Española Valley, Rio Grande and Tributaries, New Mexico

Final Integrated Feasibility Report and
Environmental Assessment

December 2017

US Army Corps
of Engineers

Albuquerque District
South Pacific Division

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DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

Española Valley, Rio Grande and Tributaries, New Mexico

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Environmental Assessment

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DRAFT FINDING OF NO SIGNIFICANT IMPACT (FONSI)

The U.S. Army Corps of Engineers (USACE) proposes to construct 280 acres of habitat measures to restore the bosque in the floodplain communities of the Pueblos of Ohkay Owingeh and Santa Clara by (1) improving hydrologic function by constructing grade restoration facilities (GRFs), high-flow channels, terrace lowering, willow swales, ponds, and wetlands, and (2) restoring native vegetation and habitat by removing exotic species, and restoring riparian gallery forest (*bosque*). The approximate first cost of the project is $61,981,000 (October 2017 dollars).

The proposed management measures for Ohkay Owingeh Pueblo include: 6 GRFs (1 located along the Rio Chama, 1 located along the Rio Grande upstream of the Rio Grande/Rio Chama confluence, and 4 located below the Rio Grande/Rio Chama confluence), terrace lowering, non-native vegetation removal and high flow channels. The proposed management measures for Santa Clara Pueblo include: vegetation removal, high-flow channels, swales, and bank line lowering. San Ildefonso Pueblo removed ecosystem restoration from their objectives and did not participate in this process with the other sponsors.

USACE working with the Pueblos of Ohkay Owingeh, San Ildefonso, and Santa Clara evaluated structural and non-structural flood damage reduction measures. The measures evaluated included levees, ring levees, floodwalls, flood proofing, emergency action plans, and other non-structural measures. At the conclusion of the planning process there were no FRM alternatives that met both USACE and sponsor goals and objectives. Therefore, no FRM measures were included in the final array of alternatives.

The Recommended Plan alternative 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 reestablish fluvial processes in the bosque, creating new wetland habitat, recreating hydraulic connections between the bosque and river, protecting and enhancing potential habitat for listed species, and creating opportunities for recreational, educational and interpretive features.

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 water or wetlands of the United States. During proposed construction, USACE would follow Nationwide Permit 33 (Temporary Construction, Access, and Dewatering) because of the potential need to dewater the channel for construction of the grade restoration facilities, and at the bank of the river when constructing the high-flow channels; and Nationwide Permit 27 (Aquatic Habitat Restoration, Establishment, and Enhancement Activities) for the proposed restoration features listed above. All conditions under Nationwide Permits 33 and 27 would be adhered to during construction. Water quality certification permits under Section 401 of the CWA have been obtained from the Pueblos.

The Recommended Plan has been designed to avoid adverse effects to historic properties. USACE has determined that the Recommended Plan would have no adverse effect to historic properties on Ohkay Owingeh, and that there would be no historic properties affected by the proposed work on Santa Clara; the New Mexico State Historic Preservation Office (SHPO) concurred with this determination on February 2, 2017 for those portions of the project within Ohkay Owingeh, and the Santa Clara Pueblo Tribal Historic Preservation Office (THPO) concurred with this determination on August 4, 2016 for those portions of the project within Santa Clara Pueblo. 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 SHPO, the Santa Clara THPO, the Pueblos of Ohkay Owingeh and Santa Clara, and with American Indian Tribes that have cultural concerns in the area.

USACE consulted with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act, and concurrence was requested. USFWS concurred with the Corps' statement that the Recommended Plan "may affect, but is not likely to adversely affect," the Southwestern Willow Flycatcher, "may affect, but not likely to adversely affect," the Yellow-billed Cuckoo, and "may affect, but not likely to adversely affect," the New Mexico Meadow Jumping Mouse. The USFWS also concurs that the Recommended Plan "May affect, but not likely to adversely modify designated or proposed critical habitat" for these three species. The Corps would implement all reasonable and prudent measures (RPMs) stated in the Biological Opinion during construction.

All Best Management Practices described in this document would be adhered to during project implementation including: (1) construction sequencing as described in Section 2; (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 Recommended Plan would result in only minor, short-term and temporary adverse impacts to soils; water quality; air quality and noise levels; aesthetics; vegetation; floodplains and wetlands; fish and wildlife; endangered species; socioeconomic considerations; and recreational resources during construction. The long-term benefits of the Recommended Plan include a decrease in noxious weeds combined with increases and improvements to soil moisture; water quality; aesthetics; floodplains and wetlands; native vegetation and biodiversity; native habitat for fish and wildlife; potential habitat for endangered species; and recreational resources. The positive cumulative effects 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; and environmental justice.

The Recommended Plan 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 Recommended Plan would not have a significant effect on the human environment. Therefore, an Environmental Impact Statement will not be prepared for this project, and the Recommended Plan is recommended for construction.

Date	James L. Booth Lieutenant Colonel, U.S. Army District Commander

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EXECUTIVE SUMMARY

This integrated Feasibility Report and Environmental Assessment (FREA) addresses alternative plans to provide flood risk management (FRM) and ecosystem restoration in the floodplain communities of the Pueblos of Ohkay Owingeh, Santa Clara and San Ildefonso. During the course of this study, the San Ildefonso Pueblo Tribal Council determined to remove ecosystem restoration from their part of the study. USACE and all three Pueblos continued to formulate FRM alternatives.

The Flood Control Act 18 Aug 1941, Section 4, Public Law (PL) 228, 77th Congress, 1st Session, H.R. 4911, Section 4, states in part "The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: Rio Grande and Tributaries." On 10 December 2009, the U.S. Senate Committee on Environment and Public Works of the 111th Congress, 1st Session, directed the Secretary of the Army to review the report of the Chief of Engineers on the Rio Grande and Tributaries transmitted to Congress on 27 June 1949, and related reports to determine whether additional projects were necessary in the Española Valley to meet Federal flood risk management, ecosystem restoration and allied goals.

