistance of the USFWS, developed specifically for this project.

The selection of species to include in a HEP model is based on several criteria. First, the geographic range for the species must include the project vicinity. The species selected must also use the habitat type or types that are currently present or are proposed for restoration. Existing HSI models for the species are preferred because they have been tested widely during their development. Using the previously developed and tested models designed by USFWS provides a greater level of certainty and significantly reduces the time necessary to prepare an appropriate HEP. Suitable HSI models must include habitat variables where data can be collected, given the availability of time and resources. Finally, variables should also show a change in score for the proposed project measures. If the project does not affect the suitability index score for a species, it will not be possible to quantify an effect. Habitat variables that do not meet these requirements will generally be omitted.

Although only a few species are selected out of the many that could be present in the project area, the species selected represent guilds that currently do or could use habitats in the project area or are listed species under the ESA or species of concern in the project area

The individual HSIs for various habitat parameters for each species are combined to yield an overall index score for the species. Scores for each species can be used individually or combined to yield an overall index score for a site for multiple species or species assemblages. The index score for either the individual species or the multiple species community is multiplied by the area of habitat that may be affected by a project. This final score is called a Habitat Unit (HU). Habitat units can be calculated separately for each species or for a combined score for multiple species. The future with- and without-project HUs are compared to evaluate the net difference (either positive or negative) between alternatives. The time chosen for this project comparison is 50 years. Existing conditions (TY0) data are based on field data collection in 2007, supplemented with recent vegetation data from field surveys conducted June through August 2010, provided by the Tamarisk Coalition. Future, without project conditions are determined based on projections of invasive species colonization and growth from observations at nearby sites.

5.2.1 **Models**

For the purpose of this HEP analysis, three models have been developed: an aquatic model, a riparian model and a geomorphic model. Suitability Indices (HSI) models for both aquatic and riparian habitats are used for this HEP, and their scores calculated separately. The aquatic and riparian habitat HEP models proposed for this project are community-based models with multiple species selected to represent aquatic and riparian habitats. The species selected for the models are expected to be indicators of habitat conditions for additional species found in aquatic and riparian habitats of the project area. In addition to the aquatic and riparian models, a geomorphic model and score is generated to reflect the geomorphic conditions that could be improved by the project. These improved geomorphic conditions are identified as having the potential to improve habitat to benefit native fishes. Note that the aquatic model and geomorphic model are weighted by a value of 2.5. The purpose of weighting these models is to equate the value of the aquatic and geomorphic habitats to the riparian habitats, which total 2 times greater, in area, than the aquatic and geomorphic habitat combined. All three models are discussed in detail in the following sections.

5.2.1.1 **Aquatic Habitat**

A number of aquatic species could be present in the project area, including the following native species: flannelmouth sucker (*Catostomus latipinnis)*, razorback sucker (*Xyrauchuen texanus)*, bluehead sucker (*Catostomus discobolus)*, Colorado pikeminnow (*Ptychocheilus lucius)*, bonytail (*Gila elegans)*, humpback chub (*Gila cypha)*, roundtail chub (*Gila robusta)*, and speckled dace (*Rhinichthys osculus)*. Non-native species that could be present in the project area include common carp (*Cyprinus carpio)*, sand shiner (*Notropis stramineus)*, red shiner (*Cyprinella lutrensis)*, fathead minnow (*Pimephales promelas)*, channel catfish (*Ictalurus punctatus)*, black bullhead (*Ameiurus melas)*, plains killifish (*Fundulus zebrinus)*, Western mosquito fish (*Gambusia affinis)*, smallmouth bass (*Micropterus dolomieu)*, largemouth bass (*Micropterus salmoides)*, green sunfish (*Lepomis cyanellus)*, and bluegill (*Lepomis macrochirus)* (BLM 2004).

The species chosen to represent the aquatic community for this HEP analysis are listed as endangered species and include Colorado pikeminnow and razorback sucker. Both of these species use pools, gravel and cobble beds, and backwaters for habitat and have been adversely affected by the loss or reduction of these habitats and the growth of tamarisk and other invasive species, particularly on gravel and cobble bars. Other fish species with developed HSI models do not occur in this part of the Colorado River.

Colorado Pikeminnow
The Colorado pikeminnow was listed as endangered by USFWS in 1967. It has been listed as endangered under Colorado law since 1976, but was downlisted to threatened in 1998. It has also been protected under Utah law since 1973 (USFWS 2002a).

Table 5.2 Aquatic species in the project area.

Common Name	Scientific Name	Native	Non-Native
flannelmouth sucker	*Catostomus latipinnis*	X	
razorback sucker	*Xyrauchuen texanus*	X	
bluehead sucker	*Catostomus discobolus*	X	
Colorado pikeminnow	*Ptychocheilus lucius*	X	
bonytail	*Gila elegans*	X	
humpback chub	*Gila cypha*	X	
roundtail chub	*Gila robusta*	X	
speckled dace	*Rhinichthys osculus*	X	
common carp	*Cyprinus carpio*		X
sand shiner	*Notropis stramineus*		X
red shiner	*Cyprinella lutrensis*		X
fathead minnow	*Pimephales promelas*		X
channel catfish	*Ictalurus punctatus*		X
black bullhead	*Ameiurus melas*		X
plains killifish	*Fundulus zebrinus*		X
Western mosquito fish	*Gambusia affinis*		X
smallmouth bass	*Micropterus dolomieu*		X
largemouth bass	*Micropterus salmoides*		X
green sunfish	*Lepomis cyanellus*		X
bluegill	*Lepomis macrochirus*		X

The Colorado pikeminnow spawn between late June and early September when they are 5 to 6 years old and at least 16 inches long. The pikeminnow has been known to migrate more than 200 miles to spawn. Water temperatures for spawning are optimal between 18 and 23°C; preferred spawning habitat is riffles with cobble substrate (USFWS 2002a).

After they hatch and emerge from the spawning substrate, Colorado pikeminnow larvae drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life. These backwaters are typically flooded during spring runoff and remain connected to the river at the lower end of the backwater as flows recede. The preferred conditions in backwaters are large and warm water with average depths about 0.3 meters. (USFWS 2002a).

Adults require near-shore deep pools, deep runs, and eddy habitats maintained by high spring flows. In the spring, adults use floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows. Pikeminnow have been found to prefer areas of complexity, including side channel backwaters, and side channel confluence areas (Osmundson, 2007).

Razorback Sucker

The razorback sucker (*Xyrauchen texanus*) was listed as endangered under Federal law in 1991 and listed as endangered under Colorado law since 1979 (USFWS 2002b). Hatchery supplementation is being implemented by the Recovery Program to help sustain and recover this species (USFWS 2002b).

