Rio Grande, Sandia Pueblo to Isleta Pueblo, CO, NM, TX
Ecosystem Restoration Feasibility Study and
Environmental Assessment

U. S. Army Corps of Engineers
Albuquerque District

DRAFT

August 2018

US Army Corps
of Engineers ®
Albuquerque District

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U.S. ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT

DRAFT
FINDING OF NO SIGNIFICANT IMPACT

for the

Rio Grande, Sandia Pueblo to Isleta Pueblo, CO, NM, TX
Ecosystem Restoration Project

The U.S. Army Corps of Engineers (USACE), Albuquerque District, proposes to restore approximately 216 acres of the Middle Rio Grande bosque (1) improving hydrologic function by constructing high-flow channels, willow swales, and wetlands, and (2) by restoring native vegetation and habitat from exotic species/fuel reduction and restoring the riparian gallery forest. The approximate cost of the project is $22,587,023.

Design alternatives and the No Action alternative were evaluated to meet the overall purpose and need of the project, which includes improving habitat quality and increasing the amount of native bosque communities, promoting bosque habitat heterogeneity, implementing measures to work with fluvial and ecological processes in the bosque to create new wetland habitat, reduce the fire hazard, improve hydraulic connections between the bosque and river, and protect/enhance potential habitat for listed species.

Section 404 of the Clean Water Act (CWA) requires analysis under the EPA's 404 (b)(1) Guidelines if USACE proposes to discharge fill material into a water or wetlands of the United States. A 404 (b)(1) Evaluation was completed for this project and is enclosed in Appendix E. The 404 (b)(1) analysis has been completed under Nationwide Permit 33 (Temporary Construction, Access, and Dewatering) because of to the potential need to dewater at the bank of the river when constructing the high-flow channels, and under Nationwide Permit 27 (Aquatic Habitat Restoration, Establishment, and Enhancement activities) for the proposed measures listed above. All conditions under Nationwide Permits 33 and 27 would be adhered to during construction. A water quality certification permit under Section 401 of the CWA will be obtained from the New Mexico Environmental Department (NMED). USACE will follow all terms and conditions within the Section 401 permit.

There are a total of five known historic properties in the project area. Two of these sites are eligible to the National Register of Historic Places (NRHP), two properties are of undetermined eligibility, and one property is considered not eligible to the NRHP. Approximately 30 acres of the 260-acre project area still need to be surveyed for cultural resources. This survey and Section 106 consultation with the State Historic Preservation Office regarding effects to historic properties will be completed before the final report is submitted. The Recommended Plan will be designed to avoid adverse effects to historic properties. Should previously unknown artifacts or other historic properties be encountered during construction, work would cease in the immediate vicinity of the resource. A determination of significance would be made and further consultation on measures to avoid, minimize, and/or mitigate potential adverse effects would take place with the New Mexico State Historic Preservation Office, the Middle Rio Grande Conservancy District, and with American Indian Tribes that have cultural concerns in the area.

The Proposed Action would result in only minor, short-term and temporary adverse impacts to soils, water quality, air quality and noise levels, aesthetics, vegetation, floodplains and wetland, fish and wildlife, socioeconomic considerations, and recreational resources during construction. The long-term benefits of the Proposed Action include a decrease in noxious weeds and improved and/or increased soil moisture, aesthetics, floodplains and wetlands, native vegetation and biodiversity, native habitat for fish and wildlife, potential habitat for endangered species and positive cumulative effects that would outweigh short-term adverse impacts. The following elements have been analyzed and would not be adversely affected by the Proposed Action: hydrology, hydraulics and geomorphology; cultural resources, Indian Trust Assets, prime and unique farmland; hazardous, toxic and radioactive wastes (HTRW); and environmental justice.

The Albuquerque District has prepared a Biological Assessment (BA) pursuant to Section 7(a)(2) and Section 7(c) of the Endangered Species Act of 1973, as amended, and it will be submitted to the USFWS. The Albuquerque District is requesting formal consultation on the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*), the Western Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*), and the Rio Grande silvery minnow (*Hybognathus amarus*). The Albuquerque District is also requesting formal consultation on the critical habitat for the Western Yellow-billed Cuckoo and the Rio Grande silvery minnow. USACE has made the determination within the BA that the Planned Action "may affect, but is not likely to adversely affect the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, or the Yellow-billed Cuckoo. Also, USACE has made the determination that the Planned Action "may affect, but is not likely to adversely modify designated critical habitat of the Rio Grande silvery minnow or the Yellow-billed Cuckoo. Depending on USFWS' concurrence with USACE's determination, this draft Environmental Assessment will be updated to reflect their Biological Opinion resulting from consultation. USACE would implement all reasonable and prudent measures (RPMs) stated in the Biological Opinion during construction.

All Best Management Practices described in the document would be adhered to during project implementation to include: (1) construction sequencing as described in Section 5; (2) sediment management ;(3) equipment inspection; (4) compliance with water quality permits; (5) adherence to schedule and best management practices to avoid impacts to endangered, protected, or avian nesting species; (6) equipment cleaning prior to entering and before leaving project areas to avoid transfer of weed seed; (7) adherence to all recommendations in the Fish and Wildlife Coordination Act Report and Biological Opinion; and (8) oversight by a qualified biologist to monitor adherence to these conditions during construction.

The Proposed Action has been coordinated with Federal, State, tribal and local governments with jurisdiction over the ecological, cultural, and hydrologic resources of the project area. Based on these factors and others discussed in the Environmental Assessment, the planned action would not have a significant effect on the human environment. Therefore, an Environmental Impact Statement will not be prepared for this project, and the Proposed Action is recommended for construction.

______________________ ______________________________

Date

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Lieutenant Colonel, U.S. Army
District Engineer

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Regional Terms

Some of the terms used in the southwestern U.S. water resources planning may be unfamiliar to readers outside of the region. Definitions of some of these terms are provided here.

Arroyo – n. a water-carved gully or channel: dry wash, ravine

Bosque – n. woods or forest

Kellner Jetty Jack (jetty jack) – n. permeable form of bank protection that traps sediment and debris during flood events and essentially building up its own levee to confine the river channel

Pueblo – n. any of some 25 Native American peoples living in established villages in northern and western New Mexico and northeast Arizona.

pueblo – n. a permanent village or community of any of the Pueblo peoples, typically consisting of multilevel adobe or stone apartment dwellings of terraced design clustered around a central plaza.

rio – n. river

1 - Introduction

1.1 Study Authority*

The Rio Grande, Sandia Pueblo to Isleta Pueblo, CO, NM, TX Ecosystem Restoration Feasibility Study is being conducted as the first study under the Rio Grande Environmental Management Program (RGEMP) for the Rio Grande basin. The RGEMP has been authorized by Section 5056 of the Water Resources Development Act of 2007 (WRDA 2007), as amended by Section 4006 of the Water Resources Reform Development Act of 2014 (WRRDA 2014). The RGEMP is established for the planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement; and implementation of a long-term monitoring, computerized data inventory and analysis, applied research, and adaptive management program in consultation with the States of Colorado, New Mexico, and Texas, and other appropriate entities.

Ecosystem Restoration is one of the primary missions of the Civil Works program. The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology.

1.2 Study Purpose and Scope*

The Bosque of the Middle Rio Grande (MRG) is an ideal location for restoration because of its unique quality and critical value as wildlife habitat and its importance on a local, regional, national, and international scale. Resource values within the Albuquerque reach of the MRG are significant because the Bosque:

- Remains the only corridor for aquatic, terrestrial and avian species through the state's largest urbanized area.
- Functions as a critical link in a corridor connecting two designated Wild and Scenic River areas, eight national wildlife refuges, and several state parks and wildlife management areas.
- Embodies the largest remaining continuous cottonwood forest found in North America.
- Constitutes a critical travel corridor connecting Central and South America to North America along the Rio Grande Flyway. Over half of the 277 land birds found in the MRG are residents, and 54 bird species breed within this habitat (Yong and Finch 2002).
- Provides breeding and foraging habitat for three Federally listed animals, of which one fish is found only within this reach of river. The study area also provides habitat for eight additional species listed as state or Federal special status species.

Habitat loss, fragmentation, and alteration have caused the loss of 12 fish species from the MRG, two of which are now extinct. The Federally listed Rio Grande silvery minnow naturally occurs only in this reach of river, which is approximately 10% of its historic range. Restoration within the MRG will provide additional habitat allowing the species to potentially increase in number. The project will also provide a more stable environment for population sustainability. These same benefits will extend to the overall wildlife community.

In addition to carrying out the authorities granted to USACE for ecosystem restoration and specific legislation provided for initiation and support of this study, the project complies with the letter or intent of several Federal laws, executive orders, and treaties, with which USACE must comply, concerning restoration and conservation efforts, which include:

- North American Waterfowl Management Plan. The project will increase the amount and quality of resting, breeding, and foraging habitat for waterfowl.

- Executive Order No. 11990 (Protection of Wetlands) and North American Wetlands Conservation Act of 1989. The MRG restoration project will conserve, create, or improve a significant portion of the 5,000-acre project area, which is largely considered wetland habitat under the Executive Order and Act. Permanent and seasonal wetlands will be created and temporary inundation of the floodplain will be restored to over 25 percent of the study area.

- Executive Order No. 11988 (Floodplain Management). Through restoration efforts, the project will improve, and in most cases restore, critical functions that provide for the health of the floodplain.

- Endangered Species Act of 1973, as amended. The project will provide essential hatching and rearing habitat for the endangered Rio Grande silvery minnow through extended areas of inundation of the floodplain during high flows.

- Bald Eagle Protection Act of 1940. The project would ensure existing and future roost sites for migratory eagles. The restoration would indirectly benefit the eagle from water quality and higher fish availability.

- Migratory Bird Treaty Act of 1918, Migratory Bird Conservation Act of 1929, and associated treaties. Habitat improvements and diversification will benefit migratory birds using the MRG as a travel corridor and breeding site. Habitat improvements will benefit neotropical migrants by providing essential feeding and resting habitats along the Rio Grande flyway.

1.3 Non-Federal Sponsors

The non-Federal sponsor for the Rio Grande, Sandia Pueblo to Isleta Pueblo, CO, NM, TX Feasibility Study is the Middle Rio Grande Conservancy District (MRGCD). MRGCD signed a Feasibility Cost Share Agreement with USACE in August of 2016.

1.4 Study Area*

The Rio Grande originates in southern Colorado and reaches 1,865 miles to the Gulf of Mexico, constituting the fourth largest river in the United States in terms of length and drainage area. The river bisects New Mexico in a north-to-south direction and delineates the 1,250-mile international boundary between Texas and Mexico. This study is focusing on the Rio Grande bosque between the northern boundary of the Sandia Pueblo and the southern boundary of the Pueblo of Isleta (Figure 1).

The Middle Rio Grande Bosque is a riparian area located in the middle reach of the Rio Grande, in the vicinity of the City of Albuquerque, New Mexico. The bosque area is maintained within levee systems constructed under the authorities of the Middle Rio Grande Flood Control Acts of 1941 and 1950, spoilbanks created by MRGCD, and is within the facilities of the Middle Rio Grande Floodway Project between Cochiti and San Marcial, New Mexico (USACE 2002, 2003a, 2007, 2008a, b). The Bosque area within Albuquerque was designated as the Rio Grande Valley State Park (RGVSP) through the State of New Mexico's Park Act of 1983 and is cooperatively managed by the City of Albuquerque Open Space Division (AOSD) and the MRGCD.

Figure 1. Rio Grande, Sandia Pueblo to Isleta Pueblo Study Area

Although the Pueblos of Sandia and Isleta are included in the authorized study area, neither Pueblo expressed interest in participating in the study. Consequently USACE and MRGCD reduced the study area to that represented in the Middle Rio Grande Bosque Study (Figure 2). The study area is approximately 26 miles in length along the river and roughly 5,300 acres in areal extent. The average width of the floodway area between the levees is 1,500 feet (Lagasse, 1981) and consists of the river channel and narrow strips of riparian habitat on each bank. The area is defined on the east and west by the Albuquerque Levee system, although the areas outside and adjacent to the levees within the original floodplain have also been considered in the study.

The State of New Mexico has created the 4,300-acre RGVSP that constitutes the study area. A local organization, the Bosque del Rio Grande Nature Preserve Society, was crucial in establishing the state park. The park was designated by the state and is managed by AOSD under a joint powers agreement. The Rio Grande Nature Center represents the visitor's center for the park whose mission is to preserve and protect the Rio Grande Bosque, to educate the public about Rio Grande ecosystems, and to foster positive human interactions with those systems. Trails from the nature center meander through various Bosque habitats and demonstrate the importance of this ecosystem to wildlife and the human environment. AOSD has established parking lots, trails, and interpretive centers throughout the study area to provide residents and tourists the opportunity to experience this rare ecosystem.

Local efforts to conserve or restore the MRG Bosque include that of the Bosque School, in which 5,000 students from 40 local schools participate in the Bosque Ecosystem Monitoring Program. The program performs field data collection monitoring key indicators of structural and functional change in the Middle Rio Grande riparian forest. The Bosque Youth Conservation Corps works on projects that protect, restore, and enhance Albuquerque's thriving Bosque environment along a two-mile stretch of the Rio Grande.

Because the RGEMP-I study area is so large, and the relative effects of proposed designs are localized to some degree, and to maintain consistency with the Middle Rio Grande Bosque Study, USACE divided the project area into five reaches (Figure 2). Reach designation allows for simplified hydrologic analysis of existing conditions and evaluation of proposed restoration plans. Bridges denote the upstream and downstream boundaries for each reach because bridge crossings tend to have the greatest influence on hydrology and, therefore, constitute a logical break point. The reach designations are amenable to consideration of stakeholder interests, vegetative community makeup, and geographic location.

1.5 Prior Studies and Reports

Many studies have been conducted pertaining to water and related land resources within the study area and the region. These studies have examined themes including development trends, environmental resources, special status species, water supply, groundwater recharge, wastewater management, flooding and erosion, geology, cultural resources, history, and recreation. The following is not intended to be a comprehensive list of previous reports, but to provide a sample of the types of studies that have been completed in the study area and the region.

1.5.1 U.S. Army Corps of Engineers Reports

a. Middle Rio Grande Flow Frequency Study, U.S. Army Corps of Engineers Hydrologic Engineering Center, June 2006.

The purpose of this study was to develop a flow frequency curve for the Rio Grande at Albuquerque. Peak flows at Albuquerque are caused by snowmelt and rainfall upstream of reservoirs on the Rio Grande and major tributaries, as well as from intense rainfall on areas downstream of the reservoirs. Separate flow frequency curves were developed for two runoff mechanisms, regulated flow from the reservoirs and runoff from local areas downstream of the reservoirs, and combined into one flow frequency curve at Albuquerque.

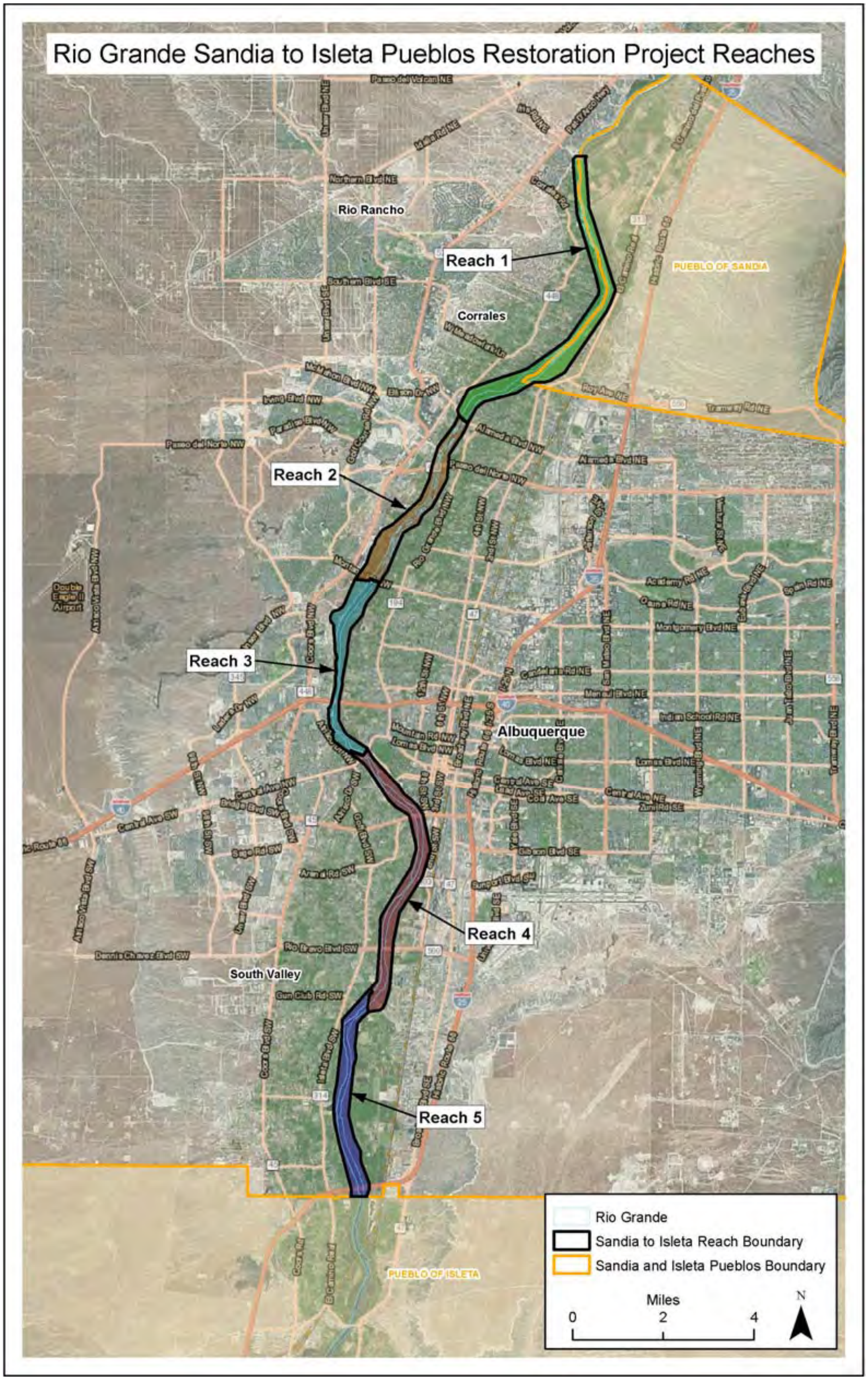

Figure 2. Study Area Reaches

b. Upper Rio Grande Basin Water Operations Review Environmental Impact Statement, June 2007.

The Upper Rio Grande Basin Water Operations Review (Review) and Environmental Impact Statement is a comprehensive system-wide review of the water operations activities that are conducted under the existing authorities of the Joint Lead Agencies, USACE, the U.S. Bureau of Reclamation (Reclamation), and the New Mexico Interstate Stream Commission (NMISC) in the Rio Grande basin above Fort Quitman, Texas. These operations consist of the storage and release of water at reservoirs. The review will consider the means available to exercise existing water operations authorities of Reclamation, Corps, and NMISC with respect to Upper Rio Grande Water Operations to (1) meet agricultural, domestic, municipal, industrial, and environmental water needs, including water needs to conserve endangered and threatened species as required by law, consistent with the allocation of supplies and priority of water rights under state law; (2) meet downstream water delivery requirements mandated by the Rio Grande Compact and international treaty; (3) provide flood protection and sediment control; (4) assure safe dam operations; (5) support compliance with local, state, Federal, and tribal water quality regulations; (6) increase system efficiency; and (7) support compliance of the Reclamation and USACE with the provisions of the National Environmental Policy Act (NEPA) for Upper Rio Grande Basin Water Operations and activities and support compliance of all signatories with the Endangered Species Act.

c. Environmental Assessment for the Bosque Wildfire Project, Bernalillo and Sandoval Counties, New Mexico, September 2004.

Work under the Bosque Wildfire Project has included the following within Bernalillo and Sandoval Counties: selective thinning of areas with high fuel loads and/or non-native plant species populations; removal of jetty jacks and removal of debris; improvement of emergency access in the form of drain crossings, levee road improvement, and construction of turn-arounds; and revegetation of burned and thinned areas.

d. Detailed Project Report and Environmental Assessment for Albuquerque Biological Park Wetland Restoration Project, Albuquerque, New Mexico, January 2004.

The project is located south of Central Avenue in Albuquerque, between Tingley Drive and the Rio Grande, within the Rio Grande Waterway, Bernalillo County, New Mexico, immediately adjacent to the levee of the Rio Grande Floodway. The ecosystem restoration project included approximately 15 acres of pond reconstruction, 9 acres of wetland considered this project during the planning process so that the projects would benefit rather than conflict with one another.

e. Detailed Project Report and Environmental Assessment, Ecosystem Restoration at Route 66 Habitat Restoration Project, September 2008.

This project is a Section 1135 Program Ecosystem Restoration project within the RGVSP between Interstate 40 and Bridge Boulevard. Construction began in January 2009 and was completed in April 2010. The feasibility study considered this project during the planning process so that the projects would benefit rather than conflict with one another.

f. Middle Rio Grande Bosque Restoration Supplemental Planning Document – July 2003.

This report was generated as the final documentation of the Middle Rio Grande Bosque Restoration 905(b) Reconnaissance Study. The information gathered from other projects and studies involving the Bosque has been collected, updated, and combined with field notes, additional graphics, and maps to develop the concepts and information presented in this document. The synthesized material has been used in this feasibility study as an aid in determining which restoration measures will be further analyzed.

g. Method & Cost Evaluation Report for the Middle Rio Grande Bosque Jetty Jack Removal Evaluation Study, January 2003.

This study was an initial evaluation of various methods of jetty jack removal within the Bosque. The intent of this study was to evaluate the efficiency and cost effectiveness of different removal methods with regard to jetty jack position, surroundings, and degree of sedimentary entrainment while attempting to minimize adverse environmental impacts.

h. Middle Rio Grande Bosque Reconnaissance Study, Section 905(b) Analysis, July 2002.

The purpose of the reconnaissance phase of this study, initiated in March 2002, was to determine if there was a Federal interest in participating in cost-shared feasibility studies to investigate ecosystem environmental restoration and low-impact recreation opportunities for the study area. The reconnaissance study determined that a Federal interest exists in continuing the study into the feasibility phase. The purpose of the Section 905(b) Analysis was to document the basis for this finding and establish the scope of the feasibility study.

i. Environmental Assessment and Finding of No Significant Impact for Middle Rio Grande Bosque Jetty Jack Removal Evaluation Study, July 2002.

The study evaluated various methods (manual, heavy equipment, *etc.*) for jetty jack removal with regard to position, surroundings, and degree of sedimentary entrainment while attempting to preserve the existing native vegetation to the greatest extent possible.

j. Rio Grande Floodway, Albuquerque Unit Evaluation Report, Albuquerque, New Mexico, October 2009.

This report documented the current conditions of the Albuquerque Levee system, which exists within the area of feasibility study. Information learned in this study has been considered during the planning process for this feasibility study.

m. Rio Grande Nature Center Habitat Restoration Project Environmental Assessment, December 2006.

The project is a Middle Rio Grande Endangered Species Act Collaborative Program (MRGESACP) project to provide habitat that would potentially benefit the Rio Grande silvery minnow (RGSM) and the Southwestern Willow Flycatcher. Project construction was completed in 2007 by reconnecting an historic remnant side channel that runs through the Rio Grande Nature Center State Park to the main stem of the river. Water flows in the side channel when the river is flowing 1500-2000 cubic feet per second (cfs) and greater. Off-channel embayments were constructed to provide nursery habitat for the RGSM. Lessons learned from construction and monitoring of this project and other MRGESACP projects were taken into consideration during the planning phase of this feasibility study.

n. Historical Documentation of Middle Rio Grande Flood Protection Projects (Corrales to San Marcial), 1997

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This report was prepared to meet USACE requirement to comply with Section 106 of the National Historic Preservation Act of 1966 for a project to upgrade the existing levees. The report documents the MRGCD spoil-embankment levees that were constructed in the 1930s and the reconstructed levees designed to manage a flood of 42,000 cfs. The report also documents the construction of various flood risk management measures that exist in the floodway, in addition to the levees, and the impacts of these measures on the hydrologic system and the valley.

p. Middle Rio Grande Biological Survey, U.S. Army Corps of Engineers, 1989.

This report prepared by Hink and Ohmart is the seminal biological survey for the middle reach of the Rio Grande. The report documents the type and status of vegetation and wildlife communities and provides recommendations for conservation, restoration, and further research. Updates have been made in 2002 and 2005.

1.5.2 Other Agency Reports

a. Middle Rio Grande Ecosystem Bosque Biological Management Plan - The First Decade: A Review & Update, Lisa Robert et al., June 2005.

This is an update to the *Middle Rio Grande Ecosystem: Bosque Biological Management Plan*. Included within this document are discussions concerning developments since the first plan, how the physical landscape has changed, and the additional knowledge gained regarding river function. The updates include technical updates to the hydrology of the river, listing of endangered species, and ecosystem restoration.

b. Bosque Landscape Alteration Strategy, Objectives, Basic Requirements and Guidelines, Yasmeen Najmi, Sterling Grogan, and Cliff Crawford, June 2005.

This report presents a vision of the Bosque which would recreate a patchy mosaic of native riparian trees and open spaces characteristic of the wider historic floodplain. The knowledge base for this report was the culmination of two workshops organized by the Utton Transboundary Resources Center at the University of New Mexico School of Law. The workshops brought together scientists, managers, advocates, and citizens who are concerned about the Bosque.

c. Habitat Restoration Plan for the Middle Rio Grande, September 2004.

Prepared for the MRGESACP, this document provides a framework plan to implement and integrate actions needed to address both water and endangered species management issues in the MRG. This document was developed for the Habitat Restoration Workgroup in order to aid in the development of reach-specific habitat restoration plans.

d. Effects of Fuels-Reduction and Exotic Plant Removal on Vertebrates, Vegetation and Water Resources in the Middle Grand Bosque: Final Environmental Assessment, US Fish and Wildlife Service, and MRGCD, 2001.

This report summarizes the effects of fuel reduction on the Bosque ecosystem. The report found no significant negative impact. This study was a precursor to a multi-pronged effort to reduce fuels in the MRG Bosque, which is currently being implemented by the MRGCD in several areas.

e. Middle Rio Grande Conservancy District Interim Progress Report for the Bosque Improvement Group, U.S. Fish and Wildlife Service and MRGCD, 2001.
This is an interim report by the MRGCD to report on activities pertaining to fuel reduction research (Valencia & Socorro Counties, NM), fuel reduction efforts (Belen, NM), wildfire rehabilitation/restoration (Bosque, NM), and combined fuel reduction and trail improvements (Socorro, NM).

f. River Bars of the Middle Rio Grande: Progress Report Year II, Natural Heritage Program, Biology Department, University of New Mexico, Albuquerque, New Mexico, February 2000.

This report provides an overview of a multi-year study of the vegetation of river bars in the Albuquerque reach of the MRG in relation to environmental and biological factors. River bars are a critical element in floodplain and terrace development and possibly the most diverse and biologically active component of the Bosque ecosystem. Follow-up reports have included *Progress Report Year III* and *River Bars of the Middle Rio Grande: A Comparative Study of Plant and Arthropod Diversity*.

g. Albuquerque Open Space Facilities Plan – Albuquerque Open Space Division, 1999.

The purpose of this plan was to establish guidelines for development of the Major Public Open Space resources (Open Space) in the City of Albuquerque and Bernalillo County. The plan establishes policy for planning and management of Open Space, land use decision-making as it relates to or affects Open Space, and acquisition of additional Open Space. Each Open Space area has a management plan based on the landscape typology and neighborhood input.

h. San Antonio Oxbow Management Plan – Albuquerque Open Space Division, 1996.

This management plan documents existing conditions and describes management strategies for maintaining the oxbow marsh habitat on the west side of the Rio Grande near the confluence of the San Antonio Arroyo. The plan contains information about resident wildlife in the area. The plan recommends sediment management strategies to protect the wetland from impacts of recurrent siltation at the outlet of the San Antonio Arroyo. Implementation of measures proposed in this feasibility study would support implementation of the San Antonio Oxbow Management Plan.

i. Bosque Protection Master Plan Scoping Report – Middle Rio Grande Conservancy District, 1995.

This study's objective was to develop a management master plan for the Bosque in the middle reach of the Rio Grande that would guide municipalities and Pueblos in the development of local Bosque management plans as a part of their open space, land use, and resource planning efforts. The plan focused primarily on human impacts that are incompatible with protection of the Bosque ecosystems. Existing levels of disturbance and human-caused impacts are assessed and listed by type. The report concludes with recommendations for interim and permanent restrictions on access to the Bosque, as well as for a process to develop a planning procedure for the development of a comprehensive master plan for the MRG Bosque.

j. The Middle Rio Grande Ecosystem: Bosque Biological Management Plan, Cliff Crawford, Anne Culley, Rob Leutheuser, Mark Sifuentes, Larry White, James Wilber, October 1993.

In September 1991, Senator Domenici appointed the Rio Grande Bosque Conservation Committee, which presented him with a report in June of 1993. The report recommended that a biological management plan for the MRG be developed as "the first step towards restoring the Bosque's health". The report included historic and recent (1993) information regarding hydrological conditions, aquatic and terrestrial resources, and organisms, climate, river morphology, population trends, land use, and water management practices of the MRG. The plan reviews the history and evolution of the existing Bosque ecosystem, and portrays the basic ecosystem functions and services provided by the floodplain hydrologic regime, the cottonwood riparian woodland, and riparian wetlands. The report also describes changes in the hydrologic regime resulting from human interventions and the corresponding changes in aquatic, wetland, and forest habitat over time. The report concludes with 21 recommendations for future management of the river and its riparian corridor. These recommendations range from proposed ecological restoration goals, processes, and techniques to basic parameters for recreation, hunting, and other human use of the Bosque.

k. Bosque Action Plan – City of Albuquerque Open Space Division, 1993.

The Bosque Action Plan identifies the RGVSP as one of the few remaining intact riparian habitats in the southwest and one whose value has increased as a recreational amenity because of its location in the heart of Albuquerque. The purpose of the Bosque Action Plan was to identify specific environmental and recreational improvements for the RGVSP. The Bosque Action Plan establishes a framework specifying how to effectively manage the RGVSP as a public park without neglecting the ecological system function of the Bosque. The policy framework was developed using issues and concerns identified by the Citizen and Technical Planning Teams as well as comments received from the public and recommendations from the contemporaneous inventories and studies completed before or during the planning process. The Plan describes the park and management policies and lists specific actions and projects to be taken to implement these policies. Under the plan, the agency that became the AOSD was to implement the plan in coordination with the MRGCD, State Highway Department, Albuquerque Metropolitan Arroyo Flood Control Authority, USACE, and Reclamation. Some but not all of the projects have been completed. Implementation of measures proposed in the MRGB study would support implementation of the Bosque Action Plan.

l. Bosque Fire Management Study – Albuquerque Open Space Division, 1992.

This study was undertaken for the AOSD to come up with management recommendations for reducing the fire hazard of the Bosque within the RGVSP. The report maps the Bosque by fuel type and identifies high fuel load areas. The report presents a series of recommendations to prioritize and manage fuels in the Bosque. Parts of this study are currently being implemented in areas identified for restoration by the AOSD. Fuel load reduction is a management goal of the AOSD in the Bosque.

m. Rio Grande Valley State Park Management Plan – State of New Mexico Department of Natural Resources and Albuquerque Open Space Division, 1983.

The management plan documents the agreements between the State of New Mexico and the City of Albuquerque regarding the city's management of RGVSP and legislative mandates for city responsibilities within the park. Implementation of measures proposed in MRGB study would support implementation of the RGVSP Management Plan.

n. Corrales Bosque Preserve Habitat Management Plan, Corrales Bosque Advisory Commission, April 2009.

The management plan provides recommendations for the Bosque in the Corrales reach of the Rio Grande, the Corrales Bosque Preserve, which is designated a nature preserve. Implementation of measures proposed in the MRGB study would support implementation of the Corrales Bosque Preserve Habitat Management Plan.

1.6 Need for the Project/Proposed Action*

River systems and their attendant wetland and riparian woodland communities provide significant resources for both humans and wildlife in the semi-arid western United States. In New Mexico, riparian habitats make up less than two percent of the State's land cover, yet nearly 50 percent of the vertebrate species are riparian obligates (NMDGF 2004). Although these riparian ecosystems are considered to be the most productive and biologically diverse ecosystems in the region, they are now believed to be the most threatened (Johnson and Jones 1977, Johnson *et al.* 1985, Knopf *et al.*1988, Ohmart *et al*. 1988, Johnson 1991, Minckley and Brown 1994). Substantial impacts from human activities, beginning approximately 250 years ago, have resulted in compounding rates of change in structure and vegetation dynamics to the point that the Bosque ecosystem is now on the verge of irreversible conversion (Crawford *et al.* 1996). Open water or wet soil habitat is scarce in arid regions, by definition, and increasing demands on water further threaten this resource.

The Rio Grande's riparian ecosystem continues to provide habitat for a wide variety of wildlife species, although in a much reduced and degraded state compared to its historic status. The Rio Grande remains a critical travel corridor for many species, especially migratory birds that include neotropical songbirds, waterfowl, raptors, and cranes. Wildlife diversity within the MRG riparian corridor is substantially higher than any upland habitats in the rest of the state. Both the increase in uniformity of the geomorphic character of the river and the decline in aquatic and riparian habitat value threaten this diversity. The persistence of species, however, provides the opportunity for these species to expand their occupied area or increase numbers once adjacent habitats are restored or existing habitats are improved. Water resource management activities (diversions, dams, levees, drains, channelization, jetty jacks) have significantly altered the nature of the hydrologic regime, ecological processes, water table, and sediment transport of the Rio Grande within New Mexico, contributing to the loss and attrition of the Bosque and subsequent loss of species diversity.

This report provides an interim response to the study authority cited in Section 1.1, *Study Authority*, and is intended to be a complete decision document that presents the results of the feasibility phase of the RGEMP-I General Investigation effort. This report presents the results and findings of the study, so that readers can reach independent conclusions regarding the reasonableness of the report recommendations.

The scope of this feasibility study consists of:

- Identifying problems and needs associated with ecosystem degradation and related water and land resource problems and recreational needs within the approximately 26-mile-long study reach of the Rio Grande in Bernalillo County, New Mexico;

- Formulating and identifying alternative measures for ecosystem restoration, for increasing the amount or value of associated water and land resources, and for recreational needs, including National Environmental Restoration (NER), and

- Identifying a “Locally Preferred Plan” (LPP) if different from NER plan.

1.7 Planning Process and Report Organization

The feasibility study for the Sandia to Isleta project follows USACE six-step planning process specified in Engineer Regulation (ER) 1105-2-100. The process is used to identify and respond to problems and opportunities associated with the Federal objective and specific state and local stakeholder concerns. The process also provides a rational framework for problem solving and sound decision making. The plan formulation process includes the following steps:

- The specific problems and opportunities to be addressed in the study are identified and the causes of the problems are discussed and documented. Planning goals are set, objectives are established, and constraints are identified.

- Existing and future without-project conditions are identified, analyzed, and forecasted. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation are characterized and documented.

- The study team formulates alternative plans that address the planning objectives. An initial set of alternatives is developed and evaluated at a preliminary level of detail.

- Alternative project plans are evaluated for effectiveness, efficiency, completeness, and acceptability. The impacts of alternative plans are evaluated using the system of accounts framework specified in USACE Principles and Guidelines (Yoe and Orth, 1996) and the Planning Guidance Notebook (Engineer Regulation (ER) 1105-2-100, 2000).

- Alternative plans are compared. A cost effectiveness and incremental cost analysis is used to prioritize and rank ecosystem restoration alternatives. A public involvement program obtains public participation in the alternative identification and evaluation process.

- Selecting the recommended plan. The study team then selects plans that maximize benefits and minimize costs (consistent with the Federal objective).

A number of alternative plans have been developed by the Project Development Team (PDT) and compared with a reasonable estimation of the future without-project condition. The comparison provides a metric allowing for the ultimate identification of the recommended plan or National Ecosystem Restoration (NER) Plan. The NER Plan reasonably maximizes ecosystem restoration benefits compared to costs, considering the cost-effectiveness and incremental cost of implementing other restoration options. In addition to considering the system benefits and costs, the NER Plan considers information that cannot be quantified, such as environmental significance and scarcity, socioeconomic impacts, and historic properties information.

The feasibility report is intended to serve as the basis for authorizing a specific project for construction, and as such, must include steps that guide the planning process to ensure the success of any selected plan. This report is organized to follow the planning process. Chapter 1 includes problems and opportunities. Chapters 2 and 3 contain the inventory and forecast of resource conditions. Chapter 4 describes the formulation, evaluations, and comparisons of alternative plans, and Chapter 5 describes the recommended plan in greater detail.

2 - Existing Environmental Setting*

The following sections discuss resources that may be affected by activities under study. USACE has considered potential effects to socioeconomics and environmental justice under any proposed action and determined them to be minimal in nature. Therefore, detailed analysis of socioeconomics and environmental justice are not included in this report.

2.1 Geology and Soils

2.1.1 Regional and Site Geology

The study area boundaries fall within the Albuquerque Basin, along the Rio Grande. The Albuquerque Basin is bounded by the Sandia, Manzanita, and Manzano uplifts on the east, by the Lucero uplift and Puerco platform on the west, and by the southern end of the Naciemento uplift on the northwest. Small volcanoes and fissure flows mark the boundaries at several locations. The age of the rocks in the mountains ranges from Pre-Cambrian to Pennsylvanian. The Sandia Mountains are composed primarily of Precambrian granite overlain by an eastward dipping sedimentary sequence of Pennsylvanian age limestone. The western face of the Sandia Mountains is partially buried by alluvial fans to the west. The basin is filled with poorly consolidated Cenozoic deposits whose constituents were eroded from the uplands. These sediments have formed coalescing alluvial fans. The sediments that make up the fans are angular to subangular pieces of limestone that are deposited with sands, silts, and clays. The soil also contains large limestone cobbles and boulders. The fans generally grade into finer materials as one moves westward toward the center of the basin. Sediments deposited along the floodplain of the Rio Grande consist primarily of silts and sands with clay and rounded gravels. These sediments have been transported from both the headlands to the north along the Rio Grande and from the Sandia Mountains to the east and were deposited/reworked in the area of Albuquerque. The stratigraphic relationships between different depositional environments are complex and soil/sediment types are not consistent over short ranges.

2.1.2 Previous Geotechnical Explorations

Subsurface investigation was not specifically performed for this study. Boring locations map, boring logs, and laboratory analysis for the Phase II and Phase III Albuquerque levees are provided in the Geotechnical Appendix of this report (Appendix G). Sixty-three soil borings were advanced between June 8, 2006 and June 23, 2006 along the Phase II and Phase III portions of the Albuquerque levees. These borings lie in the same general region as this project. This data was not used to evaluate the condition of the levees as part of this study, but rather to provide general information on the foundation conditions in the project areas.

2.2 Climate

Climate change analysis was conducted in accordance with ECB 2016-25, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects. Detailed results can be found in Appendix B, Climate Change, and summary information presented in the appropriate sections of this combined feasibility-EIS document.

Based on data from the Albuquerque International Airport (Station 290234), the climate in the vicinity of the study area is arid continental with large daily and seasonal temperature differences. Summers tend to be hot and dry while winters tend towards cool days and cold nights, with most days above freezing and overnight temperatures averaging 28°F. Precipitation averages 9.45” per year. In most months, precipitation is 0.75” or less, but is higher during the July-September monsoon season: July receives an average of 1.5”, August 1.58”, and September 1.08”. Precipitation may fall as snow from October through April, but such snow rarely persists on the ground for more than one day

Average temperatures have increased approximately 1.6°F (0.9°C) over the historic period (1901-2010), resulting in increased frequency of heat waves, reduced frequency of cold waves, and the expansion of the growing season by 17 days (7%) during 2001-2010 compared to the average season length for the 20th Century. No trends have been observed in annual water year precipitation from 1895/96 through 2010/11 for the six-state Southwest (NOAA 2013). There has been no overall trend in the frequency of extreme precipitation events across the Southwest (NOAA 2011). Throughout the 20th century and into the early 21st century, the number of 1-day-duration and 5-year return interval precipitation events fluctuated, but remained within the range of early 20th century values. Significant changes in regulation and reductions in winter precipitation over the period of record at the USGS stream gage Rio Grande at Albuquerque (8330000) gage have contributed to reductions in the annual maximum flow time series (see the analysis from the Climate Hydrology Assessment Tool in Appendix B, Climate Change).