The study area is located in southern Rio Arriba County and includes a small portion of northern Santa Fe County. Study area boundaries include the 0.02% exceedance floodplain along both the Rio Chama and Rio Grande from the northern border of Ohkay Owingeh Pueblo, through the Santa Clara Pueblo lands, and to the southern border of San Ildefonso. The Rio Grande tributaries, Santa Cruz River, Arroyo Guachupangue, and the Rio Pojoaque, are also included in the study area.

Flood damages caused by high flows in the Rio Grande and its tributaries occur in the study area. At the conclusion of the planning process there were no flood risk management (FRM) alternatives that met both Army Corps of Engineers (USACE) and sponsor goals and objectives. Therefore, no FRM measures are proposed for implementation.

The Rio Grande and its tributaries have suffered severe channel degradation and loss of riparian habitat. Historically, the Rio Grande and the Rio Chama supported substantial growths of cottonwoods, willows, New Mexico olives, shrubs, and wetlands (locally, these riparian communities are termed *bosque*). Bosque is the name for areas of gallery forest found along the flood plains of streams and rivers in the southwestern United States. It derives its name from the Spanish word for woodlands. Substantial stands of cottonwoods, willows, New Mexico olives, and shrubs once occupied the valley bottom within the floodplains. The Rio Grande is highly incised and no longer regularly inundates the riparian areas, as a result, these communities are not regenerating. The Rio Grande and the Rio Chama once flowed with braided channel and supported a mix of riparian and wetland habitats.

The bosque is more than simply a location; it is a place of deep cultural importance to the people of Ohkay Owingeh, Santa Clara, and San Ildefonso. Along with the Rio Grande and its tributaries, the bosque is an integral part of the cultural landscape and its health and the health of the rivers are fundamentally intertwined with significant cultural practices. For most tribes, the landscape is an essential part of constructing social identity and the transmission and survival of historical and cultural knowledge and practice. People define themselves in relation to the landscape, and the landscape is an interface where the past gives meaning and context to the present. Loss of the bosque is more than simply the loss of plants and animals; it presents a real threat to customs, beliefs, and practices essential to the cultural identity and continuity of the people of Santa Clara, Ohkay Owingeh, and San Ildefonso. As such, the bosque itself is a vital cultural resource, and the protection of that cultural resource is one of the foundations of this restoration effort.

A broad range of measures were considered to develop alternatives for Ecosystem Restoration (ER).

- Boulder Weirs
- Grade Restoration Facilities (GRFs)
- Deformable Riffles
- Rock Sills
- Riprap Grade Control
- Low Head Stone Weirs
- Terrace Lowering
- High-flow Channels
- Willow Swales / Wetlands
- Bank Line Embayment

The array of preliminary alternatives is described in detail in Section 4.0. These alternatives and measures were compared to the forecasted future condition without a project (No-Action Alternative) through a 50-year period of analysis. Of the alternative plans evaluated, the recommended plan meets the project's ecosystem restoration objectives as well as planning criteria for completeness, effectiveness, acceptability, and efficiency. The recommended plan is the National Ecosystem Restoration (NER) plan, which increases the net quantity and / or quality of desired ecosystem resources.

The recommended alternative reflects feasibility level planning and design. The major feature of the NER plan are the GRFs necessary to create overbanking at more frequent precipitation events. The recommended plan was chosen from the array of alternatives because it met the study objectives in a cost efficient manner. The PDT and Pueblo sponsors selected best buy (BB) 36 as the NER plan.

The results of the study show that the total first cost for the project is expected to be $61,980,000 (October 2017 dollars). Of that, the management measures for Ohkay Owingeh are expected to cost $31,063,000 and the management measures for Santa Clara are expected to cost $30,916,000. Within Ohkay Owingeh Pueblo, the management measures include: 6 GRFs (1 located along the Rio Chama, 1 located along the Rio Grande upstream of the Rio Grande/Rio Chama confluence, and 4 located below the Rio Grande/Rio Chama confluence), terrace lowering, non-native vegetation removal and high flow channels. For Santa Clara Pueblo, management measures include: vegetation removal, high-flow channels, swales, vegetation removal and bank line lowering. The recommended alternative provides contributions to all of the study and Federal objectives. It is the least cost plan to meet all three objective targets while providing an even distribution and composition of measures across the entire study.

Both Pueblos, Ohkay Owingeh and Santa Clara, have expressed confidence that they will be able to provide their cost share for implementation of the project which is expected to have a ten year construction period.

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F	Geotechnical Engineering
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J	Civil Engineering
K	Cost Engineering

List of Acronyms

AAHU	Average annual habitat units
ACE	Annual Chance Exceedance
AF	Acre-feet
AFY	Acre-feet per year
APE	Area of potential effect
ARMS	Archaeological Records Management System
BCR	Benefit-cost ratio
BISON-M	Biota Information System of New Mexico
BOR	U.S. Bureau of Reclamation
CDP	Census data population
CE/ICA	Cost estimate/incremental cost analysis
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Cfs	Cubic feet per second
CHAP	Combined Habitat Assessment Protocols
CWA	Clean Water Act
EAD	Equivalent annual damages
EPA	U.S. Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FRM	Flood risk management
GRF	Grade restoration facility
HEAT	Habitat Evaluation Assessment Tool
HEC-EFM	Hydrologic Engineering Center-Ecosystem Functions Model (software)
HEC-FDA	Hydrologic Engineering Center-Flood Damage Assessment (software)
HEC-HMS	Hydrologic Engineering Center –Hydrologic Modeling System (software)
HEC-RAS	Hydrologic Engineering Center-River Analysis System (software)
HU	Habitat unit
IBIS	Interactive Habitat and Biodiversity Information System
ITR	Independent technical review