The razorback sucker can spawn as early as November or as late as June. In the upper Colorado River, spawning typically takes place between mid-April and mid-June. These fish are known to migrate long distances to spawn and congregate in large numbers in spawning areas. Spawning typically occurs over bars of cobble, gravel, and coarse sand substrates during spring runoff at temperatures greater than 14°C.

Young require nursery environments with quiet, warm, shallow water such as tributary mouths, backwaters, or inundated floodplain habitats in rivers, and coves or shorelines in reservoirs. These backwaters and floodplain wetlands are believed to be essential to the survival of young razorback suckers and the recovery of the species.

Adults require deep runs, eddies, backwaters, and flooded off-channel environments in spring; runs and pools often in shallow water associated with submerged sandbars in summer; and low-velocity runs, pools, and eddies in winter. Bottomlands, low-lying wetlands, and oxbow channels flooded and ephemerally connected to the main channel by high spring flows appear to be important habitats for all life stages of razorback sucker. These backwaters provide warm water temperatures, low-velocity flows, and increased availability of food (USFWS 2002b).

5.2.1.2 **Aquatic Model Development**

Both the Colorado pikeminnow young and razorback sucker for all life stages require quite warm shallow water for the development of the young, found typically in backwaters, including bottomland ponds, oxbows and side channels. Both of these species have been adversely affected by the loss or reduction of these habitats and the growth of tamarisk and other invasive species, The aquatic habitat species and references for model development is focused on the presences of these systems under current and future conditions as presented in Table 5.3, Table 5.4 and the following discussion.

Table 5.3 Aquatic habitat model species and references for model development.

Habitat	**Common Name**	**Scientific Name**	**Model Source**
Aquatic Habitat	Colorado Pikeminnow Razorback Sucker	*Ptychocheilus lucius* *Xyrauchen texanus*	USFWS 2002a; Doug Osmundson, pers. comm. USFWS 2002b; Doug Osmundson, pers. comm..

Table 5.4 Aquatic habitat model HSI variables.

Aquatic Habitat Species	
Colorado Pikeminnow and Razorback Sucker	V_1 = Backwater habitat water velocities V_2 = Backwater habitat water depths V_3 = Habitat complexity

For the purpose of this analysis, the aquatic habitat area, or backwater areas are areas that flood on a yearly basis, typically during spring runoff, and are generally cut-off from the main channel as flows recede to approximately 3000 and 5000 cubic feet per second (cfs) (above and below the Gunnison confluence respectively), typical of early spring, late summer and fall conditions. Flows of 6400 and 8080 cfs, which correspond to the yearly spring runoff (1.01-year flood) above and below the Gunnison confluence respectively, are used to identify the flooded areas when compared to inundated areas from 3000 and 5000 cfs. These flows are then analyzed using HEC-2 and HEC-RAS models to determine approximate velocities and backwater depths, represented as HSI variables V_1 and V_2. . Floodplain mapping and area delineation is prepared using Mesa County GIS aerial photography with 2 foot contour mapping. Habitat complexity (V_3) is determined through field observations.

Some of the backwater areas are very isolated, such as constructed lakes or abandoned gravel pits, and/or are areas proposed to be fully vegetated as part of this 206 project. In these cases, the areas are omitted from analysis since they will not be suitably connected to the river to serve as habitat for the target aquatic species.

The variables from selected HSIs in Table 5.5 have been combined into a final HEP model for aquatic habitat. The HSIs proposed for this model apply to backwater habitats for juvenile rearing and adult holding and foraging for the fish species.

Table 5.5 V1 = Backwater habitat water velocities.
(USFWS 2002a, 2002b, Doug Osmundson, USFWS pers. Comm.)

Water Velocities (meters/second)	HSI
0.0	1.0
0.01 - 0.4	0.9
0.4 – 1.0	0.5
>1.0	0.1

Table 5.6 V_2 = Backwater habitat depths.

(USFWS 2002a and Doug Osmundson, USFWS pers. Comm.)

Backwater Habitat Depths (meters)	**HSI**
<0.6	0.1
0.6 – 2.2	1.0
2.2 – 3.4	0.4
>3.4	0.1

Table 5.7 V3 = Habitat complexity**.**

(USFWS 2002a, 2002b, Doug Osmundson, USFWS pers. Comm.)

Number of Habitat Types (backwaters, side channels, floodplain wetland, floodplain ponds, gravel bars)	**HSI**
1	0.25
2	0.5
3	0.75
≥4	1.0

The aquatic habitat HSI is then calculated from the results of the HSI variables using the equation below.

Aquatic Habitat Equation	$\mathbf{HSI_{Aquatic} = (V_1 \times V_2 \times V_3)^{1/3}}$

The final step of the habitat benefit evaluation process is to derive habitat units (HU) by multiplying the results of the HEP model by the aquatic habitat area (acres). In addition, the weighting factor of 2 is applied to the aquatic habitat equation to equate the value of the aquatic habitat, cobined with the geomorphic habitat, to the riparian habitats, which total 2 times greater, in area.

$$\mathbf{HU_{Aquatic} = HSI_{Aquatic} \times Area \times 2.5}$$

5.2.1.3 **Future Conditions**

Under future-without project conditions, Tamarisk leaf beetle would be successfully defoliating and reducing Tamaris densities up to nearly 0% on cobble bars within a ten-year time period. However, Russian olive will continue to spread furthering the loss of aquatic habitat types, by simplifying channel morphology, continuing the loss of natural and dynamic sediment transport and bed mobilization in the system. As a result it is projected that the velocities, depths and areas of the off-channel habitats will eventually be reduced for the without project condition. The projected decreases are 10 percent at 5 years, 25 percent at 10 years, 50 percent at 25 years, and 75 percent at 50 years and are noted in Table 5.8.

Table 5.8 Aquatic area – future without project.

1-year	Unchanged from current conditions
5-year	Depth, velocity and area @ 5yr w/o project = Current Aquatic Area - (Current Aquatic Area x 0.1)
10-year	Depth, velocity and area @ 10yr w/o project = Current Aquatic Area - (Current Aquatic Area x 0.25)
25-year	Depth, velocity and area @ 25yr w/o project = Current Aquatic Area - (Current Aquatic Area x 0.5)
50-year	Depth, velocity and area @ 50yr w/o project = Current Aquatic Area - (Current Aquatic Area x 0.75)

Future-with project conditions assume that more natural dynamics of sediment transport and erosion will be allowed to occur without the stabilizing effects on the riverbanks and bars created by the presence of tamarisk and Russian olive. This action will result in increased area and depths of side channels and off-channel aquatic habitats. However, it will require a few years for the tamarisk root system to release hold of the riverbanks after the plant is either mechanically cut down or defoliated from the beetle, therefore changes to the aquatic habitat will be delayed ten years. The projected increases in aquatic habitat depths and area are 10 percent at 10 years, 25 percent at 25 years, and 40 percent at 50 years. The projected increases are noted in Table 5.9.