2.3 Hydrology, Hydraulics and Geomorphology (Sediment-Continuity Analysis)

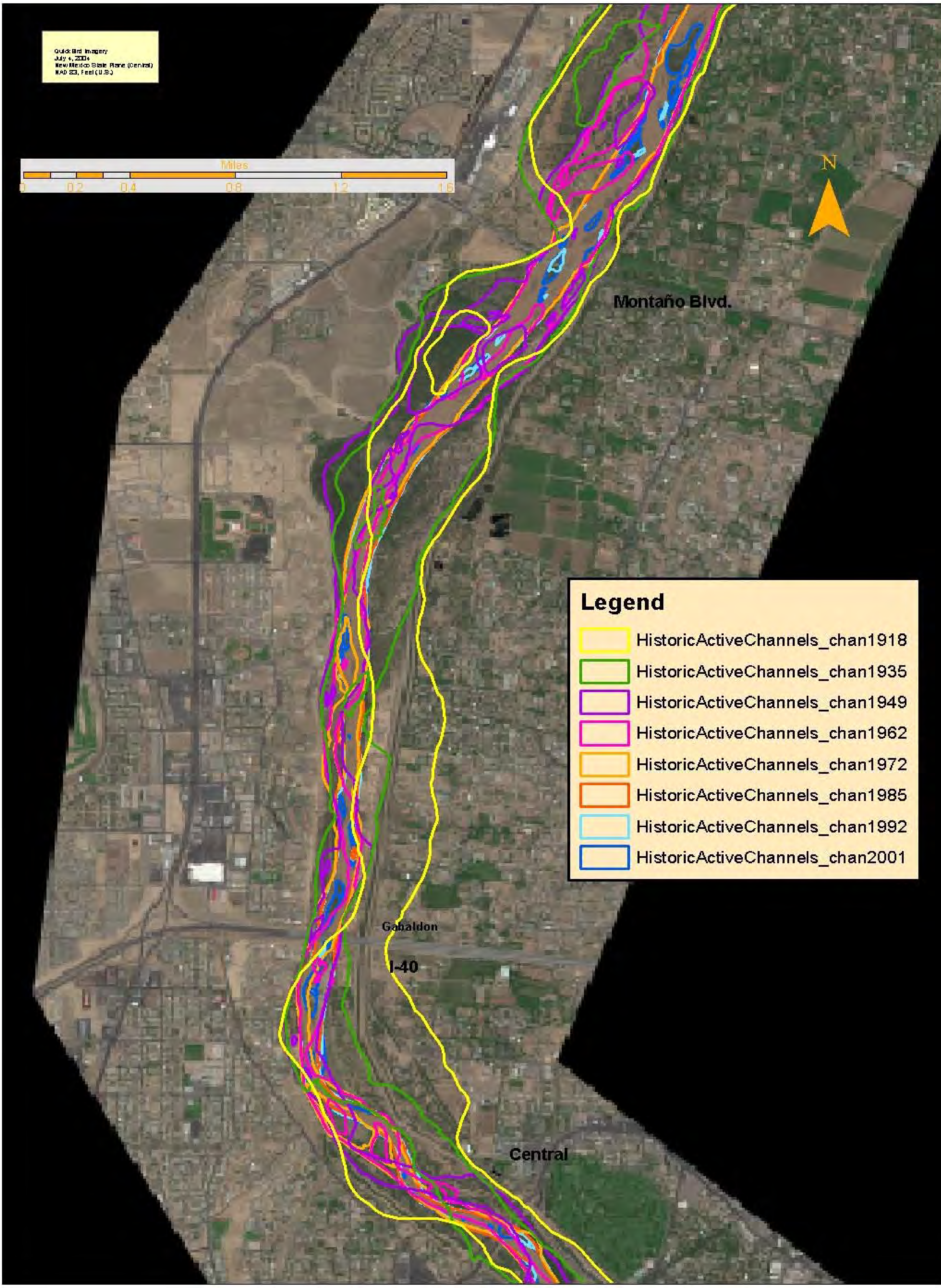
2.3.1 History

The river morphology of the Middle Rio Grande was once that of a wide, shallow braided channel characterized by high sediment loads and frequent flood events (USACE 2003). The channel over the last several hundred years has moved across or flooded in its entirety what is now the approximate location of the 500-year flood zone, as shown in Figure 2.1. Today, the Rio Grande in the Albuquerque area is no longer a braided channel nor is the river able to meander across the original floodplain.

The Rio Grande is now confined as a result of the many water resource activities previously described and by the construction of the Albuquerque Levees Projects built in the mid 1950's and the Corrales Levee Project built in 1996. Anthropogenic changes, coupled with climatic variability, have altered the hydrologic and sediment regimes on the MRG, however the MRG is still primarily a spring snow-pack driven fluvial system. The hydrologic cycle in the Middle Rio Grande Valley (delineated as Cochiti Lake to Elephant Butte Lake) is critical to the function of the bosque cottonwood riparian communities and wetlands. It follows a pattern of high flows during spring snowmelt runoff and low flows during the fall and winter months. Additional high flows of short duration result from thunderstorms that occur in the late summer months.

Middle Rio Grande - Albuquerque Reach
Channel Change, 1918-2001

May 6, 2005



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2.3.2 Effect of Regulated Flow on the Study Reach

The Middle Rio Grande hydrology has been altered dramatically. Historic annual peak discharges have changed from peak flows of over 20,000 cubic feet per second (cfs) prior to World War II to peak flows of less than 10,000 cfs after the construction of Cochiti Dam in 1973. The post Cochiti average annual peak discharge has been affected as well and will be discussed in more detail later in this text.

The change in seasonal discharges has also impacted channel-forming processes. Discharge is one of the dominant variables that affect channel morphology, but sediment supply, channel bed and bank material, floodplain constrictions, and other hydraulic factors are also important influences. Historically, the wide shallow channel was described as a sand-bed stream (Nordin and Beverage 1965) with a braided pattern (Lane and Borland 1953) likely resulting from sediment overload (Woodson 1961). The river followed a pattern of scouring and filling during floods and was in an aggrading regime (accumulating sediment). Flood hazards associated with the aggrading riverbed prompted the building of levees along the floodway. However, the levee system confined the sediment and increased the rate of aggradation in the floodway.

Additionally, channel stabilization works which included jetty jack installations during the 1950s and 1960s contributed to building up and stabilizing the over-bank areas where the bosque currently exists. Construction of dams at Jemez Canyon (1953), Abiquiu (1963), Galisteo Creek (1970), and Cochiti (1973) slowed aggradation. The flood control improvements have reduced the sediment load in the Middle Rio Grande and accomplished flood control objectives for much of the river valley. This has caused changes in the geomorphology of the Rio Grande through the Albuquerque reach and affected the conveyance capacity of the active river channel. The result of geomorphic, sediment supply, and hydrologic changes has been a reduction in the frequency of over-banking flows into the Rio Grande Bosque.

In June 2006, the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) prepared a report for the Albuquerque District U.S. Army Corps of Engineers entitled, “Middle Rio Grande Flow Frequency Study” (2006 HEC Report – see H&H Appendix). The purpose of this study was to develop a flow frequency curve for the Rio Grande at Albuquerque.

In order to develop unregulated volume frequency curves, unregulated daily flows were needed for the Rio Grande, the Rio Chama, and the Jemez River. The Rio Chama and Middle Rio Grande contain a number of reservoirs: El Vado, Abiquiu, and Cochiti. Reservoirs have also been constructed on tributaries flowing into the Rio Grande, such as the Jemez Canyon Dam on the Jemez River. The development by HEC of the unregulated flow time-series removed effects caused by the reservoirs on the flow time-series at Albuquerque. Table 2.1 provides a comparison of Daily Average Peak Flows for the Gage at Albuquerque for Regulated versus Unregulated Daily Average Peak Flow to demonstrate the effect of regulation on daily peak flow at Albuquerque.

Cochiti Dam began regulating flow on the Rio Grande in 1974. Table 2.2 is provided to demonstrate the effects of regulation at Albuquerque for the post-Cochiti Dam period. The following page (Table 1) gives a comparison of daily average peak flow for the “Rio Grande at Albuquerque” gage versus unregulated daily average peak flows for Albuquerque given in the

2006 HEC Report. Only floods generated by snowmelt and rainfall upstream of the reservoirs were included in this comparison. All flows are given in cubic feet per second (cfs).

Table 1. Comparison of Daily Average Peak Flows for the Gage at Albuquerque.

Year	Regulated Daily Average Peak Flow (in cfs)	Unregulated Daily Average Peak Flow (in cfs) (From 2006 HEC Report)
1975	5800	8848
1976	3170	4103
1978	4320	5528
1979	7870	15873
1980	7130	11023
1982	4620	6680
1983	6970	11965
1984	8260	13433
1985	8650	16503
1986	4490	8052
1987	5990	10881
1989	3670	4798
1992	5360	7916
1993	6960	10314
1994	5230	10070
1995	6370	9413
1997	5430	8171
1998	3940	4708
1999	4520	6018
2001	4730	5528

Table 1 is provided to demonstrate the effects of regulation at Albuquerque for the post-Cochiti Dam period from 2002 through 2016. The following page (Table 2) gives a comparison of daily average spring peak flow for the “Rio Grande at Albuquerque” gage (located downstream from Cochiti Dam) versus “Rio Grande at Otowi Bridge, NM” (located upstream from Cochiti Dam). Only floods generated by snowmelt and rainfall upstream of the reservoir during the spring period (March through June) were included in this comparison. All flows are given in cubic feet per second (cfs).

Table 2. Comparison of Daily Average Peak Spring Flows for the Gage at Albuquerque versus the Gage at Otowi.

Year	Albuquerque Gage (Downstream from Cochiti) Flow (cfs)	Otowi Gage (Upstream from Cochiti) Flow (cfs)
2002	1240	1710
2003	1260	1820
2004	3120	3400
2005	6510	8970
2006	1390	1560
2007	3700	3740
2008	5150	5840
2009	4940	5890
2010	4900	4580
2011	1330	2290
2012	2070	2240
2013	705	1200
2014	1550	2260
2015	2870	4080
2016	3630	4170

Table 2 indicates that were it not for the regulation of upstream flows, the Rio Grande at the Albuquerque gage could have experienced spring flows of 10,000 cfs or greater a total of eight (8) times between 1975 and 2001. This is consistent with the pre-Cochiti Dam flow record which shows that from 1942 to 1973 spring flows reached or exceeded 10,000 cfs a total of seven (7) times at the Albuquerque gage. The gage record shows that flows of 10,000 cfs or greater were never reached at the Albuquerque gage during the post-Cochiti Dam period (1974 to present). The results of the 2006 HEC Report show that flow releases from Cochiti Dam can be regulated to 7,000 cfs for flows generated by snowmelt and rainfall upstream of the reservoirs for any event up to the 200 year frequency event. In the 200 year frequency event the HEC Report predicts a spillway flow resulting in a total combined discharge of 10,000 cfs.

For comparative purposes, Figure 3, below shows the 1987 hydrograph taken from the gage record. This hydrograph was selected because were it not for the effects of regulated flow from Cochiti Dam, this hydrograph would have reached a peak flow of 10,881 cfs resulting in widespread overbank flows at Albuquerque.

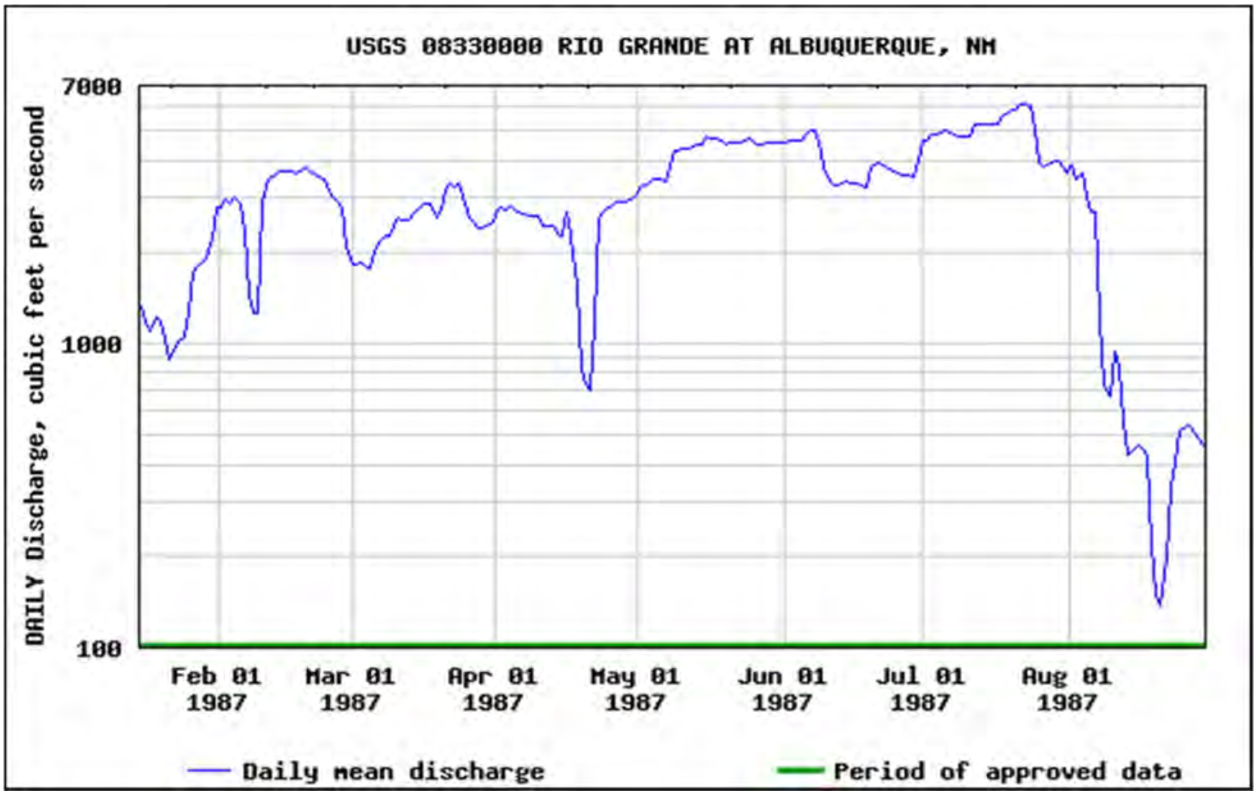

Figure 3. 1987 Hydrograph for USGS Gage at Albuquerque.

However, from the FLO-2D analysis for this study described briefly below and included in the H&H Appendix, it is unlikely that significant overbank flow would be experienced if the 1987 hydrograph were to occur under the existing conditions except where MRG Bosque Restoration Projects have been constructed. In fact, the spring 2005 hydrograph was similar in peak flow and resulted in relatively limited overbank flows prior to MRG Bosque Restoration Projects. The 2005 hydrograph is shown below in **Error! Reference source not found.**:

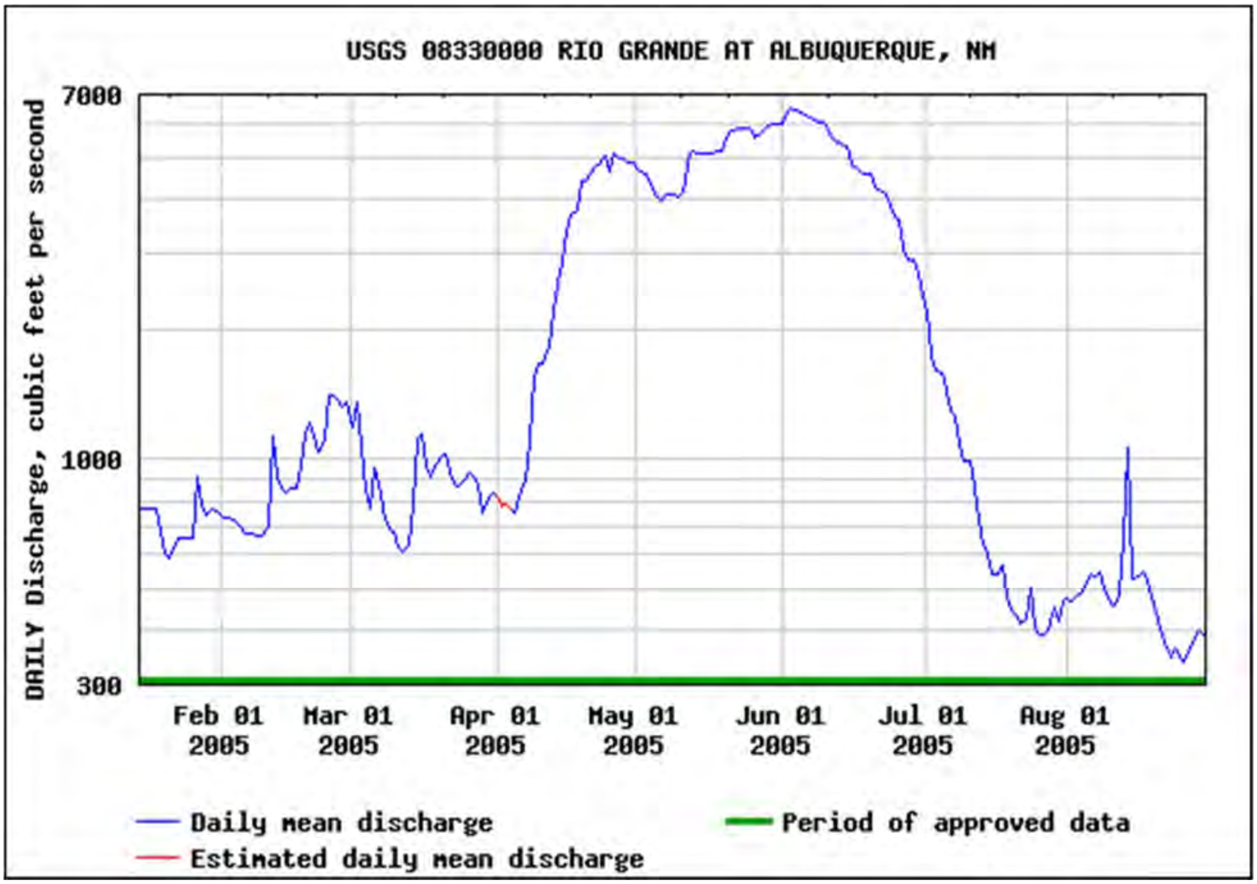

Figure 4. 2005 Hydrograph for USGS Gage at Albuquerque.

According to Figure 3 above, the unregulated flow for 1987 would have been 10,881 cfs. This would perhaps be comparable to the 1949 hydrograph with a peak daily flow of 10,556 cfs. This flow rate would cause widespread overbank flows through the Rio Grande bosque under existing conditions based on the results from the FLO-2D analysis. The 1949 hydrograph is shown in Figure 5 below:

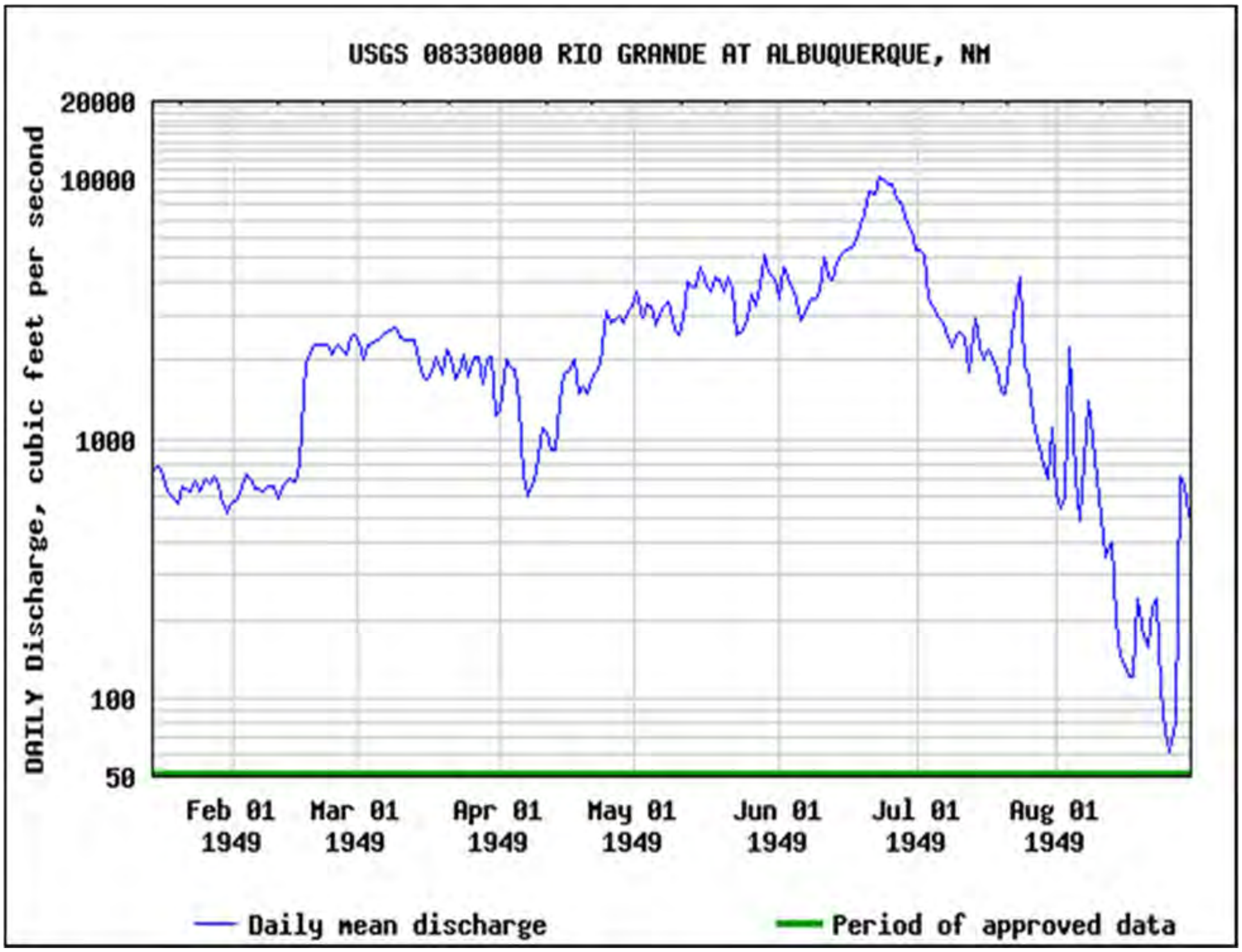

Figure 5. 1949 Hydrograph for USGS Gage at Albuquerque.

When the results of the 2006 HEC Report are combined with the results of the FLO-2D analysis (H&H appendix), evidence is provided that watershed regulation has significantly reduced overbank flows throughout the study reach. This is also generally consistent with observations made during spring flow events since 2001 through the study reach with the exception of areas where MRG Bosque Restoration Projects have been constructed which have successfully induced overbank inundation.

2.3.3 Inundation analysis

Mussetter Engineering, Inc. (MEI) was retained by USACE to perform FLO-2D modeling in support of this planning study. The inundation scenarios evaluated from this modeling exercise were used to evaluate the existing conditions. While a summary of the results are provided herein, a more detailed explanation and review of the results are provided in the complete report, which is included within the H&H Appendix.

Four hydrologic scenarios were used to estimate the existing project conditions. These four scenarios are briefly described below:

- **Active channel-full flow (6,000 cfs peak**)–MEI (2008) determined the active channel-full flow in this reach to be close to 6,000 cfs.
- **Representative post-Cochiti annual spring runoff hydrograph (3,770 cfs peak**)–MEI (2008) analyzed the daily flow record at the Albuquerque USGS gage from 1974 to 2002 to estimate a 50 percent discharge hydrograph using a log-Pearson type III analysis and a mass shifting of the hydrographs. The peak of this representative post-Cochiti annual spring runoff hydrograph has a mean-daily flow of 3,770.
- **10,000-cfs post-Cochiti flow hydrograph (10,000 cfs peak)**–This hydrology scenario was scaled by MEI (2008) from the 10-percent exceedance hydrograph (6,536 cfs) to provide a peak discharge of 10,000 cfs and a duration that achieved a target volume of 1,467,000 ac-ft. Scaling was used to provide a realistic hydrograph shape.
- **The 100-year post-Cochiti flood-flow hydrograph (7,750 cfs peak)** – Hydrologic modeling by the Hydrologic Engineering Center (HEC 2006) indicated that the 100-year snow melt hydrograph has a peak discharge of approximately 7,750 cfs. This snowmelt hydrograph was developed by routing actual hydrographs from time-series analysis of unregulated flows through the upstream reservoirs using the ResSim model. The resulting hydrograph was used by MEI (2008) to route through Cochiti Reservoir downstream through the project reach using the FLO-2D model. The regulation by Cochiti Dam keeps the resulting hydrograph around 7,000 cfs.

A detailed discussion of the model development, calibration and validation can be found in the report in the H&H Appendix and will not be discussed in detail here. However, comparison of the predicted water-surface elevation from the updated FLO-2D model with the 2005 high-flow event shows very good agreement. The performance of the model was also evaluated over a broader range of flows and compared to water surface elevations at four bridges where measured water-surface elevations were available. Based on the results, the updated FLO-2D model appears to be reasonably well validated.

The validated existing conditions FLO-2D model was run for the four hydrology scenarios, and the results were used to compare the main channel water-surface elevations with the top-of-bank elevations and to map and evaluate the extent, depth, and duration of overbank inundation along the reach (H&H Appendix). Existing conditions for the four hydrologic scenarios are summarized in the following bullets and listed in Table 3 and Table 4. Table 3 indicates the amount of overbank inundation which occurred in each subreach prior to the construction of MRG Bosque Restoration Projects, while Table 4 is the modeled inundation after construction. Additional modeling details are provided in the H&H Appendix.

- **Active channel-full flow (6,000 cfs peak**)–MEI's (2008) modeling results indicate that the water-surface elevation is at or above the top of bank elevation at several locations along the project reach. Additional overbanking occurs where MRG Bosque Restoration Projects have been constructed.
- **Representative post-Cochiti annual spring runoff hydrograph (3,770 cfs peak**) – Modeling results (MEI 2008) indicate that the top-of-bank elevation is exceeded at some locations along the project reach but the overall area of inundation was small prior to the construction of MRG Bosque Restoration Projects.

- **10,000-cfs post-Cochiti flow hydrograph (10,000 cfs peak)** – MEI's (2008) 10,000 cfs snowmelt hydrograph indicates that overbank inundation occurs at similar locations to the channel full condition, but with larger areas of inundation.
- **The 100-year post-Cochiti flood-flow hydrograph (7,750 cfs peak)** – MEI (2008) showed that overbank inundation for this scenario occurs at similar locations to the 10,000 cfs hydrograph, but with less total area of inundation. The majority of the overbank inundation occurs for approximately 14 to 16 days during the 3-month hydrograph.

Table 3. Summary of area of inundation for existing conditions prior to the construction of MRG Bosque Restoration Projects (acres).

Hydrology Scenario	Description	Subreach					
		1	2	3	4	5	Total
1	Channel Full Conditions	77.2	41.3	25.2	34.4	75.6	253.7
2	Annual Spring Runoff	45.2	23.1	7.7	4.0	7.9	87.9
3	10,000 cfs hydrograph	181.9	125.6	82.2	233.7	412.9	1,036.3
4	100-year Peak Snowmelt	84.4	59.9	14.6	133.4	364.9	657.2

Table 4. Summary of area of inundation for existing conditions which includes the construction of MRG Bosque Restoration Projects (acres).

Hydrology Scenario	Description	Subreach					
		1	2	3	4	5	Total
1	Channel Full Conditions	145.2	46.1	31.3	55.5	85.5	363.6
2	Annual Spring Runoff	113.3	25.2	16.6	30.7	42.9	228.7
3	10,000 cfs hydrograph	181.9	125.6	82.2	233.7	412.9	1,036.3
4	100-year Peak Snowmelt	84.4	59.9	14.6	133.4	364.9	657.2

Sediment-Continuity Analysis

A baseline sediment-continuity analysis was also performed by MEI (2008) to evaluate the potential for aggradation or degradation in response to both individual short-term hydrographs and longer-term flows (50-year project life) given the present channel configuration and reservoir operations. In general, the analysis estimated the sediment transport capacity by subreach for each hydrology scenario and compared that to the predicted sediment supply. Only hydrologic scenarios 2, 3, and 4 (described previously) were utilized for this analysis. Sediment transport used representative bed material gradations (nominal grain size is described as a coarse/very coarse sand) and the Yang (sand) sediment-transport equation (Yang 1973). MEI (2004) had previously found this sediment-transport equation to be best correlated with measured data within the study area. Sediment supply was estimated using the upstream reach from Arroyo de la Baranca (about 2 miles downstream of Bernalillo) to the Corrales Siphon and including sediment loading from Calabacillas Arroyo, North Diversion Channel, and South Diversion Channel. In comparing the volumes, when the transport capacity of a particular subreach exceeds the supply, the channel will respond by either degrading (i.e., channel downcutting) or coarsening its bed material, and when the supply exceeds the capacity, the channel will respond by aggrading or fining its bed material (Lane 1954).

The analysis results (MEI 2008) indicate that the bed-material transport capacity is relatively consistent from subreach to subreach, although there is a slight net degradational tendency, in the absence of tributary sediment inputs. For the average annual hydrograph, the transport capacity at the downstream end of the reach is about 104 ac-ft compared to the upstream supply of about 101 ac-ft. For the 10,000-cfs hydrograph, the transport capacity at the downstream end is about 468 ac-ft capacity versus 444 ac-ft of supply, and for the 100-year snowmelt hydrograph, the downstream capacity is about 657 ac-ft capacity at the downstream end versus 622 ac-ft of supply. On a long-term average annual basis, the transport capacity at the downstream end of the reach is about 246 ac-ft compared to the supply of 209 ac-ft. In spite of the overall degradational tendency, Subreach 4 tends to be aggradational for all of the hydrology scenarios. Over time, the upstream three subreaches were expected to show coarsening of their bed material. The coarsening of the bed in these reaches was expected to decrease the future sediment supply for subreach 4, reducing the aggradation potential.

2.4 Water Quality

Water quality on the Rio Grande within the project area are monitored by several federal agencies (e.g., USGS, USACE, USBOR, and USFWS), New Mexico Environment Department (NMED), local agencies (e.g., AMAFCA. City of Albuquerque) and the University of New Mexico. The designated uses of the Rio Grande within the project area are irrigation, marginal warmwater aquatic life, livestock watering, public water supply, wildlife habitat and primary contact (recreational uses) (New Mexico Water Quality Control Commission 2000). With these designations, criteria applicable to existing, designated or attainable uses have been developed (20.6.4.900 NMAC). In addition to the use-specific numeric criteria, several reach specific criteria have been developed for river flow, total dissolved solids, sulfate, and chloride (20.6.4.105B NMAC). The Rio Grande within the study area has been designated as impaired for dissolved oxygen, water temperature, and polychlorinated biphenyl (PCB) in fish tissue (based on current fish consumption advisory). Per USEPA guidance, these advisories demonstrate non-attainment of CWA goals stating that all waters should be "fishable". NMED has developed Total Maximum Daily Loads (TMDL) for *E. coli* and fecal coliform for the Rio Grande within the project area (NMED 2001, NMED 2010). Contributors to the *E. coli* and fecal coliform load include avian, livestock, impervious surface/parking lot runoff, municipal point source discharges, and on-site treatment systems (septic systems), and pet waste (NMED 2010).

Long-term and continuous monitoring of water temperature, pH, dissolved oxygen (DO), turbidity, and specific conductance are measured at three stations (i.e., Alameda Bridge, Rio Bravo Bridge, and I-25 Bridge) within the project area since 2006 (Dahm et al. 2013, Van Horn et al. 2016). Figure 6 provides a representative example of the daily and seasonal temporal variability in water quality parameters on the Rio Grande (i.e., Alameda Bridge) within the project area during a recent water year (i.e., 2015). Low DO has been documented from the AMAFCA North Diversion Channel (NDC) (DBSA 2009, Van Horn Unpublished). Recent modifications to improve the NDC outfall to reduce the volume of anoxic water that accumulates there in warm months have been implemented (SWCA 2015, USFWS 2015). To date, the effectiveness of these modifications have not been evaluated. The Las Conchas fire (2011) also impacted water quality within the study area through 2013 (Dahm et al. 2015, Reale et al. 2015). Impairments included multiple DO sags to less than 2 mg L^{-1}.

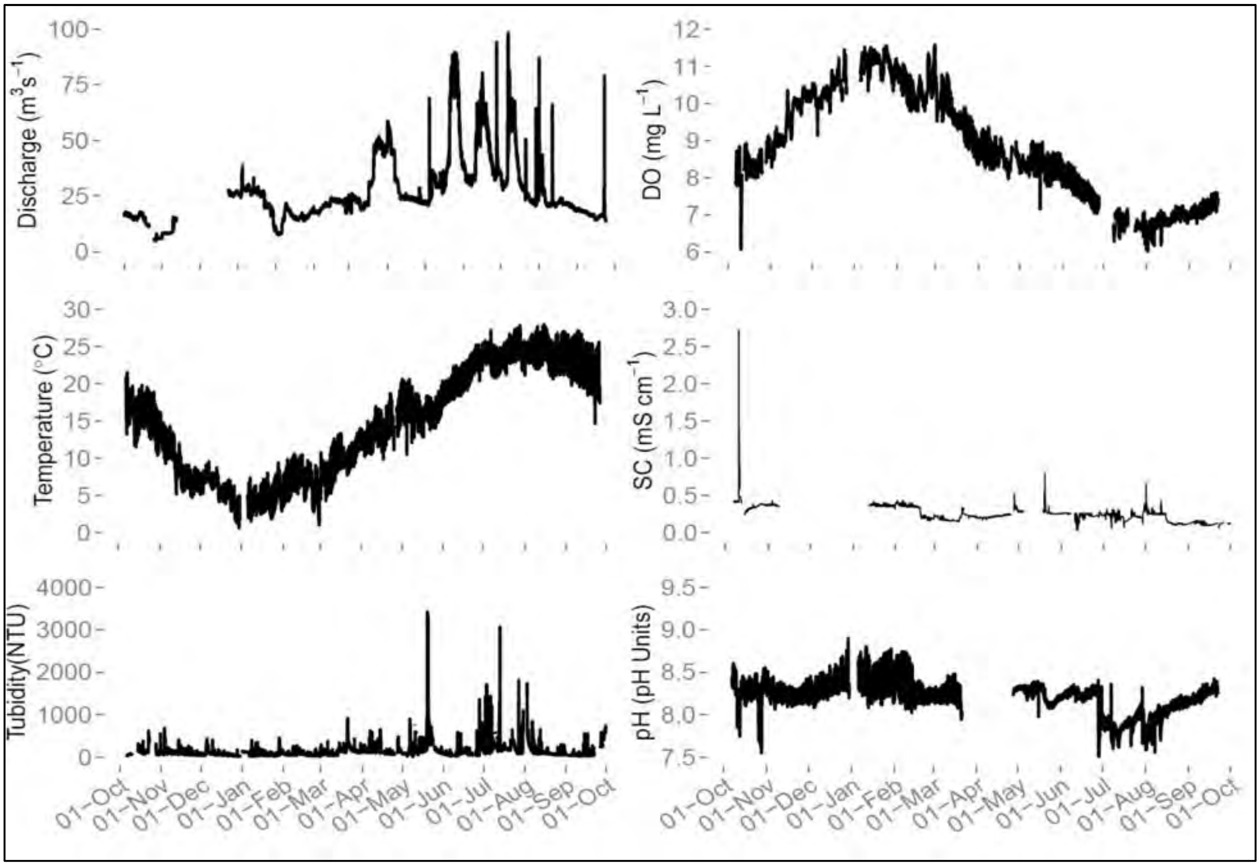

Figure 6. Water quality and discharge data for the Rio Grande at Alameda during Water Year 2015. Discharge data is from the USGS gage at Alameda (Van Horn et al. 2016).

The USGS also monitored daily suspended sediment at the stream gage at Central Avenue (Gage No. 08330600) from 1970-2016 and exhibited considerable variability, with annual mean concentrations of 898 ± 837 mg L^{-1} for the period of record. These data suggest considerable seasonal and annual variability for several water quality parameters within the project area.

2.5 Air Quality and Noise

The Project Area is located within New Mexico's Air Quality Control Region No. 152, which encompasses all of Bernalillo County and most of Sandoval and Valencia counties. These three counties are "in attainment" (i.e. do not exceed State and Federal Environmental Protection Agency air quality standards) for all criteria pollutants (NMED, 2018). Air quality in the project area is generally good. The closest Class I area is Bandelier National Monument, approximately 50 miles to the north of the project area. A Class I area is a wilderness area or a National Park. Air quality in the proposed project area is generally good to excellent due to the lack of urban industrial development. Although high winds are common in and around the proposed project area, blowing dust is generally not a problem except during extremely dry years. Airborne particulate and carbon monoxide concentrations from wood burning in the Rio Grande valley are occasionally high during winter months when temperature inversions and wood stove use are both more prevalent.

The OSHA (Occupational Safety and Health Administration) noise standard limits noise levels to 90 dBA averaged over an eight-hour day (29 CFR 1910.95), although hearing damage can begin at levels as low as 80 dBA over an eight-hour day. No worker may be exposed to noise in excess of 115 dBA without protection, which would reduce the exposure below 115 dBA (AFSCME, 2018).

Albuquerque's noise control ordinance was placed into effect in June 1975. The Environmental Health Department's Consumer Protection Division personnel are responsible for enforcing the ordinance. Noise control enforcement may involve many sources of excessive noise: radios, stereos, television, live bands, machinery, equipment fans, air conditions, construction, vehicle repairs, motor vehicles, and general noise. The ordinance stipulates a property-line value in which the noise level emitted must not exceed 50 decibels (dB) or 10 decibels above the ambient level; whichever is greater (Mitzelfelt, 1996).

Noise levels in the proposed project area are relatively low. In some areas of the proposed project area, noise levels may be somewhat higher due to the proximity of more urban settings within the City of Albuquerque. Major sources of intermittent noise in the area are attributed to automobile traffic, farm operations, and river and bosque maintenance operations.

2.6 Ecological Resources

2.6.1 Vegetation Communities

2.6.1.1 Historic Vegetative Conditions

The following quote summarized the processes prior to major human impacts on the Middle Rio Grande:

> *…(the river experienced) periods of stability that allowed riparian vegetation to become established on riverbanks (mostly on the inside of river bends) and islands alternating with periods of instability (e.g., extreme flooding) that provided, by erosion and deposition, new locations for riparian vegetation. A mosaic of cottonwood and willow community types, of varying age classes, size, and extent, would be interspersed with more open areas of ponded water, grasslands, marshes, and wet meadows. Areas where erosion forces were less active would produce older age class stands of native vegetation (Hanson 1997, Crawford et al. 1993, Leopold 1964).*

Loss of hydrological conditions necessary for regeneration of native riparian plants and increasing abundance of nonnative species were identified in river systems throughout the western U.S. beginning in the mid-1970's, with main-stem impoundments typically identified as the primary factor driving alteration of ecosystem structure and function (Fenner *et al*., 1985; Howe and Knopf, 1991). Impoundments alter the hydrograph and reduce sediment supply in downstream reaches and cause channel incision and narrowing of the floodplain (Williams and Wolman, 1984). Installation of jetty jacks, levee construction, sediment and vegetation removal, and irrigation diversions have exacerbated these effects in the Proposed Action Area (Crawford *et al*., 1983). Changes brought by impoundments and channel modifications in the Proposed

Action Area have created a riparian ecosystem organized by autogenic factors, including plant succession and invasion by nonnative species, and novel allogenic factors such as fire. Conversely, the naturally functioning bosque ecosystem was structured largely by fluvial geomorphic processes (cf. Déscamps *et al*., 1988).

Many factors influence the structure of riparian vegetation. The frequency, duration, and timing of inundation (timed for seed dispersal), as well as the rate of the falling limb of the hydrograph are all contributing factors (Wheeler and Kapp, 1978; Kozlowski, 1984). Riparian plant species vary in their tolerance to inundation and resulting anoxic conditions (Amlin and Rood, 2001). Growth and regeneration of many riparian tree species declines with increasing hydroperiod, and permanent inundation results in eventual loss of tree cover in most riparian ecosystems. Seedlings are particularly sensitive to inundation and tolerance of plants generally increases with age (Jones *et al*., 1994).