IWR	USACE Institute for Water Resources
IWR-Plan	IWR planning software
KEC	Key environmental correlates
KEF	Key ecological functions
LERDDS	Lands, easements, rights-of-way, relocation, and disposal areas
LiDAR	Light detection and ranging (aerial laser used to develop topography)
MRG	Middle Rio Grande
MRGCD	Middle Rio Grande Conservancy District
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NHPA	National Historic Preservation Act
NMCRIS	New Mexico Cultural Resources Information System
NMED	New Mexico Environment Department
NRHP	National Register of Historic Places
OMRR&R	Operation and maintenance, repair, replacement and rehabilitation
OSE	Other Social Effects
P&G	USACE Planning Guidance Notebook (ER1105-2-100)
PCEs	Primary constituent elements
PDT	Project development team
PED	Pre-engineering and design
RED	Regional Economic Development
SHPO	State Historic Preservation Office/Officer
SJC	San Juan Chama project
TCP	Traditional cultural property
THPO	Tribal Historic Preservation Office/Officer
Tmax	Maximum temperature (generally, highest daytime temperature)
Tmin	Minimum temperature (generally, lowest overnight temperature)
USACE	U.S. Army Corps of Engineers
USC	U.S. Civil Code
USGS	U.S. Geological Survey

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

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 - Project Information

1.1 Project Authorization

This report was prepared as a response to the Flood Control Act of 1941 and by Congressional Resolution, Española, Rio Grande and Tributaries, NM (2009). These authorities are described below.

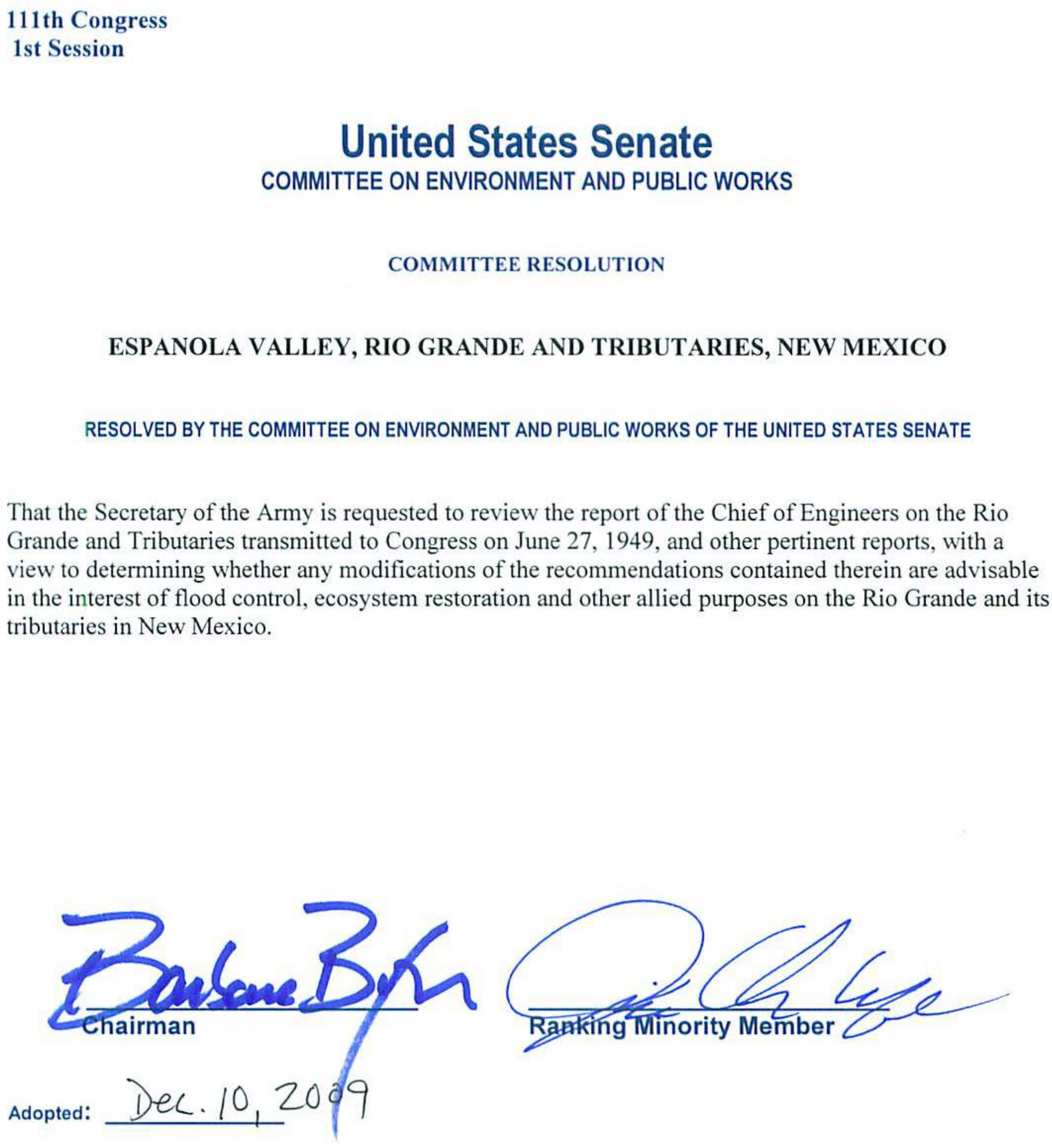
1.1.1 **Flood Control Act 18 Aug 1941**

The Flood Control Act, 18 Aug 1941, Section 4, Public Law (PL) 228, 77th Congress, 1st Session, H.R. 4911 authorized examinations and surveys for flood control throughout the Rio Grande Basin, including its tributaries. The Act states, in part:

> *Section 4. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities, and the Secretary of Agriculture is authorized and directed to cause preliminary examinations and surveys for runoff and water-flow retardation and soil erosion prevention on such drainage areas; the cost thereof to be paid from appropriations heretofore or hereafter made for such purpose: PROVIDED, That after the regular or formal reports made on any examination, survey, project, or work under way or proposed are submitted to Congress, no supplemental or additional report or estimate shall be made unless authorized by law except that the Secretary of War may cause a review of any examination or survey to be made and a report thereon submitted to the Congress if such review is required by the National defense or by changed physical or economic conditions; AND PROVIDED FURTHER, That the Government shall not be deemed to have entered upon any project for the improvement of any waterway or harbor mentioned in this Act until the project for the proposed work shall have been adopted by law:*
>
> *Rio Grande and Tributaries, New Mexico.*

1.1.2 **Resolution, Senate Committee on Environment and Public Works**

On 10 December 2009, the U.S. Senate Committee on Environment and Public Works of the 111th Congress, 1st Session, requested the Secretary of the Army to review the report of the Chief of Engineers on the Rio Grande and Tributaries transmitted to Congress on 27 June 1949 and related reports to determine whether additional projects were necessary in the Española Valley to meet Federal flood risk management, ecosystem restoration and allied goals (Figure 1).



111th Congress
1st Session

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

COMMITTEE RESOLUTION

ESPANOLA VALLEY, RIO GRANDE AND TRIBUTARIES, NEW MEXICO

RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE

That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Rio Grande and Tributaries transmitted to Congress on June 27, 1949, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable in the interest of flood control, ecosystem restoration and other allied purposes on the Rio Grande and its tributaries in New Mexico.

Chairman

Ranking Minority Member

Adopted: Dec. 10, 2009

Figure 1 Copy of the resolution of the Senate Committee on Environment and Public Works authorizing ecosystem restoration as a part of the original flood risk management study.

1.2 Federal Interest

The purpose of this study is to determine whether or not there is a Federal interest in the implementation of a project along the Rio Grande and its tributaries' floodplains within the study area. This study is to determine whether or not flood risk management (FRM), ecosystem restoration, and recreation alternatives are technically feasible, economically practicable, sound with respect to environmental considerations, and legally acceptable. The three Tribes, as the non-Federal sponsors, support the project purposes to provide FRM, ecosystem restoration, and passive recreation.

1.3 Non-Federal Sponsors

The non-Federal sponsors for the Española Valley, Rio Grande and Tributaries, New Mexico study are the three dependent sovereign nations: Ohkay Owingeh Pueblo, Santa Clara Pueblo, and San Ildefonso Pueblo. The 2010 U.S. Census determined that for the Ohkay Owingeh Pueblo, Santa Clara Pueblo and the San Ildefonso Pueblo, the populations living within pueblo boundaries were 1,143, 1,018 and 524 respectively.

All three Pueblos signed the project Feasibility Cost Sharing Agreement (FCSA) on 21 December 2005 to investigate FRM measures. In 2009, the Senate Committee on Environment and Public Works passed a Committee Resolution provided for Ecosystem restoration as part of the study purpose. All three Pueblos demonstrated interest in pursuing both purposes until 2011, when San Ildefonso Pueblo expressed their desire not to pursue ecosystem restoration any further. All three Pueblos participated in the FRM purpose through the identification of alternatives. Since no FRM measures were recommended for Federal participation under this authority, the Pueblos of Santa Clara and Ohkay Owingeh are pursuing ecosystem restoration measures.

1.4 Study Area*

The study area is located in southern Rio Arriba County and includes a small portion of northern Santa Fe County. Study area boundaries are the 0.2% annual chance exceedance (ACE) event[1] floodplains for the Rio Grande and Rio Chama from the northern border of Ohkay Owingeh Pueblo, through the Santa Clara Pueblo lands and to the southern border of San Ildefonso. The lowest reaches of three tributaries of the Rio Grande (Santa Cruz River, Arroyo Guachupangue, and the Rio Pojoaque) are also included in the study area (Figure 1).

The City of Española lies within the study area and extends along both the east and west banks of the Rio Grande. Española is approximately 25 miles north-northwest of Santa Fe and 85 miles south of the New Mexico-Colorado border. The 2000 U.S. Census determined that 9,688 of Rio Arriba County's 41,190 people lived within Española.

Ohkay Owingeh Pueblo is the northernmost pueblo in the study area. It is mainly situated north of the Rio Grande/Rio Chama confluence and includes both banks of the upstream (north of the confluence) Rio Grande and Rio Chama. Ohkay Owingeh Pueblo's Rio Grande and Rio Chama

[1] 500-year event

corridors are a heavily “checker boarded” area with many private, non-Indian in-holdings close by, including those belonging to the City of Española.

Santa Clara Pueblo is located south of Ohkay Owingeh Pueblo and is separated from Ohkay Owingeh Pueblo by non-Tribal land. Santa Clara Pueblo is situated immediately next to the City of Española along the Rio Grande, south of the Rio Chama confluence (denoted in Appendix B as the “downstream Rio Grande”) and includes three tributaries that flow directly into the Rio Grande. They include: the Santa Cruz River, which flows into the Rio Grande from the east; Arroyo Guachupangue, which flows into the Rio Grande from the west; and Santa Clara Creek, which is south of the Guachupangue and flows into the Rio Grande from the west. Santa Clara Pueblo’s Rio Grande corridor is a heavily “checker boarded” area with many private, non-Indian in-holdings close by, including those belonging to the City of Española. The majority of the City of Española is located within the boundaries of Santa Clara Pueblo.