Table 5.9 Aquatic area – future with project.

1-year	Unchanged from current conditions
5-year	Minor reduction, not significant so assume unchanged from current conditions.
10-year	Depth, velocity and area @ 10yr with project = Current Aquatic Area + (Current Aquatic Area x 0.1)
25-year	Depth, velocity and area @ 25yr with project = Current Aquatic Area + (Current Aquatic Area x 0.25)
50-year	Depth, velocity and area @ 50yr with project = Current Aquatic Area + (Current Aquatic Area x 0.4)

Sites with backwater areas including side channels, oxbows and connected ponds are listed below along with the area of existing (or current) infestation that is also exposed to sediment transporting flows, Areas adjusted for future conditions, both with and without project are presented in the HEP analysis contained in Exhibit 6.

5.2.2 **Riparian Habitat**

The project area can be generally described as bottomland riparian habitat. Natural riparian vegetation would primarily be cottonwood gallery woodland and willow-dominated streambanks, along with floodplain emergent wetlands. Tamarisk, Russian olive, and Siberian elm (*Ulmus pumila*)have become established throughout the project area and are dominant in many locations. Some representative wildlife species that occur in the area and likely currently use or would use riparian habitats include mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), beaver *(Castor*, *spp)*, mountain lion (*Puma concolor*), black bear (*Ursus americanus*), various songbirds (yellow warbler and black-capped chickadee as examples), bald eagle, Swainson's hawk (*Buteo swainsoni)*, red-tailed hawk (*Buteo jamaicensis*), and great blue heron (*Ardea Herodias*).

Table 5.10 Aquatic area – existing or current area of backwater.

Backwater site	Total area of segment	Size of existing (current) inundated backwater area
	acres	acres
06W01	3.4	2.1
08W03	10.9	6.3
09W01	21.2	11.7
10W04	5.6	2.4
10W05	22.0	13.0
10W09	17.0	4.9
12W01	13.4	11.5
13W01	8.2	0.8
14W01	7.1	5.6
17W06	13.1	13.1
18AW01	14.0	1.7
18AW02	2.3	2.0
18BW01	6.6	6.6
19W02	10.6	5.0
19W03	2.2	1.0

Two wildlife species are chosen to represent riparian-dependent wildlife: yellow warbler and beaver. These species use the riparian zone to a significant extent. Other species that occur in the project area with developed models included bald eagle, great blue heron, downy woodpecker (*Picoides pubescens*), and hairy woodpecker (*Picoides villosus*). Although all of these species use the project area, the existing models do not consider parameters relevant to the proposed project and potential changes to the habitat.

The HSIs proposed for this model apply for the breeding season (yellow warbler) or for the typical habitat limited season (winter for beaver). The beaver model has been modified slightly to eliminate variables that will not change as a result of the project (river gradient and fluctuations in water level).

Yellow Warbler

Yellow warblers are a breeding bird throughout the United States (U.S.). The existing HSI model for this species is described in Schroeder (1982). Yellow warblers prefer riparian habitats composed of abundant, moderately tall, deciduous shrubs ranging in height from 1.5 to 4 meters. Shrub densities between 60 and 80 percent are considered optimal, and coniferous areas are avoided. More than 90 percent of prey is insects, and foraging takes place primarily on small limbs in deciduous foliage. Nests are generally located 0.9 to 2.4 m above the ground in deciduous, hydrophytic shrubs such as willows, cottonwood, and alder. Male yellow warblers had greater mating success in shrubs less than 3 meters tall.

Beaver

Beaver are herbivorous aquatic mammals found throughout North America wherever suitable riparian and wetland habitats occur. Beaver were once so numerous (60 million) that most aquatic habitats in North America were shaped by beaver activity. The existing model is described in Allen (1982); habitat requirements are summarized below. Beaver are generalized herbivores, but have strong preferences for specific plant species and size classes. Aspen, willow, cottonwood, and alder are the preferred species. Red-osier dogwood and green ash are also primary winter foods in North Dakota. Woody stems less than 4 inches in diameter near water are preferred, and herbaceous vegetation and leaves are consumed during the summer. Aquatic vegetation is also eaten. It appears that beaver populations may be declining in areas with tamarisk invasions (Boer and Schmidly 1977, as cited in Zouhar 2003).

5.2.2.1 Riparian Model Development

The riparian habitat species and references for model development are presented in Table 5.11. Table 5.12 presents variables selected for the Riparian HSI model.

Table 5.11 Riparian habitat model species and references for model development.

Habitat	Common Name	Scientific Name	Model Source
Riparian Habitat	Yellow Warbler Beaver	*Dendroica petechia* *Castor canadensis*	Schroeder 1982 Allen 1982

The variables from selected HSIs in Table 5.12 have been combined into the final HEP model for riparian habitats. The HSIs proposed for this model apply for the breeding season (yellow warbler) or for the typical habitat limited season (winter for beaver). The beaver model has been modified slightly to eliminate variables that will not change as a result of the project (river gradient and fluctuations in water level). All variables listed in Table 5.12 were determined through field observation.

Table 5.12 Riparian habitat model HSI variables.

Riparian Habitat	
Yellow Warbler: Breeding/Nesting Habitat	V_1 = Percent deciduous shrub crown cover V_2 = Average height of deciduous shrub canopy
Beaver: Winter Food	V_1 = Percent tree canopy closure V_2 = Percent of trees in 2.5 to 15.2 cm dbh size class V_3 = Percent shrub crown cover V_4 = Average height of shrub canopy V_5 = Species composition of woody vegetation

The following tables present a range of possible habitat conditions for each variable and the corresponding habitat suitability index value.

Yellow Warbler (from Schroeder 1982)

Table 5.13 V_1 = Percent deciduous shrub crown cover.

Percent cover	HSI
0	0
25	0.4
50	0.8
75	1.0
100	0.6

Table 5.14 V_2 = Average height of deciduous shrub canopy.

Average height (meters)	HSI
0	0
0.5	0.25
1	0.5
1.5	0.75
>/=2	1.0

Beaver (from Allen 1982)

Table 5.15 V_1 = Percent tree canopy closure.