Moisture gradients are a major determinant of the distribution of riparian plant species (Weaver, 1960; Bush and Van Auken, 1984; Tanner, 1986). Soil texture affects moisture regime. Sands drain quickly and, thus, anoxic conditions occur only with high water tables or extended inundation. Fine-particles soils, which are deposited in areas of low current velocity, have high water-holding capacity and slow drainage. Fine-grained soils may accumulate at arroyo mouths on the floodplain, behind natural trees, and in oxbows.

Soil moisture levels and depth to ground water on floodplain sites are influenced primarily by surface topography, the variation of which is created through ecological, fluvial, and geomorphic processes (Malanson 1993). The limits of riparian vegetation are controlled by depth to the water table. Moisture in upper soil layers is a primary influence on establishment of tree species while groundwater levels are important for their persistence (Dawson and Ehleringer 1991). Soil moisture has a major influence on seed germination and seeding germination and seedling survival of cottonwood (Moss 1938, Bradley and Smith 1986, Mahoney and Rood 1993) and willow (Taylor *et al*. 1999).

Salt cedar is a non-native, invasive species that is a prominent colonizer of exposed, bare-soil sites in the Bosque (Smith *et al*., 2002). While individual cottonwood seedlings have a greater competitive effect relative to salt cedar seedlings under ideal soil moisture conditions (Sher *et al*., 2000), the competitive effect is lost under conditions of water stress (Segelquist *et al*., 1993) or elevated salinity (Busch and Smith 1995). Salt cedar produces seed for several months beginning in late spring (Ware and Penfound 1949, Horton *et al*., 1960) and colonized bare, moist-soil sites throughout the summer. Conversely, cottonwood produces seed for only a short time in the spring, and seed remains viable for approximately a month and a half under ideal conditions (Horton *et al*., 1960). The flowering and fruiting phenology of salt cedar allows seedlings to establish and dominate open sites wetted by runoff, rainfall, or river flows during the summer, precluding the possibility for cottonwood establishment on potentially suitable sites the following spring. Salt cedar also becomes established in the understory of mature cottonwood stands in the study area where sufficient lights exists (Crawford *et al*., 1996).

Russian olive is a non-native, invasive species that is established by seed in the understory of mature cottonwood stands and also colonizes openings along the river, often forming dense stands (Hink and Ohmart 1984, Sivinski *et al*., 1990). Russian olive is shade tolerant and can survive in areas where cottonwood canopy exists. Seeds germinate in moist-to-dry sites, and the plant sprouts readily from the root crown after damage to or removal of above-ground portions of the plant (Sivinski et al. 1990). Russian olive was present in the understory in 1981 (Hink and Ohmart 1984) and continues to increase in the Bosque in the study area (Sivinski et al. 1990).

Several other non-native tree species, in addition to salt cedar and Russian olive, are at least locally common, if not abundant, in the overstory. These species are Siberian elm, tree of heaven, and Russian mulberry (*Morus alba* var. *tatarica*). All three species are shade-tolerant and readily colonize disturbed sites (Crawford *et al*., Sivinski *et al*., 1990). Siberian elm was rare in the bosque in 1981 when it was found only at very low densities, ranging from less than 0.5 tree/acre to 3 trees/acre (Hink and Ohmart, 1984). However, Siberian elm had become increasingly abundant by 1990 (Sivinski et al., 1990) and is now very common in the overstory. This species produces large seed crops and is ubiquitous in the project area as seedlings, saplings, and mature trees. It sprouts readily from the root crown. Siberian elm seed will germinate under normal rainfall conditions and does not require moist or saturated soils (Sivinski et al., 1990). Tree of heaven and Russian mulberry are more localized in their distribution in the project area than salt cedar, Russian olive, or Siberian elm. Both of these species typically colonize disturbed areas, such as along levees and in severely burned sites (Sivinski et al., 1990).

Fire was virtually unknown in naturally functioning, low-elevation riparian ecosystems of the Southwest (Busch and Smith, 1993; Stuever, 1997). However, fuel accumulations coupled with mainly human-caused ignitions have introduced fire as a major disturbance mechanism in the bosque ecosystem (Stuever, 1997). While cottonwood is highly susceptible to fire-induced mortality (Stuever, 1997), salt cedar re-sprouts vigorously following fire (Busch and Smith, 1993; Busch, 1995). Cottonwood and willow (*Salix* spp.) are poorly adapted to fire and lack an efficient post-fire res-sprouting mechanism such as that found in salt cedar (Busch and Smith, 1993).

Post-fire soils have significantly higher salinity than soils of unburned areas, which may suppress growth of cottonwood and willow seedlings and allow establishment of salt cedar seedlings (Busch and Smith, 1993). Salt cedar has a higher salinity tolerance than willow and cottonwood and adjusts to high salinity sites through accumulation of salts and osmotic adjustment, whereas willow and cottonwood exclude ions at the root endodermis (Busch and Smith, 1995). Salt cedar uses the absorbed ions to maintain turgor pressure at low water potential and also exudes salts through special glands, allowing it to tolerate higher salinities and water stress than cottonwood and will (Busch and Smith, 1995). Halophytes, such as salt cedar, may salinize soils when well supplied with moisture to reduce water update and transpiration (Busch and Smith, 1995).

Two large fires occurred in the Bosque in Albuquerque in June 2003, burning a total of 253 acres. Since that time, AOSD has initiated an extensive fuel-wood thinning project in order to prevent fires in the Albuquerque area. Unfortunately, two more fires occurred in 2004. One fire occurred between Rio Bravo and Interstate-25 on both sides of the river, burning approximately 63 acres, and the other fire occurred south of Bridge Boulevard on the east side of the river, burning approximately 18 acres. In 2012, a fire started in Corrales and burned five acres before the fire jumped the Rio Grande and spread to Sandia Pueblo. This fire was called the Romero fire and burned more than 400 acres. Prior to, and between, these fires, the City of Albuquerque has been thinning most areas within the (RGVSP). To date, the majority of the Bosque acres in the RGVSP have been “treated” in some way to reduce fire hazards by the AOSD, Ciudad Soil and Water Conservation District (SWCD), USACE (through the Bosque Wildfire Project) and other agencies and private organizations. This makes up the majority of the acreage within the study area.

2.6.1.2 More Recent Vegetative Conditions

From 2003 to the present, several major restoration projects have been constructed throughout the Albuquerque Reach of the Middle Rio Grande. From 2004 to 2006, the Bosque Wildfire Project was implemented, which thinned areas with high fuel loads and/or non-native vegetation, removed jetty jacks and debris, improved emergency access, and revegetated burned and thinned areas with native vegetation. In 2005, USACE finished construction on the Albuquerque BioPark Wetland Restoration Project, which thinned areas of non-native vegetation, planted native vegetation, and created wetlands and a wet meadow. In 2007, construction for the Rio Grande Nature Center Habitat Restoration Project was implemented. This project restored an ephemeral side channel of the Rio Grande, reconnecting the floodplain of the bosque to the river in order to reestablish native habitat. In 2009, USACE implemented the Ecosystem Revitalization at Route 66 Project, which removed non-native vegetation across 121 acres of bosque, constructed 3 high-flow channels, and enhanced one outfall wetland. Planting of native vegetation also occurred throughout the project area and construction of willow swales. Planning for the Middle Rio Grande Project (MRG Project) started in 2002 and was ready for construction by late 2011. Phase 1 of the MRG Project was completed in 2014. Phase 2 began in 2014 and was completed in 2017. The MRG Project, implemented by USACE, expanded, created, and improved fish and wildlife habitat along a 22-mile reach of the Middle Rio Grande between the north boundary of the Village of Corrales downstream to the Interstate 25 (I-25) bridge near the north boundary of Isleta Pueblo. The MRG Project restored a total of 916 acres of the Middle Rio Grande Bosque by enhancing hydrologic function (by constructing wet measures such as high-flow channels, willow swales, and wetlands) and restoring native vegetation and habitat by removing jetty jacks, exotic species/fuel reduction, and riparian forest restoration. In addition to these projects, a number of Middle Rio Grande Endangered Species Collaborative Program projects have been constructed in the Albuquerque Reach.

2.6.1.3 Current Vegetative Conditions

Within the Proposed Study Area, current vegetative conditions varies vastly depending on recent restoration efforts and where they have occurred. During the feasibility study of the MRG Project, USACE used an existing inventory of the habitats within the study area to obtain a value of the existing habitat. The “Middle Rio Grande Biological Survey” completed by Hink and Ohmart in 1984, described the plant communities within the study area’s riparian zone and provided detailed information on species composition and the structure of cover types. Hink and Ohmart (1984) developed six general plant vegetation categories based on several parameters including height and density of the vegetation and the make-up of the mid and understory or lower layers. Figures 24 through 29 show the habitat structure types used in the initial inventory.

Type 1: Mature Riparian Forests with tall trees ranging from 50 to 60 feet in height, closed canopies, and well established (relatively dense) understories composed of saplings and shrubs.

Figure 7. Classic examples of Type 1 vegetation in the Proposed Project Area.

Type II: Mature Riparian Forests with tall trees exceeding 40 feet in height and nearly closed canopies, but limited saplings and shrub understories.

Figure 8. Classic examples of Type II vegetation in the Proposed Project Area.

Type III: Intermediate-aged Riparian Woodlands characterized by mid-sized trees less than 30 feet in height, but with closed canopies and dense understories.

Figure 9. Classic examples of Type III vegetation in the Proposed Project Area.

Type IV: Intermediate-aged Riparian Woodland/Savannahs characterized by open stands of mid-sized trees with widely scattered shrubs and sparse herbaceous growth underneath.

Figure 10. Classic examples of Type IV vegetation in the Proposed Project Area.

Type V: Riparian shrubs characterized by dense vegetation (shrubs and saplings) up to 15 feet in height, but lacking tall trees species, and often having dense herbaceous growth underneath.

Figure 11. Classic examples of Type V vegetation in the Proposed Project Area.

Type VI: Dry grass meadows and wet marshes characterized by scattered plant growth composed of short shrubs (less than 5 feet in height), seedlings, and grasses. This category includes both dry meadows and the rare marshes found in the oxbow of the Rio Grande that are vegetated with cattail, bulrush, sedges, watercress and algae.

Figure 12. Classic examples of Type VI vegetation within the Proposed Project Area.

For purposes of the MRG Project and this study, these six cover types (which were changed to 1-6) were subsequently divided into "Treated" (T), for areas where dead and down material was removed and/or selective thinning of non-native vegetation has occurred, or "Untreated" (U) categories, indicating the condition of "fire management" within their boundaries. Therefore, in addition to the six vegetation types, four of the types were subdivided into T or U as appropriate and resulted in Types 2T, 2U, 4T, 4U, 6T, and 6U. A "wet" (W) descriptor also was added for Type 6 yielding a Type 6W category. Therefore, a total of ten categories exist. During the MRG Project feasibility phase, Corps' biologist established approximately 30 transects throughout the study area so that three sites were selected for each cover type mentioned above. Data was collected along each transect and was used as input information into a Habitat Suitability Index Model (HSI) that was used for that project.

Although the Proposed Project Area is within the same footprint as the MRG Project, there are areas throughout the Proposed Project Area where measures were not implemented and were left untreated. As mentioned above, the current vegetative conditions within the Proposed Project Area vary. Within the MRG Project constructed areas, the dynamic mosaic of riparian wetlands, channels, woodlands, shrub thickets, and periodically wet meadows have been reintroduced. Restoration of native vegetation and the reduction of exotic and invasive species also have occurred. However, areas that have not been restored are more comparable to the recent conditions section described above. These area of the bosque are declining in habitat value. The size and density of non-native vegetation patches, composed of Siberian elm, Russian olive, salt cedar, tree of heaven, white-mulberry, and Ravenna grass are increasing as they compete with the native cottonwoods, willows, and other native understory and mid-canopy plants. In these areas where measures were not implemented, diversity of habitat is decreasing and the dynamic mosaic of historical times is vanishing. In order to validate trends that were forecasted under the MRG Project feasibility study and to understand existing conditions in non-restored sites, Corps' biologist replicated data collection at the original transects in areas that were not constructed under the MRG Project. Ten transects were surveyed throughout the Proposed Project Area and covered most cover types. Data shows comparable information to the data received in 2005. However, as forecasted under the MRG Project Future Without Project Condition Trends, conditions are declining. All sites are declining at comparable rates.

2.6.1.4 Noxious Weeds

Executive Order 13112 directs Federal agencies to prevent the introduction of invasive (exotic) species; minimizes the economic, ecological, and human health impacts that they cause, and provides for their control. In addition, the State of New Mexico, under administration of the United States Department of Agriculture, designates and lists certain weed species as noxious. “Noxious” in this context means any species of plant that is, or is liable to be, detrimental or destructive and difficult to control or eradicate. New Mexico state-listed noxious weeds are weeds that are defined Class A, Class B, and Class C species. Class A species are currently not present in New Mexico, or have limited distribution. Preventing new infestations of these species and eradicating existing infestations is the highest priority. Class B species are limited to portions of the state. In areas with severe infestations, management should be designed to contain the infestation and stop any further spread. Class C species are wide-spread in the state. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation. Currently, there are 20 Class A species, 11 Class B species, and 12 Class C species in the state of New Mexico (NMDA, 2009). Noxious weeds from the New Mexico Noxious Weed List that are at a level of concern within the Proposed Project Area can be found below in Table 8.

Table 5. New Mexico Noxious Weeds within the Proposed Project Area that are at a Level of Concern.

Common Name	Scientific Name	Class Designation	Picture
Ravenna grass	*Saccharum ravennae*	Class A	
Russian olive	*Elaeagnus angustifolia*	Class C	
Salt cedar	*Tamarisk spp.*	Class C	

Siberian elm	*Ulmus pumila*	Class C	
Tree of heaven	*Ailanthus altissima*	Class C	

2.6.2 Floodplains and Wetlands

Wetlands consist of marshes, wet meadows, and seasonal ponds that typically support hydrophytic plants such as cattails, sedges, and rushes. Wet meadows were the most extensive habitat type in the Middle Rio Grande valley prior to the construction of the MRGCD drains and ditches (Crawford et al. 1993). Wetlands are an integral component of the Bosque ecosystem, not only increasing its diversity but also enhancing the value of surrounding plant communities for wildlife. Wetlands have experience the greatest historical decline of any floodplain plant community. From 1918 to present, wetland-associated habitats have undergone a 93% reduction (Hink and Ohmart, 1984, Scurlock 1998). Among the greatest needs of the riparian ecosystem are the preservation of existing wetlands and expansion or creation of additional wetlands (Crawford *et al.* 1993).

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by shallow water (Scurlock 1998). Saturation with water determines the nature of soil development and, in turn, the types of plant and animals inhabiting these areas. Wetlands occurring within the riparian zone might be dominated by the same plant species common in the Bosque; however, wetlands exhibit wetter soils and support many additional plant and animal species.

Historically, the Rio Grande channel meandered throughout the floodplain, and abandoned channels often contained sufficient groundwater discharge to support marshes (cienegas), sloughs (esteros), and oxbow lakes (charcos; Scurlock 1998, Ackerly 1999). Currently, the extent of wetland plant communities within the Middle Rio Grande has been significantly reduced. The construction of drains in the 1930s significantly lower the groundwater elevation throughout the valley. Wetland areas throughout the floodplain have been directly displaced by agricultural and urban development. Irrigation and flood control operations have reduced the magnitude of discharges within the floodway, especially during the spring runoff period, and limit the extent of overbank flooding.

Jurisdictional wetlands (relative to the Clean Water Act) do occur in the study area. Most wetlands within the floodway have developed in areas with a high groundwater table. Those in shallow basins or relatively far from the river are likely seasonally or temporarily flooded; that is, inundated during the majority, or just a portion, of the growing season, respectively. Within the Rio Grande Floodway, most islands, point bars, and side channels are periodically inundated by river flows and support marsh, meadow, or shrub wetland communities.

Abandoned channels or depressions deep enough to intersect the regional groundwater table often support permanently or semi-permanently flooded ponds and marshes. The San Antonio Oxbow is an example of this type of abandoned channel within the study area, and the oxbow is one of the largest wetland complexes in the Middle Rio Grande valley. This wetland's water regime is influenced by shallow groundwater and surface water from the Rio Grande, San Antonio Arroyo, and the riverside drain.

Executive Order 11988 (Floodplain Management) provides Federal guidance for activities within the floodplain of inland and coastal waters. Preservation of the natural values of floodplains is of critical importance to the nation and the State of New Mexico. Federal agencies are required to "ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management."

2.6.3 Wildlife

An estimated 494 species of vertebrates might occur in aquatic, semi-aquatic, or riparian habitat in Bernalillo and Sandoval Counties, based on a query of the Biota Information System of New Mexico (access September 2017). This estimate includes 24 species of fish, 11 amphibian taxa, 53 species of reptiles, 320 species of birds, and 86 mammalian taxa. Birds are the most significant group, based on number of taxa, comprising 65 percent of all vertebrate species in the estimate.

Herptile abundance and diversity was found to be greatest in habitats that lacked dense canopy cover and that were characterized by sandy soils and sparse ground cover (Hink and Ohmart 1984). Many of the species found in the bosque were representative of drier upland habitats. Hink and Ohmart (1084) described a distinct assemblage of species associated with denser vegetation cover in mesic or hydric habitats. Common species included tiger salamander (*Ambystoma tigrinum*), western chorus frog (*Pseudocris triseriata*), bullfrog (*Rana catesbeiana*), northern leopard frog (*Rana pipiens*), Great Plains skink (*Eumeces obsoletus*), New Mexico garter snake (*Thamnophis sirtalis dorsalis*), western painted turtle (*Chrysemys picta bellii*), and spiny softshell turtle (*Trionyx spiniferus*). Studies done by Bateman *et al*. (2008) found that eastern fence lizards (*Sceloporus undulates*) and New Mexico whiptails (*Cnemidophorus neomexicanus*) increased in relative abundance after non-native plants were removed. Another common species found in the 2008 study is Woodhouse's toad (*Bufo woodhousii*). The study indicated that removing non-native plants in the understory perhaps allows more opportunities for heliothermic lizards to bask in areas where light penetrates the cottonwood canopy.

Small mammals were found to be more abundant in moister, densely vegetated habitats and those with dense coyote willow than at drier sites (Hink and Ohmart 1984). However, dominant species differed between various habitat types so that a variety of habitats increased the diversity of small mammals in the study area.

Hink and Ohmart (1984) recorded 277 species of birds in the Bosque ecosystem during the Middle Rio Grande Biological Surveys (MRGBS), which took place from 1981 to1983. Highest bird densities and species diversity were found in mature cottonwood/Russian olive stands and in dense, intermediate-aged cottonwood/coyote willow stands, especially along the edges of the levees. Studies done by Finch (2000) indicated that bird densities of the mid-story nest guild show declining trends following treatment and removal of invasive plant species. Removal of some invasive plant species reduced the availability of nesting and foraging substrates for bird species that use the mid-story layer of habitat. Emergent marsh and other wetland habitats also had relatively high bird density and species richness. Thirty of the 46 species of breeding birds found in the Bosque used cottonwood forest habitat. No bird species showed a strong preference for Russian olive stands (Hink and Ohmart 1984). However, when Russian olive was present as a component of the understory in cottonwood stands, the species appeared to influence the quality of those stands for birds. Therefore, the higher bird densities appear to relate to the structure of the habitat rather than species of plant making up that component.

Hawks Aloft, Inc. conducted a follow-up study to the 1980's MRGBS mentioned above by Hink and Ohmart (Hawks Aloft, Inc., 2016). The question they wanted to address was whether the abundance and presence of specific species had changed since the early 1980's. Comparable to the 1980's surveys, approximately 280 bird species were documented during the HAI surveys (detection rates data were calculated from data collected during 2004-2014). However, fewer than 60 species met the criteria to assure an accurate assessment regarding a potential change in status since the early 1980's. Hawks Aloft, Inc., found 15 species that have experienced significant declines and 17 species that have either experienced significant increases or did not occur in central New Mexico during the e3arly 1980's. Some species showing the most significant changes in status are the Yellow-billed Cuckoo (decline), Black-headed Grosbeak (decline), Mourning Dove (decline), Western Meadowlark (decline), Spotted Towhee (increase), and the Summer Tanager.

The MRG is a major migratory flyway for avian species (Yong and Finch 2002). Hundreds of species migrate through and nest within the study area. More recent bird sampling in the RGVSP found 62 species in winter and 90 during the breading season (Stahlecker and Cox 1997). Of the 90 bird species found in summer in RGVSP, only 31 were found in the study area, and 15 of these species and highest bird density in both winter and summer was found in emergent marsh habitat.

According to Stahlecker and Cox (1997), the 10 most common species during the winter of 1996-1997 were Dark-eyed Junco (*Junco Hyemalis*), American Crow (*Corvus brachyrhynchos*), American Goldfinch (*Carduelis tristis*), White-Crowned Sparrow (*Zonotrichia leucophrys*), American Robin (*Turdus migratorius*), Canada Goose (*Branta canadensis*), Red-Winged Blackbird (*Agelaius phoeniceus*), Mallard (*Anas platyrhynchos*), European Starling (*Sturmus vulgaris*), and House Finch (*Carpodacus mexicanus*). The 10 most common species during the summer of 1997 were Black-chinned Hummingbird (*Archilochus alexandri*), Red-winged Blackbird, Black-headed Grosbeak (*Pheucticus melanocephalus*), Spotted Towhee (*Pipilo* *maculatus*), Brown-headed Cowbird (*Molothrus ater*), Mourning Dove (*Zenaida macroura*), Bewick's Wren (*Thryomanes bewickii*), Black-Capped Chickadee (*Poecile atricapillus*), Cliff Swallow (*Petrochelidon pyrrhonota*), House Finch, and European Starling. The most abundant bird species found along the river in winter were Mallard, Canada Goose, and wood duck (Aix sponsa). Red-tailed Hawk (*Buteo jamaicensis*), Cooper's Hawk (*Accipiter cooperii*), Western Screech-Owl (*Otus kennicottii*), and Great-horned Owl (*Bubo virginianus*) also occur in the proposed project area (Stahlecker and Cox 1997).

Along the length of the Rio Grande within New Mexico, 27 native fish species and 33 non-native species are documented (Sublette et al. 1990). Coldwater species are prevalent in the upper reach (upstream of Cochiti Lake) and warm water species occur near Elephant Butte Reservoir. Common fish species of the MRG include river sarpsucker (*Carpoides carpio*), flathead chub (*Platygobio gracilis*), common carp (Cyprinus carpio), western mosquitofish (*Gambusia affinis*), and red shiner (*Cyprinella lutrensis*) (Platania 1993). Less common fish species present in the system are channel catfish (Ictalurus punctatus), fathead minnow (Pimephales promelas), longnose dace (*Rhinichthys cataractae*), white sucker (*Catostomus commersoni*), and the Rio Grande silvery minnow (*Hybognathus amarus*). Critical habitat for the endangered Rio Grande silvery minnow is present in the river adjacent the Proposed Project Area. Western mosquitofish, white sucker, and common carp are introduced species that are now common throughout the MRG.

2.7 Special Status Species

Three agencies have responsibility for the conservation of animal and plant species in New Mexico are the USFWS, under authority of the Endangered Species Act of 1973, as amended; the New Mexico Department of Game and Fish, under the authority of the Wildlife Conservation Act of 1974; and the New Mexico Energy, Mineral, and Natural Resources Department, under authority of the New Mexico Endangered Plant Species Act and Rule No. NMFRCD 91-1. Each agency maintains a list of animal and plant species that have been classified, or are candidates for classification, as endangered or threatened based on resent status and potential threat to future survival and recruitment. Within the study area, the Information for Planning and Consultation (IPaC)(https://ecos.fws.gov/ipac/), which is a planning tool that assists the USFWS, identifies five species that are federally listed under the Federal Endangered Species Act (ESA). Federally-listed endangered species include the Rio Grande silvery minnow (*Hybognathus amarus*) (RGSM), Southwestern Willow Flycatcher (*Empidonax traillii extimus*) (SWFL), and the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). Federally-listed threatened species include the Mexican Spotted Owl (*Strix occidentalis lucida*) and the Yellow-billed Cuckoo (*Coccyzus americanus*)(YBCC). Table 6 contains the five Federally listed species. Critical habitat has been designated under the ESA within the study area for the RGSM and YBCC. That is, the USFWS has determined that these habitats are critical to the continued existence and recovery of these species. Three of the federally listed species, the RGSM, SWFL, and YBCC, have been documented in the study area, and will be further discussed below.

Table 6. Special status species with the potential to occur in the study area.

Common Name	Scientific Name	Federal Listing	Date of Listing	Critical Habitat	Habitat Type	Presence in Project Area
Rio Grande silvery minnow	*Hybognathus amarus*	Federal Endangered	1994	Yes, in project area	Aquatic	Yes
Mexican Spotted Owl	*Strix occidentalis lucida*	Federal Threatened	1993	Yes, but not within project area	Subalpine coniferous forest	No
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Federal Endangered	1995	Yes, but not within the project area	Dense riparian	As migrant only
Yellow-billed Cuckoo	*Coccyzus americanus*	Federal Endangered	2014	Yes, in project area	Riparian	Yes, has been detected
New Mexico meadow jumping mouse	*Zapus hudsonius luteus*	Federal Endangered	2014	Yes, but not within project area	Dense riparian/wetland	No

2.7.1 Rio Grande Silvery Minnow

Rio Grande silvery minnow (*Hybognathus amarus*)(RGSM) historically occurred in the Rio Grande drainage in New Mexico and Texas (Lee et al. 1980, Propst 1999). The species was historically one of the most abundant and widespread fishes in the Rio Grande drainage (Bestgen and Platania 1991). In New Mexico, the historic range of the species included the Rio Chama from Abiquiu to the Rio Grande confluence, the main stem of the Rio Grande from Velarde downstream to the New Mexico-Texas state line, and the Pecos River downstream from Santa Rosa (Sublette et al. 1990). RGSM was extirpated from the Rio Grande downstream of the Pecos River by 1961 and from Pecos River by the mid-1970s. This species was also extirpated from the Rio Grande upstream form Cochiti Dam and downstream from Elephant Butte Reservoir. One of the greatest threats to its survival is poor water quality. Currently, RGSM is present only in the Rio Grande between Cochiti Reservoir and the upper end of the Elephant Butte Reservoir, which represents less than 10% of its historic distribution (Bestgen and Platania 1991, Propst 1999). Abundance of RGSM has declined markedly from 1994 to the present time and the population has become concentrated in the reach of the Rio Grande between San Acacia Diversion Dam and the headwaters of Elephant Butte Reservoir.

Designated critical habitat for the Middle Rio Grande extends from Cochiti Dam downstream to the utility line crossing the Rio Grande at the upstream end of the Elephant Butte Reservoir, which means that there is designated critical habitat within the Proposed Project Area. The designation excludes the tribal lands of Santo Domingo, Santa Ana, Sandia, and Isleta Pueblos.

The USFWS considered the Lower Rio Grande around Big Bend National Park, and the Pecos River between Ft. Sumner Dam and Brantley Reservoir for critical habitat but elected not to designate these areas even though they are essential to silvery minnow conservation (e.g., possible re-introduction). For all of these reaches, the later extent of critical habitat includes those areas bounded by existing spoil banks or their replacement levees. In areas without these structures, the lateral extent of critical habitat is defined as 300 feet (91.4m) of riparian zone adjacent to each side of the river.

RGSM is a pelagic-broadcast spawner, producing non-adhesive, semi-buoyant eggs (Platania and Altenbach 1998). Spawning is initiated by elevated stream discharge and occurs primarily in the late spring and early summer when water temperatures range between 68˚F and 75˚F (Propst 1999). Females can produce three to 18 clutches of eggs, each clutch numbering from 200 to 300 eggs. Growth to maturation occurs in about two months. RGSM typically live only about one year, with less than 10% of the adult population surviving up to two years (Platania and Altenbach 1998, Propst 1999). Habitat used by adult RGSM is characterized by silty to sandy substrate, depths of eight inches to 2.6 feet, and slow to moderate current velocity ranging from zero feet/second to 0.98 feet/second (Dudley and Platania 1997). Habitats with slow current velocity and associated cover are used in winter. RGSM feed on algae and detritus (Propst 1999, USFWS 1999). Major threats of persistence to RGSM include diminution of river flows and dewatering by surface water diversions and dam regulation, modification of aquatic habitats that result in faster current velocities and narrower channels, and introduction of non-native fishes (USFWS 1999). Recovery of RGSM requires stabilizing the population in the MRG and reestablishing the species in suitable habitats within its historic range (USFWS 1999).

Dudley and Platania (1997) documented habitat preferences of RGSM. They found that individuals were most commonly collected in shallow water (less than 40 centimeters [cm]) with low-water velocities (less than 10cm/second [cm/s]) and small substrate size, primarily silt and sand. Low-velocity habitats, such as backwaters and embayments, provide nursery areas for larvae (Dudley and Platania 1997), which grow rapidly in these areas. Restoration efforts that increase the availability of these habitat conditions would benefit RGSM. In addition to the quantity of preferred habitat, food availability might be influenced directly by river restoration activities. RGSM are herbivores that eat primarily diatoms, cyanobacteria, and green algae associated with sand or silt substrates in shallow areas of the river channel (Shirey 2004).

Recent research (Pease *et al* 2006; Porter and Massong 2004, 2006; U.S. Bureau of Reclamation 2007) indicates nursery habitat on inundated point bars, islands, and the floodplain provide essential conditions for spawning, with survival of RGSM eggs and larvae. Increased recruitment during average spring flow result in increased fall populations (US Army Corps of Engineers 2007), supporting the value of habitat restoration and hydrograph management for producing RGSM in the river. Currently, *Hybognathus amarus* is the only remaining endemic minnow with semi-buoyant eggs in the MRG. The pelagic spawning speckled chub (*Extrarius aestivalus*), Rio Grande shiner (*Notropis jemezanus*), phantom shiner (*Notropis orca*), and bluntnose shiner (*Notropis simus simus*) are either extinct or have been extirpated from the MRG (Bestgen and Platania 1991).

The remaining population of the slivery minnow is restricted to approximately ten percent of its historic range. Every year since 1996, at least one drying event in the river has negatively affected the silver minnow population. The population is unable to expand its distribution because poor habitat quality. In addition, dams prevent upstream and downstream movement (USFWS 1999). Augmentation of silvery minnows with captive-reared fish will continue; however, continued monitoring and evaluation of these fish is necessary to obtain information regarding the survival and movement of individuals.

Several habitat restoration projects have been completed in the Albuquerque reach through the Middle Rio Grande Endangered Species Collaborative Program and other agencies. These projects include two woody debris installation projects to encourage the development of pools and wintering habitat, and a river bar modification project south of the Interstate 40 Bridge designed to create side and backwater channels on an existing bar as well as modify the top surface of the bar to create habitat over a range of flows. Additionally, in 2005, the NMISC started a multi-year habitat restoration program that implements several island, bar, and bank-line modification techniques throughout the Albuquerque reach. In April, USACE completed the Rio Grande Nature Center Habitat Restoration Project, which reconnected an ephemeral side channel to the river for silvery minnow habitat. USACE, outside of the MRGESCP, completed the Middle Rio Grande Ecosystem Restoration Project in 2012. This project provided habitat for the RGSM and created additional suitable nursery habitat through the creation of high-flow channels with embayments.

Various conservation efforts also have been undertaken in the past, and other efforts are currently being carried out in the MRG. Fish community surveys have been conducted since 1993 (with the exception of 1998) in the Rio Grande of New Mexico between Angostura Diversion Dam (RM 209.7) and Elephant Butte Reservoir (RM 58.8). Silvery minnow abundance increased during 2003-2005. Abundance declined in 2006, however, increased the following year until 2009. Abundance declined progressively from 2010 to 2013 before increasing markedly from 2014-2016 (Dudley et al 2017).

2.7.2 Southwestern Willow Flycatcher

The Southwestern Willow Flycatcher (flycatcher) is found in the U.S. from May until September. It winters in southern Mexico, Central America, and northern South America (Unitt 1987). In New Mexico, the flycatcher is distributed in nine drainages (Gila River, Rio Grande, Rio Chama, Coyote Creek, Nutria Creek, Rio Grande de Ranchos, Zuni River, Bluewater Creek, and San Francisco River). The flycatcher is an endangered species on the USFWS Endangered Species List, and Critical Habitat has been designated in the MRG, though not in the proposed project area. As of 1996, it was estimated that there were only about 400 Southwestern Willow Flycatchers in New Mexico, representing about 42% of the total population of the subspecies. Southwestern Willow Flycatchers occur in riparian habitats along rivers, streams, or other wetlands, where dense growth of willows (*Salix* spp.), Baccharis, arrowweed (*Pluchea* sp.), salt cedar or other plants are present, often with a scattered overstory of cottonwood (Unitt 1987, Sogge *et al*. 1997, Finch and Stoleson 2000). These riparian communities provide nesting and foraging habitat. Throughout the range of Southwestern Willow Flycatcher, these riparian habitat tends to be rare, widely separated, and often liner locales, separated by vast expanses of arid lands. The flycatcher is endangered by extensive loss and modification of suitable riparian habitat and other factors, including brood parasitism by the Brown-Headed Cowbird (*Molothrus ater*, Unitt 1987).

The Southwestern Willow Flycatcher is an obligate riparian species and nests in thickets associated with streams and other wetlands where dense growth of willow, Russian olive, salt cedar, or other shrubs are present. Nests are frequently associated with an overstory of scattered cottonwood. Southwestern Willow Flycatchers nest in thickets of trees and shrubs approximately six to 23 feet in height or taller, with a densely vegetated understory approximately 12 feet or more in height. Surface water or saturated soil is usually present beneath or next to occupied thickets (Muiznieks *et al*. 1994). At some nest sites, surface water might be present early in the breeding season with only damp soil present by late June or early July (Muiznieks et al. 1994). Habitats not selected for nesting include narrow (less than 30 feet wide) riparian strips, small willow patches, and stands with low stem density. Suitable habitat adjacent to high gradient streams, and stands with low stem density. Suitable habitat adjacent to high gradient streams does not appear to be used for nesting. Areas not utilized for nesting might still be used during migration. Breeding pairs have been found within the MRG from Elephant Butte Reservoir upstream to the vicinity of Española. Southwestern Willow Flycatchers begin arriving in New Mexico in early May. Breeding activity begins immediately, and young might fledge as soon as late June. Late nests and renesting attempts might not fledge young until late summer (Sogge *et al*. 1997).

Occupied and potential Southwestern Willow Flycatcher nesting habitat occurs within the MRG. Occupied and potential habitat is primarily composed of riparian shrubs and trees, chiefly Goodding's willow and peachleaf willow, Rio Grande cottonwood, coyote willow, and salt cedar. The nearest known breeding Southwestern Willow Flycatchers from the proposed project area occur along the Rio Grande at Isleta Pueblo. Potential habitat exists adjacent to the proposed project area. Designated Critical Habitat was determined for the flycatcher in November 2005 but is not located within the project area.

Since 2004, USACE has contracted Hawks Aloft to conduct Willow Flycatcher surveys; in 2016, surveys were conducted at six sites: Brown Burn, Durand Outfall, I-25 West, Rio Bravo Northeast, South Corrales, and Tingley Bar. Six Willow Flycatchers were detected in survey areas in 2016 (Hawks Aloft, 2016). All six were detected in the first survey period meaning that there were no detection during the second and third survey periods. The detections occurred at Brown Burn, I-25 West, and at South Corrales. In 2017, surveys were conducted by Tetra Tech and USACE. Southwestern Willow Flycathers were detected during the first survey period only. They were detected at the following locations: Sandia Pueblo, Corrales, Oxbow, Tingley, Rt.66, Rio Bravo NE and SE, and Isleta. No detection were made during the second or third survey periods.

2.7.3 Western Yellow-billed Cuckoo

In the Southwestern U.S., cuckoos typically arrive at their breeding grounds by late-May/early-June and initiate migration back to their wintering grounds by late-August (Halterman *et al.* 2000). In New Mexico, nesting activities typically begin in mid-June and end in late August (Hughes 1999). Fall migration from its breeding grounds in New Mexico generally occurs from late-August through mid-September (Halterman *et al.* 2000). On October 3, 2014, the USFWS published the final rule to list the Western U.S. Distinct Population Segment ("DPS") of the Yellow-billed Cuckoo (*Coccyzus americanus occidentalis;* cuckoo) as a Federally threatened species (Service 2014a).

The USFWS identified cuckoos west of the Continental Divide as a Distinct Population Segment (DPS) based on physical, biological, ecological and behavioral factors; but in central and southern New Mexico, the boundary of the western DPS is along the crest of the southern Rocky

Mountains (see Figure 6) (USFWS 2014b). Cuckoos currently breed in California, Arizona, New Mexico, Utah, Wyoming, Colorado, Idaho, and Texas (USFWS 2014a). The State of New Mexico currently does not include the cuckoo in any formal protection category.

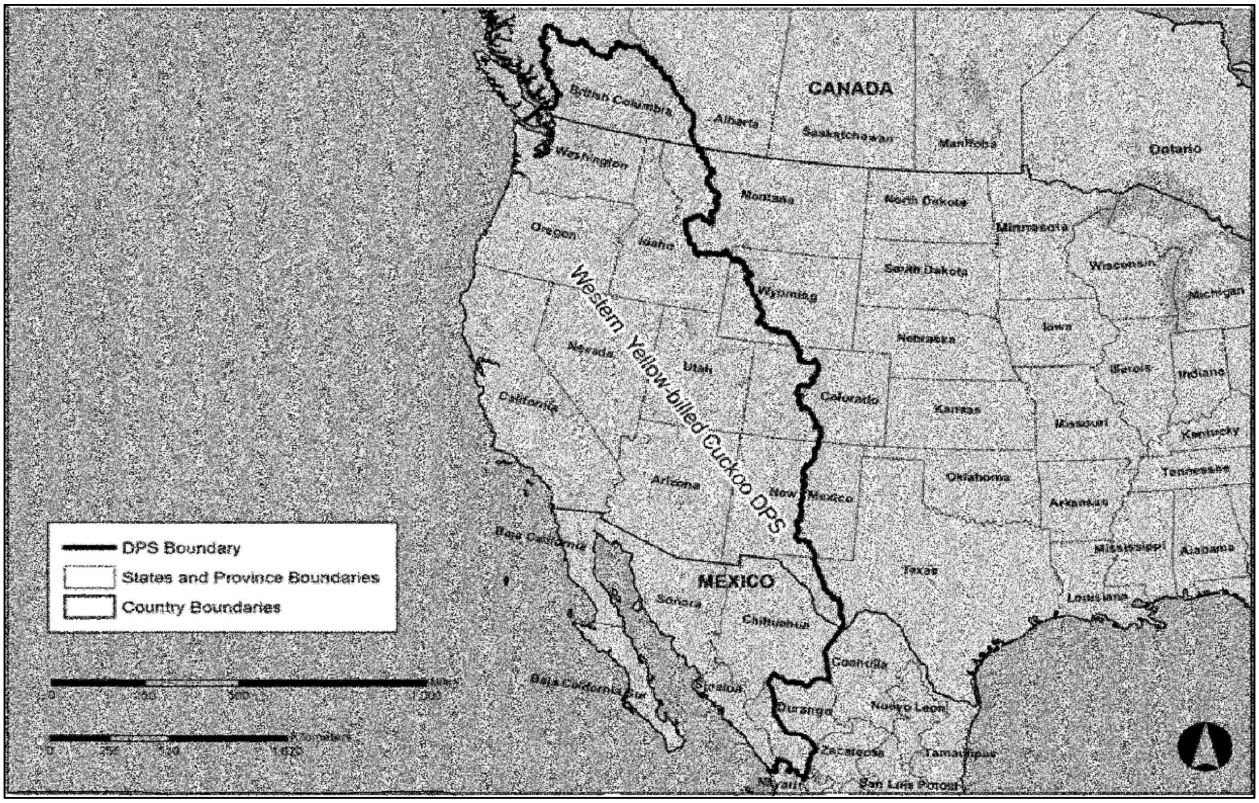

Figure 13. Range of the Western Distinct Population Segment of the Yellow-billed Cuckoo.

Critical habitat for the Western U.S. DPS was proposed on August 15, 2014 (USFWS 2014b) in 80 separate units in Arizona, California, Colorado, Idaho, Nevada, New Mexico, Texas, Utah, and Wyoming. Proposed critical habitat in the action area is within Unit 52, NM-8, and includes the Rio Grande from Elephant Butte Reservoir in Sierra County upstream through Socorro, Valencia, and Bernalillo Counties to below Cochiti Dam in Cochiti Pueblo in Sandoval County.