Santa Clara Creek was removed from the study after the Las Conchas fire in the late summer of 2011. Due to the heavy losses of vegetation in the upper watershed, and the resulting changed hydrology, the Pueblo of Santa Clara requested a new flood risk management study be started under Section 205 focused on the Santa Clara Creek watershed.

San Ildefonso Pueblo is the southernmost pueblo within the study area. It lies south of the City of Española and Santa Clara Pueblo along the Rio Grande. San Ildefonso is also situated at the downstream end of the Rio Pojoaque, which flows into the Rio Grande from the east.

This study area falls within New Mexico Congressional District number 3.

1.5 Purpose and Need for Action*

The Pueblos of Ohkay Owingeh, Santa Clara and San Ildefonso, in partnership with USACE, are conducting this feasibility study to identify and define flood risk management, ecological degradation, and incidental passive recreation resource problems and to develop solutions to reduce flood risk to structures, infrastructure, and human safety, to improve riparian habitat and functionality, and to create passive recreation opportunities.

1.5.1 Flood risk management

Flood damages caused by high flows in the Rio Grande and its tributaries are a primary issue of local concern. Existing conditions floodplain mapping shows that the areas of highest concern are the confluences of the Rio Grande and its tributaries; the Santa Cruz River and the Guachupangue Arroyo (Santa Clara Pueblo); and the Rio Pojoaque (San Ildefonso Pueblo).

USACE working with the Pueblos of Ohkay Owingeh, San Ildefonso, and Santa Clara evaluated structural and non-structural flood damage reduction measures. The measures evaluated included levees, ring levees, floodwalls, flood proofing, emergency action plans, and other non-structural measures. At the conclusion of the planning process there were no FRM alternatives that met both USACE and sponsor goals and objectives. Therefore, no FRM measures were included in the final array of alternatives. See Appendix I for more detail of the FRM analysis.

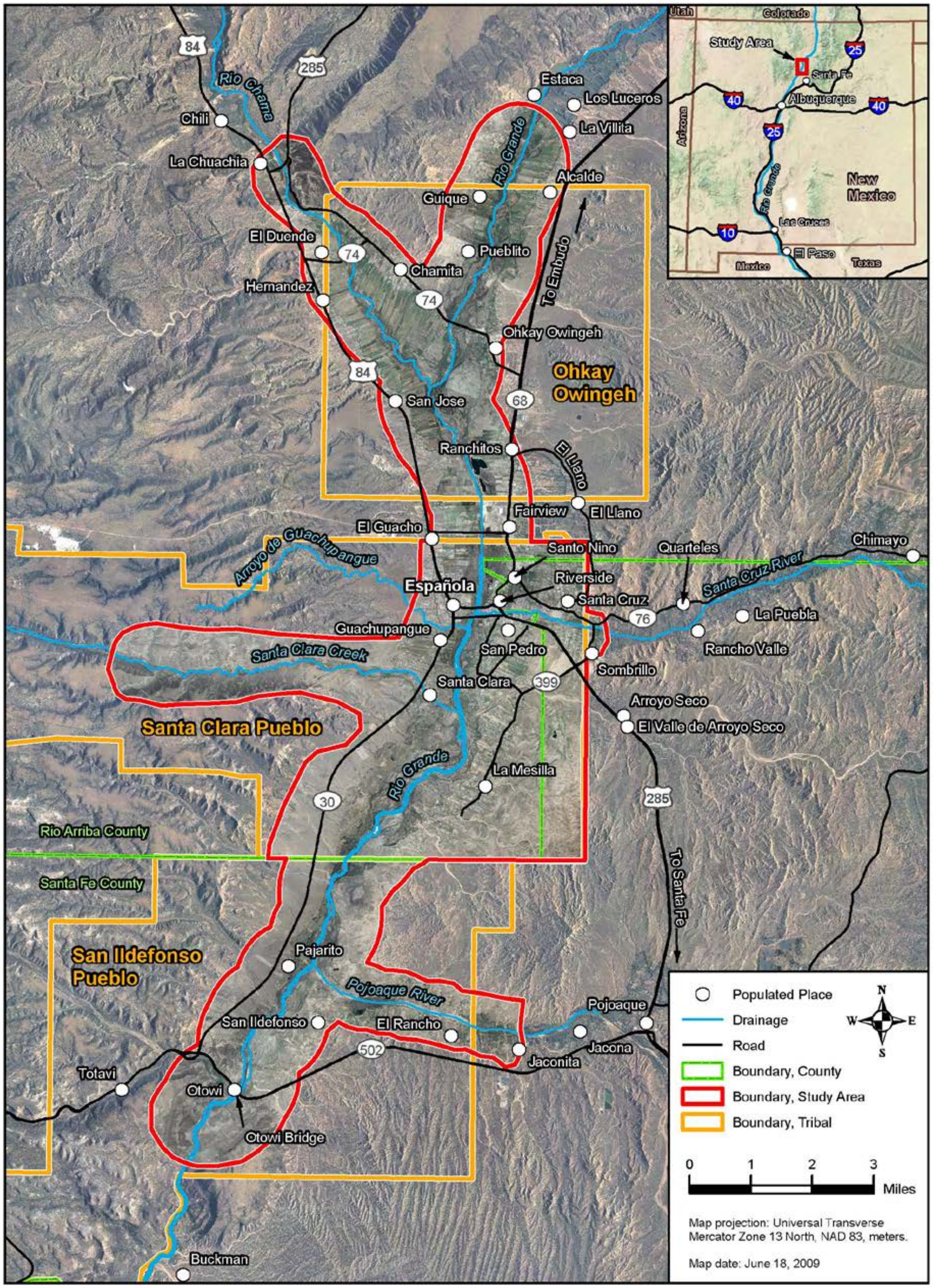


Figure 2 Vicinity and study area.