Percent canopy closure	HSI
0	0
25	0.5
50	1.0
75	0.8
100	0.6

Table 5.16 V_2 = Percent of trees in 2.5 to 15.2 cm dbh size class.

Percent	HSI
0	0.2
25	0.4
50	0.6
75	0.8
100	1.0

Table 5.17 V_3 =Percent shrub crown cover.

Percent cover	HSI
0	0
25	0.6
50	1.0
75	0.9
100	0.8

Table 5.18 V_4 =Average height of shrub canopy.

Average height (meters)	HSI
0	0
1	0.3
2	1.0
3	1.0
4	1.0

Table 5.19 V_5 =Species composition of woody vegetation (trees or shrubs).

Species Composition	HSI
A= Woody vegetation dominated (>50 percent) by one or more of the following species: aspen, willow, cottonwood, alder	1.0
B = Woody vegetation dominated by other deciduous species	0.6
C = Woody vegetation dominated by coniferous species	0.2

Table 5.20 describes the variables that are omitted from the existing species model and the reason for their omission.

Table 5.20 Omitted variables.

Variable Omitted	*Description*	*Reason for Omitting*
Yellow Warbler, V_3	Percent of shrub canopy composed of hydrophytic shrubs	Will not change as a result of the project
Beaver, V_7	Percent stream gradient	Currently optimal, will not change as a result of the project
Beaver, V_8	Average water fluctuation on annual basis	Is not optimal, but will not change as a result of the project

The riparian habitat HEP is then calculated from the results of the HSI variables using the equations below.

Yellow Warbler Equation	$HSI_{Yellow\ Warbler} = (V_1 \times V_2)^{1/2}$
Beaver Equation	$HSI_{Beaver} = [(V_1 \times V_2)^{1/2} \times V_5]^{1/2} + [(V_3 \times V_4)^{1/2} \times V_5]^{1/2}$ *(within 100 m)* + $0.5[(V_1 \times V_2)^{1/2} \times V_5]^{1/2} + [(V_3 \times V_4)^{1/2} \times V_5]^{1/2}$ *(100-200 m)* /2
Riparian Habitat Equation	$\mathbf{HSI_{Riparian} = (HSI_{Yellow\ Warbler} + HSI_{Beaver})/2}$

The final step of the habitat benefit evaluation process is to derive habitat units (HU) by multiplying the results of the HEP model by the riparian habitat area (acres).

$$\mathbf{HU_{Riparian} = HSI_{Riparian} \times Area}$$

5.2.2.2 Future Conditions

Under future without-project conditions, Russian olive and Russian knapweed densities are assumed to increase. Eventually, the Russian olive trees will become a dense forest cover that will shade out native species. Tree canopy cover increases incrementally to 50% at 5 year, 75% at 10 years, and 100% at 25 years. Percent of smaller trees between 2.5 and 15.2cm DBH decreases to 75% at 5 years, 50% at 10 years, 25% at 25 years and 0% at 50 years. Percent of shrub cover increases 10% at 5 years, 25% at 10 years, 50% at 25 years, and 75% at 50 years. The height of shrubs remains the same at >2m until at 50 years when the forest conditions stabilize and shrubs are on average 0.5 m. Shrub cover first decreases with the removal of the tamarisk and then gradually increases and stabilizes with 10% at 1 year, 50% at 5 years, 66% at 10 years, and 60 percent at 25 years and stabilizing at 50% at 50 years. In addition, it was assumed that with the reduction in aquatic habitat, under without project this area would be converted to riparian habitat, and therefore, this acreage was added to the total riparian area. Acreage alteration factors are noted in Table 5.21.

Table 5.21 Riparian habitat area – future without project.

1-year	Unchanged
5-year	Riparian Area @ 5yr w/o project = Current Riparian Area + (Current Aquatic Area x 0.1)
10-year	Riparian Area @ 10yr w/o project = Current Riparian Area + (Current Aquatic Area x 0.25)
25-year	Riparian Area @ 25yr w/o project = Current Riparian Area + (Current Aquatic Area x 0.5)
50-year	Riparian Area @ 50yr w/o project = Current Riparian Area + (Current Aquatic Area x 0.75)

For future with-project conditions, the following assumptions are made:

1. Densities of tamarisk, Russian olive, and Russian knapweed will immediately be reduced due to removal (mechanical and hand control) or in combination with defoliation by the leaf beetle within the ten-year time period as described above for the without project conditions (resulting in a drop in HEP scores for TY5).

2. Cottonwood densities and other native species will increase due to natural colonization, plantings and maintenance. Tree canopy will also increase as the cottonwoods mature 10% at 1 year and 5 years, 25% at 10 years, 50% at 25 years, 50% in 50 years. Trees between 2.5 and 15.2cm DBH will decrease to 10% at 1 year and then increase to 25% at 10 years, 50% at 25 years, and 75% at 50 years.

3. An initial reduction of shrub canopy will occur from the removal/dieback of tamarisk that will eventually increase over time as the native species re-establish. Percent shrub and shrub cover canopy will both decrease at year 1 to 25% and year 5 at 5% and then increase to 25% at year 10, 50% at year 25 and 75% at year 50. Shrub height will decrease to .25 m at 5 years, and then increase to 1 m at 10 years, and >2 m at 25 years.

In addition, it was assumed that with the increase in aquatic habitat under with-project conditions, this area would be converted from riparian habitat, to aquatic habitat and there would be a equal loss in riparian habitat area as aquatic habitat gained. Estimates of future conditions in the riparian model are therefore adjusted to equate with the losses or gains for the aquatic habitat. Acreage adjustments are noted in Table 5.22, below.

Table 5.22 Riparian habitat area – future with project.

1-year	Unchanged from current conditions
5-year	Minor reduction, not significant so assume unchanged from current conditions
10-year	Riparian Area @ 10yr with project = Current Riparian Area - (Current Aquatic Area x 0.1)
25-year	Riparian Area @ 25yr with project = Current Riparian Area - (Current Aquatic Area x 0.25)
50-year	Riparian Area @ 50yr with project = Current Riparian Area - (Current Aquatic Area x 0.4)

5.2.3 **Geomorphic Model**

As previously discussed, both the pikeminnow and razorback sucker spawn over bars of cobble, gravel, and coarse sand substrates during spring runoff. Spawning success is dependent on clean inter-gravel environment, relatively free from fine sediment. The emergence of tamarisk on cobble bars has resulted in sediment accumulation in and around the base of the tree as it blocks and slows flows, resulting in excessive sediment deposition and loss of spawning habitat. Thus, one of the goals of this Project is to remove tamarisk from cobble bars to improve the geomorphic processes of the river system for the benefit of the endangered fish species. Note that other native non-endangered fish will also benefit from a more natural dynamic river regime, providing improved spawning substrates and adequate interstitial spaces for periphyton and aquatic invertebrates (McAda 2003).