The cuckoo nests almost exclusively in low- to moderate-elevation riparian woodlands with native, broadleaf trees and shrubs that are at least 50 acres in size and at least 325 ft (100 m) in width (USFWS 2013d). Areas with strips of habitat less than 325 feet in width are rarely occupied by cuckoos (USFWS 2014b). Nests are typically associated with dense patches of broad-leaved deciduous trees, usually with a relatively thick understory (Hughes 1999). In New Mexico, cuckoo's nest in large patches of riparian vegetation with a cottonwood (*Populus deltoides*) / Goodding's willow (*Salix gooddingii*) overstory (Ehrlich *et al.* 1988) with a dense understory that may include saltcedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*) or native vegetation (e.g. *Salix* spp.) (Reclamation 2013a; Sechrist *et al.* 2009). Territories range in size from 4 to 40 ha (Halterman 2001), with an average home range size of 82 ha (Sechrist *et al.* 2009). The cuckoo prefers patch dimensions larger than 100 × 300 m, and exceeding 80 ha (200 ac) in area (USFWS 2014a).

In 2016, USACE started conducting official surveys for the Yellow-Billed Cuckoo using the current standard survey protocol. In 2016, USACE surveyed eight sites (from Corrales to the northern boundary of Isleta Pueblo) during five different survey periods. There were no detections at any of the sites during any survey period. In 2017, USACE and Tetra Tech (under contract by USACE) conducted Yellow-Billed Cuckoo surveys within the same footprint as the year prior. Again, no detections were made. As mentioned above, Hawks Aloft (under contract by USACE) has done yearly Southwestern Willow Flycatcher surveys since 2004. During one of their surveys in 2014, a Yellow-Billed Cuckoo was documented during the second survey period at Brown Burn (located approximately 5km south of Rio Bravo Blvd on the west side of the Rio Grande in Albuquerque)(Hawks Aloft, 2016). However, no detections have been made since.

2.8 Generating a Target Mosaic

As noted above in *Historic and Existing Vegetative Conditions*, the nature of the Bosque and the mosaic of habitats or patches have changed dramatically since the 17th Century (Pittenger 2003, Scurlock 1998). With changes in land use and settlement, the size and composition of various patches within the Bosque have also changed. The existence in recent decades of a continuous mature cottonwood forest between the river and the levee appears to be unprecedented. That is, changes in land use had resulted in a Bosque dominated by a single habitat type made up of mature cottonwood trees with sparse understory and a grassy groundcover. Many Bosque researchers and commentators now believe that historically the Bosque was a dynamic mosaic of riparian wetlands, channels, woodlands, shrub thickets, and periodically wet meadows (Pittenger 2003, Crawford et al. 1998). Frequency of flooding, water table elevation, and the type of sediment substrate were and continue to be important determining factors of patch type and structure. The formerly dynamic river would destroy old growth forests and create wetlands, willow stands, channels, and areas recolonized by new cottonwood stands through river meandering across the unencumbered floodplain. Frequency of flooding, water table elevation, and the type of sediment substrate were, and continue to be, important determining factors of patch type and structure.

Although all Bosque patch types contribute to the overall habitat value of the Bosque, key types of patches support a larger number of species and individuals, including wetlands and patches with thicker vegetation (Hink and Ohmart 1984, Pittenger 2003, Najmi et al. 2005). The latter would include Bosque forest or woodland areas with denser understories and shrub thickets. Hink and Ohmart's survey and subsequent research suggests that the edges of these patches, especially where they meet channels, open meadows or wetlands, are of particular importance for wildlife. Therefore, an overall mosaic that includes both "open" and "dense" patches as well as wet areas is the key to maximizing restoration opportunities.

Because of the importance of the mosaic to the goal of wildlife restoration, it was determined that a target mosaic consisting of various types of habitat including varying-aged cottonwood stands, shrub patches, grass meadow, and wet measures (high-flow channels, backwater channels, willow swales) should be a basis for the planning process. The target mosaic needed to be based on accounts or descriptions of the Bosque prior to major flood risk management measures., yet no such accounts exist prior to the 20th Century. Written Information descriptions of habitat types were completed prior to the 20th century (Scurlock 1998) on the composition of the Bosque was recorded beginning in the early 20th Century. Starting in 1918, there are surveys of the vegetation types and communities along the MRG (Pittenger 2003). Aerial photographs were taken in 1935 and subsequently have been interpreted to generate vegetation cover maps. Beginning with the work done by Hink and Ohmart, vegetation in the MRG has been surveyed and classified by community type and structure on a decennial basis.

As in Section 2, the riparian ecosystem of the study area was much larger and functioned very differently than it does now. Periodic flood events maintained a dynamic Bosque with a mosaic of patches diverse in size, age, and species composition. With urbanization and the advent of flood risk management measures, however, flooding to the former extent is not possible in the study area (Pittenger 2003). The goal of the restoration project is to continue to provide for a more natural condition to the study area that approximates the pre-flood risk management habitat mosaic. As mentioned above, the MRG Bosque Restoration Project, which was completed in 2014, is very similar to what is being proposed. All restoration measures that are part of the Proposed Action also were constructed under the MRG Bosque Restoration Project. Under the MRG Bosque Restoration Project, in order to evaluate the most current conditions and to project potential alternative vegetative mosaics, the PDT decided to use a newer modeling tool. The Habitat Evaluation Assessment Tool (HEAT) model combines the Habitat Evaluation Procedure (HEP) with some hydrological components in order to evaluate projects that would provide reconnection between the Bosque and river. The modeling tool and how it was used is further described in Appendix F, Model Documentation Report.

2.9 Habitat Modeling

To evaluate the ecological benefits of proposed ecosystem restoration plans, USACE and its stakeholders needed an assessment methodology that could capture the complex ecosystem process and patterns operating at both the local and landscape levels across multiple habitat types. Two methodologies were used to determine outputs of the restoration project. These methodologies used HEP to quantify outputs and based their habitat value on Habitat Suitability Index (HSI) and Spatial Heterogeneity Index (SHI), respectively. Each of these methodologies is discussed in detail in the Model Documentation Report (Appendix F). USACE guidance on ecosystem restoration requires that benefits from the project meet the objectives listed in Engineer Regulation 1105-2-100, specifically, "The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the absence of human changes to the landscape and hydrology." Because the HSI describes outputs in line with this guidance, the NER plan and, therefore, the recommended plan were selected using the HSI model only. For the purposes of this document, the discussion of benefits are restricted to the HSI outputs leading to the NER plan.

2.9.1 Using HEP to Assess the Habitat Potential (Suitability)

Habitat Suitability Indices are simple mathematical models that reflects a species' or community's sensitivity to a change in a limiting factor (i.e., variable) within the habitat type. Traditional HSI models reflect the basic requirements for a species existence such as food, shelter, water, and reproduction. These models provide a method of measuring habitat variables to determine the "suitability" of a habitat to support a population of that species. These measurements, or SI, are used in the HEP framework to quantify the outcomes of impact, mitigation, or restoration scenarios. These suitability relationships are depicted using scatter plots and bar charts (i.e., suitability curves). The SI value (Y-axis) ranges from 0.0 to 1.0, where an SI = 0.0 represents a variable that is extremely limiting, and an SI = 1.0 represents a variable in abundance (not limiting) for the species or community.

For these reasons, a community based HSI becomes a more useful tool in assessing habitat in this region. The community based HSI treats the habitat community, in this case the Bosque, as an organism, and the HSI include those functional components that the Bosque needs to persist.

Under the MRG Bosque Restoration Project, a series of ten workshops were held over the period of three years (2005-2008) to develop models, characterize baseline conditions of the study area, then formulate plans and assess alternatives for the ecosystem restoration study. Along with the U.S. Army Engineer Research and Development Center's Environmental Lab (ERDC-EL), several federal, state, and local agencies, as well as local and regional experts from the stakeholder organizations, and private consultants, participated in the model workshops. This group who attended these workshops were referred to as the "E-Team". The Bosque Community HSI model was developed under this paradigm. A summary follows; however, the details of these metrics are presented in the Model Documentation Report (Appendix F). As a first step in the index model development process, the E-Team, along with assistance from ERDC-EL, developed a conceptual model to illustrate the relationships between these system-wide drivers and stressors and tried to highlight the ecosystem responses to these pressures across the entire Rio Grande-Albuquerque watershed (see Figure 14).

For the Bosque (Riparian) Community Index Model (BCIM) three categories: (1) Hydrology, (2) Structure/Soils/Biotic Integrity, and (3) Spatial Integrity and Disturbance were identified as the key functional components necessary to model the ecosystem integrity of MRGB's Bosque community. Flow diagrams best illustrate the model's component relationships. Figure 15 shows two versions of the model; model use depends on the cover types being evaluated. Cover Types 1 through 5 (Forest and Shrubs) use the upper diagram, and Cover Type 6 (Marsh and Wet Prairies) uses the lower diagram.

During the early planning phase of this proposed project, the PDT discussed the benefits of using the HEAT software, which is certified for national use, as well as the Bosque Community HSI. Because the study area for this proposed project was within the same footprint as the MRG Bosque Restoration Project and had similar restoration measures, the PDT, in coordination with the ECO-PCX, decided to use these tools. Furthermore, the PDT used outputs from a previous run of the model that was run under the MRG Bosque Restoration Project. The PDT's biologist validated these outputs by gathering data from the same vegetation transect lines that were used under the MRG Bosque Restoration Project. Data collected showed similar information to the projected trends that were developed under the MRG Bosque Restoration Project. In order to use the Bosque Community HSI model, the PDT had to go through a review and approval process with the ECO-PCX. On January 13, 2018, the ECO-PCX granted a draft single-use recommendation for the proposed project. The recommendation memo has been submitted to the ECO-PCX Director for approval under the delegated approval authority.

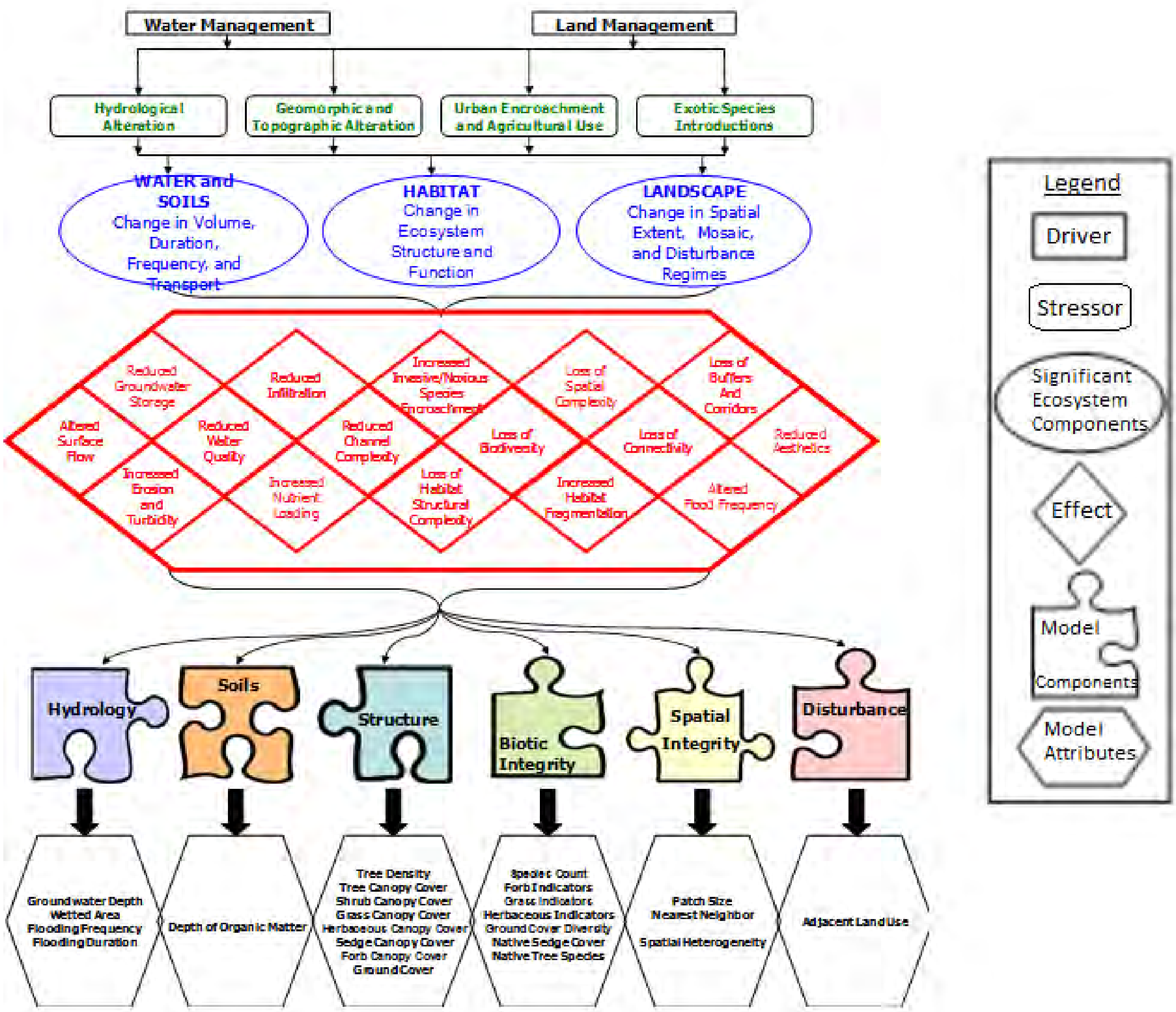

Figure 14 Conceptual Model for the Middle Rio Grande Bosque Ecosystem.

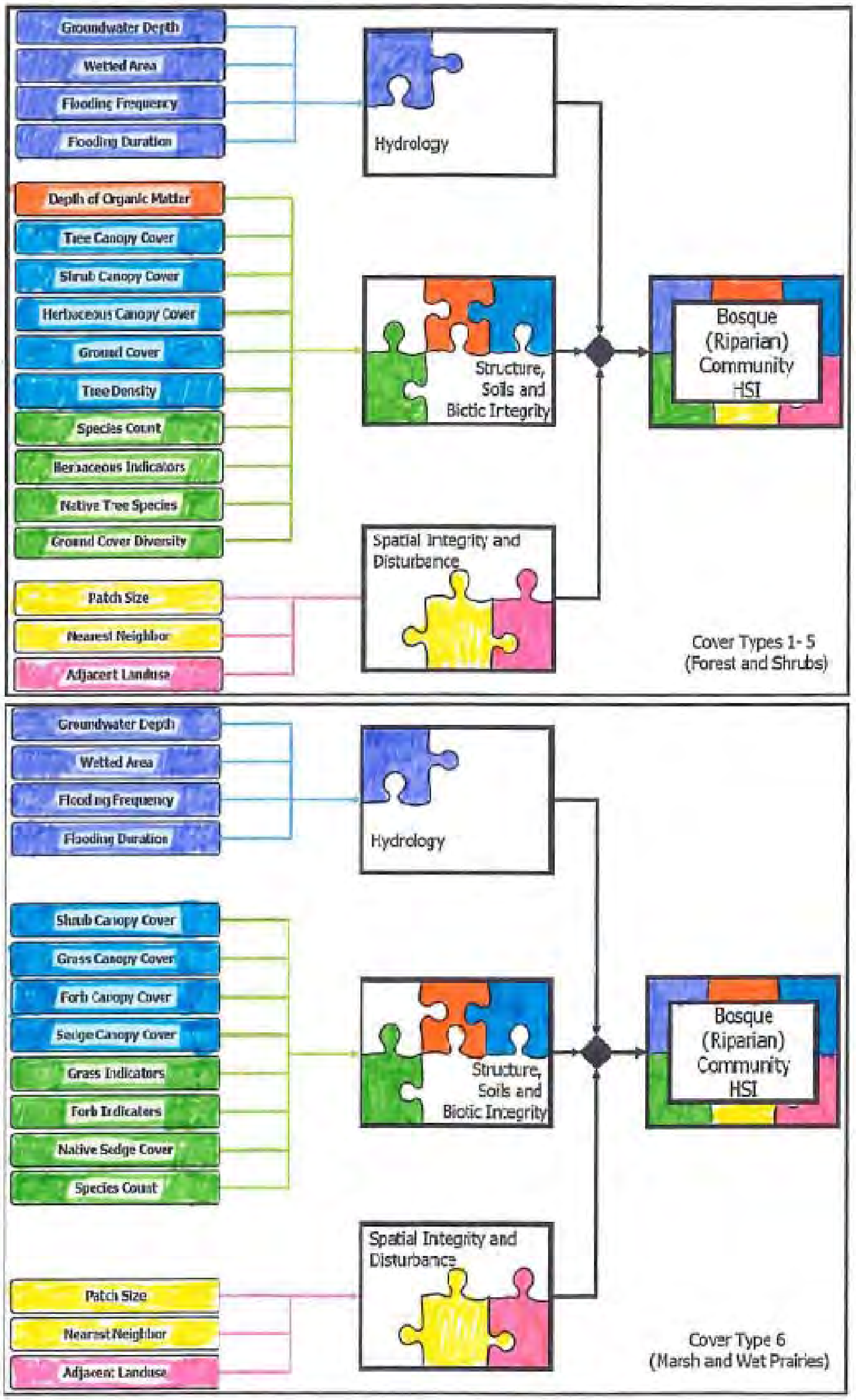

Figure 15 Flow diagram depicting combinations of model components and variables to from the Bosque community index model.

2.10 Cultural Resources

Section 106 of the National Historic Preservation Act [54 U.S.C § 300101 et. seq.] (NHPA) and its implementing regulations, 36 CFR Part 800, require Federal agencies to take into account the effects of their undertakings (e.g., projects or permits) on historic properties. Historic properties are legally considered to be those properties (cultural resources) eligible for listing on the National Register of Historic Places (NRHP). To be eligible for listing, a property must have "the quality of significance in American history, architecture, archeology, engineering and culture" that can be "present in districts, sites, buildings, structures, and objects" and which must "possess integrity of location, design, setting, materials, workmanship, feeling, and association" and meet at least one of a set of four criteria relating to association with historical events, historically significant people, distinctive characteristics of a period or style, and/or are likely to yield information important to prehistory or history. There are many of examples of historic properties, including archaeological sites, historic structures, traditional cultural properties (TCPs), and historic districts.

In order to comply with Section 106 of the NHPA, Federal agencies must consult on the effects of their undertakings on historic properties with the State Historic Preservation Officer (SHPO), Native American Tribes, other stakeholders, and the public. In the case of undertakings on tribal lands of Tribes that have assumed the role of the SHPO pursuant to Section 302702 of the NHPA, the Tribal Historic Preservation Officer (THPO) for that Tribe will be consulted. At the time of this report, no portion of the project falls on tribal lands.

Considerable information is available from archaeological resources within the Middle Rio Grande Valley. Archaeological sites in the valley span nearly the entire known period of human occupation in North America. See Appendix C, Cultural Resources for a culture history narrative of the Middle Rio Grande Valley.

2.10.1 Summary of Cultural Resources Inventory

This section reviews the results of data investigations using the New Mexico Cultural Resources Information System (NMCRIS) database to identify known cultural resources within the study area. In addition, information about TCPs is discussed along with expectations of future cultural resources surveys. National and State listed properties are identified.

A review of Corps records and an online records check of the NMCRIS database was conducted on September 26, 2017. Within reaches 2 through 5, there are 48 surveys, and 32 previously recorded historic properties (See Tables 1 and 2 of Appendix C, Cultural Resources). Of the 4,120.5 total acres in reaches 2 through 5, 2,360.1 acres (57%) have been previously surveyed for cultural resources. Of the 32 properties, 11 are considered eligible to the NRHP, 11 are of undetermined eligibility, and 8 have been determined not eligible. Two properties immediately adjacent to reaches 2 through 5 are included in Table 2 of Appendix C because they are listed on the State Register of Cultural Properties (SRCP) and the NRHP, and depending on the location of the preferred alternative, may need to be considered during project planning. All 32 archaeological sites are historic in age, and most date to within the last 100 years.

2.10.2 Tribal Consultation and Traditional Cultural Properties

Consistent with the Department of Defense's American Indian and Alaska Native Policy of 1998, and pursuant to 36 CFR 800.2(c)(2)(i), tribal consultation on this project will be conducted with all Native American tribes that indicated they have concerns in Bernalillo County. This consultation will take place immediately after the results of the cultural resources survey are known, and before this document is submitted for agency technical review and public comment.

Traditional Cultural Properties (TCPs) are recognized and protected by the National Historic Preservation Act, and are defined and described in National Register Bulletin 38 (Parker and King, 1990). A TCP is defined as a property "that is eligible for inclusion in the National Register because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community" (Parker and King 1990:1). TCPs are often hard to recognize; they can even be a natural feature, such as a lake or mountaintop.

TCPs are rarely recognized during archaeological survey; rather, Tribes are the best source of knowledge on their TCPs. However, Tribes are often reluctant to discuss TCPs, due to the often deep religious and cultural significance they carry, and may be reluctant to provide the location of those properties on a map. By working closely with Tribal partners, projects can be designed to minimize or avoid impacts to TCPs. USACE is not currently aware of any Traditional Cultural Properties within the project area.

2.10.3 State and National Register Listed Properties

In addition to the NMCRIS search for surveys and historic properties, a records check of State and National Register properties was conducted on September 26, 2017. None of the sites within the project area are currently listed on either register. However, two properties listed on both the State and National Registers share a border with the general project area: The Los Poblanos Historic District (SR# 853, NR# 82003321, 4803 Rio Grande Avenue NW) and the West San Jose School (SR# 1645, NR# 96001385, 1701 4th Street NW). These properties should be taken into consideration when planning for project effects.

2.10.4 Expectations for Future Cultural Resources Inventories

At present, approximately 60% of the total area of Reaches 2 through 5 has been surveyed for cultural resources. Site density within the Rio Grande Floodway tends to be very low, and is mostly limited to historic sites, most of which are less than 100 years old.

Subsequent to completion of the archaeological investigation, USACE will consult with interested parties including the State Historic Preservation Officer and Native American Tribes regarding the survey results, eligibility, and project effects to historic properties. If cultural resources occur within or adjacent to a project area, avoidance is preferred and dependent upon the significance of the historic property, the project will be redesigned to avoid the historic property.

Construction of the proposed projects within Reaches 2 through 5 will be a multi-year, multi-project undertaking and for this reason it is not currently possible to identify all necessary project locations, staging areas and access routes. As these areas are identified during planning for each construction phase, USACE will perform cultural resources inventories and consultation with the SHPO and tribes as appropriate prior to beginning construction of each project.

Pursuant to 36 CFR 800.13, should previously unknown artifacts or archaeological resources be encountered during construction, work would cease in the immediate vicinity of the resource. A determination of significance would be made, and a mitigation plan would be formulated in consultation with the State Historic Preservation Officer and American Indian Tribes that have cultural concerns in the area. USACE' construction contract plans and specifications have provisions to ensure that all known and unknown historic properties eligible for nomination to or listed on the National Register of Historic Places are protected.

2.11 Land Use and Recreational Resources

2.11.1 Land Use

Land use in the bosque is limited today to a floodway with passive recreation and educational uses. Historically, the bosque had a rich legacy as a cultural landscape, which has already been described in detail above. Most of the historic uses such as wood cutting and agriculture have either been outlawed or displaced to adjacent areas.

As with many bottomlands on the margins of urban areas, the bosque also has long functioned as a dump. Early levee construction and armoring techniques also employed the dumping large amounts of construction debris. This use of the bosque continued until relatively recently, with construction debris from as late as the 1980s present in some areas along the levees. In general, dumping has been one of the most frequently raised concerns of community members and stakeholders alike, and the OSD has worked diligently to curb the dumping within the RGVSP limits.

Land use adjacent to the bosque also has changed a great deal over time. Currently, the primary uses are either residential or public in the form of the Albuquerque Biological Park (Zoo, Botanical Garden, and Aquarium) or one of a number of Bernalillo County and City of Albuquerque Parks. Other land uses within and adjacent to the Proposed Project Area include flood control structures (such as levees and drains), bridges crossing the river, and other restoration projects mentioned above. Historically, similarly situated floodplain the MRG areas would have been a mosaic of wetlands, especially salt grass meadows, pasture lands, irrigated croplands and dumps. With the advent of major flood control measures, the active floodplain has been reduced to a tiny sliver; residential and other urban uses have claimed land that was formerly considered undevelopable right up to the riverside drain. The current mosaic of adjacent land uses tends to be patterned by the bridges and more recent commercial uses. Dumps and major industrial areas have become public parks and open spaces (for example the Albuquerque Country Club Golf Course, Kit Carson Park, the Zoo, and the County Open Space that had been the Serna Trucking Site). There are still isolated areas of irrigated farmland, small pastures and other rural uses adjacent to the riverside drain which lies between the bosque and private homes.

The Proposed Action Area is located in Bernalillo and Sandoval Counties. The area is within the *Facilities of the Middle Rio Grande Floodway Project*. The bosque area within Albuquerque is designated as the RGVSP through the Park Act of 1983 and is cooperatively managed by the OSD and MRGCD. These relationships have been long-term involvement in this stretch of the river. All parties have agreed to continue collaborative work to manage, maintain and monitor this site. All applicable permits and licenses would be obtained from the appropriate agency as listed above.

2.11.2 Recreational Resources

The Proposed Action Area lies within the RGVSP. The RGVSP received heavy use from walkers, joggers, equestrians, and bicyclists along its estimated 24.6 miles of trails, although precise numbers are not available. Trails within the RGVSP exist on both sides of the river and are a natural surface (in most cases dirt though in some cases a formalized crusher fine trail has been constructed). Various levels of recreation take place on the paved trail including jogging, bicycling, roller blading and walking. On the natural surface trails jogging and walking take place but mountain biking and horseback riding are also favorite uses. No motorized vehicles, except for maintenance and emergency vehicles, are allowed per City of Albuquerque and Bernalillo County ordinances.

Another recreational activity that takes place is fishing. Within the RGVSP, there are various fishing locations. Tingley Ponds is the main fishing location, with two large fishing ponds a children's fishing pond. Other areas remaining open to anglers include the Rio Bravo Picnic Area fishing pier, which is over the drain at the northeast corner of Rio Brave and the river. Other fishing takes place on the drain at Paseo del Norte, Bridge Street on the east side of the river and other various locations through these are not formalized.

The remainder of the Proposed Action Area is frequented by hikers, equestrians along informal trails and roads. The current trail network is poorly configured; duplicate trail segments run throughout the area. The use of informal trails in some places has caused deterioration of vegetation and disrupted wildlife habitat. The Middle Rio Grande Bosque Restoration Supplemental Master Plan was developed in 2003 and promotes the bosque's primary land use as open space maintained for wildlife habitat and recreational uses. Project areas have been identified by the MRGCD to decrease the encroachment of invasive species, satisfy the recreational demand, promote educational use, and reduce hazardous loads and risk of wildlife in the bosque.

2.12 Hazardous, Toxic, and Radiologic Waste (HTRW)

Field observations during previous Civil Works projects (i.e., Albuquerque Levee (2009) and MRG Bosque Restoration (2011)) occurring within the bosque, that encompass or are in close proximity to the project, were used to summarize the general existing conditions for this project. Previous surveys documented surficial solid waste in small concentrations typically restricted to the terminus of storm water outfalls. This waste was typically plastic bottles, bags, cups, glass, and other household waste that were washed through the storm water drainage systems and deposited near the outfalls. Other sporadic waste as described above was observed and likely deposited by wind and users of nearby pathways. Isolated dump sites, consisting of construction debris and household waste have also been documented within the bosque during previous Civil Works projects constructed by USACE.

A mixture of recreational, residential, commercial, and industrial land uses are located adjacent to the Rio Grande. In the event of a flood event that inundates these lands, some commercial and industrial properties have a potential to pose an imminent threat to the river from the release of hazardous wastes, hazardous substances, or petroleum products.

An Environmental Data Report (EDR) identifies locations that currently store hazardous materials, hazardous wastes, and petroleum products and where there have been significant releases of these in the past are identified within a one-mile radius of project areas. EDRs from recently completed USACE projects (i.e., Albuquerque Levee (2009) and MRG Bosque Restoration (2011)) that encompass the proposed project areas were reviewed to assess the potential areas of concern (AoC). The previous EDRs identified several AoCs within the one-mile radius. However, no AoCs were identified inside of the levees. The proposed TSP does not include any construction activities occurring outside of the levee system.

When the tentatively selected plan is approved, USACE will move toward conducting a Phase I Environmental Site Assessment (ESA; ASTM 2247-02) for Forestland or Rural Property to determine the likelihood of the existence of Hazardous, Toxic & Radioactive Waste (HTRW). The ESA will be completed prior to the construction contract award. Previous ESAs (i.e., Albuquerque Levee (2009) and MRG Bosque Restoration (2011)) that encompass or are in close proximity to the project have not identified any environmental concerns that warranted further investigation (i.e., Phase II ESA, ASTM E1903-11) or prevented construction within the levee system. The detailed study areas are not contiguous, however, the Phase I ESA will be compiled into a single Phase I ESA document. The Phase I ESA will be conducted in accordance with both an American Society for Testing and Materials (ASTM) standard and US Army Corps of Engineers protocol. As part of the Phase I, site visits to the project areas will be inspected by personnel from the USACE Albuquerque District Environmental Engineering Section who are trained in identifying the presence of and impacts from hazardous wastes and petroleum products.

2.13 Aesthetics

Aesthetics of the bosque may be characterized as ranging from poor to high quality. In areas where fires have occurred and burn restoration (removal of burned and dead trees) has not been implemented, the aesthetics would be considered poor as the bare, burned ground and standing dead trees dominates the view.

In other areas, non-native vegetation has been thinned and dead material has been reduced. Some areas have been replanted with native vegetation (such as cottonwood, willow, New Mexico olive, etc.) as well. Maintenance efforts are ongoing to keep non-native vegetation to a minimum, but resprouting from roots or stumps has occurred in all areas that have been treated. In these areas, the aesthetics generally would be characterized as medium to high. The view is dominated by cottonwoods, with clear views of the river, sometimes obstructed by jetty jacks.

In areas where the bosque is functioning as a health ecosystem, aesthetics would be considered medium to high. Thea area is dominated by cottonwoods and native understory vegetation, obstructing the view of the river.

3 - Future Without-Project Conditions and Effects of the No-Action Alternative*

3.1 Geology and Soils

Erosion or deposition within the river corridor may change surface soils, however the regional geology and subsurface conditions of the study area will not be greatly impacted if this project is not implemented.

3.2 Climate

Recent overviews of climate change in the Southwestern United States have been provided in Garfin et al. (2013), Melillo et al. (2014), and NOAA (2013), with important syntheses of climate change impacts to New Mexico (New Mexico Office of the State Engineer 2006; Reclamation et al. 2013). These sources indicate that observed trends are likely to continue. Models project substantial warming over the 21^{st} Century of 5-7°F by 2100 as compared to late 20^{th} averages; warming may reach as much as 8.5 to 10°F by 2100 under plausible high emissions (large radiative forcing) scenarios. Even with no net changes in total precipitation, warming will affect regional hydrology through changes in the snowpack (Elias et al. 2015). Higher temperatures will delay the date at which precipitation falls as snow in the fall and cause a 4-6 week earlier shift in the date at which precipitation reverts to rain in the spring. The altitude at which a winter snowpack will develop is anticipated to rise. The combination of these trends is an overall reduction in snowpack volume to support ecologically-essential spring runoff flows, as well as reductions in baseflows during the remainder of the year. For the Rio Grande basin above Elephant Butte, declines in snow water equivalence, annual runoff, December-March runoff and April-July runoff are all anticipated (Reclamation 2011). Increases in the frequency, intensity and duration of both droughts and floods are expected (Reclamation et al. 2013).

Riparian and aquatic ecosystems along the Rio Grande and tributaries are likely to be affected by changes in stream flow that alter water quantity, seasonal water availability, water quality (temperature, nutrients, dissolved oxygen, pollutant concentration), and increases in riparian evaporation. Projected reductions in annual maximum monthly flows likely relate to changes in the spring runoff hydrograph likely to reduce the average amount and extent of flooding of restoration measures on the floodplain. However, the amount of this projected reduction is small relative to the interannual variability, adding considerable uncertainty to estimates of ecological impacts. Projected impacts to the Middle Rio Grande riparian areas (Friggens et al. 2013) that are likely to be broadly applicable to northern New Mexico riparian areas include:

- Reduced riparian habitat due to decreased stream flows and longer drought.
- Decline in cottonwood gallery forests due to lower flows, more frequent wildfires, disease.
- Loss/reduction of native vegetation and replacement by invasive tree and grass species due to fire and lower water tables, and changes in spring runoff timing/volumes.
- Increasingly arid conditions would favor replacement of grassland and woodland habitats with scrubland, accompanied by reductions in vegetation cover.

- Increased duration of drought, with increases in droughts lasting 5 years or more and increases in drought intensity.

3.3 Future Without-Project Hydraulic and Sediment Transport Analysis

Mussetter Engineering, Inc. (MEI) was retained by USACE to perform FLO-2D modeling in support of this planning study. The inundation scenarios evaluated from this modeling exercise were used to evaluate the existing-without project conditions. While a summary of the results are provided herein, a more detailed explanation and review of the results are provided in the complete report, which is included within the H&H Appendix.

FLO-2D modeling was conducted to evaluate depth, extent and duration of overbank inundation for the “No Action Plan”. The analysis was conducted for the initial channel conditions (Year 0) for all hydrologic scenarios. Future channel conditions were modeled for the two hydrologic scenarios applicable to restoration activities (channel full conditions [6,000 cfs] and post-Cochiti annual spring hydrograph [3,770 cfs]) to evaluate the effects of aggradation or degradation on overbank inundation 5, 20, 30 and 50 years into the future. Sediment conditions (aggradation or degradation) in the future were simulated using a calibrated HEC-6T model and a 50 year mean daily record comprised of actual post-Cochiti flow records (MEI 2008). All Results from this analysis are used to provide baseline conditions for comparison with the restoration alternatives investigated.

The amount of overbank inundation predicted by the FLO-2D model for each simulation under the “No Action Plan” was estimated for each subreach prior to the construction of MRG Bosque Restoration Projects (H&H Appendix). Currently, the “No Action Plan” includes the previously constructed MRG Bosque Restoration Project. Inundation effects from implementation of this project were simulated under the “Moderate Effort A” plan (H&H Appendix). Inundation acreage is listed in Table 7 and Table 8. The modeling shows that the extent of inundation is greater with the completion of the MRG Bosque Restoration project for hydrologic scenarios one and two. The greater inundation extent associated with hydrologic scenarios three and four indicate widespread inundation for these discharges independent of completed restoration activities. Less inundation is anticipated, based on modeling results, for future conditions, since there is a slight degradation trend through the project reach over the evaluated 50 year period. As the active channel degrades, the same discharge has less accessibility to the floodway. Therefore, it could be surmised that in the absence of any restoration efforts, the occurrence of overbanking will continue to be infrequent for the future without project condition. Additional details on the modeling results can be found in the H&H Appendix.

Table 7. Summary of areas of inundation for Existing Conditions and Future Conditions Without-Project (No MRG Bosque).

Hydrology Scenario	Description	Future Channel Condition (year)	Reach (acres) 1	2	3	4	5	Total
1	Channel Full Conditions	0	77.2	41.3	25.2	34.4	75.6	253.7
		5	78.0	41.1	23.9	34.0	74.0	251.0
		20	76.7	40.9	23.5	32.0	73.5	246.6
		30	76.7	40.7	23.3	32.0	74.6	247.3
		50	75.9	40.7	23.7	30.0	73.6	243.9
2	Annual Spring Runoff	0	45.2	23.1	7.7	4.0	7.9	87.9
		5	45.2	23.0	7.9	4.0	8.0	88.1
		20	43.6	22.1	8.3	6.7	5.7	86.4
		30	43.9	22.8	7.9	7.0	6.3	87.9
		50	43.2	22.3	7.9	6.8	6.1	86.3
3	10,000 cfs Hydrograph	0	181.9	125.6	82.2	233.7	412.9	1036.3
4	100 – year Peak Snowmelt	0	84.4	59.9	14.6	133.4	364.9	657.2

Table 8. Summary of areas of inundation for Existing Conditions and Future Conditions Without Project (With MRG Bosque).

Hydrology Scenario	Description	Future Channel Condition (year)	Reach (acres)					
			1	2	3	4	5	Total
1	Channel Full Conditions	0	145.2	46.1	31.3	55.5	85.5	363.6
		5	147.7	45.5	28.8	53.8	84.1	360.0
		20	146.7	45.4	28.6	53.9	83.3	357.8
		30	147.5	45.7	28.4	54.7	82.7	358.9
		50	148.9	45.5	28.6	54.8	82.8	360.5
2	Annual Spring Runoff	0	113.3	25.2	16.6	30.7	42.9	228.7
		5	113.3	25.4	20.0	38.1	48.8	245.6
		20	111.8	26.0	16.7	30.6	28.7	213.8
		30	112.8	25.8	16.7	30.2	28.5	214.2
		50	111.6	25.8	16.9	29.6	28.1	212.1
3	10,000 cfs Hydrograph	0	181.9	125.6	82.2	233.7	412.9	1036.3
4	100 – year Peak Snowmelt	0	84.4	59.9	14.6	133.4	364.9	657.2

3.4 Water Quality

If the project is not implemented, the potential short-term contribution of sediment to the Rio Grande during and after construction (see Section 6.5) would be eliminated. There would be no long-term positive or negative effect to water quality if this project is not implemented. However, in general, water quality is predicted to be impacted as a result of changing climate and population growth (Vörösmarty et al. 2000, Murdoch et al. 2000, Whitehead et al. 2009, and van Vliet et al. 2013).

3.5 Air Quality and Noise

Under future conditions, without the project, no projected effects on air quality are expected in the proposed project area, and the area is expected to remain in attainment for criteria pollutants. Current noise levels in the area would continue to be affected by existing conditions, and would therefore not change in the future without-project conditions.

3.6 Ecological Resources

3.6.1 Vegetation Communities

Continued isolation of riparian vegetation in the study area through ecological, fluvial, and geomorphic processes will eventually result in complete dominance of the plant communities by non-native plant species, including salt cedar, Russian olive, Siberian elm, white mulberry, and tree of heaven. Current vegetation management techniques such as understory clearing and planting of native species might temporarily reset patches of Bosque to more natural structural states, but gradual replacement by non-native species could continue to occur unless the function of the Bosque ecosystem and structure of the dynamic mosaic is restored. Eventual conversion of the Bosque to a non-native-plant-dominated ecosystem uninfluenced by hydrologic processes, with fire as the new main disturbance mechanism, would diminish habitat suitability and quality for many native animal species. Larger scale plantings, bank lowering, or high-flow channel creation would not likely occur due to financial limitations. Some maintenance activities would likely continue by other agencies or private organizations. Some areas have been planted with native shrubs and trees through other projects. This native vegetation would continue to grow and provide some additional habitat for wildlife.

Inundation of the Bosque would remain infrequent and limited without modifications to high-flow channels and bank lowering. Without inundation, the key component of a functioning Bosque would remain absent limiting native plant recruitment, nutrient cycling, and recharge of the shallow aquifer. Existing wetlands would continue to diminish and remain isolated from other similar habitats as they are now.

3.6.2 Invasive Species

A number of invasive tree species are proposed to be removed and/or reduced in number under the proposed action. These include salt cedar, Russian olive, Siberian elm, tree of heaven, and Russian mulberry. These species compete successfully with the native species and can convert riparian habitat to a drier, more upland habitat. Left unchecked, these species can successfully compete with all native vegetation and take over. This shift would eliminate the native riparian Bosque that the goals of this proposed project aim to protect and restore. In the future without project condition, invasive tree species would continue to spread throughout the Bosque. Some management of these species is performed by local agencies, but to a limited degree on an annual basis.

3.6.3 Noxious Weeds

Under the future without project condition, noxious weeds would continue to spread throughout the Bosque and would not be managed in the proposed project area.

3.6.4 Wildlife

With a trend towards larger dominance of non-native plant species, the abundance of some species would increase at the expense of overall diversity in the Bosque. Those species preferring the dense, low, and mid-story habitat structure would benefit while those preferring open mature cottonwood stands with open mid and understory would become less common. If native Bosque patches became smaller and distances between patches larger, some wildlife species might be lost to the area altogether. The overall trend would be for a less heterogeneous habitat favoring only a portion of the existing animal species. Likewise, migratory species relying on varying age stands of cottonwood Bosque, wetland, or open meadow would be forced to travel farther and possibly bypass the MRG near Albuquerque to find favorable habitat.