1.5.2 Ecosystem restoration

The Rio Grande and its tributaries have suffered severe channel degradation and loss of riparian habitat. Historically, the Rio Grande and the Rio Chama supported substantial growths of cottonwoods, willows, New Mexico olives, shrubs, and wetlands (locally, these riparian communities are termed *bosque*). The Rio Grande is highly incised and no longer regularly inundates the riparian areas (Appendices C and I), as a result of which these communities are not regenerating. With local sponsorship, the Corps can participate through its congressional authorities to restore function and increase high value habitat through the Española Valley study area. The goal of this collaborative effort is to formulate and evaluate a suite of alternatives in order to identify a cost effective plan, the recommended plan, which meets the objectives of the study and can be implemented to improve the bosque ecosystem structure and function.

As a result of incision and other changes, stands of healthy native riparian habitat, including wetlands, are rare and scattered in the study area. Loss of riparian habitat is an important conservation issue in the arid Southwest. Riparian habitat comprised approximately 720,000 acres in the 1780s of what would later become the State of New Mexico (only 0.9 percent of New Mexico). As of 1998, approximately 33 percent of the riparian habitat had already been lost in New Mexico (USEPA and NMED 1998). This combination of riparian, wetland, and fringe habitat is extremely valuable due to its rarity. The Nature Conservancy lists desert riparian woodland as a very rare although significantly important cover type and describes restoration of wetland and riparian systems as critical (Marshall et al 2000).

The bosque of the Española Valley study area 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.

For the people of Ohkay Owingeh, Santa Clara and San Ildefonso Pueblos, the bosque is a place of deep cultural importance. Along with the Rio Grande and its tributaries, the bosque is an integral part of the cultural landscape and its health and the health of the rivers are fundamentally intertwined with significant cultural practices. For most tribes, the landscape is an essential part of constructing social identity and the transmission and survival of historical and cultural knowledge and practice. People define themselves in relation to the landscape, and the landscape is an interface where the past gives meaning and context to the present. Loss of the bosque is more than simply the loss of plants and animals; it presents a real threat to customs, beliefs, and practices essential to the cultural identity and continuity of the people of Santa Clara, Ohkay Owingeh, and San Ildefonso. As such, the bosque itself is a vital cultural resource, and the protection of that cultural resource is one of the foundations of this restoration effort.

Wildlife resource values within the Española reach of the Rio Grande are significant because the bosque:

- Remains an important corridor for terrestrial and avian species.
- 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. Over half of the 277 land birds found along the Rio Grande in New Mexico are residents, and 54 bird species breed within this habitat (Yong and Finch 2002).
- Constitutes a critical travel corridor connecting Central and South America to North America along the Rio Grande Flyway.

It has been estimated that up to 70 percent of bird species in the arid Southwest are riparian-dependent during some part of their life cycles (Krueper 1993). As a direct consequence of the loss and degradation of riparian habitat, the area has experienced a major reduction in bird species diversity and in the populations of remaining species. In addition, destruction of native riparian habitat facilitates an increase in invasive plant species that are more tolerant of disturbed conditions. Such plants consume more water than do native vegetation because of their ability to occupy a greater areal extent on the landscape, placing additional strains on limited water supply.

The Pueblo of Ohkay Owingeh completed approximately 930 acres of habitat restoration between 2004 and 2008 using funds from the Middle Rio Grande Endangered Species Collaborative Program, USFWS, and the Bureau of Indian Affairs. These projects focused on treating invasive salt cedar and Russian olive, combined with construction of small high-flow channels.

Tribal sponsors have identified lands available for future restoration projects. There are opportunities to accomplish significant restoration within the study area. Restoration options have the potential to increase wetland and riparian habitat acreage and quality, thereby expanding wildlife diversity and quantity, controlling invasive plant species, reducing the risk of wildfires and providing an ecological resource that is historically and culturally significant and valuable to the tribes and the region.

In addition to carrying out the authorities granted to the Corps for ecosystem restoration and specific legislation provided for initiation and support of this study, the project provides for the letter or intent of several Federal laws, executive orders, and treaties 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 restoration project will conserve, create, or improve a significant portion of the study 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 400 acres 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 important habitat for the endangered Southwestern Willow Flycatcher, Yellow-Billed Cuckoo, and New Mexico Meadow Jumping Mouse.
- 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 140 resident and 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.

Many aspects of the bosque are associated “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). Restoring the bosque, therefore, also provides cultural and religious benefits for the Tribal sponsors (see Section 2.4.1.2 Traditional Cultural Properties).

Additional information regarding Purpose and Need for ecosystem restoration may be found in Appendix C – Environmental Resources, or for recreation may be found in Appendix B – Economics.

1.5.3 **Recreation**

In addition to restoration efforts, opportunities exist to improve passive recreation opportunities associated with the restored floodplain. Historically, the bosque has been used by recreationists for fishing, hunting, hiking, horseback riding, bird watching, and picnicking. Ecological degradation of the bosque within the study area has caused the numbers of people who use the bosque for passive recreation to decline. In addition, the bosque is culturally important to the members of the Tribal sponsors.

1.6 Regulatory Compliance

This Environmental Assessment (EA) was prepared by USACE, Albuquerque District, in compliance with all applicable Federal Statutes, Regulations, and Executive Orders, including the following:

- National Historic Preservation Act (16 U.S.C. 470 *et seq*.)
- Archaeological Resources Protection Act (16 U.S.C. 470 *et seq*.)
- 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*.)
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations
- Occupational Safety and Health Act of 1970 (29 U.S.C. 651 *et seq*.)