Based on the USFWS's Recovery Program, extensive work addressing flow regimes, flow operations are currently being revised and implemented to simulate flow conditions that mimic a more natural, dynamic process (McAda 2003). Flow re-regulations include adequate spring flushing flows for the movement of fine sediments from the interstitial spaces within the cobble bars. The removal of these invasive plants, in combination with flow operations, should help 1) unlock trapped sediment, 2) simulate a more natural river system, particularly a more dynamic system associated with increased sediment transport, and 3) increase bed mobilization.

5.2.3.1 **Geomorphic Model Development**

As part of the evaluation process, each segment's contribution to reestablishing the geomorphic process of sediment transport to the project area is ranked. This contribution is a function of the size of individual cobble bar sites and the availability for sediments to be transported by predicted flows, as determined by site elevation. For the purpose of the geomorphic component of this HEP analysis, shear and velocities are evaluated for the 'sediment balance/initial motion discharges' of 9,800 and 19,400 cf, above and below the Gunnison confluence respectively for those sites with shear stresses at and above 0.03 lbs/ft^2. See Section 2.20 for discussion of 'sediment balance/initial motion discharges.' These flows and shear stresses are selected as representative of a generalized condition that provides a balance in sediment over the long run by re-mobilizing surficial fine sediment while also potentially limiting the growth of non-native vegetation, primarily tamarisk. Although use of a single flow for representation of these hydraulic conditions is a simplification given that not all cobble bars are represented by these average conditions, it does provide a relatively equitable level of comparison for which to weigh the relative scale of improvements from segment to segment.

The inundated areas for the geomorphic model is based on results from the HEC-2 and HEC-RAS models developed for the hydraulic and backwater analyses. Acres of tamarisk infestation on the cobble bars is based on field observations. Floodplain mapping and area delineation is prepared using Mesa County GIS aerial photography with 2 foot contour mapping.

The geomorphic model reflects the estimated area of cobble bars that is exposed to sediment transporting flows. The geomorphic model is presented in Table 5.23. In addition, the weighting factor of 2.5 is applied to the geomorphic equation to equate the value of the geomorphic habitat, combined with the aquatic habitat, to the riparian habitats, which total 2.5 times greater, in area.

Table 5.23 Geomorphic model variables.

Geomorphic Model	V_1 = Area of sediments to be exposed by vegetation removal V_2 = Percent of area exposed to sediment transporting flows.
Geomorphic Equation	**$HU_{Geomorph} = 2.5 (V_1 \times V_2)$**

5.2.3.2 **Future Conditions**

Field observations indicate that the tamarisk beetle are beginning to migrate into the project area, defoliating tamarisk and reducing the tamarisk cover. This is beginning now and anticipated to continue even without project implementation. However, tamarisk cover without project implementation will only be reduced to a certain minimum level. Based on research conducted by the Tamarisk Coalition, current trends show that the beetle will defoliate tamarisk to a minimum, sustained level density of approximately 9 percent. Typically, the rate of defoliation is 2.1 percent per year based on an average decline from 30- to 9-percent density in 10 years. For the purposes of this analysis, it is assumed that areas with higher densities will defoliate at the same rate of 2.1 percent, but require longer time periods to reach the minimum sustained level of 9%. Those sites with less than 9-percent coverage at the beginning are assumed to remain at the current levels.

Table 5.24 Area with Tamarisk – Future without project.

1-year	Tam. Cover @ 1yr w/o project = Current Tam. Cover – (0.021 x Current Tam. Cover)
5-year	Tam. Cover @ 5yr w/o project = 1yr w/o project – (4 x 0.021 x 1yr w/o project)
10-year	Tam. Cover @ 10yr w/o project = 5yr w/o project – (5 x 0.021 x 5yr w/o project)
25-year	Tam. Cover @ 25yr w/o project= 10yr w/o project – (15 x 0.021 x 10yr w/o project)
50-year	Tam. Cover @ 50yr w/o project= 25yr w/o project – (25 x 0.021 x 25yr w/o project)

For the future with-project conditions, most of the tamarisk removal is accomplished with the beetle and there will be additional defoliation due to follow-up maintenance, bio-control etc. In the case of future with-project conditions, it is assumed that over 50 years with maintenance the rate of decline will not be limited to 9 percent. Also due to initial tamarisk removal in some sites, the initial decline in tamarisk in the first year will exceed that which could be achieved by the beetle alone. Rates of tamarisk decline used in the geomorphic model for future with and without-project are noted below.

Table 5.25 Area with Tamarisk – Future with project.

1-year	Tam. Cover @ 1yr with project = 5yr w/o project – (0.03 x 5yr w/o project)
5-year	Tam. Cover @ 5yr with project = 1yr with project – (4 x 0.03 x 1yr with project)
10-year	Tam. Cover @ 10yr with project = 5yr with project – (5 x 0.03 x 5yr with project)
25-year	Tam. Cover @ 25yr with project= 10yr with project – (15 x 0.03 x 10yr with project)
50-year	Tam. Cover @ 50yr with project= 25yr with project – (25 x 0.03 x 25yr with project)

Table 5.26 Cobble bar data.

Segment	**Site**	**Area within site that is cobble/gravel**	**Cobble on channel bank**	**Cobble on island bank**	**Tamarisk, existing**	**Area innundated on cobble bar**	**Area with existing tams exposed to sediment transporting**	**High priority**
		acres			%	ac	ac	
4	04R02	8.2	√		10	5.3	0.53	
	04R04	6.8		√	20	4.6	0.92	
5	05R07	0.9		√	10	0.9	0.09	√
	05R08	8.0		√	20	6.1	1.22	√
	05R09	1.5	√		20	0.4	0.08	√
6	06R09	8.6			30	8.2	2.46	
	06R10	2.8			20	2.5	0.50	
8	08R07	1.1			0	1.1	0.00	√
10	10R08	7.3	√		0	3.5	0.00	√
	10R11	3.3			50	1.6	0.80	√
	10R13	5.8	√		10	5.0	0.50	√
	10R15	4.9			40	4.1	1.64	√
	10R16	2.6			40	1.6	0.64	√
	10R17	3.1			40	1.5	0.60	√
	10R20	21.0	√		60	13.0	7.80	√
11	11R06	18.4	√		5	7.9	0.40	√
	11R08	2.8	√		5	2.8	0.14	√
12	12R04	3.8			1	1.5	0.02	√
	12R05	18.6			30	15.1	4.53	√
13	13R03	7.5			5	5.2	0.26	√
	14R02	1.0			0	1.0	0.00	√
16	16R01	2.1			40	0.8	0.32	
17	17R19	5.0			20	4.3	0.86	√
18	18AR05	4.3			20	2.4	0.48	
	18AR06	2.6	√		50	2.2	1.10	
	18AR07	7.9			40	4.1	1.64	
	18AR09	8.2			5	2.3	0.12	
19	19R05	6.6	√		20	2.0	0.40	√
	19R07	16.4	√		20	13.7	2.74	√
	19R09	9.1			20	6.8	1.36	√

Sites, including islands with cobble bars are listed in Table 5.26 along with the area of existing (or current) infestation that is also exposed to sediment transporting flows. Areas adjusted for future conditions, both with and without project, are presented in the HEP analysis contained in Exhibit 6.