The lack of connectivity between the river and floodplain also would favor upland species that are fairly common in the region while the rare floodplain species would remain scarce.

3.7 Special Status Species

The three special status species known to occur in the study area, and the potential future without project effects to them, are discussed below.

3.7.1 Rio Grande Silvery Minnow

Floodplain habitat appears important for supporting silver minnow recruitment (Fluder et al. 2007; Gonzales et al. 2014; Hatch and Gonzales 2008; Porter and Massong 2004a, b; SWCA 2008). Silvery minnows are capable of moving through narrower incised channels with faster water velocities by remaining in the boundary layer adjacent to the bank to avoid the main current (Porter and Massong 2004b). A Primary Constituent Element for minnow critical habitat is that the hydrologic regime is capable of forming and maintaining a diversity of aquatic habitats, including backwaters, shallow side channels, pools, eddies, and runs to support all silvery minnow life-history stages. Without initiation of the proposed project, floodplain connectivity measures that would benefit the Rio Grande silvery minnow would not be implemented and efforts to increase desirable habitat would not occur under this project. Other agency initiatives might propose projects to benefit the Rio Grande silvery minnow in the area, although none are known at this time.

3.7.2 Southwestern Willow Flycatcher

Wetlands and native woody riparian vegetation, particularly dense growths of willows often with a scattered overstory of cottonwood, would continue to decline in the study area with future without project condition, further diminishing habitat suitability for these species and contributing to their decline. Again, other agency initiatives (such as those under the Middle Rio Grande Endangered Species Collaborative Program) might propose projects to benefit the Southwestern Willow Flycatcher in the area, although none are known at this time.

3.7.3 Yellow-billed Cuckoo

Riparian woodlands with mixed willow and cottonwood vegetation would continue to decline in the study area with the future without project condition, further reducing suitable habitat for these species and contributing to their decline. Without initiation of the proposed project, an increase in potential native riparian habitat to benefit the Yellow-Billed Cuckoo would not be implemented.

3.8 Cultural Resources

Without the implementation of a Federal project, any historic properties within the proposed project's APE would be expected to remain in approximately their current condition. With available information, there is no indication that any historic properties are currently at risk or undergoing active change at the present time. As time progresses, there may be identification of additional properties or features that are eligible for listing on the National Register of Historic Places (NRHP).

3.9 Land Use and Recreational Resources

Increased growth in the Albuquerque Metropolitan Area would be a further burden on the river and the lands along the bosque. Land in the Proposed Project Area is part of the RGVSP, and as a result, would remain otherwise undeveloped. Residential development adjacent to the Proposed Project Area, and further development of the Albuquerque Area could increase the number of bosque users. Under the future without project conditions, the lack of restoration could result in even greater disturbance of the bosque, further accelerating its decline. Based on the current regulatory regime, other problematic land uses such as dumping and wood harvesting should be limited, but would continue. Some of these problems may be addressed by local agencies if the project were not implemented, but not at as large of scale or as expeditiously.

Under the future without project condition, the educational and recreational activities currently enjoyed by the citizens of Albuquerque and visitors would remain roughly as they are. As the bosque in the Proposed Action Area becomes increasingly hazardous and unsafe due to increased densities of non-native and dead and down vegetation, however, the quality and time for these activities would be increasingly diminished. The bosque would have to remain closed for longer periods of time because of the fire hazard, and the experience would be further degraded. Again, some improvements by local agencies or other initiatives may improve this situation, but not to the level that the Proposed Project entails.

3.10 Hazardous, Toxic, and Radiologic Waste (HTRW)

Given the current regulatory regime and policing of the bosque, the current hazardous, toxic and radiological waste is unlikely to change significantly in the future. Existing construction debris and household waste would remain and accumulate over time, and illegal dumping would likely continue in areas that are easily accessible to vehicular traffic.

3.11 Aesthetics

Under the future without project condition, it can be expected that the Proposed Project Area would continue to deteriorate aesthetically according to both conventional scenic vista and proposed vibrant ecology standards. In addition to failing to mitigate impacts to the aesthetic experience of the bosque, increased cottonwood mortality and increased non-native populations would limit visibility and mobility and likely lead to an increase in the number of unsightly homeless encampments, dumping activities, and damaging fires. Under the future without project condition, points for viewing the bosque and its natural features and environs would become increasingly limited. Some efforts by local agencies and other initiatives may assist in improving aesthetics, but not to the level and amount that is proposed by this project.

3.12 Floodplain and Wetlands

In the future without project condition, additional wetlands and reconnection with the floodplain would not occur. The river and Bosque would continue to be disconnected stemming from river channelization, combined with installation of dams, levees and jetty jacks. The installation of these flood control devices have ‘perched’ the Bosque and the river, so that natural overbank flooding no longer occurs. Loss of wetland habitat also would continue due to the reduction of inundation events.

4 - Plan Formulation and Evaluation

4.1 Alternative Development and Rationale

Alternatives are formulated to address a comprehensive Federal project for ecosystem restoration in order to:

- Ensure that a wide variety of possible solutions were considered that incorporate public and stakeholder concerns, the highest cost benefit output feasible, and the least negative impact on the human environment;
- Provide decision-makers, both Federal and local, with information that might be used to help determine the balance between construction costs and social issues and concerns;
- Comply with NEPA and other environmental laws and regulations;
- Restore a diversity of riparian and associated floodplain habitats to a more natural state;
- Provide an acceptable means of capturing storm water using existing outfall structures to benefit restored ecosystems and habitat areas;
- Maintain or enhance existing conveyance of peak discharges and ensure that project implementation would not increase flood flows or worsen flooding conditions downstream in existing developed areas;
- Produce NER benefits while positively contributing to the NED Account, the Regional Economic Development Account and the Other Social Effects Account;
- Provide a framework for responding to future urban development in the floodplain consistent with Executive Order 11988; and
- Blend existing and proposed improvements where possible to take advantage of local improvements and to be consistent with future master planning of the local community.

4.2 Public Scoping and Collaboration

4.2.1 Public Scoping

Scoping letters were sent to various Federal, state, and local agencies on January 4, 2018 (see Appendix F for scoping letter and distribution list). Input was received and is in Appendix F. Information received from agencies helped guide potential locations for project measures. These agencies have constructed restoration projects within the Middle Rio Grande Bosque, specifically in the Albuquerque reach, therefore, knowing these existing sites was very useful to avoid overlap of projects.

4.2.2 Collaboration

Under the MRG Bosque Restoration Project, a series of ten workshops was held over the period of three years (2005-2008) to develop models, characterize baseline conditions of the study area, then formulate plans and assess alternatives for the ecosystem restoration study. Several Federal, state, and local agencies, as well as local and regional experts from the stakeholder organizations, and private consultants, called the ecosystem team or "E-Team", participated in the model workshops. The outputs from the model that was created under MRG Bosque Restoration Project was used to help evaluate alternatives.

More current collaboration has occurred between USACE and the Middle Rio Grande Conservancy District, City of Albuquerque Open Space Division, Water Utility Authority, and the Interstate Stream Commission. Several meetings were held to discuss possible overlap of restoration projects between the agencies and what foreseeable projects each agency may have within these areas.

As mentioned above, the Middle Rio Grande Endangered Species Collaborative Program (Program) is a partnership involving 20+ current signatories organized to protect and improve the status of endangered species along the Middle Rio Grande (MRG) of New Mexico while simultaneously protecting existing and future regional water uses. A subgroup of the Program, Habitat Restoration, meets monthly to discuss potential habitat restoration projects among many other things. USACE has collaborated with the Program during these meetings and have discussed the Proposed Project.

4.3 Public Concerns*

The non-Federal sponsor and the public have expressed interest in restoring function and habitat value within the constraints of current water use restrictions and without imposing flood damages. Decline of natural riparian structure and function of the bosque ecosystem was recognized in the 1980s as a major ecological change in the Middle Rio Grande (Hink and Ohmart 1984; Howe and Knopf 1991). In ecological terms, the cumulative effects of agriculture, urban development, and flood risk management measures initiated over the last seven decades have resulted in a disruption of the original hydrologic (hydraulic) regime along the Albuquerque reach of the Middle Rio Grande and the ultimate degradation of the Bosque ecosystem. This regime is crucial to sustaining and regenerating a variety of ecological components that make up the bosque and the wildlife that it supports.

4.4 Problems and Opportunities

Public concerns were identified during the course of the reconnaissance study. Contributions from Federal, state, and local agencies were received through coordination and project meetings as well as quarterly agency coordination meetings. These meetings were attended by MRGCD, the Albuquerque Open Space Division, Reclamation, USFWS, the Middle Rio Grande Council of Governments, the Albuquerque Downtown Action Team, City of Albuquerque Planning Department, and others. On April 1, 2002, a meeting was held with stakeholders, including the above agencies and several non-governmental organizations and researchers, to poll concerns on issues in the MRG.

In February of 2003, a public meeting was held to present restoration efforts beginning in the MRG and poll public concerns. The public and agency concerns that are related to the establishment of planning objectives and planning constraints are:

- Environmental degradation of the Bosque ecosystem;
- Loss of habitat for special status species;
- Existence of fire hazard;
- Limited recreational access and use of the Bosque;
- Persistence of non-native plant species;
- Personal security within the Bosque;
- Cultural awareness and environmental justice;
- Environmental education and outreach;
- Reduce current and minimize future operations and maintenance costs;
- Need for coordination of multi-agency effort and ongoing projects.
- Impact of neighboring land uses on the Bosque;
- Availability of water for multiple uses.

Water resources projects are planned and implemented to solve problems, meet challenges, and seize opportunities. In the planning setting, a problem can be thought of as an undesirable condition such as those expressed by the public above. An opportunity offers a chance for progress or improvement of the situation. The identification of problems and opportunities gives focus to the planning effort and aids in the development of planning objectives. Problems and opportunities can also be viewed as local and regional resource conditions that could be modified in response to expressed public concerns. This section identifies the problems and opportunities in the study area based on the assessment of existing and expected future without-project conditions.

On a regional scale, estimates of riparian habitat loss in the Southwest range from 40% to 90% (Dahl 1990), and desert riparian habitats are considered to be one of this region's most endangered ecosystems (Minckley and Brown 1994, Noss *et al*. 1995). Decline of natural riparian structure and function of the Bosque ecosystem was recognized in the 1980s as a major ecological change in the MRG (Hink and Ohmart 1984; Howe and Knopf 1991). In ecological terms, the cumulative effects of agriculture, urban development, and flood risk management measures initiated over the last seven decades have resulted in a disruption of the original hydrologic (hydraulic) regime along the Albuquerque reach of the MRG and the ultimate degradation of the Bosque ecosystem. This regime is crucial to sustaining and regenerating a variety of ecological components that make up the Bosque and the wildlife that it supports. Whereas it is not possible to return the MRG to its pre-flood risk management state, abundant opportunities exist to restore function and habitat value within the constraints of current water use restrictions and without imposing flood damages.

Along the approximately 26 miles of the Rio Grande within the Albuquerque reach of the MRG, several hydrologic and ecological problems have been identified along with corresponding opportunities:

- The past water management operations and flood risk management measures, including levees, jetty jacks, and upstream dams, have eliminated the historic broad, meandering channel and the flood regime that had resulted after periodic inundation of the Bosque. Even with these limitations, however, an opportunity exists to recreate limited overbank flow and areas of inundation within the levees by reconnecting existing high-flow side channels and excavating swales and expanding existing wet habitats.

- Confinement of the river channel and its subsequent deepening, coupled with the colonization of river banks by vegetation, has resulted in perched banks and stabilized islands. The low, sloping bank no longer exists to provide a wet-soil terrestrial or shallow, slow moving riverine environment at the water-land interface. The opportunity to devegetate and destabilize banks and islands will restore this habitat, facilitate overbank flows, and provide sediment for the natural geomorphic systems.

- The loss of wetlands, braided channels, and backwaters has reduced the extent and quality of aquatic habitat and the potential for aquifer recharge. An opportunity exists to restore and create new wetland habitat and backwaters, which would improve aquatic habitat and recharge potential, as well as provide storm water filtration.

- Confinement of the river channel by levees and jetty jacks and eventual degradation has deepened the channel and increased velocities through the study area. Levees and protective works remain critical. However,the opportunity exists to remove jetty jacks as well as reconnect side channels, recreate embayments, and provide additional areas of low river velocity within the levees.

- The lack of inundation, scouring and sediment deposition within the Bosque, as well as the lowering of the water table, has curtailed seedling recruitment of native tree species and increased the mortality rate of existing cottonwoods and willows. This has resulted in a skewed age structure in the remaining cottonwood stands and resulted in significant build-up of leaf litter and dead and down wood. An opportunity exists to reconnect the floodplain and river to restore the essential functions of forest renewal and nutrient cycling.

- Human uses in the Bosque have further degraded the Bosque through accidental fires and high-impact recreational uses. The opportunity exists to revegetate burn sites, limit vehicular access, and provide a formal recreational system that provides an experience that will promote community involvement and pride.

- The cumulative impact of the loss of inundation, confinement of the channel, the lower water table, cottonwood mortality, and urbanization has led to the replacement of the mosaic of native woodlands and wetlands in many parts of the study area by dense stands of non-native salt cedar, Russian olive, Siberian elm, tree of heaven, and white mulberry trees. An opportunity exists to remove non-native plants and revegetate with a variety of native plants, thereby improving and diversifying native habitat types.

- The altered vegetation structure of the Bosque has increased the potential for a catastrophic fire in the Bosque. The brushy growth form of non-native trees creates a hazardous fuel condition. The jetty jacks and heavy brush can also make access to fight fires difficult and potentially dangerous. An opportunity exists to remove some of the jetty jacks and much of the vegetation that has created the existing fire hazard.

- The change from a mosaic of native plant communities of various structures and ages to increasingly large stands of non-native forest has affected the overall value of aquatic and terrestrial wildlife habitat provided by the Bosque. An opportunity exists to rehabilitate the existing Bosque into a dynamic mosaic of native vegetation patches of various ages, structure types, and constituent species.

- The uncontrolled access, neglect, and degradation of the Bosque ecosystem have impaired interpretive, educational, and recreational uses of the Bosque. An opportunity exists to develop existing trails into an aesthetically pleasing and safe interpretive system that furthers the overall goal of restoration.

4.5 Planning Objectives and Constraints

Planning objectives and constraints provide a framework for the development of alternative plans. Planning objectives are statements of what a plan is attempting to achieve. Planning objectives communicate to others the intended purpose of the planning process. Constraints are limitations imposed on the scope of the study from physical, political, or social considerations. For instance, this restoration project hinges on the amount of water that flows through the study area and yet additional water cannot be provided because water is allocated per the Rio Grande Water Compact and MRGCD water delivery requirements. This study must focus on the effective use of water as it flows through the study area without impacting the delivery requirements downstream. Project specific objectives and constraints are listed in Section 4.6.2.

4.5.1 Federal Objectives

As planning objectives for this investigation, it is in the Federal interest to:

- Contribute to the National Ecosystem Restoration (NER) objective through restoration, with contributions measured by changes in the amounts and values of habitat. Numerous Federal laws and executive orders exist that have established the National policy for, and Federal interest in, the protection, restoration, conservation, and management of environmental resources. The focus of NER projects is "the restoration of ecosystems and ecological resources and not restoration of cultural and historic resources, aesthetic resource or cleanup of hazardous and toxic wastes" (ER 1105-2-100, Appendix E). Ecosystem restoration projects implemented by USACE might not be capable of addressing every undesirable condition associated with an ecosystem, but rather, should focus on restoration of "degraded significant ecosystem structure, function and dynamic processes to a less degraded, more natural condition" (ER 1105-2-100, Appendix E).

- Contribute to the National Economic Development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

- The Regional Economic Development (RED) account is intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment.

- The Environmental Quality (EQ) account is another means of evaluating the alternatives to assist in making a plan recommendation. This account is intended to display the long-term effects the alternative plans could have on significant environmental resources.

- Contributions to the Other Social Effects (OSE) account include long-term impacts to public facilities, health and safety, recreation, and community values.

4.5.1.1 Principles and Guidelines Criteria

Principles and Guidelines (P&G) criteria are applied to plans as part of plan formulation. The criteria are as follow:

- Completeness: The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.
- Effectiveness: The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
- Efficiency: The extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.
- Acceptability: The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

4.5.2 Project Specific Objectives

The national objectives of NED and NER are general statements and not sufficiently specific for direct use in plan formulation. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without-project conditions.

Ecosystem restoration projects require that the planning team develop objectives and constraints that apply to a systems approach and take into consideration "aquatic wetland and terrestrial complexes, as appropriate, in order to improve the potential for long-term survival as self-regulating, functioning systems" (ER 1105-2-100, Appendix E). Objectives and constraints must be specific to the ecosystem as well as realistic and attainable in order for the planning process to succeed.
Working from the problems and opportunities identified in Section 1.9, *Corps Planning Process,* key objectives of the feasibility study were developed and include:

- Improve habitat quality and increase the amount of native Bosque communities to a sustainable level. Sustainability of Bosque habitats refers to the habitat's ability to perform key riparian functions that perpetuate those habitats. Using the Bosque Community Index Model, a habitat score of 0.50 to 0.59 is considered "moderately high functionality" (discussed in Appendix F, Model Documentation Report). The objective of the restoration project is to achieve a moderately high functionality or higher habitat value over 30 percent or more of the areas of consideration. This value will be achieved in 20 years or less after project implementation and be sustained for the remaining 30 years of the period of analysis.

- Restore hydrologic connection between the Bosque and the river characterized by a more frequent overbank inundation pattern. A 25 percent or more increase in the area of inundation during flow events of 3,000 cfs or greater is the objective of the Sandia to Isleta restoration project. For RGSM, overbank flooding provides areas for hatching and rearing; therefore, a 25 percent or more increase in area of inundation would significantly increase minnow reproduction.

- Protect, extend, and improve areas of potential habitat for listed species within the Bosque. The project objective is to provide an over-25-percent increase in high quality habitats suitable for migration and feeding by the SWFL.

Restoration efforts will be implemented over a five-year period beginning in 2021 and provide benefits through the 50-year period of analysis and beyond. Although positioning of each measure area is dependent on the specific conditions present at a particular location, restoration measures could be dispersed throughout the study area. Constructed measures that affect the response of the fluvial processes could realize benefits immediately or within the first year after implementation. Restoration measures that involve manipulation of existing habitat might realize some benefits immediately after implementation; however, measures that include establishing plants could take five to 20 years to realize full benefits. In addition to these goals, the study ensures that any restoration implemented will be integrated with other established or ongoing restoration efforts in the Bosque.

4.5.3 Constraints

The following constraints represent restrictions that limit alternative development or need to be overcome:

- Water delivery policies and regulations will affect water availability for ecosystem restoration measures. Water-oriented legislation and policies include, but are not limited to, the following:
    - Rio Grande Compact
    - New Mexico State Engineer’s Regulations
    - MRGCD Water Delivery Requirements

- Levees, dams, and existing channel conveyance and capacity necessary for existing water delivery and flood risk management cannot be compromised by environmental restoration developed for this project.

- Proposed restoration measures cannot impair the City of Albuquerque Public Works Department’s ability to draw surface water from the Rio Grande for its potable and non-potable water projects.

- Water quality cannot be adversely affected as a result of restoration activities. Water quality will be addressed through the NEPA and Clean Water Act processes.

- Budget and capacity of local management agencies to maintain restoration measures over the long term must be considered.
- Proposed measures must not have a significant negative effect on endangered species or impair existing habitat for endangered species in the future.

The requirement to not compromise flood risk management infrastructure, the impracticality of acquiring water, and converting land use outside the levees ultimately limit the scope of the proposed project to restoration within the existing flood risk management levees along this reach of the Rio Grande. In several locations downstream of the study area, the risk exists of overtopping or failure of non-engineered (spoil-bank) levees at higher discharges. For this reason, operational water releases from Cochiti Reservoir are regulated to not exceed 6,500 cfs. A recent effort was made by the multi-agency MRGESACP to maximize the efficient use of water for competing purposes in the MRG and discussed in the *Upper Rio Grande Basin Water Operations Review Environmental Impact Statement* (USACE 2007). This effort succeeded in providing longer durations of higher flow events within operational parameters. This study examined ways to restore overbank inundation at discharge levels below 6,500 cfs.

4.6 Development of Alternative Plans*

The study team implemented a proactive strategy to formulate ecosystem restoration plans specifically tailored to focus on restorative initiatives at a landscape level on a system-wide basis. The PDT identified a set of alternative restoration plans that addressed the planning goals and objectives of the study. Each alternative plan is made up of smaller components called measures. Restoration measures, the smallest components of the alternative plans, were developed to provide a specific element or restorative function, such as creating a high-flow side channel or planting native riparian trees. Measures were then combined based on position in the landscape, dependencies, and combinability to form restoration alternatives. Plan areas are a combination of several compatible measures at a specific location that achieves functional and sustainable restoration at that site. At any given location, more than one measure might be possible, but they must be mutually exclusive. For instance, a measure that includes creation of a wetland could not be implemented at the same place as a measure that includes planting a new stand of cottonwood trees. Alternative plans were formulated from various combinations of management measures, added together, rescaled, and otherwise modified so that the resultant suite of formulated alternative plans addressed the planning goals and objectives enumerated earlier.

4.6.1 Description of Proposed Restoration Measures

4.6.1.1 Jetty Jack Removal

The removal of non-essential jetty jacks would be necessary to allow the removal of non-native vegetation and the creation of additional restorative measures (*i.e.*, high-flow channels). Removal of non-essential jetty jacks would also provide access for fire or emergency crews, enhance the aesthetic qualities of the Bosque, and increase safety to potential visitors.

Within the study area, all jetty jacks were assessed by USACE, Reclamation, and the MRGCD. Both non-essential jetty jacks and jetty jacks that continue to provide necessary stabilization functions were identified and mapped. The three agencies agreed to the strategy of identifying non-essential jetty jacks (Figures 34 and 35), and the agencies agreed that jetty jacks within these areas can be removed by any of these agencies and/or other local stakeholders as part of restoration projects after receiving approval from USACE, MRGCD, and Reclamation. Any proposed alternatives that include areas where jetty jacks cannot be removed without additional protection would be evaluated to determine what type of protection would be needed in order to remove the jetty jacks as part of the study.

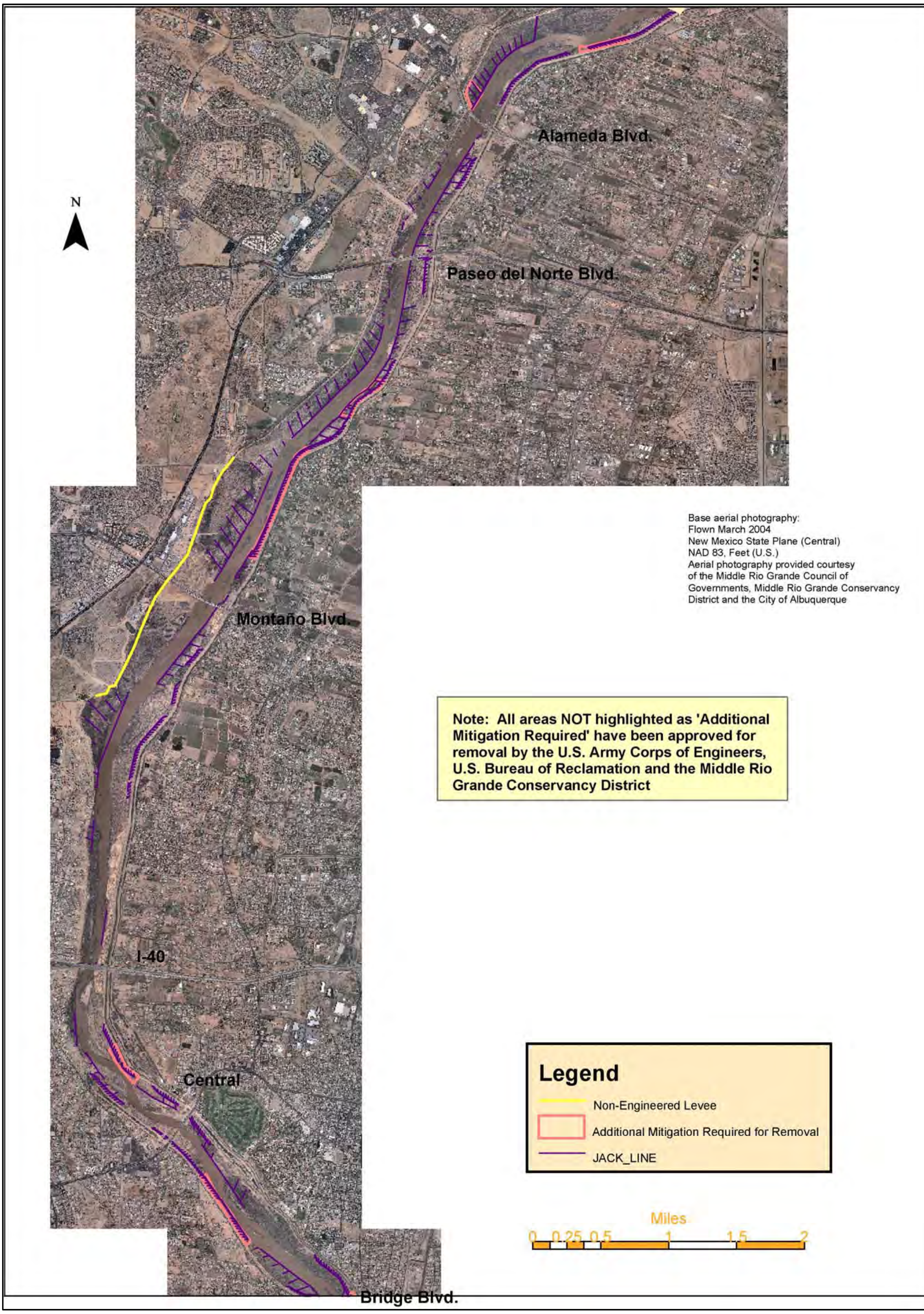

Figure 16. North Jetty Jack Locations and Segments Approved for Removal.

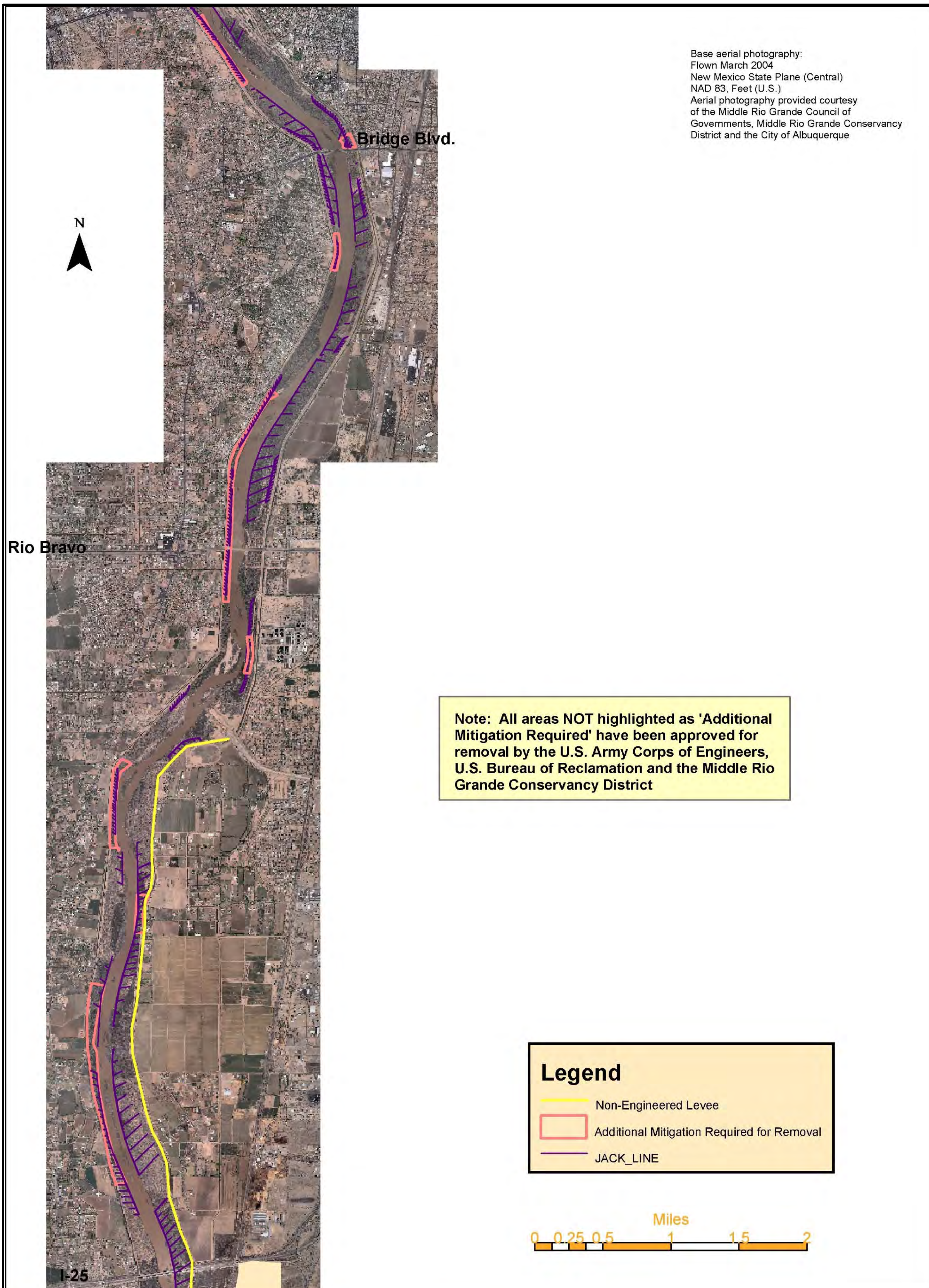

Figure 17. South Jetty Jack Locations and Segments Approved for Removal.

4.6.1.2 Exotic Species Removal and Fuel Load Reduction

Non-native plant removal would facilitate restoration efforts by removing the chief competition to native trees, shrubs, forbs, and grasses. Non-native plant removal would also reduce the fire hazard, enhance aesthetic and recreational aspects of the Bosque, and improve security. In many areas, continued maintenance and repeated treatment for stump sprouting and removal of juvenile volunteer non-natives would be necessary. This is provided for under the operations and maintenance portion of the project. Both the removal of jetty jacks (where needed) and the thinning of non-native vegetation and the reduction of fuel loads would have to occur prior to initiating the remaining measures discussed below.

4.6.1.3 Water Measures

Establishment of healthy stands of cottonwoods and other native species requires water, preferably in the form of flooding for brief periods of time, until the roots are mature enough to reach essential fluids and nutrients. The purpose of the water-related measures described in this section is to attempt to mimic natural periods of inundation in specific areas under certain conditions. This would create a hospitable environment for propagation of native vegetation and produce wetted areas that would increase the diversity of habitat types.

A number of water measures were considered and will be discussed. The measures include wetland restoration/construction, bank lowering, construction of high-flow channels, and construction of willow swales. To maintain water delivery requirements and not induce losses of water to evaporation or infiltration, the Interstate Stream Commission requires water related measures (wetland, high-flow channel) to be implemented within 300 feet from existing channel centerline.

4.6.1.3.1 Wetland Restoration/Construction

Wetlands consist of marshes, wet meadows, and seasonal ponds that typically support hydrophytic plants such as cattails, sedges, and rushes. Wet meadows were the most extensive habitat type in Middle Rio Grande valley prior to the construction of the MRGCD drains and ditches. From 1918 to present, wetland-associated habitats have undergone a 93% reduction (Hink and Ohmart 1984, Scurlock 1998). Wetlands are an integral component of the Bosque ecosystem, not only increasing diversity but also enhancing the value of surrounding plant communities for wildlife. Wetlands have experienced the greatest historical decline of any floodplain plant community. Among the greatest needs of the riparian ecosystem are the preservation of existing wetlands and expansion or creation of additional wetlands (Crawford *et al.* 1993). Wetland restoration/construction measures in the form of open water wetlands, outfall wetlands and marsh wetlands were considered in all reaches of the study area.

An open water wetland could be something similar to that constructed at the Albuquerque Biological Park Wetland (Figure 18). Wetlands of this type provide open water habitat for migrating and local waterfowl and aquatic habitat for numerous species.

Figure 18. Albuquerque Biological Park Wetlands prior to wetland plant establishment.

Outfall wetlands could be constructed and enhanced in areas where stormwater outfalls exist but currently do not create or use the potential to create habitat. Simple modifications to existing outfalls could provide several benefits. The conceptual idea is to connect the outfall through the Bosque and to the river, providing wetland and/or moist soil habitat. Each area can be designed based depending on the outfall size.

The concept is to divert the low flows from the outfall into a reconstructed channel. The majority of the pollutants and trash from these systems is generally contained in the ”first flush“, that is, the storm water associated with the first 0.25 inches of runoff. The conceptual design includes a sediment pond to collect the bulk of the sediment and pollutants exiting the system during these low flows and a series of shelves within the channel to help address the issues discussed above. The channel would be planted with wetland plants to promote biological activity. Screening devices, either directly on the outlet of the pipes, or a „dam" within the sedimentation pond, could be designed to remove the trash and help deposit the sediment. Extremely large flows would quickly run through the channel habitat system. Some erosion protection could be included on a site-specific basis if needed for the existing flow paths. These measures would serve to replicate some of the benefits of historical wetlands by removing the contaminants through both biological and hydraulic means (settling) and providing diverse habitat. The channel would function as backwater habitat.

When flows are low, the shelf' adjacent to the river would contain water. As flows increase, water would move from the river back into the channel and create wet habitat.

A marsh wetland (or wet meadow) would have fluctuating water levels and various vegetative species. These areas can be created by lowering the ground level and/or letting surface water from a wetland area flow into a riparian area. Marshy or moist soil habitat is created, similar to that of the wet meadow at the Albuquerque Biological Park Wetland (Figure 19).

Figure 19. Albuquerque Biological Park Wetlands Wet Meadow, May 2007.

4.6.1.3.2 Bank Lowering

Bank lowering involves the removal of vegetation and excavation of soils adjacent to the main channel to enhance the potential for overbank flooding (Tetra Tech 2004). This technique, demonstrated in Figure 20, has been used in various locations of the Middle Rio Grande, primarily for creation of potential habitat for the Rio Grande silvery minnow by the MRGESCP. The E-team analyzed various locations for bank lowering potential.

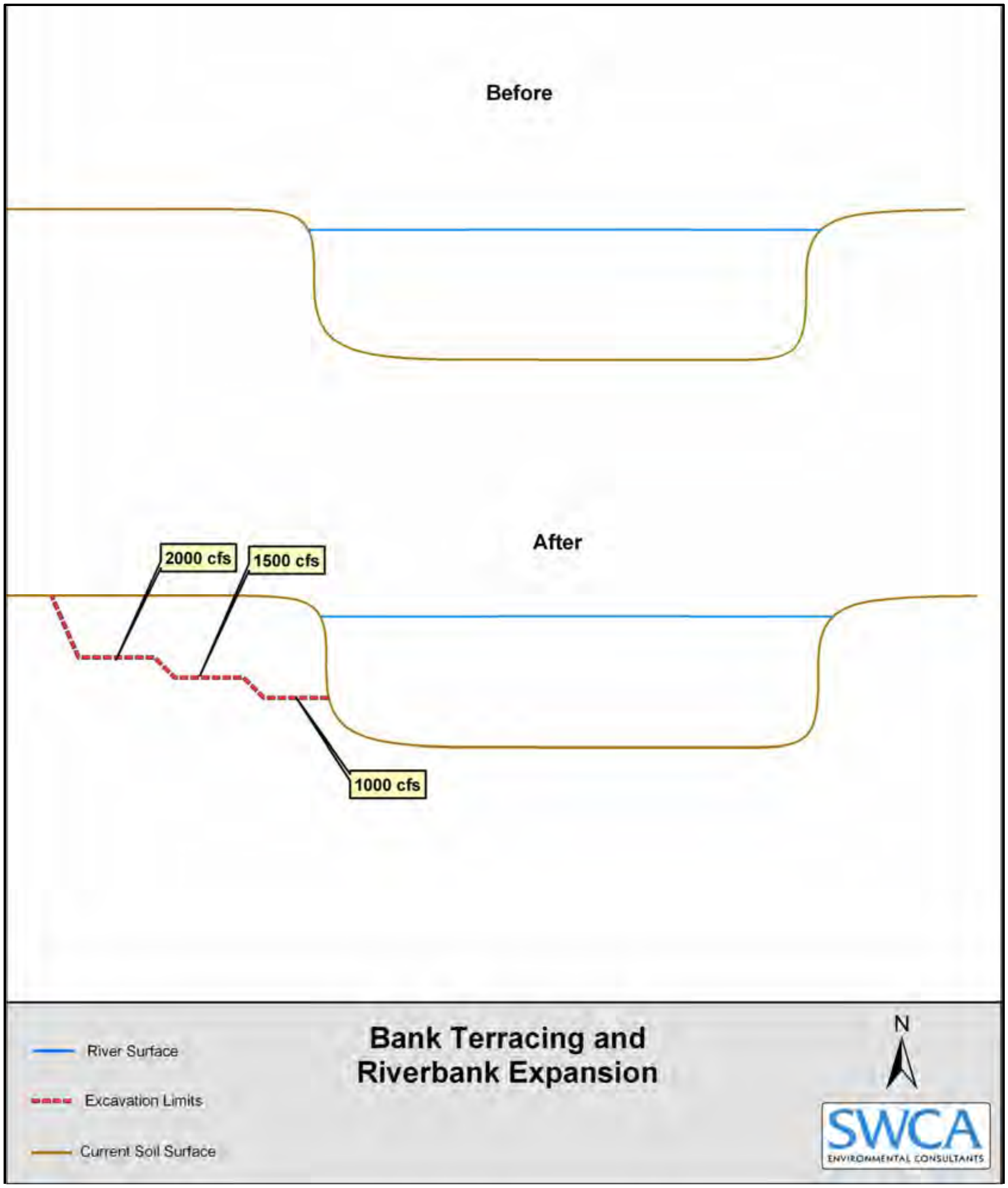

Figure 20. Schematic of bank (lowering) (SWCA, 2006).

4.6.1.3.3 High-Flow Channels

Under historic flood flow regimes, high-flow channels once represented an integral part of the river form and function (Figure 21). Evidence of former channels is present in many locations within the study area. The objective of this measure is to re-establish the connections between the river and the Bosque by creating a situation in which side channels would become inundated at flows between 2,500 cfs to 3,500 cfs. Actions necessary for this measure typically include dredging the sediment from the upstream and downstream portions of the remnant high-flow channels in order to re-establish the Bosque-river connection, clearing out debris and non-native plants, and revegetating with native plants to increase the habitat quality within the Bosque. High-flow channels would deliver much-needed water to Bosque vegetation and increase potential water-based habitats for animals.

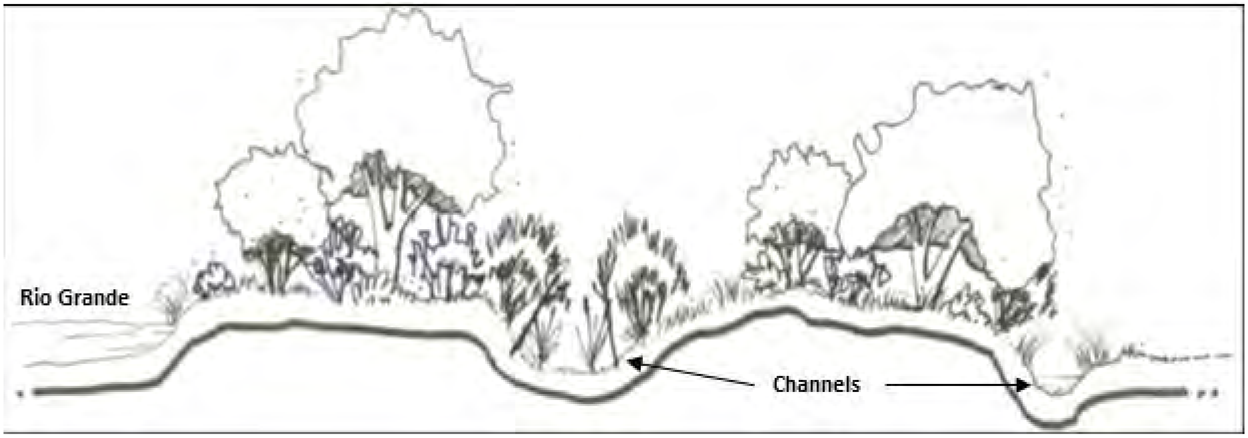

Figure 21. High flow channel schematic.