- Executive Order 11988, Floodplain Management
- 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*.)
- Native American Graves Protection and Repatriation Act (25 U.S.C. 3001 *et seq*.)
- Executive Order 11593, Protection and Enhancement of the Cultural Environment
- Executive Order 11990, Protection of Wetlands
- U.S. Army Corps of Engineers' Procedures for Implementing NEPA (33 CFR Part 230; ER 200-2-2)
- Farmland Protection Policy Act (7 U.S.C. 4201 *et seq.*)
- Executive Order 13112, Invasive Species
- Federal Noxious Weed Act (7 U.S.C. 2814)
- Migratory Bird Treaty Act (16 U.S.C. 703 *et seq.*)
- Fish and Wildlife Coordination Act (48 Stat. 401; 16 USC 661 *et. seq.*)
- Section 438 of the Energy Independence and Security Act of 2007 (Public Law 110-140 Section 438, 121 Stat. 1492, 1620)
- Executive Order 13524, Federal Leadership in Environmental, Energy, and Economic Performance
- EO 13653, Preparing the United States for the Impacts of Climate Change

This EA also reflects compliance with all applicable State and local regulations, statutes, policies, and standards for conserving the environment such as water and air quality, endangered plants and animals, and cultural resources.

1.7 Planning Process

The USACE plan formulation process, as specified in ER 1105-2-100 (Planning Guidance Notebook) was used to develop measures and elements used in solving identified problems and ultimately to develop an array of comprehensive alternatives from which a plan is recommended for implementation.

This section presents the rationale for the development of a plan or alternative for implementation. It describes the USACE iterative six-step planning process used to develop, evaluate, and compare the array of management measures and preliminary alternatives that have been considered. The six steps used in the plan formulation process include:

1. **Identifying Problems and Opportunities:** 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. This has been accomplished for the current study stage.

2. **Inventorying and Forecasting Resources:** Existing and future without-project conditions are identified, analyzed, and forecast for a 50-year period of analysis. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation are characterized and documented. This has been accomplished for the current study stage. A forecast of conditions that will exist for a 50-year period of analysis without a Federal project was used as the baseline.

3. **Formulating Alternative Plans:** Alternative plans are formulated that address the planning objectives. An initial set of alternatives are developed and evaluated at a preliminary level of detail, and are subsequently screened into a more final array of alternatives. A public involvement program was used to obtain public input to the alternative identification and evaluation process. Each plan is evaluated for its costs, potential effects, and benefits, and is compared with the No Action alternative for the 50-year period of analysis.

4. **Evaluating Alternative Plans:** Alternative project plans are evaluated for their potential to meet specified objectives and constraints, effectiveness, efficiency, completeness, and acceptability. The impacts of alternative plans are evaluated using the system of accounts framework (National Economic Development [NED], Environmental Quality [EQ], Regional Economic Development [RED], and Other Social Effects [OSE]) specified in USACE' *Principles and Guidelines* and ER 1105-2-100. This has taken place for the final array of alternatives and recommended plan during this phase of study.

5. **Comparing Alternative Plans:** Alternative plans are compared with one another and with the No Action alternative. Results of analyses are presented (e.g., benefits and costs, potential environmental effects, trade-offs, risks and uncertainties) to prioritize and rank FRM and ecosystem restoration alternatives. For the current study thus far, benefits and costs have been evaluated for the final array of alternatives, and a rationale is provided to justify selection of a selected plan.

6. **Selecting the Recommended Plan:** A plan is selected for recommendation, and related responsibilities and cost allocations are identified for project approval and implementation.

1.7.1 Public Concerns

The non-Federal sponsors and the public have expressed interest in addressing flooding risk management issues from the Rio Grande, the Arroyo Guachupangue, the Santa Cruz River, and the Rio Pojoaque. These watercourses have caused damages in the past from small, frequent events, and there is concern that larger, less frequent events, will result in significant damages.

Ohkay Owingeh Pueblo has also expressed an interest in addressing FRM resulting from flows in the Rio Grande and its tributaries. These problems are affecting critical infrastructure within the floodplains, in particular the San Juan Elementary School. They have also expressed an interest in bosque habitat restoration, including the removal of non-native species and the planting of native species. Some of the bosque area is used in traditional / cultural practices.

Santa Clara Pueblo has expressed an interest in addressing FRM problems throughout the Pueblo. The central Pueblo area frequently suffers from flood problems. Also, the existing spoil banks along the Santa Cruz River are inadequate, with frequent flood damages resulting from their poor condition. For many areas in the bosque, there is a need for a hazardous fuels reduction treatment plan that can be accomplished through ecosystem restoration measures. The Pueblo expressed an interest in restoring the bosque areas and potentially including recreational facilities, such as picnic areas, river walks, and biological exhibit areas. Some of the bosque area is used in traditional / cultural practices.

San Ildefonso Pueblo has expressed an interest in addressing FRM problems along the main stem of the Rio Grande and the Rio Pojoaque. They have also expressed an interest in restoring the Rio Grande's floodplains and its bosque, including the removal of non-native species and replanting with traditional native species. Some of the bosque area is used in traditional / cultural practices.

1.7.2 **Problems and Opportunities**

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.