5.2.4 **HEP Results**

The HEP model is run for existing conditions (TY0) and for future-with and future-without project conditions in TY1, TY5, TY10, TY25, and TY50. Detailed tabulations are prepared in Excel format appended separately. A summary of the average annual benefits is presented in Table 5.27. High priority sites are shown in bold. Note that under with-project conditions, habitat units increase in TY1 but decrease in TY5. This is expected and reflects the immediate positive response to construction in TY1 but a slight decrease by year 5 (TY5) as native vegetation is re-establishing over the extended time period that is required for the leaf beetle to defoliate the tamarisk. Overall, habitat units increase over time.

Under with-project conditions, habitat units show a decrease in habitat units, at first as native vegetation is establishing but an overall increase occurs over time.

Table 5.27 Total habitat units created by each project segment.

	HU (ac.)															
	Segment 4		Segment 5		Segment 6		Segment 8		Segment 9		Segment 10		Segment 11		Segment 12	
	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project
TY0	13.9	13.9	58.1	58.1	32.1	32.1	95.9	95.9	157.9	157.9	298.8	298.8	150.3	150.3	81.5	81.5
TY1	14.0	14.3	58.2	74.4	32.2	34.4	95.2	111.7	157.2	170.8	299.2	380.8	149.5	156.2	81.7	114.8
TY5	14.2	14.5	56.3	43.9	32.3	25.4	93.1	58.1	147.1	82.3	296.1	220.7	143.9	68.1	81.2	88.5
TY10	14.4	14.8	53.2	67.1	31.2	33.1	84.8	98.5	135.7	148.3	271.5	347.6	127.5	132.5	77.0	112.3
TY25	14.9	15.5	46.8	97.4	30.1	43.6	71.9	149.6	114.5	231.6	235.8	513.2	112.4	214.6	72.2	144.4
TY50	14.9	16.1	28.1	103.7	24.8	46.6	36.2	159.7	55.5	253.7	132.7	552.5	57.6	229.0	49.9	154.6
Ave. Annual	14.8	15.6	39.1	92.8	27.8	42.4	57.5	141.5	90.6	221.2	193.9	490.2	89.8	200.7	62.5	141.2

	HU (ac.)													
	Segment 13		Segment 14		Segment 16		Segment 17		Segment 18A		Segment 18B		Segment 19	
	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project	w/o project	with project
TY0	40.3	40.3	57.3	57.3	42.2	42.2	46.1	46.1	95.9	95.9	14.1	14.1	81.5	81.5
TY1	39.7	50.2	56.9	73.2	42.0	42.1	46.8	69.6	95.8	104.6	14.1	25.4	81.4	135.4
TY5	38.4	31.4	46.8	49.1	38.7	17.4	44.9	54.5	90.6	57.3	13.6	23.3	83.7	101.0
TY10	35.7	45.6	43.0	69.2	36.4	35.4	42.5	68.3	86.0	92.9	13.0	26.3	76.4	129.7
TY25	31.4	63.9	37.0	95.0	31.2	58.4	36.3	85.7	74.4	138.6	11.6	30.2	70.5	168.1
TY50	19.4	67.5	18.6	102.3	14.8	61.9	22.3	121.9	47.3	147.5	8.6	32.3	53.3	181.9
Ave. Annu	26.5	61.0	29.6	91.9	24.3	54.3	30.8	99.2	63.7	131.3	10.4	30.2	63.7	165.2

6.0 TENTATIVELY SELECTED PLAN

6.1 Tentitively Selected Plan and Project Costs

The Tentatively Selected Plan is based on technical and econiomic feasibility, the Corps of Engineers determinatons of envirommetnal soundness and compliance with environmental stutues; and agency and non-Federal (Tamarisk Coalition) input. The Tentatively Selected Plan comnsist of implementing improvemetns at Segments 8, 9, 10, 12, 13, 14, 17, and 19. Recommended plan elements include removal of tamarisk and Russian olives, biocontrol, secondary weed control, grass seeding, shrub plantings, and tree plantings. Table 6.1 provides a summary for the 8 sites comprising the Tentatively Selected Plan.

The Corps of Engineers' software program IWR-PLAN was used to compile combinations of the mutually exclusive Segments. The analysis, procedures and results of the analysis are contained in the main body of the report. The Tentatively Selected Plan consists of the most cost effective Segments and includes Segments 8, 9, 10, 12, 13, 14, 17, and 19. All selected segments are high priority as identified by the USFWS, Upper Colorado Recovery Program being areas where restoration will also benefit the habitat of native and endangered fish species.

Project costs listed below include restoration and recreation as estimated using the Corps' MCACES software program for the feasibility-level design. These costs include a 10% contingency plus escalation costs, as the project requires a 5-year construction time period. The cost to prepare plans and specifications are based on estimates provided by the Tamarisk Coalition. This is relatively minimal as there are no design elements outside of the removal of invasive species, revegetation and excavation as Segment 10. The costs for monitoring are also provide by Tamarisk Coalition for all three years. Real estate (LERRDS) based on records from Mesa County for similar property acquisition. The MCACES detail is provided in Exhibit 7. A summary is presented in Table 6.2.

Table 6.1 Summary of restoration elements for the tentatively selected plan.