4.6.1.3.4 Swales

The willow swale measure entails optimizing the depressions created by removal of non-native vegetation, dumped debris, and jetty jacks to provide micro-environments to contain native plants that can thrive due to the decreased distance to the water table and moist soils. In certain areas of the Bosque, the depth-to-water table is minimal, and even slight excavations expose water (Figure 22). Willow swales also help create vegetative habitat where establishment of native plants or seed would be challenging due to soil type. Sample plots have illustrated that standing water can occur when the non-native phreatophytes are removed. These excavated areas could be planted with riparian shrub, wetland, or mesophytic plants. Depending upon the location, there could be a series of willow swales that become progressively drier with increasing distance from the river or water table. Once established, native plants could thrive in these depressions. This measure would create wet meadow and shrub habitat. A series of depressions, approximately one half acre in size, would be created within a five- to 10-acre area. The number of depressions within each swale would be determined by site-specific conditions.

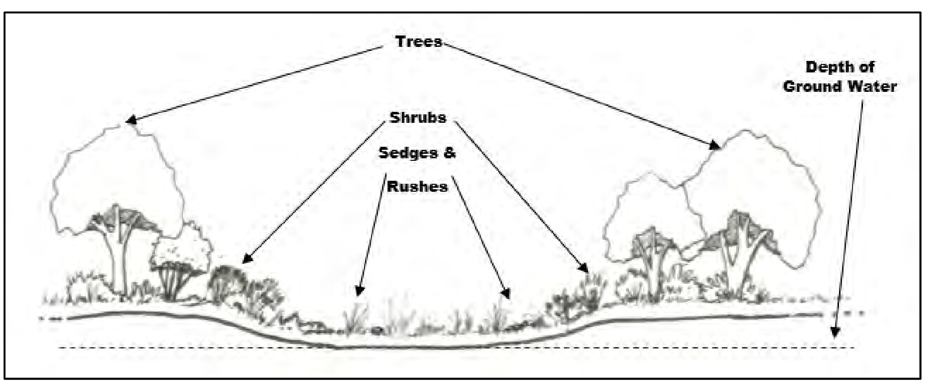

Figure 22. Schematic concept for Swale.

4.6.1.4 Riparian Gallery Forest Mosaic Restoration

Planting strategies to target a riparian gallery forest mosaic would include the following:

- **Seeding** with native grasses and forbs, such as Indian rice grass (*Oryzopsis hymenoides*), galleta grass (*Hilaria jamesii*), side oats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), and sunflower (*Helianthus annuus*) and in wetter areas, yerba mansa (*Anemopsis californicus*), emory sedge (*Carex emoryi*), and salt grass (*Distichlis stricta*). Seeding involves sowing seed via methods such as broadcasting, crimp and drill, or hydro-mulching. Other than the gel in the hydro mulch, no irrigation would be applied. Timing of seeding would be critical to the establishment of the vegetative cover. Late summer is usually the optimum time.

- **Bare root container or plug planting** with native shrubs, such as peach leaf willow (*Salix amygdaloides*), New Mexico olive (*Forestiera neomexicana*), four wing saltbush (*Atriplex canescens*), chamisa (*Chrysothamnus nauseosus*), false indigo (*Amorpha fruticosa*), golden currant (*Ribes aureum*), three leaf sumac, woodbine, and in wetter areas, coyote willow (*Salix exigua*), black willow (*Salix nigra* var. *gooddingii*), and seep willow (*Baccharis salicifolia*) would be an important strategy for establishing woody plants. Bare-root planting refers to planting a plant with roots directly in the ground without a rootball that has soil surrounding it. Container planting refers to planting small plants in small containers, and plug planting refers to planting small seedlings with soil or growth medium. The juvenile plants would be planted as bare root with hydro gel (a.k.a. Dri-Water™). Hydro-gel refers to containers filled with water-absorbing gel particles that absorb water and then slowly release it to the plants. Containers of gel are placed around the root zone of the plant at the time of planting and watered well. Replacements or refills of the containers might be necessary once or twice per growing season during the time of establishment (generally two years). Another technique used is long stem plants, which are plants with deep roots. These deep roots provide a means to get the plant closer to the water table. Shrubs would be planted at various densities depending on what is currently at the location. If no native understory vegetation exists at a location, then shrub planting density would be higher (500 stems per acre or more). If existing native vegetation is growing in the area, then a lower density of native shrubs would be installed (100 to 500 stems per acre as needed).

- **Pole planting** of native trees, such as the Rio Grande cottonwood (*Populus fremontii* var. *wislizenii*), black willow (*Salix nigra* var. *gooddingii*), coyote willow (*Salix exigua*), and peach leaf willow (*Salix amygdaloides*). Pole planting is the technique most frequently used in the restoration of riparian areas. Many of the pilot projects in the Bosque have used pole planting, and according to AOSD, they have a 90-percent success rate (Tony Barron, Pers. comm., 2002). Branches of cottonwoods and willows, 10 feet to 15 feet in length, are slipped into holes that have been augered through the soil to the water table. Little maintenance is required beyond taking precautions to protect the young trees from beavers. Trees would be planted at a fairly low density because cottonwoods exist throughout the study area. The trees would be supplemented in some areas as needed but at a very low density (10 to 50 stem per acre). Willow trees are lacking in some areas of the study area and would be planted at a higher density in those areas (25 to 75 stems per acre).

Planting strategies would not include planting larger plants, such as balled and burlapped or container trees, because they would not be successful in the study area without significant irrigation. Restoration projects occasionally include temporary irrigation, and it would be physically possible to flood irrigate portions of the Bosque from the drain if water rights were allocated for that purpose.

However, the restoration would not include irrigation due to the cost and the lack of availability of water and dedicated water rights. Planting potted plants was also ruled out as a strategy because of cost (water and maintenance time). This method of planting refers to planting small container plants (1 to 5 gallon), accompanied by a pipe to the root zone though which water would be provided by hand from a truck until the plant is well established.

The overall restoration strategy is to revegetate the Bosque with shrubs and juvenile trees to re-create the missing native understory in Bosque forest woodland areas and the native shrub thickets in open areas. At the same time, gaps are to be left in between the revegetated areas to create edge habitat, the richest type of habitat, and to create firebreaks to limit the potential for catastrophic fire. Two types of measures have been generated for revegetation of the Bosque, (1) Bosque patches, which restore the understory to the Bosque forest and woodland areas and (2) shrub thickets, which restore dense shrubby zones to open areas where existing vegetation has been cleared and removed.

Seeding would be applied wherever restoration occurs. In firebreak areas, seeding is the only revegetation strategy proposed. Bosque patch and shrub thicket areas would receive pole planting of trees and bare root, container, or plug planting of shrubs. Maintenance and adaptive management would be important to the long-term success of the revegetated areas. Ongoing removal of non-native stump sprouts and volunteers would be necessary in all planted areas. In firebreak areas, the vegetation would be mowed or "brush-hogged" periodically, in order to maintain the function as a firebreak and to keep out woody plants.

These different planting strategies would be combined in order to create the target mosaic mixture of different ecosystem types (Bosque forest, grass meadow, wet measures).

4.6.1.5 Gradient Restoration Facility (GRF)

Considering the objectives of habitat restoration, channel bed stabilization is useful in light of the future degradational tendency of the Rio Grande expected for this reach. A gradient restoration facility (GRF) would be considered for grade control to stabilize the current river bed also while providing fish passage opportunities. A GRF is a sloping rock structure that can provide vertical channel stabilization while maintaining fish passage (Figure 23). GRF's include several structural components: sheet pile/cutoff wall, main channel apron, overbank armor, upstream and downstream channel transitions, upstream and downstream overbank cap, and bankline revetment keys. The GRF acts as an artificial riffle and provides a gradual increase in channel and water surface elevations rather than a vertical drop structure.

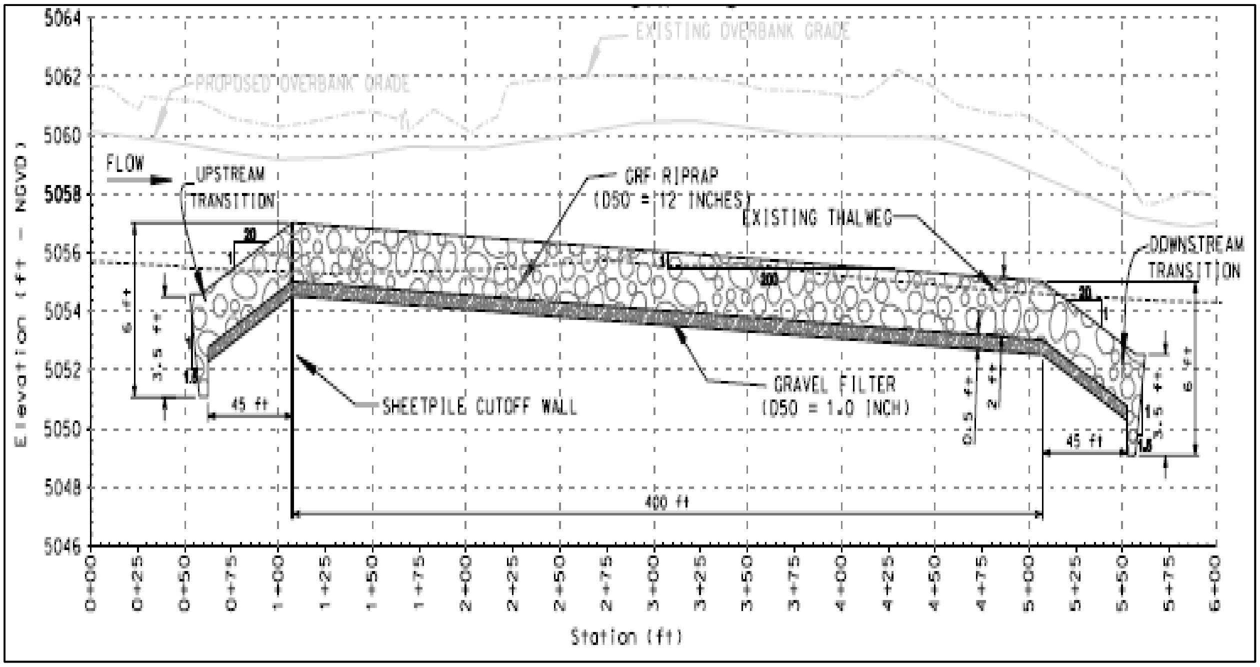

Figure 23. Grade Reduction Facility Conceptual Design.

4.6.2 Plan Areas

As described in Section 4.6, measures were combined into 22 plan areas within the four study reaches. Selection of plan areas was done by looking at areas with no previous restoration activities and that had been identified as being included in Best Buy plans from the MRG Bosque Restoration Study (USACE, 2007), but not implemented. The plan areas were assigned a letter designation to aid in identification and entry into the IWR Planning Suite for Cost Effectiveness/Incremental Cost Analysis (CE/ICA) described in Section 4.7.1. Following discussions with the Sponsor and stakeholders, two areas (C and S) were dropped from consideration due to restoration activities undertaken by others (Table 9).

4.6.3 Formulation of Alternative Plans

Once measures to be included in the project were identified, locations identified as being part of Best Buy plans from the MRG Bosque Restoration Study (USACE, 2007) were re-evaluated to determine whether or not actions had been implemented in those areas. For areas that had not had restoration activities, the PDT reviewed the previously recommended measures and how they contributed to meeting study objectives. Measures that were not mutually exclusive (same footprint and competing outputs) and contributed to meeting study objectives were retained for the areas.

Table 9. Plan Areas for Alternative Analysis.

Plan Area*	Study Reach	Measures	Approximate Area (acres)
A	2	Wet meadow, Treat-Retreat-Reveg, Groundwater Channel, Willow Swale, Bankline terrace, Hi-flow Channel, Divert outfall flows	127.12
B	2	Bankline terrace, Hi-flow Channel, Willow swale, Treat-Retreat-Reveg, Wetland	195.08
C	2	Wet meadow, Treat-Retreat-Reveg, Willow swale, Enhance ditch for wet habitat	75.14
D	2	Willow swale, Treat-Retreat-Reveg	7.54
E	2	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel	44.75
F	2	Willow swale, Treat-Retreat-Reveg	42.59
G	2	Willow swale, Treat-Retreat-Reveg, Wetland	9.92
H	3	Willow swale, Treat-Retreat-Reveg, Bankline terrace, Hi-flow Channel, Remove berm	47.7
J	3	Wetland, Willow swale, Treat-Retreat-Reveg	13.68
K	3	Wetland, Treat-Retreat-Reveg	77.03
L	3	Willow swale, Treat-Retreat-Reveg	77.8
M	3	Wetland, Willow swale, Treat-Retreat-Reveg	39.48
N	4	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel, Remove berm and Jetty Jacks	51.13
P	4	Treat-Retreat-Reveg, Hi-flow connection	15.82
Q	4	Wet meadow, Connection to River, Enhance ditch for wet habitat	10.43
R	4	Willow swale, Treat-Retreat-Reveg, Water measure	71.78
S	4	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel	36.8
T	4	Willow swale, Treat-Retreat-Reveg, Divert outfall flows	28.8
U	4	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel	40.82
V	5	Willow swale, Treat-Retreat-Reveg, Wetland, Connect wetlands, Connect to river	32.26
W	5	Willow swale, Treat-Retreat-Reveg, Enhance outfall	88.65
X	5	Treat-Retreat-Reveg, Bankline terrace, Wetland, Hi-flow Channel	131.21
Approximate Total Area:			**1,265.53**

** I and O are not used due to looking like the numbers one and zero in IWR Planning Suite. Areas C and S were removed due to restoration activities by others.*

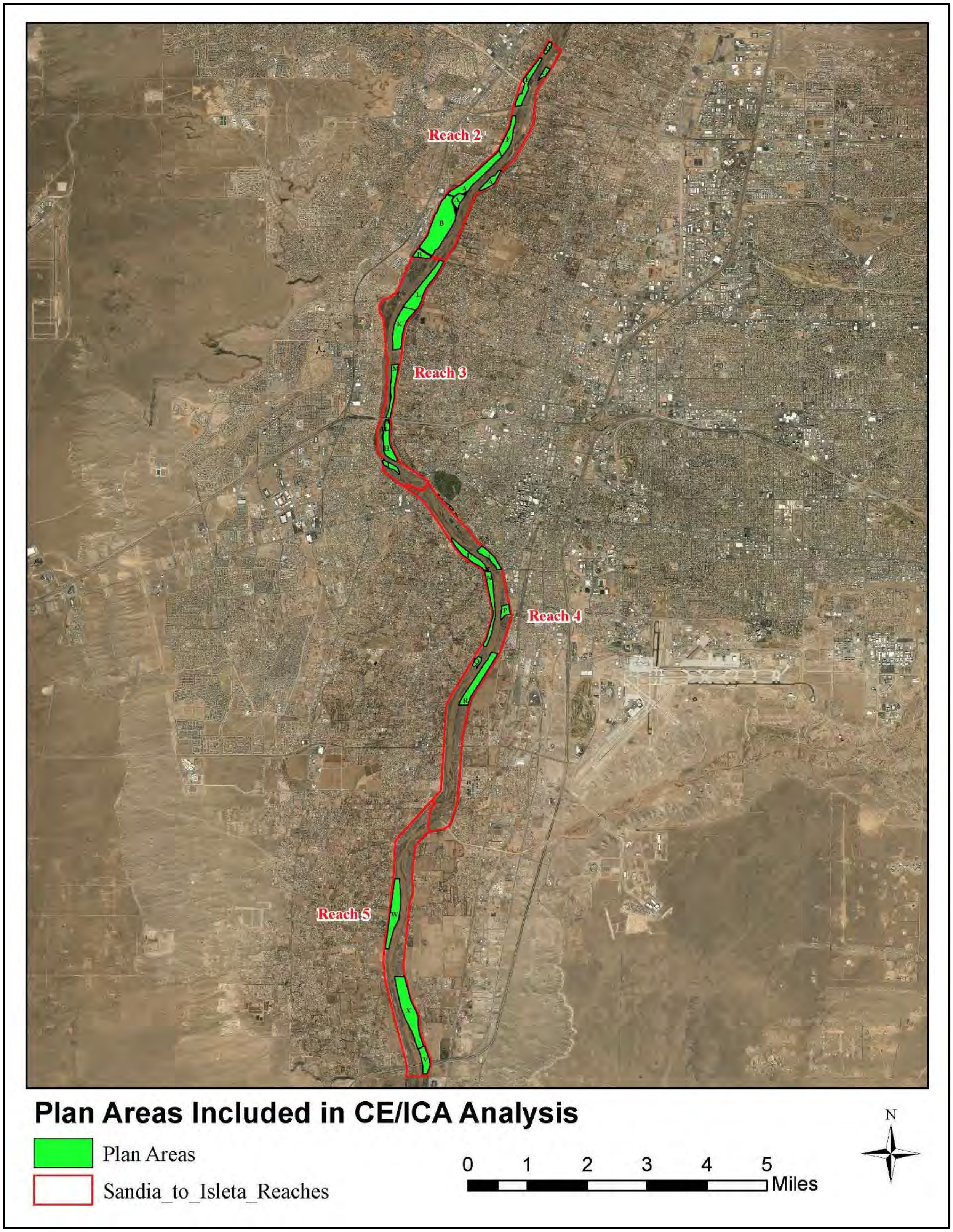

Figure 24. Plan Areas Included in CE/ICA Analysis.

4.7 Evaluation of Alternative Plans*

4.7.1 General Approach

The PDT reviewed the plan areas for distribution throughout the study reaches acknowledging previous restoration work. After the 22 plan areas described in Section 4.6.2 were discussed with the PDT and stakeholders, Areas C and S were dropped due to restoration activities having been implemented in those areas. This resulted in six plan areas in Reach 2, five in Reach 3, six in Reach 4, and three in Reach 5. For these plan areas, information on cost and outputs was developed. This information was used for the analysis described in Section 4.7.3.

4.7.2 Environmental Outputs

Habitat units (HU) were annualized by estimating the HUs at designated target years throughout the period of analysis (50 years total) to estimate changes in habitat value with-project (WP) and without-project (WOP). The results of this calculation are referred to as average annual habitat units (AAHUs). Using HU's as a metric, the WP and WOP conditions can be compared over time based on the forecast conditions. In this way it is possible to quantify a change in habitat by implementing the project and evaluate the cost effectiveness.

Field data collected between 2003 and 2008 was compiled on a reach-by-reach basis. Data for each variable per cover type were recorded and the variable means/modes were calculated to generate watershed baseline indices on a reach-by-reach basis. Twenty-four variables were measured across the five reaches (see Appendix F for more information in the Model Documentation Report).

The results of the ecosystem assessments for the reaches are summarized below. Habitat Suitability Index (HSIs) captured the quality of the acreage within the reach for the bosque community index model. Units (i.e., HUs) took this quality and applied it to the governing area though multiplication (Quality X Quantity = Units) for both HEP analyses. Interpretations of these findings are generalized in the following manner (Table 10).

Table 10 Interpretation of Index Scores Resulting from HEP Assessments

Index Score	Interpretations
0.0	Not suitable – the community does not perform to a measureable level and will not recover through natural processes
Above 0.0 to 0.19	Extremely low or very poor functionality (i.e., habitat suitability) – the community functionality can be measured, but it cannot be recovered through natural processes.
0.2 to 0.29	Low or poor functionality
0.3 to 0.39	Fair to moderately low functionality
0.4 to 0.49	Moderate functionality

0.5 to 0.59	Moderately high functionality
0.6 to 0.79	High or good functionality
0.8 to 0.99	Very high or excellent functionality
1.0	Optimum functionality – the community performs functions at the highest level – the same level as reference standard settings

4.7.3 Alternative Comparison – Cost Effectiveness/Incremental Cost Analysis

The IWR Planning Suite was used to compare every possible combination of the 20 plan areas. The software evaluated each combination or alternative plan based on economic criteria through the process known as Cost Effectiveness/Incremental Cost Analysis (CE/ICA). This process is discussed further in Appendix D, Economics.

In order to perform the CE/ICA, each of the 20 individual plan areas required a cost and output. Costs for implementation of each area were estimated using experience with similar constructed projects and parametric cost data. Each of the 20 plan areas consist of specific environmental restoration measures, such as, excavation or plantings to include all construction activities, such as, construction access, staging and soil disposal. The same assumptions were used for estimating the costs of restoration construction components to develop a consistent basis for costs to avoid skewing the CE/ICA process, and to support unbiased plan selection.

Outputs from implementation of each measure were determined by the increase in value or quality of the habitat measured in Habitat Units (HUs). Differences between similar measures in different locations would be predicated on the difference in existing habitat value and size of the area treated.

The CE/ICA process also looks at relationships between measures and areas related to combinability and dependency. In a typical USACE study, management measures may or may not be mutually exclusive, and it is the property of *combinability* that allows planners to mix and match measures into different plans. Conversely, some measures may preclude others, and this will limit the ability to mix and match the measures. In consideration of *combinability*, two measures might be mutually exclusive because of:

- Location, where two different measures cannot occupy the same space at the same time;
- Function, where two different measures may work against one another

In addition to being combinable, many measures may be dependent on other measures in order to be implemented. *Dependency* relationships between two measures may exist for several reasons, including:

- Necessary to function;
- Reduce risk or uncertainty;
- Improve performance

For this study, the measures are combinable with the assumption that the Treat-Retreat-Reveg measure would be the first implemented for any plan area, then other measures implemented. This assumption implies *dependency* of other measures on the Treat-Retreat-Reveg measure, but the measures can function separately so there is not *dependency*. The plan areas are discrete and can function independently, so there is no *dependency* between plan areas.

Once the cost and output of each of the 20 plan areas were assigned, the CE/ICA determined which combinations of plan areas or alternative plans produced the most output for the unit cost. The CE/ICA was used to screen out all alternative plans that were not cost effective. The results of the analysis resulted in a set of 140 alternatives, of which 44 were cost effective and 20 were best buys (Figure 25). The cost of the best buy plans ranges from $597,000 to $101,000,000. Output is measured by the HEAT/BCIM as increase in average annual habitat units (AAHUs), ranges from 104 AAHU to 1872 AAHU. Figure 26 shows the distribution of the best buy plans plotted as cost versus output.

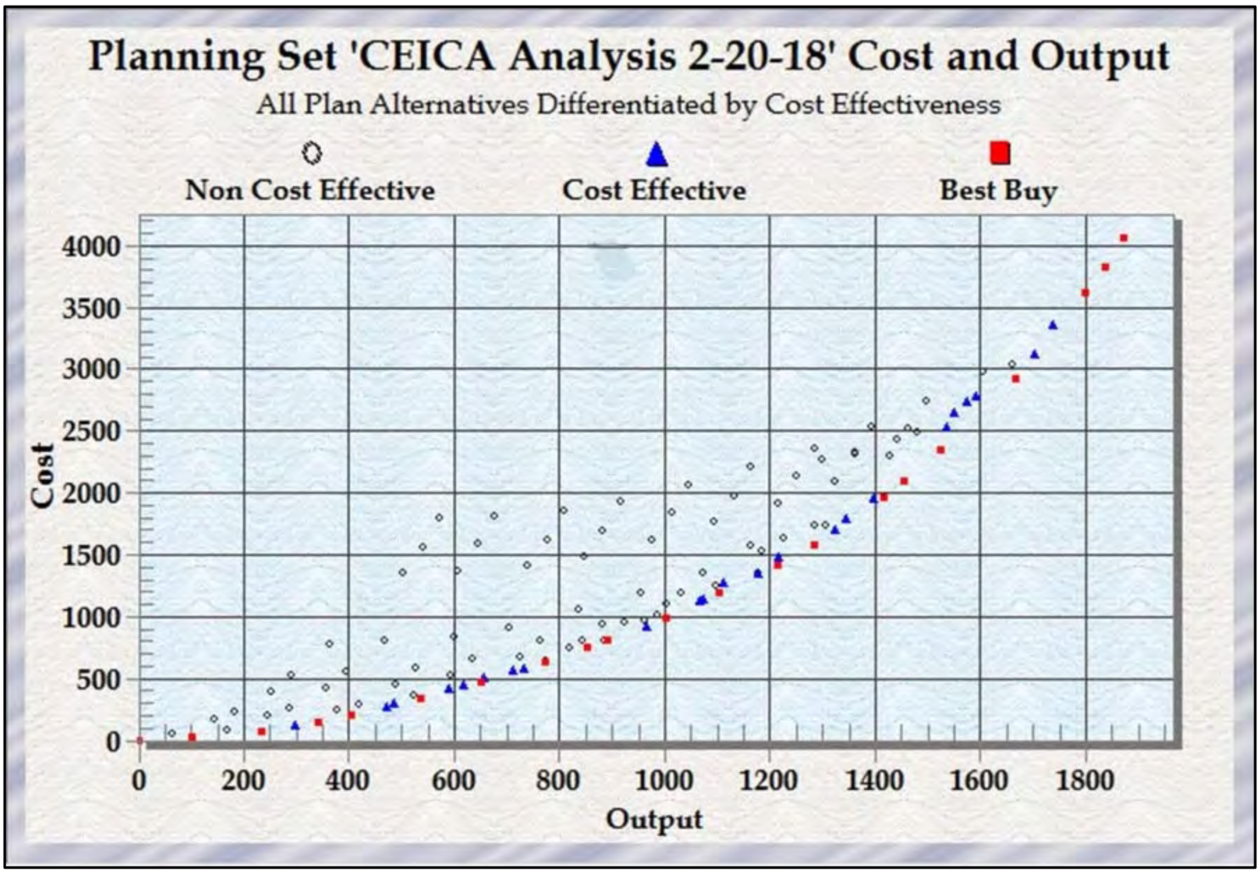

Figure 25. CE/ICA Scatter Plot Graph.

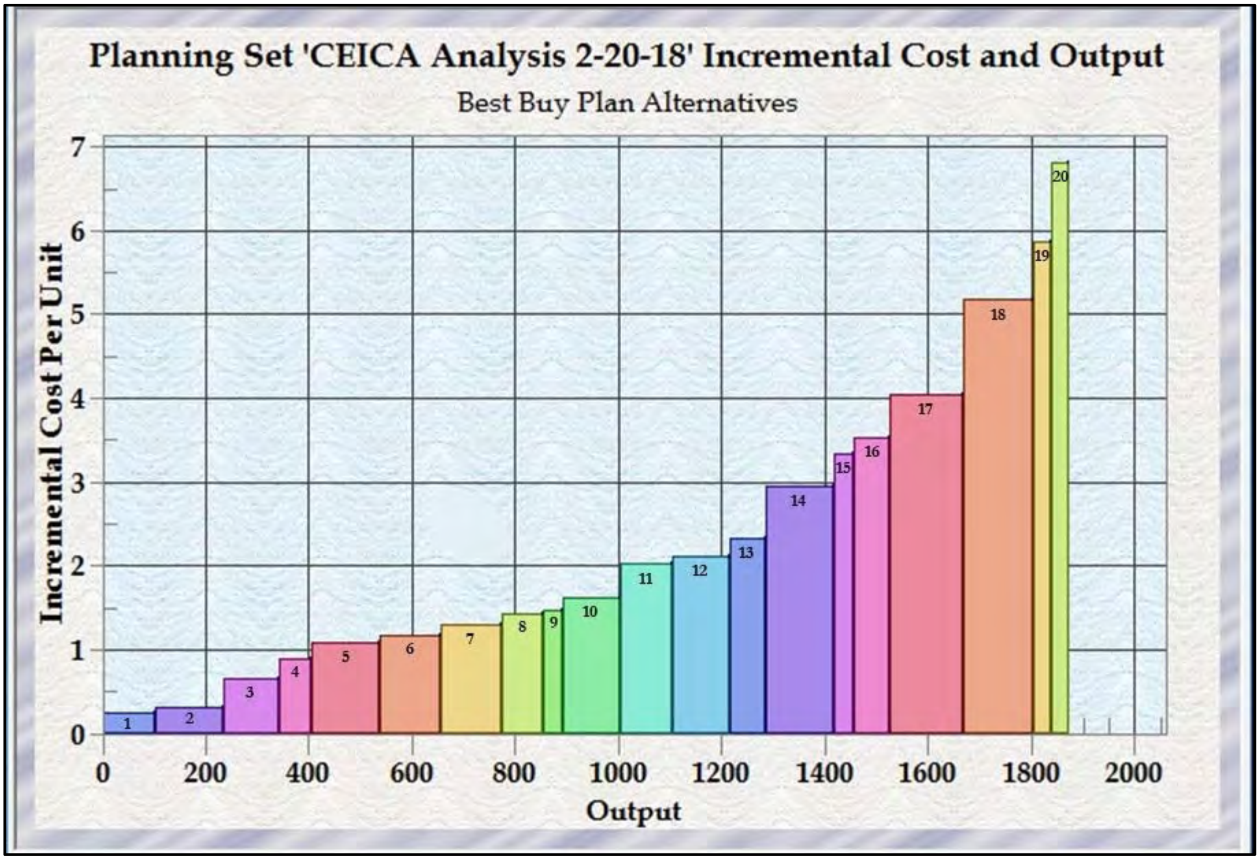

Figure 26. CE/ICA Bar Graph.

4.7.4 Selection of the Tentatively Selected Plan (TSP)

As shown in Figure 26, the CE/ICA analysis resulted in the identification of 20 Best Buy plan alternatives. The alternatives are further described in Table 14. The table shows the costs, outputs and plan areas for each alternative as well as the reaches included. As shown in Table 11, the first time actions are taken in both the north reaches (2&3) and south reaches (4&5) is Best Buy Plan 4. Activities in Reach 5 are not efficient until Best Buy Plan 15. Comparing the Best Buy Plans to the study objectives, the PDT focused on Best Buy Plans 7 thru 12 for further analysis.

Table 11. Best Buy Plans.

BB #	Plan	Total Cost	Avg Ann Cost	AAHU's	Plan Areas Reach 2&3	Plan Areas Reach 4&5	Reaches	Notes
0	No Action Plan	$0	$0	0	Do Nothing	Do Nothing	0	
1	NR1SR0	$597,313	$26,528	104	D	Do Nothing	2	
2	NR2SR0	$1,512,486	$66,514	236	D G	Do Nothing	2	
3	NR3SR0	$3,226,430	$135,833	342	D G J	Do Nothing	2, 3	
4	NR3SR1	$4,557,193	$192,454	405	D G J	Q	2,3,4	1st time work is done in Northern and Southern Reaches
5	NR4SR1	$7,687,228	$334,195	536	D E G J	Q	2,3,4	
6	NR5SR1	$10,840,879	$472,275	654	D E F G J	Q	2,3,4	
7	NR6SR1	$14,523,346	$627,230	774	D E F G J M	Q	2,3,4	
8	NR6SR2	$17,154,476	$740,825	854	D E F G J M	Q T	2,3,4	
9	NR6SR3	$18,370,270	$798,548	893	D E F G J M	P Q T	2,3,4	
10	NR7SR3	$22,587,023	$976,702	1003	D E F G H J M	P Q T	2,3,4	
11	NR8SR3	$27,092,859	$1,184,794	1106	D E F G H J K M	P Q T	2,3,4	
12	NR9SR3	$32,222,140	$1,413,958	1215	D E F G H J K L M	P Q T	2,3,4	
13	NR9SR4	$35,886,658	$1,576,153	1285	D E F G H J K L M	P Q T U	2,3,4	
14	NR10SR4	$44,826,997	$1,961,341	1416	A D E F G H J K L M	P Q T U	2,3,4	
15	NR10SR5	$47,828,053	$2,095,175	1456	A D E F G H J K L M	P Q T U V	2,3,4,5	1st time work is done in all reaches
16	NR10SR6	$53,771,996	$2,345,301	1527	A D E F G H J K L M	P Q T U V W	2,3,4,5	
17	NR10SR7	$67,093,395	$2,916,820	1668	A D E F G H J K L M	P Q T U V W X	2,3,4,5	
18	NR11SR7	$83,248,043	$3,609,801	1802	A B D E F G H J K L M	P Q T U V W X	2,3,4,5	
19	NR11SR8	$88,193,558	$3,821,289	1838	A B D E F G H J K L M	N P Q T U V W X	2,3,4,5	
20	NR11SR9	$101,363,892	$4,052,611	1872	Do All	Do All	All	

Focusing on Best Buy Plans 7 thru 12 as the final array of alternatives, gives a range of costs, increases in AAHUs and area treated. The following table summarizes the final array plans.

Table 12. Final Array of Alternatives from CE/ICA.

Alternative	Plan Areas	Approx. First Cost	Average Annual Cost	AAHU's	Approx. Area (acres)
7	D E F G J M Q	$14,523,346	$627,230	774	168.39
8	D E F G J M Q T	$17,154,476	$740,825	854	197.19
9	D E F G J M P Q T	$18,370,270	$798,548	893	213.01
10	D E F G H J M P Q T	$22,587,023	$976,702	1003	260.71
11	D E F G H J K M P Q T	$27,092,859	$1,184,794	1106	337.74
12	D E F G H J K L M P Q T	$32,222,140	$1,413,958	1215	415.54

The makeup of the final array of alternatives consists of the combination of measures included in Alternative 7 and then for each larger plan includes one or more additional plan areas. Table 13 demonstrates the number and type of measures that are incrementally added to each larger alternative.

Table 13. Final Array of Alternatives Showing Measures.

Alternative	Plan Areas		Measures
7	DEFGJMQ		24 Willow swale, 8 Treat-Retreat-Reveg, 1 Hi-flow Channel, 3 Wetland, 2 Connection to River, 1 Enhance ditch for wet habitat, 1 Wet Meadow
8	DEFGJMQT	Alt 7 plus	1 Divert outfall flows, 7 Willow swale, 1 Treat-Retreat-Reveg
9	DEFGJMQPT	Alt 8 plus	1 Hi-flow connection, 1 Treat-Retreat-Reveg
10	DEFGHJMQPT	Alt 9 plus	1 Bankline terrace, 3 Remove berm, 3 Hi-flow Channel, 11 Willow swale, 5 Treat-Retreat-Reveg
11	DEFGHJKMPQT	Alt 10 plus	1 Wetland, 1 Treat-Retreat-Reveg
12	DEFGHJKLMPQT	Alt 11 plus	5 Willow swale, 1 Treat-Retreat-Reveg

The Best Buy Plans including the final array of alternatives were also compared to the study objectives to identify the National Ecosystem Restoration Plan. Table 14 shows a Best Buy Plan's ability to address the objective and metric for meeting the objective.

Table 14. Best Buy Plans Compared to Study Objectives and Criteria.

	Best Buy Plans																				
OBJECTIVES	**No Action**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1. Improve habitat quality and increase the amount of native Bosque communities to a sustainable level. The objective is to achieve a moderately high functionality or higher habitat value over 30 percent or more of the areas of consideration. This value will be achieve in 20 years of less after project implementation and be sustained for the remaining 30 years of the proposed analysis.	NO	YES*	YES*	YES*	YES*	YES*	YES*	YES*	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**
2. Restore hydraulic processes between the Bosque and the river characterized by a higher frequency of floodway inundation pattern. A 25 percent or more increase in the area of inundation during flow events 3,000 cfs or greater is the objective of the Sandia to Isleta restoration project.	NO	NO	NO	NO	YES*	YES*	YES*	YES*	YES*	YES*	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**
3. Protect, extend, and improve areas of potential habitat for listed species within the Bosque. For RGSM, overbank flooding provides areas for hatching and rearing; therefore, a 25 percent or more increase in area of inundation as described above would help to increase minnow reproduction. The project objective is to provide an over-25 percent increase in high quality habitats suitable for migration and feeding by the SWFL.	NO	NO	NO	NO	YES*	YES*	YES*	YES*	YES*	YES*	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**	YES**

**Best Buy Plan meets the objective only (not the metric within the objective).*

***Best Buy Plan meets the objective and the metric with the objective.*

Red Best Buys do not meet objectives or metric.

Yellow Best Buys meets some objectives but not metric.

Green Best Buys meet objectives and metric.

4.7.4.1 Principles and Guidelines Criteria

Principles and Guidelines (P&G) criteria are applied to plans as part of plan formulation. The criteria are as follow:

- Completeness: The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.
- Effectiveness: The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
- Efficiency: The extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.
- Acceptability: The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

The Best Buy Plans were scored as low, medium, or high related to their ability to meet the Completeness and Effectiveness criteria. For the Efficiency and Acceptability criteria, the plans were rated Yes or No. Because of the CE/ICA process, all the Best Buy Plans meet the Efficiency criterion. Table 15 summarizes the comparison of the Best Buy Plans to the P&G criteria.

4.7.4.2 System of Accounts

The comparison and evaluation of alternatives involves the consideration of the effects of the plans on planning objectives and constraints. The following discussions address the differences and similarities between the future without project conditions and the alternatives. The four national accounts are considered in the comparison and evaluation of alternative plans, as are the associated evaluation criteria. In the 1970 Flood Control Act, Congress identified four equal national accounts for use in water resources development planning. The accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). Policy in the 1970s regarded making contributions to only two of these, NED and EQ, as national objectives.

Because the primary outputs for the Sandia to Isleta project would be ecosystem restoration, benefits are realized for the EQ as well as OSE accounts. Benefits of recreation are accounted for within the NED Account. Benefits to the RED are realized from both the restoration and recreation components.

Table 15. P&G Criteria Compared to Best Buy Plans.

P&G Planning Criteria / Best Buy Plans	Completeness	Effectiveness	Efficiency*	Acceptability
No Action	LOW	LOW	NO	NO
1	LOW	LOW	YES	NO
2	LOW	LOW	YES	NO
3	LOW	LOW	YES	NO
4	MEDIUM	LOW	YES	NO
5	MEDIUM	LOW	YES	NO
6	MEDIUM	LOW	YES	NO
7	MEDIUM	MEDIUM	YES	YES
8	MEDIUM	MEDIUM	YES	YES
9	MEDIUM	MEDIUM	YES	YES
10	MEDIUM	HIGH	YES	YES
11	MEDIUM	HIGH	YES	YES
12	MEDIUM	HIGH	YES	YES
13	MEDIUM	HIGH	YES	NO
14	MEDIUM	HIGH	YES	NO
15	HIGH	HIGH	YES	NO
16	HIGH	HIGH	YES	NO
17	HIGH	HIGH	YES	NO
18	HIGH	HIGH	YES	NO
19	HIGH	HIGH	YES	NO
20	HIGH	HIGH	YES	NO

**By definition, all Best Buy Plans are Effective. The Best Buy Plans were scored as low (red), medium (yellow), or high (green) related to their ability to meet the Completeness and Effectiveness criteria. For the Efficiency and Acceptability criteria, the plans were rated Yes (green) or No (red).*

4.7.4.2.1 Environmental Quality (EQ)

All of the Best Buy plans would contribute to the EQ account by increasing the amount and quality of high-value habitat in the study area by their respective quantity of outputs. All Best Buy plans provide an increase in habitat and benefits to the EQ account as quantified by AAHUs in Table 11. Benefits to the EQ account increase with plan outputs as do the costs for the project and incremental costs for each AAHU. As described earlier, only Best Buy plans 7 and above will meet the improvement objective of the study. Benefits would increase in the following criteria as the amount and quality of habitat increases:

- Air Quality: An increase in the number and acres of plants would contribute to absorption of carbon dioxide and release of oxygen in this urbanized area. The Bosque acts as a heat sink during warmer months and provides a corridor of shady, relatively moist environment that contrasts with the urban asphalt and concrete.

- Wildlife: The increase in habitat diversity would provide for an increase in diversity and density of wildlife species.

- Endangered Species: The three listed endangered species would benefit from project implementation due to improved habitat function and increased area of suitable habitat.

- Noise: A temporary increase in noise would occur due to construction and would potentially increase in duration with an increased project size. The Bosque itself acts as a noise sink.

The larger the project, the more benefits accrue to the account. This is quantified both in total AAHU and incremental costs per AAHU in Table 11. The cost effective analysis has provided a measure of efficiency to determine what the cost of these outputs would be.

4.7.4.2.2 Other Social Effects (OSE)

Other Social Effects (OSE) is a measure of impacts to the community in terms of satisfaction, well-being, and happiness. A new project could impact the state of community education, health, social connectedness, standard of living, and happiness. Primary affects to OSE from the proposed restoration would benefit health, standard of living and education by providing a public area of improved aesthetics and air quality. Significant benefits to the community would occur from the increase in quality of the recreational experience, and from educational opportunities within the project area ancillary to the ecosystem restoration activities.

Goals of the project include:

- Create opportunities for educational or interpretive measures, while integrating recreational measures that are compatible with ecosystem integrity.

- Engage the public in the restoration of the Bosque ecosystem by garnering public input and involvement.

The proposed project would improve existing trails, create additional access points, provide educational amenities such as signage and kiosks, and provide amenities such as benches and picnic tables for an improved recreational experience. Habitat improvements would also enhance the recreational experience through those criteria listed under the AQ account and the aesthetic quality of the Bosque. The relatively open cottonwood gallery forest or a view over a wetland is generally more pleasing than a view obstructed by thick brush 10 to 20 feet high. Habitat improvements would provide the opportunity to view wildlife considered rare outside of this Bosque.

Additional access points provide access to the benefits of the project for people living outside the immediate vicinity. The existing and additional access provides the opportunity for the area to become a destination for recreational and educational activities. The additional opportunities and improved experience increase the overall standard or living for the entire community of Albuquerque.

The scoping and public involvement has provided contribution from the local community to the study objectives. The objectives were incorporated within the constraints of the project and reflected in the array of project alternatives. Further involvement through public meetings and public involvement of monitoring will continue to engage the community and encourage public ownership of the project.

4.7.4.2.3 Regional Economic Development (RED)

The Regional Economic Develop (RED) account registers changes in the distribution of regional economic activity that result from each of the proposed alternative plans. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population. The proposed project would benefit these criteria and have the potential to increase recreation and tourism-related industry and property value immediately adjacent to the project area. Table 16 presents impacts from the Best Buy plans to local business, employment, and local government finances.

4.7.4.3 Selection of the TSP (NER Plan)

Based on the analysis presented above, the TSP, or National Ecosystem Restoration Plan, is Best Buy Plan #10. As discussed, the TSP incorporates plan areas D, E, F, G, H, J, M, Q, P, and T. The areas provide the following measures: 42 Willow swales, 15 Treat-Retreat-Reveg, 5 Hi-flow Channels, 3 Wetlands, 2 Connections to River, 1 Enhance ditch for wet habitat, 1 Wet Meadow, 1 Divert outfall flows, 1 Bankline terrace, 3 Remove berms. The TSP has an approximate cost of $22,587,023 implementing measures over approximately 261 acres and provides for an increase of 1,003 AAHUs. Figure 27 shows the TSP plan areas within the study area. Best Buy #10 is the first plan (see Table 14) to include bankline terracing which is an important water feature that meets study objectives for the lowest cost.

Figure 27. Plan Areas for the Tentatively Selected Plan.

4.7.5 Resource Significance

Table 16. Project Impacts to Regional Economic Development.

Best Buy Plan Alternative	Total Project Cost	Business and Industry	Employment	Financing required from the Local Sponsor
No Action Plan	$0	No Impact	No Impact	No Impact
BB 1	$597,313	Little to no impact at this scale.	There would be a temporary increase in employment during construction consistent with the project cost. Long term O&M would provide some benefits.	LERRDs at approximately $0. O&M at approximately $15,000 per year.
BB 2	$1,512,486			
BB 3	$3,226,430			
BB 4	$4,557,193	Increased recreation and tourist visitation to the area might increase revenues of local businesses.		
BB 5	$7,687,228			
BB 6	$10,840,879			
BB 7	$14,523,346			
BB 8	$17,154,476			
BB 9	$18,370,270			
BB 10	$22,587,023			
BB 11	$27,092,859			
BB 12	$32,222,140			
BB 13	$35,886,658			
BB 14	$44,826,997			
BB 15	$47,828,053			
BB 16	$53,771,996			
BB 17	$67,093,395			
BB 18	$83,248,043			
BB 19	$88,193,558			
BB 20	$101,363,892			

5 - Description of the Tentatively Selected Plan*

5.1 General

5.1.1 Significance of the Tentatively Selected Plan

Many of the outputs of environmental restoration cannot be measured in monetary terms. Without the option of quantifying environmental outputs in monetary terms, other criteria must be considered for evaluating and justifying environmental restoration projects in the Corps of Engineer's planning and budgetary processes. One potential criterion is the "significance" of the environmental resource(s) associated with such projects. For this purpose, resource significance can be described in terms of institutional, public, and technical significance, as defined in the Water Resources Council's Principles and Guidelines (1983).

Institutional Significance

Significance based on institutional recognition of a resource or effect means its importance is recognized and acknowledged in the laws, plans and policies of government and private groups. The importance of the MRG Bosque is readily seen from the efforts and resources committed by state and local governments to restoration of the MRG Bosque. The commitment of the State of New Mexico to conservation and restoration of the MRG Bosque is recognized from designation of the MRG State Park, participation in the study, and use of lands for the restoration efforts. The commitment by the City of Albuquerque to maintain restoration feature measures, once implemented, demonstrates how the City values the MRG Bosque as a resource. The commitment of the Middle Rio Grande Conservancy District is evident through their continued financial and technical support of the RGEMP-I study as well as other restoration efforts within the MRG.

The Tentatively Selected Plan provides for the intent and, in many cases, the letter of several Federal environmental laws, directives, and executive orders concerning restoration and conservation efforts (Table 17).

Table 17. Assessment of Tentatively Selected Plan Compared to Federal Laws, Regulations and Guidance.

<table>
<tr><td>North American Waterfowl Mgmt. Plan</td><td>The creation of permanent wetlands used for feeding and roosting sites would be constructed as well as areas of temporary flooded forest.</td></tr>
<tr><td>Executive Order No. 11990 (Protection of Wetlands)</td><td rowspan="2">Under the definition of this law and EO, much of the riparian Bosque would be considered wetland. Through this project, existing riparian and aquatic areas would be improved and protected.</td></tr>
<tr><td>North American Wetlands Conservation Act of 1989</td></tr>
<tr><td>Executive Order No. 11988 of May 1977 (Floodplain Management)</td><td>The project retains flood protections while improving function and increasing high value habitats.</td></tr>
<tr><td>Endangered Species Act of 1973, as amended</td><td>The project improves habitat for between 200 and 330 acres and creates opportunities for overbank flooding, which is essential to RGSM hatching and rearing. The project would also provide improved habitat for SWWF migration and provide additional acres of wet soil habitats used by SWWF for feeding.</td></tr>
<tr><td>Bald Eagle Protection Act of 1940</td><td>The project would ensure existing and future roost sites for migratory eagles.</td></tr>
<tr><td>Migratory Bird Conservation Act of 1929, and associated treaties</td><td rowspan="2">The restoration will provide a variety of high quality habitats that will benefit migratory birds using the MRG as a travel corridor and breeding site. Habitat improvements will benefit neotropical migrants by providing essential feeding and resting habitats.</td></tr>
<tr><td>Migratory Bird Treaty Act of 1918</td></tr>
</table>

Public Significance

Significance based on public recognition means some segment of the general public consider the resource or effect to be important. During the planning phase of the MRG Project, several meetings were held with the public to inventory interest solicit comments while developing alternatives. Feedback from the public was very positive and favored the project. Under the proposed project, similar measures are being recommended. Residents of Albuquerque have ready access to a wide array of places in the metropolitan area where they can engage in outdoor recreational activities such as hiking, bicycling, picnicking, wildlife observation, and other outdoor pursuits. However, the Rio Grande Bosque is a unique feature in the city and surrounding region. It is the only riparian area of any significant size and, as such, accounts for a substantial part of the wildlife habitat in the area and a critical urban oasis for residents and visitors. The cottonwood trees with the shrub and herbaceous growth (both native and exotic) provide a relatively cool and shady refuge from the surrounding desert grasslands and city pavement. Although recreation features are not a part of the Tentatively Selected Plan, the features that are recommended would support existing recreational and educational opportunities within Rio Grande Bosque.

Technical Significance

Significance based on technical recognition means that the importance of an environmental resources is based on scientific or technical knowledge or judgment of critical resource characteristics. The uniqueness of the Rio Grande system and its critical value as wildlife habitat make it of the utmost significance as a resource. As is suggested by the ongoing efforts described previously, the Rio Grande bosque is one of the most important and threatened ecosystems in the Southwest. The bosque is unique; it is a thin line of significant riparian habitat in an arid landscape of the Southwest. The

Rio Grande was listed as one of the World Wildlife Fund's 10 most endangered rivers in the world in 2007. The habitat quality, although diminished over the past few decades, still remains one of the most significant in the region. Over 300 species of birds, mammals, amphibians and reptiles live in the bosque, which are more than double those found in any other major ecosystem in the State. In addition to the indigenous wildlife species mentioned above, the bosque serves as a migration route for thousands of North American birds moving along the Central Flyway. Southwestern riparian ecosystems are one of the most threatened bird habitats according to the American Bird Conservancy.

Functional riparian systems such as the Middle Rio Grande bosque are becoming increasingly rare in the Southwest. Such systems found in the heart of an urban area are rarer still. The Rio Grande with its bosque is a green ribbon that weaves together different communities of the Albuquerque metropolitan area both figuratively and physically, connecting the present-day urbanites to the original inhabitants in the region. For decades the bosque has provided ecosystem services (for example, water filtration, urban heat island mitigation, etc.) for

Albuquerque and its neighboring communities. It also continues to provide unique aesthetic, cultural, educational and recreational opportunities for citizens and visitors to the region. The health of the region's many species of wildlife, as well as its human inhabitants, rests on the long-term health and viability of the Rio Grande bosque. The Middle Rio Grande is also the only habitat left (7% of the former range) for the Rio Grande silvery minnow and without restoration of nursery habitat, extinction is possible.

The Tentatively Selected Plan would improve the scarce native riparian habitat to a more pristine state, including a mosaic of habitat types. The Tentatively Selected Plan would provide habitat for the numerous migratory birds that use the area for nesting and stopover, provide additional potential habitat for listed species, and increase sustainability of the Bosque by creating connections between the Bosque and river. The Tentatively Selected Plan also meets the goals of increasing the HSI above 0.56, which is an increase in habitat value for all reaches. Increasing the habitat value above at least 0.5 would provide additional and/or improved habitat for all species. A value of 0.5 to 0.59 provides "„moderately high functionality‟ (discussed in Appendix F, Model Documentation Report).

5.2 Implementation Process

Due to the scope of the project and anticipated funding availability, implementation would likely take place over five to ten years. The project would be phased to efficiently make use of available funds and accomplish tasks requiring sequential implementation. Whereas bank lowering and side channel building at any one action area can be accomplished in a relatively short time (i.e., a few months), this activity would take place at only one or two areas simultaneously in order to minimize impacts to water quality. Removal of non-native species and revegetating with native species is generally a multiple year effort. Once the initial removal takes place, a follow-up treatment is often required six months to a year later to eliminate trees that resprout from roots or stumps. Planting of native species might not be prudent until the follow-up treatments have been performed. In some areas, removal of non-native species or jetty-jacks would be required to allow access to construct other measures.

Access to all work areas will be along the levee. A right-of-way access from MRGCD will be required for levee use, staging areas, storage areas, excess spoil, disposal sites, and construction. Staging would occur in adjacent open areas that are available from the sponsor, MRGCD. Any additional access and subsidiary staging areas to facilitate construction activities would be coordinated with local land managers, if needed.

Construction of all measures would primarily be scheduled during the typical low flow seasons on the MRG (fall and winter). However, any work scheduled during the nesting season (May 1 through August 30) would require nesting bird surveys. Fuel reduction and exotic thinning (treat, retreat, revegetation) would take place initially, followed by the construction of water measures, and finally the construction of recreation measures. Water measures would be constructed within the Bosque and then connected to the river in order to reduce sediment contribution to the river. If flows are adjacent to the inlet/outlet of the water measure (*i.e.*, high-flow channels), the flows within the river might need to be diverted using a port-a-dam or similar device. Excess soil generated by the construction of these measures would be made available to the local managing agencies (MRGCD, Reclamation, and AOSD) for their use. Material would be hauled to local areas for use or stockpiled at their facilities for future use. Best Management Practices (BMPs) would be employed throughout the project to protect water and air quality.

5.3 Risk and Uncertainty

Uncertainty and variability are inherent in water resources planning; therefore, an assessment of uncertainty is made to provide a basis for decision making. Uncertainty is described as being difficult to predict the outcome or unable to provide a probability distribution for an outcome. Alternatively, if a reasonable probability distribution can be formed for an outcome, this is described as risk. The degree of risk and uncertainty generally differs among various aspects of a project and over time. Whereas the functioning of a high-flow channel is relatively certain at a predicted water surface elevation due to the accuracy of hydrology models, the frequency at which that water surface elevation will be reached is dependent on hydrologic conditions and, therefore, difficult to predict. The risk exists for water measures in restoration alternatives to fill with sediment over the period of analysis. The team performed calculations to verify that all outputs in habitat value (HSI) were valid over the period of analysis. Similarly, the hydraulic analysis validated inundation area and duration for overbank events. Based on these analyses, the restoration measures and habitat outputs (AAHU) based on periodic inundation was validated. These restoration measures are still dependent on adequate precipitation in the Rio Grande watershed above the project to realize these outputs. Several restoration measures are dependent on hydrologic conditions. The success of exotic tree (salt cedar, Russian olive) control using standard methods varies between 65% and 85% mortality of treated plants. Dry conditions for the first year to two years following treatments increase success rates while wet conditions promote resprout or recovery of damaged plants. For the purposes of the Sandia to Isleta study, recent control methods were proposed with proven success rates of 75 to 85%. Costs for treatment and retreatment were based on these figures. USACE will phase implementation in such a way that not all areas will be treated the same year. To prevent a simultaneous loss of these habitats throughout the study area, USACE will stagger treatment over three years. Within a three year period, the risk of experiencing all dry conditions or all wet conditions is minimal; therefore, a median success rate was used to develop costs and schedules.

Similar treatment methods for revegetation is dependent on environmental conditions during planning. To minimize risk, irrigation will be used to establish new trees outside of swales. Because swales are excavated to groundwater depth, no irrigation is necessary. Grass seeding will take place to correspond with monsoon seasons; however, a particularly dry year could cause low success of seeding and require re-seeding in a wetter year. Because this would occur on a year where little or no rainfall is received, the risk is minimal.

5.4 Operations and Maintenance

Upon completion of project construction, the local sponsor will assume responsibility for Operations, Maintenance, Repair, Rebuild, and Rehabilitate (OMRR&R). Upon completion, USACE will complete an Operations and Maintenance manual for the project that summarizes all OMRR&R requirements. Currently, the annual costs for OMRR&R are estimated to be approximately $15,000. This amount includes the following:

- Spraying and removal of resprouts and seedlings from non-native plants. With approximately 261 acres of treat/retreat of vegetation, the cost is broken down by square mile of spraying and removal for resprouts. Therefore, the cost for this item would be 261acres/640acres/square mile x $10,000 = $4,078.

- Replacement of native plants that fail to become established. Based on previous experience with the Rio Grande Nature Center, this activity is not expected to experience many native plant failures per acre, therefore, USACE used a lump sum amount of $5,000 per year.

- Maintenance of the water measures (removal of sediment and vegetation as it builds up in the measures). The cost for this maintenance is based on sediment removal. Currently, the area of the Rio Grande associated with the restoration is at equilibrium. Sediment removal would be limited to the inlets and outlets of the channels. It is estimated that 500 cubic yards of sediment would be removed annually at a cost of $10 per cubic yard, which equates to an annual cost of $5,000.

5.5 Monitoring and Adaptive Management

Corps guidance, Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) – Monitoring Ecosystem Restoration, requires that a plan be developed for monitoring the success of the ecosystem restoration. This monitoring plan shall:

> *(1) include a description of the monitoring activities to be carried out, the criteria for ecosystem restoration, and the estimated costs and duration of the monitoring; and*
>
> *(2) specify that the monitoring shall continue until such time as the Secretary determines that the criteria for ecosystem restoration success will be met.*

The guidance also states that “an adaptive management plan (i.e., a contingency plan) will be developed for all ecosystem restoration projects”.

Post-project monitoring is a crucial requisite of the adaptive management process, as performance feedback might generate new insights into ecosystem response and provide a basis for determining the necessity or feasibility of subsequent design or operational modifications. Success should be measured by comparing post-project conditions to the restoration project purpose and needs and to pre-project conditions.

Monitoring also provides the feedback needed to establish protocols and make adjustments where and when necessary to achieve the desired results. Monitoring of USACE Bosque Wildfire and Albuquerque Biological Park Wetlands projects has provided information that has been useful in developing goals and alternatives for this project. Monitoring from those projects will also aid in design.

Two types of monitoring are proposed to evaluate project success and to guide adaptive management actions. The first type, termed “Validation Monitoring”, would involve various degrees of quantitative monitoring aimed at verifying that restoration objectives have been achieved for both biological and physical resources. Specific hypotheses addressing type and amount of functional improvements anticipated over specified time periods would be developed and tested as project success criteria. The second type of monitoring, termed “Effectiveness Monitoring” would be implemented to confirm that project construction elements perform as designed. For example, effectiveness monitoring would be used to evaluate percent survival of native plant material installed, to determine if high-flow channels convey water at predicted flow levels, etc. USACE would use one or both types of monitoring to guide adaptive management of proposed projects and to guide future restoration designs. See Appendix F for the complete Monitoring and Adaptive Management Plan.

5.6 Schedule for Design and Construction

Once the proposed project is approved for implementation, a Design Agreement and Project Partnership Agreement will be executed for design and construction, respectively. Design for the proposed project measures is expected to take approximately one year. Dependent upon funding availability for construction, it is expected that project implementation will take approximately two to three years. The current schedule has completion of the study in 2019, so design would be expected to be complete by 2020, with construction completed by 2022 or 2023. Monitoring and adaptive management would occur after completion of construction.

5.7 Cost Estimates

The initial costs for the Tentatively Selected Plan are summarized in Table 18 below. The cost share for the proposed project is 65% Federal, 35% non-Federal.

Table 18. Cost Apportionment Table for the Tentatively Selected Plan.

Account	Item	Federal Cost	Non-Federal Cost	Total Cost
01	Lands, Easements, Relocations, Right of Way, and Disposal Sites	$ -	$ 451,740.00	$ 451,740.00
02	Relocations	$ -	$ -	$ -
06	Ecosystem Restoration	$ 11,451,609.00	$ 6,166,251.00	$ 17,617,860.00
30	PED	$ 1,468,155.00	$ 790,545.00	$ 2,258,700.00
31	CM	$ 1,468,155.00	$ 790,545.00	$ 2,258,700.00
	Total:	**$ 14,387,919.00**	**$ 8,199,081.00**	**$ 22,587,000.00**

6 - Foreseeable Effects of the Tentatively Selected Plan*

6.1 Geology and Soils

Sandia to Isleta Measure Best Buy 10 will include excavation for high flow channels, swales, river connections, and bankline terracing. Excess material from these actions will need to be disposed of properly offsite. Care shall be taken to prevent soils disturbed during treatment and removal of invasive vegetation from entering the Rio Grande. Any damage to the levee embankment or ramps, caused by construction equipment will require repairs. Project measures that include re-vegetation should not be implemented within 15 feet of the toe of the levee.

Regional geology will not be affected by this project as the disturbance is localized and shallow in depth.

6.2 Climate

The project will have no effect on the overall trajectory of climate change in the region. Climate change is likely to impact project primarily by reducing the overall volume of water during spring runoff flows, resulting in shallower water depths in channels and other restoration measures, sedimentation within the measures, and potentially reduced water quality (see Appendix B, Climate Change).

6.3 Hydrology, Hydraulics and Sustainability

6.3.1 Hydraulic Modeling of Restoration Alternatives

Mussetter Engineering, Inc. (MEI) was retained by USACE to perform FLO-2D modeling in support of this planning study. The inundation scenarios evaluated from this modeling exercise were used to evaluate the proposed alternatives and provide a comparison to existing conditions. While a summary of the results are provided herein, a more detailed explanation and review of the results are provided in the complete report, which is included within the H&H Appendix.

FLO-2D modeling was conducted to evaluate depth, extent and duration of overbank inundation for the restoration alternatives. The existing Conditions model was modified to represent each of the restoration alternatives by making appropriate adjustments to the model geometry and roughness parameters. Alternative 1 is referred to as the “Maximum Effort” alternative, and contains all channel and overbank measures that were considered in formulating the restoration plan. Alternatives 2, 3, 4 and 5 are termed the “Minimum Effort”, “Moderate Effort”, “Moderate Effort-A”, and “Moderate Effort-B”, respectively, and they were developed using various combinations of the channel and overbank measures that were included in Alternative 1. Alternate 4, the “Moderate Effort-A” Alternative was implemented for the MRG Bosque Restoration Project. Roughness parameters were also used to assess expected temporal changes in vegetation. Specific modeling details for the various habitat restoration measures are described in more detail in the H&H Appendix.

The modified Existing Conditions for the restoration alternatives serves as the Year 0 condition for all hydrologic scenarios. Future channel conditions were modeled for the two hydrologic scenarios applicable to restoration activities (channel full conditions [6,000 cfs] and post-Cochiti annual spring hydrograph [3,770 cfs]) to evaluate the effects of aggradation or degradation on overbank inundation 5, 20, 30 and 50 years into the future. Sediment conditions (aggradation or degradation) in the future were simulated using a calibrated HEC-6T model and a 50 year mean daily record comprised of actual post-Cochiti flow records (MEI 2008). All results for the restoration alternatives are compared against the baseline conditions discussed previously. These are summarized in the following sections and provided in more detail in the H&H Appendix.

6.3.2 Restoration Alternative Results

6.3.2.1 Restoration Alternative 1 Results

Alternative 1 is the "Maximum Effort" alternative (Best Buy #20). This alternative includes approximately 232 acres of swale measures, 95 acres of water-channel measures [high-flow channels and embayments (connected to the active channel)], and 174 acres of water-pond measures [ponds (not connected to the active channel)]. Do to the amount of restoration work in the reach the simulations predict water-surface elevations would decrease slightly from the existing conditions. This water surface elevation lowering is caused by the increased conveyance capacity associated with the restoration measures, particularly the bank lowering and water measures that create a wider channel and allow more flow in the overbanks. Despite the lower water surface elevation, modeling for restoration alternative 1 indicated substantially more inundated acreage for both hydrologic scenario 1 and 2 compared to the existing conditions with the MRG Bosque Restoration project in place. The maximum inundation generally occurs during Year 5 due to modest amounts of channel aggradation. Inundation results for hydrologic scenarios 1 and 2 are listed in Table 19. The extent, maximum depth, and duration of inundation for this scenario are shown in the H&H Appendix.

Table 19. Summary of areas of inundation for existing conditions and Restoration Alternative 1 (Years 0, 5, 20, 30 and 50) (acres).

Hydrology Scenario	Description	Future Channel Condition (yr)	Reach (acres)					
			1	2	3	4	5	Total
1	Channel Full Conditions	Existing with MRG Bosque Restoration	145.2	46.1	31.3	55.5	85.5	363.6
		0	204.6	182.2	122.6	125.5	175.1	810.0
		5	199.6	179.5	122.1	132.0	179.4	812.6
		20	196.1	176.1	122.6	124.1	174.2	793.1
		30	201.8	174.7	122.5	121.5	173.6	794.1
		50	196.3	174.8	122.4	121.2	172.7	787.4
2	Annual Spring Runoff	Existing with MRG Bosque Restoration	113.3	25.2	16.6	30.7	42.9	228.7
		0	175.8	109.3	88.0	62.3	77.7	513.1
		5	180.0	109.0	89.0	65.4	93.8	537.2
		20	178.8	110.0	86.7	53.1	70.1	498.7
		30	178.8	110.4	88.8	54.3	70.8	503.1
		50	175.5	108.7	89.5	54.0	73.0	500.7

6.3.2.2 Restoration Alternative 2 Results

Alternative 2 is the “Minimum Effort” alternative. This restoration alternative was not considered for implementation in the MRG Restoration Project and will not be considered for the Sandia to Isleta Project. This alternative is no longer applicable for the current project and is given here only to demonstrate the historical perspective from previous analysis for the MRG Restoration Project. The current existing condition (with the MRG Restoration Project) exceeds the various inundation results given for the “Minimum Effort” alternative 2. Additional inundation acreage from this restoration alternative was very small compared to the historical condition prior to the MRG Restoration Project. Inundation results for hydrologic scenarios 1 and 2 are listed in Table 20. The extent, maximum depth, and duration of inundation for this scenario are shown in the H&H Appendix.

Table 20. Summary of areas of inundation for existing conditions and Restoration Alternative 2 (Years 0, 5, 20, 30 and 50) (acres).

Hydrology Scenario	Description	Future Channel Condition (yr)	Reach (acres)					
			1	2	3	4	5	Total
1	Channel Full Conditions	Existing with MRG Bosque Restoration	145.2	46.1	31.3	55.5	85.5	363.6
		0	77.5	42.9	30.0	35.2	76.0	261.6
		5	80.9	40.7	40.9	35.3	74.2	272.0
		20	79.4	39.7	40.3	32.6	73.7	265.7
		30	79.8	39.7	40.3	32.7	74.2	266.7
		50	70.1	36.8	34.6	30.6	73.2	245.3
2	Annual Spring Runoff	Existing with MRG Bosque Restoration	113.3	25.2	16.6	30.7	42.9	228.7
		0	45.1	24.6	21.0	11.2	18.3	120.2
		5	50.1	24.0	25.5	9.8	12.4	121.8
		20	43.4	22.3	24.7	9.1	11.3	110.8
		30	47.2	24.1	25.3	9.6	11.9	118.1
		50	47.0	24.5	25.4	9.7	11.9	118.5

6.3.2.3 Restoration Alternative 3 Results

Alternative 3 is the “Moderate Effort” alternative (Best Buy #15). The inundation extents under this alternative would increase significantly from the current existing conditions with the MRG Bosque Restoration in place. The maximum inundation generally occurs during Year 5 due to modest amounts of channel aggradation. Inundation results for hydrologic scenarios 1 and 2 are listed in Table 21. The extent, maximum depth, and duration of inundation for this scenario are shown in the H&H Appendix.

Table 21. Summary of areas of inundation for existing conditions and Restoration Alternative 3 (Years 0, 5, 20, 30 and 50) (acres).

Hydrology Scenario	Description	Future Channel Condition (yr)	Reach (acres)					
			1	2	3	4	5	Total
1	Channel Full Conditions	Existing with MRG Bosque Restoration	145.2	46.1	31.3	55.5	85.5	363.6
		0	152.3	133.2	40.8	66.1	85.7	478.0
		5	159.7	126.8	44.8	66.8	83.3	481.5
		20	157.2	123.5	45.1	66.1	80.7	472.7
		30	158.0	123.8	44.9	66.9	80.2	473.8
		50	159.5	123.6	45.1	67.0	80.2	475.4
2	Annual Spring Runoff	Existing with MRG Bosque Restoration	113.3	25.2	16.6	30.7	42.9	228.7
		0	116.7	86.5	32.5	41.8	42.2	319.7
		5	116.7	86.7	35.8	49.2	36.3	324.8
		20	115.2	87.3	38.5	41.7	35.2	317.9
		30	116.2	87.2	38.5	41.3	35.8	319.0
		50	115.1	87.2	34.5	40.7	35.8	313.3

6.3.2.4 Restoration Alternative 4 Results – Existing Condition Following the Construction of the MRG Restoration Project

Restoration Alternative 4 is the "Moderate Effort-A" that has been constructed. During the spring snow-melt runoff of 2017 the improvements made for the MRG Bosque Restoration Project were observed to function as designed, indicating that the modeling assumptions are still valid. Therefore, it is expected that hydraulic modeling results associated with the other restoration alternative scenarios are still valid for the Sandia to Isleta Restoration Project.

6.3.2.5 Restoration Alternative 5 Results – Sandia to Isleta Proposed Project

Restoration alternative 5 is the "Moderate Effort-B" alternative (Best Buy #10). The amount of overbank inundation for each simulation under the Moderate Effort-B Alternative is an increase from the existing conditions, but is not as extensive as the "Moderate Effort" (Alternative 3). Inundation results for hydrologic scenarios 1 and 2 are listed in Table 22. The extent, maximum depth, and duration of inundation for this scenario are shown in the H&H Appendix.

Table 22. Summary of areas of inundation for existing conditions and Restoration Alternative 5 (Years 0, 5, 20, 30 and 50) (acres).

Hydrology Scenario	Description	Future Channel Condition (yr)	Reach (acres)					
			1	2	3	4	5	Total
1	Channel Full Conditions	Existing with MRG Bosque Restoration	145.2	46.1	31.3	55.5	85.5	363.6
		0	145.2	46.1	49.0	96.6	85.5	422.4
		5	147.7	44.6	47.9	94.4	84.4	419.0
		20	146.7	45.3	44.4	95.1	88.1	419.6
		30	147.5	45.0	48.2	95.6	83.6	416.9
		50	148.9	45.7	43.9	91.3	82.3	412.1
2	Annual Spring Runoff	Existing with MRG Bosque Restoration	113.3	25.2	16.6	30.7	42.9	228.7
		0	113.3	40.3	39.5	73.6	42.9	309.6
		5	113.3	37.5	45.6	74.4	37.3	308.1
		20	111.8	40.0	45.5	67.7	21.4	286.4
		30	112.8	38.1	45.0	79.6	22.6	298.1
		50	111.6	37.6	41.5	65.2	19.1	275.0

6.3.2.6 Sustainability of Restoration Measures

In order to evaluate the long term sustainability of restoration measures, an analysis of the overbank sediment-transport characteristics was conducted. Overbank flows will cause sediment deposition within the floodway and in the proposed channel restoration measures, particularly after vegetation has become established. An estimate of the amount and rate of sediment deposition within these measures was made for Restoration Alternative 1 (Maximum Effort alternative) under Hydrology Scenario 4 (100-year post-Cochiti flood-flow snowmelt hydrograph).

The amount of overbank sedimentation that would occur was estimated from the amount of sediment in the main channel water column that would be conveyed into the overbank using the Rouse suspended sediment profile associated with a representative reach particle size (MEI 2008). The average percent of the bed-material load carried by hydrologic scenario four into the channel restoration measures for this study area was 35 percent, while the percent of bed-material load above the bank elevation averaged 12 percent.

Floodway sediment deposition depths were estimated by calculating a volume of transported sediment and then dividing by the inundation area. The restoration measure deposition by project reach, is listed in Table 23. This provides a maximum sediment deposition scenario for a single 100-year snowmelt runoff scenario (100+ days at 7,000 cfs). Additional modeling details are provided in the H&H Appendix.

Given the magnitude of the 100-year snowpack event, the predicted amount of deposition appears reasonable and relatively low. Furthermore, given that the predicted depth of overbank is an upper limit and the depth of deposition is significantly less than the depth of the measures, the overbank measures should not be unreasonably affected by sediment deposition over the 50-year life of the project. It is recommended that monitoring of measures occur, especially after a large spring snow-pack runoff to measure actual sedimentation depths.

Table 23. Predicted sedimentation depths in the channel measures (3,500-cfs measures) for the Maximum Effort, 100-year snowmelt scenario.

Reach	Sediment Transport-Main Channel (tons/day)	Sediment Transport Channel Measures (tons/day)	Average Overbank Sedimentation Depth (ft)
1	12,181.07	4,263.37	0.6
2	12,644.97	4,425.74	0.7
3	13,239.62	4,633.87	0.9
4	11,885.03	4,159.76	0.4
5	13,048.20	4,566.87	0.4

6.3.2.7 Summary of Restoration Analysis Results

A channel-stability analysis indicated that the bed-material transport capacity is relatively consistent between reaches in the study area, although there is a slight net degradational tendency, in the absence of tributary sediment inputs. A sustainability analysis of the potential sediment deposition estimated values of less than a foot. This is a relatively low value for the 100-year post-Cochiti flood-flow snowmelt hydrograph. Given the relatively low amount of deposition during this large event, the overbank measures are not expected to be unreasonably affected by sediment deposition over the 50-year life of the project, although sediment deposition monitoring is recommended.

An overall inundation acreage summary for the existing conditions and modeled restoration alternatives is shown in Table 24.

Table 24. Summary of total inundation area (acres) for existing conditions with and without the MRG Bosque Restoration Project (Modeled alternative 4) and the evaluated restoration alternatives.

Alternative	Description	Hydrologic Event / Future Channel Condition	Channel Full Flow (Steady-state)	Annual Snowmelt Hydrograph	100-year Hydrograph
	Existing conditions prior to the MRG Bosque Restoration Project	Year 0	253.7	87.9	657.2
		Year 5	251.0	88.1	
		Year 20	246.6	86.4	
		Year 30	247.3	87.9	
		Year 50	243.9	86.3	
1	Maximum Effort	Year 0	796.0	513.1	1,317.5
		Year 5	806.4	537.2	
		Year 20	789.5	498.7	
		Year 30	786.3	503.1	
		Year 50	783.5	500.7	
2	Minimal Effort	Year 0	261.6	120.2	726.7
		Year 5	272.0	121.8	
		Year 20	265.7	110.8	
		Year 30	266.7	118.1	
		Year 50	245.3	118.5	

3	Moderate Effort	Year 0	478.0	319.7	1,111.7
		Year 5	481.5	324.8	
		Year 20	472.7	317.9	
		Year 30	473.8	319.0	
		Year 50	475.4	313.3	
4	Moderate Effort-A – Existing Condition with MRG Bosque Restoration Project	Year 0	363.7	228.7	
		Year 5	360.0	245.6	
		Year 20	357.8	213.8	
		Year 30	358.9	214.2	
		Year 50	360.5	212.1	
5	Moderate Effort-B – Proposed Sandia to Isleta Project	Year 0	422.4	309.6	
		Year 5	419.0	308.1	
		Year 20	419.6	286.4	
		Year 30	416.9	298.1	
		Year 50	412.1	275.0	

6.4 Water Depletions

The Proposed Action consists of approximately 10 water measures (e.g. high flow channels and wetlands), the majority of which lie within the designated 600-foot Rio Grande Floodway. All measures would be evaluated to determine whether they require depletions offsets. Work on those measures that lie outside of the 600-foot corridor, and do require offsets, would not commence until a source of offset water satisfactory to the Office of the State Engineer has been procured. Therefore, because any increase in water depletions from the Proposed Action would be offset, there would be no effect on Water Depletions.

6.5 Water Quality

Soil disturbance would result from vegetation clearing, jetty jack removal, and excavation of wetlands, swales, and high flow channels. Denuded soils would be susceptible to erosion by wind and water. This erosion could result in introduction of sediment to the Rio Grande. The potential for storm water pollution during construction is minimal for this project. The contractors' work would be in accordance with the National Pollutant Discharge Elimination System permit as described below.

Mechanical equipment such as brush-clearing machines and excavators could potentially leak oil, fuel, or hydraulic fluid, which could reach the Rio Grande and affect surface water quality. Spills of such materials could similarly contaminate surface water in the river or riverside drain. All equipment would be inspected daily to ensure that oil, hydraulic fluid, or other potential contaminants are not leaking. All petroleum products would be stored outside of the 100-year floodplain and maintained to ensure that leaks or spills are contained and remediated at the storage site.

Section 404 of the Clean Water Act requires analysis under the EPA's 404(b)(1) Guidelines if USACE proposed to discharge fill material into a water or wetlands of the United States. The 404(b)(1) analysis has been completed for Nationwide 33 (Temporary Construction, Access, and Dewatering) due to the potential need to dewater at the bank of the river when constructing the high-flow channels); and for Nationwide Permit 27 (Aquatic Habitat Restoration, Establishment, and Enhancement Activities) for the proposed restoration measures listed above. All conditions under Nationwide Permit 33 and 27 would be adhered to during construction. A water quality certification permit under Section 401 of the CWA would be required. USACE will ensure the terms and conditions of the Section 401 permit are followed for the duration of construction.

Section 402(p) of the CWA regulates point source discharges of pollutants into waters of the United States and specifies that storm water discharges associated with construction activity be conducted under National Pollutant Discharge Elimination System (NPDES) guidance. USACE will apply for coverage under the NPDES construction general permit (CGP). A StormWater Pollution Prevention Plan (SWPPP) will be completed prior to construction and followed throughout the duration of the project.

6.6 Air Quality and Noise

Ground disturbance would occur during construction of all measures in the Proposed Action, therefore, BMPs to minimize air quality disturbance would be employed. These BMPs include tracking out of material by covering trucks to avoid fugitive dust violations; maintaining and sweeping public trails to keep them free of debris and dust; and wetting down work areas. Speed limits on levee roads would be limited to 15 mph, which also would minimize dust. A fugitive dust permit would be obtained from the City of Albuquerque. All works areas would be continually wet down to minimize dust. Any sediment deposited on the paved trail due to construction would be swept as needed. Therefore, short-term impacts to air quality are anticipated during construction but would be abated to the extent possible using BMPs as described above. There would be no long-term adverse effects to air quality from the Proposed Action.

Equipment to be used during construction would include pieces generating a fair amount of noise. This noise would be somewhat abated in adjacent neighborhoods due to the buffering by the levee road when work is taking place in the bosque. Travel on the levee roads to and from work locations also would create noise during the project. The project would take place during normal work hours between 7:00am and 5:00pm in order to minimize disturbance. All OSHA and local municipality requirements would be adhered to. Therefore, there would be minor, short-term noise impacts from the Proposed Action during construction, which would occur only during normal working hours.

6.7 Ecological Resources

6.7.1 Vegetation Communities

For the Proposed Action, revegetation of areas proposed to be thinned under this project also would be revegetated in a timely manner. Current discussions among professionals of riparian restoration include a conceptual mosaic for future vegetative conditions. The prescription for bosque landscape alteration centers on re-creating a patchy mosaic of native riparian trees and open spaces along the narrow active floodplain of the Middle Rio Grande (Crawford and Grogan, 2004). Although the present straightened and levee-bordered river would require that the mosaic be somewhat linear, it would otherwise resemble the pattern of scattered cottonwood groves interspersed by open spaces that once characterized the wider historic floodplain (Horgan 1984).

Open areas between the patches also would support grasses and shrubs, and widely spaces individual trees or groves useful for animals moving between the patchy woodlands. This combination of tree reduction (which is already occurring and is being proposed within this project) and increased open space would reduce overall evapotranspiration (ET) in the altered landscape and potentially increase water in its shallow aquifer. The conceptual mosaic is still evolving and would be site specific but an overall breakdown of vegetative communities would include approximately 30% shrub community, approximately 50% tree community (with 25% being tree with grass understory and the other 25% being tree with shrub understory), 16% grassland/herbaceous community, and the other 4% as wet meadow/wetland community.

In creating this future conceptual mosaic, revegetation strategies would be implemented. All sites would be tested for depth to groundwater, soil salinity, and soil texture. Existing topography would be coupled with this information to develop revegetation strategies for each project area.

Long-term benefits proposed by the project include reduction in fire potential, potential water savings, potential decreased soil salinity, and increased wildlife habitat value over the long-term. It should be noted that potential water savings can depend significantly on local physical variables.

Fuel loads in the Middle Rio Grande have built up over the last 50 years or more due to the lack of flooding and disconnect between the river and bosque. Flood flows used to carry away debris and allow for quicker processing of vegetative material. Since this does not readily occur, much of the dead material has built up over that period of time and created an extreme fire danger. A reduction in these fuel loads, especially in the ladder fuels (which create a ladder between the floor of the bosque and the cottonwood canopy), can greatly reduce the chance of a catastrophic fire were one to occur. This older material is also extremely dry and flammable. Removal and processing of this material is crucial to preventing future fires. Although past and recent restoration efforts have made a positive influence on fuel load, there are locations within the bosque that still have high fuel loads.

Saltcedar are fire-adapted species and have long taproots that allow them to intercept deep water tables and interfere with natural aquatic systems. Saltcedar disrupts the structure and stability of native plant communities and degrades native wildlife habitat by out-completing and replacing native plant species, monopolizing limited sources of moisture, and increasing the frequency, intensity and effect of fires and floods. Although it provides some shelter, the foliage and flowers of saltcedar provide little food value for native wildlife species that depend on nutrient-rich native plant resources (Muzika and Swearingen, 1999). Birds prefer to nest in native vegetation that contain their preferred physical structure and food source (Yong and Finch, 2002). Overall, the possible short term ill effects resulting from non-native vegetation removal and the Proposed Action would be strongly mitigation through the replacement of saltcedar with a younger, more diverse native riparian community which would add to biodiversity at the landscape level.