		Acres with Control										Revegetation				Biomass Reduction of Hand Control Work		
		Mechanical			Hand			Biocontrol	Total									
Segment	Total Site Acrage	Tamarisk	Russian olive	Subtotal Mechanical	Tamarisk	Russian olive	Subtotal Hand	Tamarisk	Acres Proposed for Control	Secondary Weed Spraying (Total Acres)	Grass Seeding (Acres)	Recommended Shrub Planting Area (Acres)	Number of Shrub Plantings	RecommendedTree Planting Area (Acres)	Number of Tree Plantings	Mulching	Fire	Natural Decomposition
8	144.9	11.3	20.4	31.6	0.0	8.8	8.8	41.0	81.3	61.5	120.3	111.0	9912	61.2	1081	0.0	3.0	5.4
9	237.5	6.7	15.0	21.6	0.0	42.8	42.8	54.8	119.2	77.4	216.3	55.5	5713	0.0	0	0.0	22.5	14.4
10	497.3	13.7	17.1	30.8	0.0	33.7	33.7	141.4	205.9	115.5	345.6	215.5	9615	105.3	1857	0.0	13.2	7.0
12	105.5	10.3	9.7	20.0	0.0	3.7	3.7	33.4	57.1	20.5	69.8	69.8	6853	21.6	381	0.0	1.9	0.6
13	56.9	0.1	0.8	0.8	0.0	8.6	8.6	12.9	22.3	8.5	41.2	2.9	208	2.9	51	0.0	3.8	3.8
14	68.1	5.5	10.0	15.5	0.0	5.6	5.6	18.1	39.2	15.9	60.0	45.1	4181	18.5	327	0.0	2.9	1.6
17	59.4	0.0	0.0	0.0	0.0	11.2	11.2	20.7	31.9	7.9	39.4	0.0	0	0.0	0	0.0	6.0	4.0
19	133.8	3.4	24.6	28.0	0.0	6.2	6.2	18.3	52.4	25.8	85.6	75.1	5616	42.0	742	0.0	1.9	1.6
Totals	1303.5	50.9	97.6	148.5	0.0	120.5	120.5	340.5	609.4	333.0	978.2	574.9	42099.2	251.6	4439.2	0.0	55.1	38.5

Table 6.2 Summary of costs for tentatively selected plan.

Feature Description	Costs
Restoration	$ 3,408,000
Recreation facilities	$ 70,000
TOTAL CONSTRUCTION COST	$ 3,478,000
Monitoring	$ 90,000
DPR/EA	$ 1,200,000
LERRDs	$ 1,159,000
Plans, Specs, EDC	$ 341,000
Supervision & Admin	$ 312,000
TOTAL COSTS	$ 6,580,000

Notes:
Current MCACES Estimate prepared Oct 2012 using VER 4.1
Effective pricing level Nov 11, 2011
Anticipated start of construction: September 2013
Anticipated construction length: 5 yrs

6.2 Considerations During Construction

6.2.1 Best Management Practices

In general, much of this work will have minimal disturbance footprints as much of the work will be done by hand. In some cases, equipment is required for control and biomass reduction.

Water Quality**:** Control of erosion from disturbed areas is the primary focus of the best management strategies. In many cases, work is being performed on dry land by hand or by the beetle over a 3 to 5 year time period and will have minimal impacts on the vegetative conditions. There is no instream work in the main river channel. There is work in the area with the pond and wetlands at the Walter Walker segment. Thus, in many cases BMPs are not necessary. Where equipment is being utilized, silt fences and coir rolls should be installed to contain sediment-laden runoff. Immediate revegetation is also required to stabilize the impacted areas.

In the case of Walter Walker, the work will be implemented in the late summer or fall seasons when work in the dry is possible. However, a water control plan will be required during construction to minimize sediment from entering the Colorado River, including blocking and diverting flows from entering the side channel. Excavated pond material will require a temporary stockpile site to dewater the material before it is moved offsite and some dewatering may be required of the pond during excavation. A permit will be required from the State of Colorado for control of stormwater runoff, as well as for dewatering the pond during excavation. Prior to construction, a qualilified wildlife biologist will be required to trap and relocate native fish and turtles, with proper disposal of non-native fish.

Air quality**:** The impacts on air quality from this project will be minimal given the minimal amount of construction equipment required to plant and establish vegetative material, and construct recreation facilities . In addition, project implementation will be over a five-year period further reducing impacts to air quality. Thus, no measures are required. Furthermore, since the project area is not within a nonattainment area, Clean Air Act conformity does not apply.

Gas-emitting equipment**:** In total, it is estimated that 780 hours of gas-emitting equipment will be required to execute the work described herein. 40 hours will be required for excavation at Walter Walker and 740 for mechanical removal of tamarisk and Russian olive. Given the nature of this work gas-emitting equipment will operate one at time and include excavators, dozers, backhoes, haul trucks, generators and personal vehicles and the 3-year plan establishment time period.

BMPs to minimize impacts to native vegetation: When there are many native species interspersed within tamarisk and Russian olive stands invasive removal must be executed in a manner that protects native vegetation and seed sources for natural recruitment. Manual control, root extraction, grab & cut-stump, vegetative fencing and mechanical mulching are methods capable of sparing interspersed natives, even 1-inch caliper saplings. At Walter Walker wetlands will be marked with signs and/or flagging to restrict access during construction.

In broad areas of infestation, such as Walter Walker Wildlife Refuge or the Tillie Bishop Wildlife Area, removal efforts will include vegetative islands and paths within broad tracts of tamarisk, to help speed native regeneration process, to provide firebreaks and minimize disturbance to existing native vegetation.

***BMPs to minimize impacts on traffic*:** With the exception of hauling material from Walter Walker, work for this project is contained on site. Thus negligible impacts to traffic are anticipated.

***BMPs to minimize impacts on recreation facilities*:** The only facilities with potential for impact are equipment impacts on trails. In general, protection of the trails requires an understanding of the trail location and routing of construction equipment around the trails, or the installation of an equipment pad to protect the trail.

6.2.2 **Earthwork**

Note that construction of Segment 10, Walter Walker, improvements required the excavation and removal of approximately 9,300 cubic yards of material; 5,500 for berms and levee deconstruction and 3,800 cubic yards of pond excavation. The material from the berm and levee deconstruction will be hauled to the United gravel pit, immediately adjacent to Walter Walker where United plans on crushing and using the material as part of their gravel operations. A location for the pond material has not yet been identified. Thus, for purposes of the construction cost estimate, it is assumed that this material must be hauled 15 miles or less, and required disposal fees. No other Segments require excavation or fill material.

6.2.3 **Utilities**

There are no known utilities that will be impacted or require relocation for implementation of this Project.

6.2.4 **Additional Field Work**

With the exception of Segment 10, Walter Walker, no additional surveys are required. For Walter Walker, it is recommended that a site plan at appropriate scale be developed for the berm and levee deconstruction.

To help guide the locations of long stem planting, monitoring wells are recommended at Segments with proposed tree plantings to locate groundwater levels. Detailed soil salinity sampling is also recommended for input on the final seed and plant selections.