Saltcedar control in mixed saltcedar/native bosque would reduce stress to native species, which are competing with exotic vegetation, and would reduce wildfire hazards (Taylor, 1999). Substrate for native species regeneration within these sites also would be provided as a result of saltcedar control and decreased salinity of soil. This alternative would maximize the production of indigenous species such as salt grass, willow, and native wet meadow species, to potentially support greater numbers of native bird species and other wildlife.

Individual locations within the Proposed Action may have a varied revegetation strategy in order to aim toward the conceptual mosaic and stay within current water demands. Replacing dead material and non-native vegetation with a mosaic of native vegetation should lead to a system of less water use, decreased fire danger, and increased diversity of native species for use by wildlife. Therefore, the long-term effects of replacing the non-native dominated vegetation system with native dominated species is proposed to outweigh the short-term negative effects, which would be caused by the Proposed Action.

6.7.2 Invasive Species

Though the goal is not to completely eradicate all of the invasive tree species, the Proposed Action does include selectively thinning these species to allow native species to be planted and given a chance to outcompete the non-native vegetation. Non-native trees would most likely always be present, but the Proposed Action goal would be to reduce them to a manageable level (for example, 10-15% of the tree population). Therefore, the Proposed Action would have a beneficial effect by removing non-native vegetation and planting native vegetation.

6.7.3 Noxious Weeds

Noxious weeds within the Proposed Action Area would be treated (if a proven method for 4treatment exists) or avoided (if no treatment method exists) in order to prevent the spread. Any new patches of weeds found during construction of the Proposed Action would be noted and treated/avoided as pertinent.

Salt cedar is a Class C Weed that also occurs within the Proposed Project Area. It is anticipated that due to efforts to treat resprouts of non-native and replanting of native species that this should impede new infestations of weedy species. Regrowth of all vegetation would be monitored throughout the duration of the project for infestation by noxious weeds and non-native species such as salt cedar and Russian olive. Also, the contractor would be required to wash all equipment being used before entering the Proposed Project Areas. Therefore, it has been determined by USACE that the Proposed Action is in compliance with Executive Order 13112 and there would be a beneficial effect from removing non-native vegetation and possibly existing weed species from the Proposed Project Area.

6.7.4 Herbicide Application and the Environmental Fate of Chemicals

Herbicide application will be used after manual and /or mechanical treatment of non-native vegetation. To minimize the exposure to non-target organisms, targeted applications (e.g., using backpack or ATV mounted sprayers) will be implemented rather than widespread treatments (e.g., broadcast or aerial application). Herbicide application best management practices will also minimize risk to non-target organisms. All activities will follow the EPA-approved label.

The preferred herbicides to use, based on active ingredient (i.e., Triclopyr), are Garlon®4 and Garlon®3A, or comparable. Within the channel, where water would enter at some point in time after construction, a formulation approved for aquatic sites would be applied (Renovate® 3, or comparable). Triclopyr acts by disturbing plant growth. It is absorbed by green bark, leaves and roots and moves throughout the plant. Triclopyr accumulates in the meristem (growth region) of the plant. Non-ionic surfactants that have been approved for use in aquatic habitats (e.g., Induce) would be used. A dye will be used to identify areas where herbicides have been applied, to prevent over-spraying.

Triclopyr is active in the soil, and is absorbed by plant roots. Microorganisms degrade triclopyr rapidly; the average half-life in soil is 46 days. Triclopyr degrades more rapidly under warm, moist conditions. The potential for leaching depends on the soil type, acidity and rainfall conditions. This herbicide is selective to woody plants and has little to no effect on grasses (Parker et al., 2005). It has been certified and labeled to be used near water by the Environmental Protection Agency (EPA, 1998).

A pesticide treatment plan will be included and updated, as information becomes available. The plan will include: sequence of treatment, dates, times, locations, pesticide trade name, EPA registration numbers, authorized uses, chemical composition, formulation, mixing, storage, original and applied concentration, application rates of active ingredient (i.e. pounds of active ingredient applied), equipment used for application and calibration of equipment, spill response, and disposal. The plan will be reviewed and approved by USACE prior to all herbicide applications. Herbicide storage will not be allowed on-site within the bosque. Mixing of herbicides may occur within the bosque, however, spill prevention and containment best management practices will be deployed to minimize the potential risk of a release.

USACE will be responsible for Federal, State, Regional and Local pest management record keeping and reporting requirements, and oversee all other permitting and licensure would be obtained by the contractor. If the application of a pesticide results in a discharge to Waters of the United States, USACE will ensure the action is covered under the current NPDES Pesticide General Permit (PGP).

To inform and protect the public, the areas will be closed and signage will be placed 24-hours prior to and following treatment at readily visible locations (e.g., trail heads, levees roads, trails). Follow-up inspections and monitoring post-herbicide application will be performed at all locations.

6.7.5 Wildlife

The proposed work would occur during the winter, which is when Bald Eagles may be in or near the Proposed Project Area. In order to minimize the potential for disturbing Bald Eagles utilizing adjacent habitat, the following guidelines would be employed. If a Bald Eagle is present within 0.25 mile upstream or downstream of the active construction site in the morning before activity starts, or is present following breaks in project activity, the contractor would be required to suspend all activity until the bird leaves of its own volition; or a Corps biologist, in consultation with the USFWS, would determine that the potential for harassment is minimal. However, if a Bald Eagle arrives during construction activities or if an eagle is greater than 0.25 mile away, construction need not be interrupted. Also, cottonwood snags or other large trees present along the riverbanks that may serve as potential roost habitat would be left intact as part of this project. Implementation of these measures would preserve undisturbed Bald Eagle us of roost, foraging and perching sites in the riparian area adjacent to the project sites.

In order to minimize potential effects on nesting birds in the project area, clearing of live vegetation would only occur between August 15 and April 15. Per Migratory Bird Treaty Act (MBTA), the proposed project would not entail the taking, killing or possession of any migratory birds listed under this Act. Since some raptors begin setting up nests as early as February, monitoring for bird nests would occur before construction to avoid any potentially active nests. The proposed project, is therefore, in compliance with the requirements of the MBTA.

The Proposed Action is approximately 25,000 feet east of the Double Eagle II Airport (which is on the west side of Albuquerque) as well. The Albuquerque International Airport is within the recommended 5-mile approach and departure airspace. The Airport currently implements procedures to reach altitudes well above the bosque canopy to attempt to avoid waterfowl and other birds utilizing the bosque. Therefore, the Proposed Action is within compliance of the Memorandum of Agreement between the Federal Aviation Administration, U.S. Air Force, U.S. Army, U.S. Environmental Protection Agency, the USFWS, and the U.S. Department of Agriculture to Address Aircraft-Wildlife Strikes (referenced in Section 3.10).

Other wildlife such as arthropods, mammals, amphibians and reptiles also would be displaced during implementation of the Proposed Action. There also is the potential to affect amphibian species in the bosque due to herbicide use. The New Mexico Department of Game and Fish suggested that risks of toxicity to this fauna could be avoided eliminating the use of herbicide use during the month of September. Therefore, herbicide use within the project area would only take place between October and April.

Since the ultimate goal is to revegetate with native species, which would create a healthier ecosystem in the long-term for native wildlife, these short-term effects of the project would be outweighed by the long-term benefits to all species. Implementation of Best Management Practices (BMPs) and timelines mentioned above also would aid in protecting species. Therefore, the Proposed Action would have short-term negative effects on wildlife with long-term positive benefits. The variability of habitat types also would provide different niches for different groups of wildlife (birds, herpetofauna, fish, small mammals and arthropods).

In accordance with the Fish and Wildlife Coordination Act, USACE has been and would continue to coordinate with the USFWS and seek their advice and recommendations on fish and wildlife resources during all phases of the project. The USFWS submitted a Final Fish and Wildlife Coordination Act Report (CAR) to USACE on November 10, 2010 (Appendix G). The CAR concluded that the proposed project would not have any permanent adverse impacts on the biological resources in the project area with implementation of recommendations outlined in the report. The CAR's short-term recommendations (to be implemented during construction) are listed below. These recommendations would be incorporated as construction BMPs where possible. Many of the recommendations overlap with specific goals of the Proposed Action. USACE would coordinate with USFWS (and other agencies as appropriate) on the more ‘long-term’ recommendations.

1. Where possible, avoid construction during the migratory bird nesting season of April 15 through August 15. Where that is not possible, tree stands or other adequately vegetated area slated for grubbing or clearing should be surveyed for the presence of nesting birds prior to construction. Avoid disturbing nesting areas until nesting is complete.

2. Employ silt curtains (without lead weights), cofferdams, dikes, straw bales or other suitable erosion control measures during construction.

3. Store and dispense fuels, lubricants, hydraulic fluids, and other petrochemicals outside the 100-year floodplain. Inspect construction equipment daily for petrochemical leaks. Contain and remove any petrochemical spills and dispose of these materials at an approved upland site. Park construction equipment outside the 100-year floodplain during periods of inactivity.

4. Ensure equipment operators carry an oil spill kit or spill blanket at all times and are knowledgeable in the use of spill containment equipment. Develop a spill contingency plan prior to initiation of construction. Immediately notify the proper Federal and state authorities in the event of a spill.

5. All work and staging areas should be limited to the minimum amount of area required. Existing roads and rights-of-way and staging areas should be used to the greatest extent practicable to transport equipment and construction materials to the project site, and described in the USACE’s project description. Provide designated areas for vehicle turn around and maneuvering to protect riparian areas from unnecessary damage.

6. Backfill should be uncontaminated earth or alluvium suitable for re-vegetation with native plant species.

7. Scarify compacted soils or replace topsoil and re-vegetate all disturbed sites with suitable mixture of native grasses, forbs, and woody shrubs.

8. Protect mature cottonwood trees from damage during clearing of non-native species or other construction activities using fencing, or other appropriate materials.

9. Use local genetic stock wherever possible in the native plant species establishment throughout the riparian area.

10. Vegetation treatments will avoid the federally endangered Southwester Willow Flycatcher migration and breeding seasons.

11. Immediately prior to construction of each unit and prior to reinitiation of work following an extended period of no action, conduct surveys to assess the possible presence of Federal and State endangered or threatened species, or Tribal species of concern. If protected species are located, coordinate with Federal, State, and Tribal wildlife agencies to prevent adverse impacts to the species.

12. Construction should be accomplished during periods of least resource impact. Work should be scheduled to avoid disturbance to breeding and nesting Neotropical migrant land birds

and to fish, especially native fishes, during the spawning and hatching periods. To minimize disturbance to wildlife, the duration of project construction should be as brief as possible.

13. Implement recovery measures for the minnow. This should include long-term monitoring throughout the proposed project area.

14. Conduct Bald Eagle surveys to determine areas of eagle use. Avoid project activity in areas where eagles are known to perch or roost from November to March.

15. Strict control and frequent monitoring of construction activity by the USACE biologist to ensure all contract specifications and agreements are being implemented and achieved.

16. Inspect all equipment daily to ensure there are no leaks or discharges of lubricants, hydraulic fluids or fuels.

6.8 Special Status Species

6.8.1 Rio Grande Silvery Minnow

Designated critical habitat for the species (68 Federal Register 8087: 8135) encompasses nearly the entire Proposed Project Area. Work would not take place in the main channel but it would take place along the bank and it may result in erosion or other inputs into the river. When work is to occur close to the bank of the river, BMPs would be enforced to prevent erosional inputs into the river. These BMPs would include, but would not be limited to: the use of silt fences adjacent to the riverbank; fueling of vehicles would not take place inside the levees; and equipment and vehicles would be cleaned prior to entering the bosque.

Additionally, this project is being constructed to provide potential habitat for the Rio Grande silvery minnow (RGSM) and would create additional suitable nursery habitat through the creation of high-flow channels with embayments, which would help with the population. High-flow channels would provide habitat in the form of ephemeral side channels (embayments) for the RGSM and potential refuge during spawning, egg, and/or juvenile stages. The Proposed Project would be closely monitored to determine the benefits for the RGSM, which are proposed to occur as an outcome of the Proposed Action.

Therefore, the Proposed Action may affect but is not likely to adversely modify designated Critical Habitat of the RGSM. The Proposed Action may affect but is not likely to adversely affect the RGSM, and may provide positive benefits to the species. USACE has submitted a Biological Assessment in reference to the RGSM (Appendix F).

6.8.2 Southwestern Willow Flycatcher

Based on the surveys conducted within the Proposed Action Areas and other surveys performed in the past within the project areas (by other entities), it is highly unlikely that nesting Southwestern Willow Flycatchers (SWFL) would occupy the project area during the construction period, proposed to begin in 2021 and continue through 2023. It is very possible that migrants would be present in the project area in spring and fall. Surveys at the locations where migrants have been detected would continue each year as they have in the past. If nesting SWFLs are detected within any area where work is proposed under the Proposed Action, then consultation with USFWS would be initiated.

Also, creation of willow swales in the Proposed Action Area would provide potential habitat for the SWFLs. Over time, these would create willow stands of the preferred density and stature for SWFLs.

Therefore, the Corps has determined that the proposed work may affect but is not likely to adversely affect the Southwestern Willow Flycatcher. Designated Critical Habitat was determined for the SWFL in November 2005 but is not within the Proposed Project Area. Construction of the measures described above may beneficially affect the SWFL. USACE has submitted a Biological Assessment in reference to the Southwestern Willow Flycatcher (Appendix F).

6.8.3 Yellow-billed Cuckoo

Habitat potentially suitable for nesting of Yellow-billed Cuckoo is present within the Proposed Project Area, primarily in the form of dense saltcedar stands, therefore, it is limited. Yellow-billed Cuckoos have been known to nest late into October. Surveys for the Yellow-billed Cuckoo have been conducted within the last couple of years. Based on the surveys done by USACE and other entities within the Proposed Project Area, it is highly unlikely that nesting Yellow-billed Cuckoos would occupy the project area during the construction period mentioned above. It is possible that migrants would be present in the project area in spring and fall. Surveys at the locations where migrants have been detected would continue each year as they have in the past. If nesting Yellow-billed Cuckoo are detected within any area where work is proposed under the Proposed Action, then consultation with USFWS would be initiated.

Also, creation of willow swales in the Proposed Action Area would provide potential habitat for the Yellow-billed Cuckoo. Over time, these measures would create dense willow thickets that are preferred by the Yellow-billed Cuckoo.

Therefore, the Proposed Action may affect but is not likely to adversely modify proposed designated Critical Habitat of the Yellow-billed Cuckoo. The Proposed Action may affect but is not likely to adversely affect the Yellow-billed Cuckoo, and may provide positive benefits to the species. USACE has submitted a Biological Assessment in reference to the Yellow-billed Cuckoo (Appendix F).

6.9 Cultural Resources

With the selection of a preferred plan, and for the purposes of Section 106, an Area of Potential Effect (APE) must be designated. The APE includes any physical area of earth disturbance, including staging areas and access roads. Depending on the historic property, it could also include an area outside of construction, but within sensory limits (auditory/visual). It should also consider cumulative effects (such as downstream effects to historic properties). Based on current project plans, the current estimated APE is presented in Figure 1, above.

There have been 15 cultural resource surveys in the preferred alternative's area of potential effect (APE) (see Table 3, Appendix C, Cultural Resources). Approximately 30.3 acres of the 261 total acres in the APE remain to be surveyed for cultural resources. Archaeological survey of these un-surveyed areas is planned while this document is undergoing DQC. USACE will consult with interested parties including the State Historic Preservation Officer and American Indian Tribes regarding the survey results, eligibility of any newly identified historic sites, and effect of the proposed project on historic properties. New survey and Section 106 consultation for staging areas and access routes may be necessary as project plans near completion.

There are five known historic properties within the preferred alternative's APE (see Table 4, Appendix C, Cultural Resources). Two of these properties are considered eligible to the NRHP, two properties are of undetermined or unevaluated eligibility, and one property is considered not eligible to the NRHP. The project intent is to avoid all eligible and undetermined properties. Pursuant to 36 CFR 800.13, should previously unknown artifacts or archaeological resources be encountered during construction, work would cease in the immediate vicinity of the resource. A determination of significance would be made, and a mitigation plan would be formulated in consultation with the State Historic Preservation Officer and American Indian Tribes that have cultural concerns in the area. USACE' construction contract plans and specifications have provisions to ensure that all known and unknown historic properties eligible for nomination to or listed on the National Register of Historic Places are protected.

6.10 Land Use and Recreational Resources

The Proposed Project Areas are within the Facilities of the Middle Rio Grande Floodway Project boundaries and would not affect adjacent agricultural land use and would not change current land status. Therefore, the Proposed Action would affect these land resources.

Construction activities would temporarily impede recreational activities in the Proposed Project Area. All work zones would be designated and signed with cautionary information. The paved trail would be kept clean for use by park visitors as much as possible and all machinery and vehicles would yield to park users. Implementation of the Proposed Action would add to the enhancement of the recreation system in the Proposed Project Area. Construction of new measures would add to the experience that the existing trails offer. Therefore, the Proposed Action would have short-term negative effects, which would cease with construction, and contribute to the long-term positive benefits to recreational resources.

6.11 Hazardous, Toxic, and Radiologic Waste (HTRW)

Given the TSP, and no identified HTRW concerns within the project area, there are no anticipated changes to HTRW as result of this project. If HTRW is encountered during construction, the Contractor will halt work and contact USACE. USACE will verify the Contractor's claim and inform the local sponsor of the issue. Per Engineering Regulation 1165-2-132, for cost-shared projects such as the proposed, the local sponsor shall be responsible for ensuring that the development and execution of Federal, State, and/or Locally required HTRW response actions are accomplished at 100 percent non-project cost. No cost sharing credit will be given for the cost of response actions.

6.12 Aesthetics

The Proposed Action includes removing jetty jacks, reducing fuel loads and thinning of non-native vegetation, creation of water measures, and revegetation with native species. In order to accomplish these goals, construction within the bosque would include machinery of varying sizes. This would cause short-term negative affects to aesthetics during construction. Post-construction, some visual effects would be noticed depending on the level of work required. Therefore, there would negative, short-term impacts by the Proposed Action to aesthetics during construction and for a short time after construction, but these impacts would decrease over a short period of time. The Proposed Action would have a long-term positive effect on aesthetics by removing what many may deem as 'unsightly' jetty jacks, burned and/or dead material and creating new wetland and other water measures. Revegetation with native vegetation species would further increase the aesthetics of the site after a few years of maturation.

6.13 Floodplain and Wetlands

The majority of these wetlands communities would be avoided during implementation of the Proposed Action. Wet meadows areas and other measures wet measures would be created, which would increase the overall wetland acreage in the Proposed Project Area. The remaining measures to be implemented in the Proposed Action would not affect existing wetland habitat.

Executive Order 11988 (Floodplain Management) provides Federal guidance for activities within the floodplain of inland and coastal waters. Preservation of the natural values of floodplains is of critical importance to the nation and the State of New Mexico. Federal agencies to "ensure that its planning programs and budget requests reflect considerations of flood hazards and floodplain management." Removal of the non-native vegetation may allow the floodplain to expand. Since excavation of the bank to reconnect channels and bank lowering are proposed as part of the restoration, there would be an impact to the existing floodplain. The constructed inlets and outlets so the high flow channels would be formed and protected with vegetation to hold it in place. Therefore, the Proposed Action may affect the floodplain, but these impacts are anticipated to be positive and not significant.

6.14 Cumulative Effects Analysis

Cumulative effects are "*the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions*" (40 CFR §1508.7). The geographic extents for which cumulative effects are considered vary for each of the resources analyzed. Similarly, actions taken in the past, present, and reasonably foreseeable future within the Proposed Action Area, when combined with the actions in the Proposed Action, could contribute to cumulative effects and may vary with the resource being considered. Environmental impacts associated with the bosque in Albuquerque have been evaluated relative to the Proposed Action.

6.14.1 Other Projects in the Region

Construction of Cochiti Dam in the 1960s has resulted in an altered baseline condition within the Middle Rio Grande. It is anticipated that the impacts attributed to the operation of Cochiti for its authorized project purposes will continue in the present manner. Its impacts to the immediate and surrounding landscape and local terrestrial ecosystem have stabilized since its construction.

The MRGESCP is a multi-agency organization that has funded a number of habitat restoration projects in the Proposed Action Area. USACE, USBR and NMISC have all constructed projects within the Proposed Action Area under the MRGESCP. These projects have been planned and constructed in coordination with each other and the development of the Middle Rio Grande Bosque Restoration Project. They have been planned so that they complement one another and do not overlap. The culmination of these projects would provide additional habitat for all species, and especially the Rio Grande silvery minnow and Southwestern Willow Flycatcher. Since they have been constructed during different times and not in overlapping geographic areas, it is anticipated there would be no cumulative negative impact considered in these projects, but potentially a cumulative positive benefit. These projects are described in further detail below:

- Habitat Restoration Plan for the Middle Rio Grande – The Middle Rio Grande Endangered Species Collaborative Program (Program) is a partnership involving 20+ current signatories organized to protect and improve the status of endangered species along the Middle Rio Grande (MRG) of New Mexico while simultaneously protecting existing and future regional water uses. Two species of particular concern to the Program are the Rio Grande silvery minnow (RGSM) and the Southwestern Willow Flycatcher (SWFL). The Habitat Restoration Plan for the Middle Rio Grande provides a framework plan to implement and integrate actions needed to address both water and endangered species management issues in the Middle Rio Grande. This document was developed for the Habitat Restoration Workgroup in order to aid in the development of reach-specific habitat restoration plans (Tetra Tech, 2004).

- A number of restoration projects have been or are being implemented by the Program within the Albuquerque Reach including:

- Middle Rio Grande Riverine Habitat Restoration Project – ISC. In this project, the ISC is restoring aquatic habitat for the benefit of the RGSM in the river in the Albuquerque Reach by manipulating islands, bars and banks to mobilize sediments. Phase I of this project constructed potential RGSM habitat by destabilizing islands and bank lines and was completed in 2004-2005. Phase II of this project will continue island and bank lowering in the Albuquerque Reach in 2008-2009. This project is documented in the "Middle Rio Grande Riverine Habitat Restoration Project Environmental Assessment, March 2005" (ISC and BOR, 2005).

- Rio Grande Nature Center Habitat Restoration Project - This project was constructed by USACE to provide habitat that would potentially benefit the RGSM and the SWFL. Project construction was completed in 2007 by reconnecting an historic remnant side channel that runs through the Rio Grande Nature Center State Park to the mainstem of the river. The side channel flows when the river is flowing 1500-2000 cfs and higher. Embayments were also constructed off of the side of the channel to provide nursery habitat for the RGSM (Environmental Assessment, December 2006).

- City of Albuquerque Habitat Restoration Project - The project constructed various habitat restoration/rehabilitation techniques to restore aquatic and riparian habitat for the benefit of RGSM and SWFL within the Albuquerque Reach of the Middle Rio Grande. Construction was completed in 2006. (Final Environmental Assessment, February 2007).

The City of Albuquerque has constructed a diversion dam in the Rio Grande south of Alameda to divert San Juan/Chama water into the City's water supply system. The City has also constructed water intakes and a crossing in the Rio Grande at Campbell Road. These works are in the river and are proposed not to effect river flows except at minimal levels when the Dam is raised which would only be at low flows (500 cfs or less) (USBR, 2004).

The City of Albuquerque's Open Space Division completed a habitat restoration project following a major Bosque fire known as the "Brown Burn." The fire contributed to significant growth of Salt Cedar (Tamarisk), an undesirable non-native deciduous tree in the Middle Rio Grande Valley, making the Glass Garden site an ideal location for habitat restoration. The Glass Garden restoration project intended benefits are to restore habitat for the benefit of the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*) in the RGVSP. The habitat restoration efforts entailed creating a series of five coyote-willow dominated swales, a total of approximately 10-acres of willow swales. An additional 10-acre area was planted with Rio Grande Cottonwood (*Populus wislizeni*) and native riparian shrubs typical of the surrounding floodplain. The site is on lands that are managed by the City of Albuquerque's Open Space Division.

Albuquerque Bernalillo County Water Utility Authority's San Juan Chama Drinking Water Mitigation Project is designed to restore habitat for the benefit of the endangered species, the RGSM and secondarily the SWFL. The habitat restoration project entailed the clearing of non-native vegetation, ultimately, reducing the fuel load for catastrophic wildfires. The creation of a 6 acre backwater embayment was constructed to provide shallow, low velocity moving water intended to retain drifting silvery minnow eggs, provide habitat for developing silvery minnow larvae during spring runoff, and create refugial habitat and provide willow-dominated flycatcher breeding and migratory bird habitat along the channel margins. The anticipated benefits are to increase the diversity of the riparian ecosystem, create silvery minnow recruitment habitat, and enhance the hydrologic connectivity between the floodplain and the river channel. The backwater embayment was constructed to receive inundation at flows of 1,500 cubic feet per second up to 2,500 cfs. The backwater embayment will be restored with a variety of native Bosque trees, to include Coyote Willow (*Salix* spp.) and Rio Grande Cottonwood (*Populus wislizeni*) along with other native riparian Bosque shrubs. The site is on lands that are owned and managed by the City of Albuquerque's Open Space Division.

The City of Albuquerque's Open Space Division, in cooperation with the Albuquerque Bernalillo County Water Utility Authority and SWCA Environmental Consultants, completed a habitat restoration project following a major Bosque fire in 2003 known as the "Montano Complex Fires." The complex of fires burned roughly 113 acres both to the north and south of the Montano Bridge. Following the "Montano Complex Fires," significant growth of Salt Cedar (*Tamarisk*), an undesirable non-native deciduous tree in the Middle Rio Grande Valley, made the La Orilla site an ideal location for habitat restoration. The La Orilla restoration project intended benefits are to restore habitat for the benefit of the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*) on a 20-acre section of the RGVSP. The habitat restoration efforts entailed creating a series of five coyote-willow dominated swales, a total of approximately 10-acres of willow swales. An additional 10-acre area was planted with Rio Grande Cottonwood (*Populus wislizeni*) and native riparian shrubs typical of the surrounding floodplain. The site is on lands that are owned and managed by the City of Albuquerque's Open Space Division.

USACE was involved in another 1135 Ecosystem Restoration projects within the RGVSP between I-40 and Bridge Boulevard, called the Ecosystem Restoration @ RT66 Project. The construction of this project was meant to be a demonstration for the MRG Bosque Restoration Project and began construction in January 2009 and was completed in April 2010. Construction of the Bio-Park Project south of Central Avenue was completed in the fall of 2006. The Proposed Action would not conflict with these plans and took them into consideration during plan formulation. These projects would benefit one another.

The Albuquerque BioPark project is a Corps 1135 Ecosystem Restoration project that consists of approximately 15 acres of pond reconstruction, 9 acres of wetland restoration, and 48 acres of riparian woodland (bosque) restoration in the bosque south of Central Ave. on the east side of the river in Albuquerque. The bosque was restored by enhancing hydrology and native vegetation. Non-native saltcedar and Russian olive were removed through brush cutting, root plowing and localized herbicide application. Project construction was completed in October 2006 (Detailed Project Report and Environmental Assessment for Albuquerque Biological Park Wetland Restoration Project, Albuquerque, New Mexico, January 2004a).

Under the Bosque Wildfire project, activities of selective thinning of areas with high fuel loads and/or non-native plant species populations; removal of jetty jacks and removal of debris; improvement of emergency access in the form of drain crossings, levee road improvement, and construction of turnarounds; and revegetation of burned areas began in 2004 in and around the Albuquerque area. Approximately 8,000 (out of 30,000) jetty jacks have been removed under this effort. The project also includes maintenance of weather stations and a live web site that provides potential fire conditions in the bosque. Again, these actions were planned and coordinated to provide an overall beneficial effect to the system. This project is documented in the "Environmental Assessment for the Bosque Wildfire Project, Bernalillo and Sandoval Counties, New Mexico, September 2004" (USACE, 2004b).

Additional non-Federal efforts include fire hazard management by OSD. The Ciudad Soil and Water Conservation District (SWCD) has also completed some thinning at locations near the Rio Grande Nature Center, the west side of the river south of Montaño Bridge and near the National Hispanic Cultural Center.

Under the Middle Rio Grande Bosque Restoration Project, 916 acres of the Middle Rio Grande bosque was restored. The principle ecological goals of this project were to (1) improve hydrologic function by constructing high-flow channels, willow swales, and wetlands and (2) restore native vegetation and habitat by removing jetty jacks, exotic species/fuel reduction, and restoring the riparian gallery forest. The first phase of this project went to construction in 2011 and was completed in 2014. Phase II was started in 2014 and was finished in 2016.

In 2016, the U.S. Fish and Wildlife Service completed a new biological opinion provided to the Bureau of Reclamation, Bureau of Indian Affairs, Middle Rio Grande Conservancy District and the State of New Mexico, providing Endangered Species Act coverage for water-related activities in the Upper and Middle Rio Grande. Reasonable and prudent measures are listed within the biological opinion to minimize impact of incidental take to the Rio Grande silvery minnow, Southwestern Willow Flycatcher, and the Yellow-billed Cuckoo. Agency-specific conservation measures also were provided to minimize impacts. This biological opinion is available to the public at https://www.fws.gov/southwest/es/NewMexico/.

As seen from above, ecosystem restoration efforts have been occurring along the Middle Rio Grande, especially within the Albuquerque reach, for many years. Improving habitat quality, restoring hydraulic processes between the bosque and river, and improving areas of potential habitat for listed species within the bosque will continue into the future.

6.14.2 Reasonably Foreseeable Future Projects in the Region

The MRGCD constructs, maintains, modifies, repairs, and replaces irrigation and flood risk reduction structures and facilities throughout the project area to ensure the proper functioning of these facilities for their intended purpose. Reclamation is responsible for operation and maintenance activities within the Rio Grande floodway throughout the proposed project area to support deliver of native water to Elephant Butte Reservoir under the Rio Grande Compact. There are several other agencies who complete maintenance activities throughout the proposed project area and all of these activities mentioned would continue into the foreseeable future. Other ecosystem restoration projects, although not identified by agencies at this time, could be proposed in the future within or near the proposed project area.

6.14.3 Irreversible and Irretrievable Commitment of Resources

In accordance with NEPA, this Draft Integrated Report discusses any irreversible and irretrievable commitment of resources that would be involved in the development of the project. Significant irreversible environmental changes are defined as uses of nonrenewable resources during the initial and continued phases of the alternatives that may be irreversible due to the large commitment of these resources.

Implementation of the recommended plan would result in the irretrievable commitment of land within the floodway. Some of the restoration work would constitute a change in land use, vegetation and habitat type. Restoration of habitat and the newly constructed water measures (wetland, swales, etc.) would be compatible with the other uses of the surrounding area. In addition, construction of engineered levees would result in the irretrievable commitment of construction materials, fossil fuels, and other energy resources.

While the recommended plan would result in the irretrievable commitment of materials and fossil fuels during the construction phase of the project, operation and maintenance is not expected to increase the use of either construction materials or fossil fuels.

6.15 Conclusion

The Proposed Action would restore 216 acres of the Middle Rio Grande bosque by enhancing hydrologic function (by constructing wet measures such as high-flow channels, willow swales, and wetlands) and restoring native vegetation and habitat by removing exotic species/fuel reduction and restoring the riparian gallery forest. All applicable laws and regulations were considered during analysis of potential effects. A summary of the effects discussed in Section 6 are shown below.

6.15.1 Summary of Effects

Existing Environment	Foreseeable Effects
Physiography, Geology, Soils	Short-term adverse effect on soils; Positive effect on soil moisture
Hydrology, Hydraulics and Geomorphology	No effect on river H&H
Water Quality	Short-term minor adverse effects that will be minor and temporary, ending with construction
Air Quality and Noise	Short-term minor adverse effects that will be minor and temporary, ending with construction
Aesthetics	Short-term negative effects with long-term positive effects by natural landscape features
Vegetation Communities	Short-term negative effects with long-term positive effects
Floodplains and Wetlands	Short-term minor adverse effects that will be minor and temporary, ending with construction Long-term positive effects
Fish and Wildlife	Short-term negative effects with long-term positive effects
Endangered and Protected Species	May affect but not likely to adversely affect: Southwester Willow Flycatcher, Yellow-billed Cuckoo, Rio Grande silvery minnow, Rio Grande silvery minnow and Yellow-billed Cuckoo critical habitat Potential positive benefits to RGSM and SWFL by high-flow channel, bank lowering and swale construction
Cultural Resources	No adverse effect to Historic Properties
Hazardous, Toxic, and Radioactive Waste	No adverse effect
Socioeconomic Considerations	Short-term positive effects with increase in construction jobs
Land Use and Recreational Resources	No adverse effect
Indian Trust Assets	No adverse effect
Environmental Justice	No adverse effect
Noxious Weeds	Positive short and long-term effects

7 - Recommendations

7.1 Consistency with Project Purpose

The Tentatively Selected Plan is consistent with Engineer Regulation 1105-2-100, specifically, "The objective of ecosystem restoration is to restore degraded ecosystem structure, function and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the absence of human changes to the landscape and hydrology." The proposed project will provide for improved access to the floodplain for high flows while increasing habitat diversity for special status species. The project would also be consistent with the authorized purposes and current operation of the Middle Rio Grande Flood Control Project, Corrales Levee Project, Albuquerque Levees, Jemez Canyon and Cochiti Dams. Activities proposed within the Sandia to Isleta project would not raise the Base Flood Elevation (1.0%-chance flood water surface elevation) of the floodway either during or after the project is completed, thus the Recommended Plan would not result in increased erosion of the existing levees. Features of the project would include removal of jetty jacks, but this would be accomplished only after an analysis has been completed which determines that the jetty jacks are no longer functioning properly or needed. Additionally, the features of the proposed project would not alter the extent or frequency of damaging discharges within or downstream from the project reach.

7.2 Cost Sharing Requirements

In accordance with Water Resources Development Act of 2007, Section 5056, as amended, construction cost will be at 65% Federal expense and 35% non-Federal expense. The non-Federal sponsor is responsible for the provision of lands, easements, rights of way, relocations and disposal areas and post project operations and maintenance. Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including, but not limited to, the items of cooperation listed below:

- Shall not use funds from other Federal programs; including any non-Federal contribution required as a matching share; therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purposes is authorized.

- Provide during construction, 35% of total project investment costs. Of which, 5% will be cash.

- Provide all lands, easements, and rights of way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights of way to enable the disposal of dredged or excavated material as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration measures;

- Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights of way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration measures, hinder operation and maintenance of the project, or interfere with the project's proper function;

- Shall not use the ecosystem restoration features or lands, easements, and rights of way required for such features as a wetlands bank or mitigation credit for any other project;

- Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4605), and the regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

- For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation measures, at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and regulations and any specific directions prescribed by the Federal government;

- Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

- Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

- Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;

- Comply with all applicable Federal and state laws and regulations, including, but not limited to:

    - National Environmental Policy Act (42 U.S.C 4321 et seq.)
    - CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Part 1500 et seq.)
    - U.S. Army Corps of Engineers' Procedures for Implementing NEPA (33 CFR Part 230; ER 200-2-2)
    - National Historic Preservation Act (16 U.S.C. 470 et seq.)
    - Resources Protection Act (16 U.S.C. 470aa et seq.)
    - Native American Graves Protection and Repatriation Act (25 U.S.C. 3001 et seq.)
    - Protection of Historic and Cultural Properties (36 CFR 800 et seq.)

- American Indian Religious Freedom Act (42 U.S.C. 1996)
- Clean Water Act (33 U.S.C 1251 et seq.)
- Clean Air Act (42 U.S.C. 7401 et seq.)
- Endangered Species Act (16 U.S.C. 1531 et seq.)
- Fish and Wildlife Coordination Act (48 Stat. 401; 16 USC 661 et. seq.)
- Migratory Bird Treaty Act (16 U.S.C. 703 et seq.)
- Noxious Weed Act (7 U.S.C. 2814)
- Farmland Protection Policy Act (7 U.S.C. 4201 et seq.)
- Executive Order 11593, Protection and Enhancement of the Cultural Environment
- Executive Order 11990, Protection of Wetlands
- Executive Order 11988, Floodplain Management
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations
- Executive Order 13112, Invasive Species
- EO 13653, Preparing the United States for the Impacts of Climate Change
- EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance
- Energy Independence and Security Act of 2007 (P.L. 110-140, Section 438, 121 Stat. 1492, 1620);

- Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal government determines to be subject to the navigation servitude, only the Federal government shall perform such investigations unless the Federal government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

- Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal government determines to be required for construction, operation, and maintenance of the project;

- Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

The MRGCD is the non-Federal sponsor of the study and would serve as the local cost-sharing sponsor for project implementation. The cost-sharing requirements and provisions would be formalized with the signing of a Project Partnership Agreement (PPA) between the MRGCD and the Department of the Army following approval of this Director's report. In the PPA, the sponsor would agree to provide all lands, easements, rights of way, relocations and disposal costs.

The basic criteria for the non-Federal cost-sharing responsibilities for this project are provided by Implementation Guidance for Section 5056 of WRDA 2007 as amended by Section 4006 of WRRDA 2014:

> *Project implementation will be cost shared 65% Federal and 35% non-Federal. The cost of O&M shall be 100% non-Federal sponsor responsibility, except the O&M of a project located on Federal land, or land owned or operated by a State or local government shall be borne by the Federal, State or local agency that has jurisdiction over fish and wildlife activities on the land.*

The total project first cost is estimated at approximately $22,587,000.

8 - Preparation, Consultation and Coordination

8.1 Preparation

8.1.1 Preparers

Patricia Phillips – Project Manager
Stacy Samuelson – Planner
Danielle Galloway – Senior Biologist
Robert Grimes – Economist
Steven Boberg – Hydrology and Hydraulics
Christina Sinkovec – Archaeologist
Ben Miranda – Real Estate
Phil Lovato – Civil Engineering
Justin Reale – Environmental Engineering
Carlos Aragon – Geotechical Engineering
Doug Walther -- GIS

8.1.2 Quality Control Reviewers

Michael Porter – Senior Biologist
Robert Browning – Economics
Jerry Fuentes – Plan Formulation
Jonathan Van Hoose – Cultural Resources
Debbie Smith – Civil Engineering
Jonathan Aubuchon – Hydrology and Hydraulics

Legal Review – Office of Counsel

8.2 Consultation and Coordination

Agencies and other entities contacted formally or informally during scoping and in preparation of this draft feasibility study with integrated environmental assessment and/or who will be notified of the public review of the document include:

- U.S. Fish and Wildlife Service
- U.S. Environmental Protection Agency, Region 6
- U.S. Department of Agriculture
- U.S. Bureau of Reclamation
- New Mexico State Forestry Division-Energy, Minerals, and Natural Resources Department
- New Mexico Department of Game and Fish
- New Mexico State Historic Preservation Office
- New Mexico Interstate Stream Commission
- Surface Water Quality Bureau
- Middle Rio Grande Conservancy District
- Albuquerque Metropolitan Arroyo Flood Control Authority
- City of Albuquerque Open Space Division
- Albuquerque Bernalillo County Water Utility Authority
- Ciudad Soil and Water Conservation District
- Bosque School
- Jicarilla Apache Nation
- Navajo Nation
- Ohkay Owingeh
- Pueblo of Isleta
- Pueblo of Laguna
- Pueblo of Sandia
- Ysleta del Sur Pueblo
- White Mountain Apache Tribe

9 - Real Estate Requirements

Real estate required for the Tentatively Selected Plan includes lands in the bosque owned or managed by the City of Albuquerque, the Village of Corrales, Sandia Pueblo, State Land Office and the MRGCD/USBR. The MRGCD has been a non-Federal sponsor for several district projects, has expressed strong support for this project, and will provide appropriate easements. Required lands consist of standard and non-standard estates. The MRGCD/USBR owned lands are standard estates, whereas lands owned by the City of Albuquerque, and the State of New Mexico are non-standard estates for which an environmental ecosystem easement will be acquired. MRGCD will not acquire the City of Albuquerque lands in fee because MRGCD has cooperative working agreements with the landowner regarding the maintenance and operation of the lands and the MRGCD‟s facilities upon the lands.

All work will occur within the right of way of the Albuquerque levee system. All access to the sites will be by public roadway and along the levee roadway; rights of use will be required for the use of levee roadway. Access in the remaining areas for surveying, staging, and construction activities will be obtained from the MRGCD and Bureau of Reclamation. MRGCD owns fee or easement rights for irrigation water delivery and drainage purposes; these rights would be used for temporary access for exploration and testing, surveying, staging, construction, and monitoring activities associated with the proposed project to avoid the need to obtain cost prohibitive permanent ownership of the properties. Appendix I presents the complete Real Estate Plan.

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