6.2.5 **Irrigation**

Based on the extensive experience of the Tamarisk Coalition, the planting and seeding techniques presented herein are designed to be successful without irrigation. This presents a significant cost savings. The purpose of using longstem plantings is that they are planted at the water table (hence the need for monitoring wells) so they do not need irrigation. Seed types are native materials known for their ability to sprout under natural conditions, and also do not require irrigation. Timing of seed planting is important and considered in the overall scheduling of restoration activities.

6.3 Schedule

Following the completion of the final ecosystem restoration report and Division approval in San Fransisco, plans and specifications for construction of the project will follow. Plans and specifications will not require an extensive amount of time given the lack of complexity for this Project. Tamarisk Coalition is very experienced in preparing plans and specifications for this type of work, and estimate no more than four months. Walter Walker is the most complicated and will require excavation and grading, in addition to the invasive species removal and revegetation. Soil testing, required for revegetation and plantings, has been completed. Some additional surveys at Walter Walker may be required, but these are likely to be minimal and will supplement the two-foot aerial mapping already available.

Construction will be implemented over a 5-year timeframe, with specific seasonal requirements as outlined in Section 3.4. The preferred sequencing is to start upstream at the Town of Palisade, and work downstream to reduce the tamarisk seed from spreading on to newly restored sites. The design and construction will be coordinated with appropriate agencies and all project stakeholders. Detailed surveys, designs and calculations will be initiated as required at the start of preparation of construction drawings and specifications. Both Segments 17 and 19 (Orchard Mesa and Colorado River Wildlife Areas and Tillie Bishop Wildlife Area) have access restrictions from mid-March to late July for nesting seasons. However, this is considered in the overall 5-year construction and plant establishment time frame noted in Table 6.2 below and Table 3.6 in Section 3.4 of this appendix. A schedule for design and construction is shown in Table 6.1.

Table 6.3 Estimated schedule for design and construction.

Task	Estimated Duration	Estimated Start Date	Estimated Finish Date
Complete DPR and EA	-	-	5-Feb-13
Prepare Plans and Sprecifications	6 months	6-Feb-13	3-Aug-13
Approve Plans and Sprecifications	1 1/2 mth	3-Aug-13	16-Sep-13
Acquire Easements	1 1/2 mth	3-Aug-13	16-Sep-13
Development of tree and plant material	5 yrs	16-Sep-13	15-Sep-18
Tamarisk and Russian olive removal			
Site 19		16-Sep-13	13-Jun-14
Site 17		16-Sep-13	13-Jun-14
Site 14		11-Sep-14	12-Jun-15
Site 13		11-Sep-14	12-Jun-15
Site 12		11-Sep-14	12-Jun-15
Site 10		11-Sep-15	11-Jun-16
Site 9		12-Sep-16	13-Jun-17
Site 8		12-Sep-16	13-Jun-17
Resprout treaments	3 yrs	11-Sep-14	09-Jun-17
Secondary invasive weed treatments	4 yrs	11-Sep-14	11-Jun-18
Native grass seeding	4 yrs	12-Dec-14	11-Sep-18
Plant trees and shrubs	3 yrs	11-Sep-15	11-Jun-18
Monitor and maintenance	5 yrs	16-Sep-13	18-Sep-18

Table 6.3 Estimated schedule for design and construction cont.

Task	Estimated Duration	Estimated Start Date	Estimated Finish Date
Complete DPR and EA	-	-	1-Feb-13
Prepare Plans and Sprecifications	6 months	1-Feb-13	29-Jul-13
Approve Plans and Sprecifications	1 1/2 mth	29-Jul-13	11-Sep-13
Acquire Easements	1 1/2 mth	29-Jul-13	12-Sep-13
Establishment*	5 yrs	12-Sep-13	11-Sep-18
Development of tree and plant material	5 yrs	12-Sep-13	11-Sep-18
Tamarisk and Russian olive removal	3 yrs	12-Sep-13	11-Jun-17
Site 19		12-Sep-13	12-Jun-14
Site 17		12-Sep-13	12-Jun-14
Site 14		12-Sep-14	12-Jun-15
Site 13		12-Sep-14	12-Jun-15
Site 12		12-Sep-14	12-Jun-15
Site 10		12-Sep-15	11-Jun-16
Site 9		11-Sep-16	11-Jun-17
Site 8		11-Sep-16	11-Jun-17
Resprout treaments	3 yrs	12-Sep-14	11-Jun-17
Secondary invasive weed treatments	4 yrs	12-Sep-14	11-Jun-18
Native grass seeding	4 yrs	12-Dec-14	11-Dec-17
Plant trees and shrubs	3 yrs	12-Sep-15	11-Jun-18
Monitor and maintenance	5 yrs	12-Sep-13	11-Sep-18

6.4 Monitoring

The goal of the monitoring plan is to evaluate the project's success in establishing plantings and geomorphic improvements. Monitoring is in addition to plant establishment, which is included in the project's 5-year construction period as outlined in Section 3.4 of this appendix. The 5-year construction period includes costs for plant establishment, resprout control, and control of secondary weeds. The monitoring plan is intended to follow construction, and extended for three years.

Each Segment shall have one or more monitoring stations. Each station will include at least one permanent marker. Monitoring shall be performed once a year beginning the first full growing season following construction and include monitoring of the vegetation, soils and geomorphology. Detailed testing protocol and Segment evaluation shall be developed in conjunction with the development of plans and specifications. Yearly monitoring reports shall be submitted to the Corps. The following provides a brief overview of the basic monitoring elements.

Vegetation: Vegetation and riparian plantings monitoring shall be implemented using an appropriate point intercept or transect methodology. Monitoring shall be coordinated by the sponsor and preformed by a biologist with experience using these protocols.

Soil: Soil sampling shall be performed at each of the monitoring stations. Samples shall be tested for pH, soil moisture content, soil temperature and soil salinity using instrumentation (if available) or by collection into well-marked bags (plastic or paper) for analysis in the lab.

Geomorphology: Elevations at the monitoring stations shall be collected to evaluate the long term effects of tamarisk and Russian olive removal on sediment accumulation and/or degradation in the low-lying riparian areas. Cross-sections or topographic surveys should be done in tandem with vegetation and soil texture surveys, with measurements taken at the same place, and if possible, at the same time. Methods for setting up the cross-section, and locations will differ slightly depending on what is being measured (backwater, pond, side channel, etc).

Photo points: Each monitoring station shall have photo points, as appropriate for qualitative evaluation of restoration success. The photos shall be taken at permanent markers or at documented GPS points.

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