1.7.2.1 Ecosystem restoration

Ecosystem restoration is one of the primary missions of the USACE Civil Works program. The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Ecosystem restoration efforts involve a comprehensive examination of the problems contributing to the system degradation, and the development of alternative means for their solution. The intent of restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system:

- Severe channel incision along the Rio Grande has reduced floodplain connectivity through a lack of overbank flooding. This connectivity is a critical function that has been largely lost in the study area and will worsen in the future. Illegal Gravel extraction performed in the 1980s has created a headcut that has exacerbated channel incision, reducing water availability for riparian vegetation and associated wildlife habitats.
- Surface/groundwater interactions and sedimentation dynamics that are important for sustaining and regenerating bosque habitats were lost in the 1950's following channelization activities, illegal gravel mining and creation of non-engineered spoil banks.
- Habitat diversity has been reduced from loss of critical river such as channel meander, avulsion and overbank flooding.
- Exotic invasive species have overtaken riparian habitats, created conditions conducive to wildfire and prevented regeneration of native plant species.
- Tribal and cultural resources and practices have been negatively impacted from degraded habitat and altered river morphology.

- *Opportunities exist to reconnect the Rio Grande and tributaries to their floodplains within the study area.*
- *Opportunities exist to restore sustainable ecosystem structure and function to valuable bosque habitat within the study area.*
- *Opportunities exist to improve water quality in the Rio Grande and its tributaries by addressing turbidity, sediment deposition, and aggradation through ecosystem restoration measures within the study area.*
- *Opportunities exist to expand Tribal use of the river and bosque within the study area.*

An interagency habitat team was convened with members from the Pueblos of Ohkay Owingeh, San Ildefonso, and Santa Clara, and representatives from the U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (BOR), New Mexico Department of Game and Fish (Game and Fish), the U.S. Forest Service (USFS), and the U.S. Bureau of Indian Affairs (BIA), La Calandria Consultants, and the Audubon Society. The habitat team participated in reviewing two potential models for estimating habitat values (Appendix C). The team provided input to sponsors and the USACE on possible habitat restoration measures for the project, assisted with screening measures, and reviewed documents.

1.7.3 Planning Objectives and Constraints

Planning objectives are specified in an iterative process. It begins with broad and general objectives and proceeds through a refining process to study specific objectives. Early in the study, they are vague but reasonable statements of what we want our recommended plan to produce. As the study progresses and our understanding of the problems increases, the objectives become more specific. Unless otherwise specified, it should be assumed that the period of analysis is the appropriate time frame for meeting the objectives. Constraints may evolve in a similar fashion.

*1.7.3.1 *Federal planning objectives*

Alternative plans are evaluated with respect to the four accounts discussed in Section 1.7:

- Contribute to the NED consistent with protecting the Nation's environment, pursuant to National environmental statutes and applicable Executive Orders, and following other Federal planning requirements.
- Contribute to NER through increasing the net quality and/or quantity of desired ecosystem resources.
- Determine whether ecosystem restoration plus FRM in this reach of the Rio Grande are consistent with the Federal objectives stated above.

*1.7.3.2 *Specific planning objectives*

- Reduce flood risk to private property and public infrastructure within the study area for the life of the project.

- Reduce flood risks to human health and safety within the study area for the life of the project.
- Reconnect the Rio Grande and its tributaries to their floodplains within the study area for the life of the project.
- Increase the amount and quality of valuable bosque habitat in the study area for the life of the project.
- Increase the diversity of riparian habitat types in the study area for the life of the project.
- Provide recreational opportunities to the public in the study area for the life of the project.

1.7.3.3 Specific planning constraints

Water delivery policies and regulations will affect water availability for ecosystem restoration measures. The Rio Grande Compact, in effect, limits the amount of surface water than can be depleted in the Middle Rio Grande based upon the natural flow of the river. Therefore, any increase in water use, or depletion, in one area of the river must be offset by a reduced use in another area of the river. Under the specific policy, restoration measures located within a 600-foot corridor along the active channel is not deemed an 'increase in water use' and does not require offsetting. Therefore, restoration measures were formulated to minimize potential water depletions by locating those measures within a 600 foot corridor.

Additional discussion of this subject is presented in Section 2.2 Water Depletions.

1.7.4 **Key uncertainties**

Alternative evaluation and selection of the recommended plan were based on cost estimates performed between 2014 and 2017. These estimates were based on a relatively low level design and current economic information. Contingencies were included to account for uncertainty. Extreme shifts in market conditions for construction or materials, project schedule for construction or phasing, future fuel costs will impact those costs.

Future declines in habitat value caused by future channel incision along the Rio Grande and Rio Chama will be variable. The rate of progress for upstream migration of the existing head cuts were estimated over the 50 year period of analysis and described as a linear function, that is, a constant rate of migration. Historic information and hydrologic and hydraulic modeling were used to estimate the migration rate. In reality the rate of migration of the head cuts is influenced by magnitude and frequency of flow events as well as inputs of sediment to the system. While a reasonable estimate was used, extreme events such as large floods, extreme drought or changes to the watershed landscape could impact the head cut migration rates. The status and progress of head cuts will be determined during detailed design and incorporated into affected measures.

Changes in the channel bed elevation prior to Grade Restoration Facility construction may require increasing construction material quantities. Specifically, the amount of fill material and rock to stabilize the channel bed and halt the headcut may be increased to achieve the target water surface elevations to inundate adjacent floodplain. Likewise, excavation of terraces, swales, and high-flow channels may require removal of additional materials to produce suitable elevations for floodplain and groundwater connectivity for establishment of riparian vegetation. A high survival rate (low mortality) for vegetation plantings is an important uncertainty that has significant impacts on project costs.

1.8 Existing and Ongoing Water Projects

1.8.1 **San Juan Chama Project**

Bureau of Reclamation's (BOR) San Juan Chama (SJC) Project consists of a trans-basin diversion that takes water from the Navajo, Little Navajo, and Blanco Rivers, upper tributaries of the San Juan River (of the Colorado River Basin), for use in the Rio Grande Basin in New Mexico (Reclamation 2013). The firm yield of the SJC Project is 96,200 acre feet per year, which provides Supplemental Water supplies for various communities and irrigation districts.

The water from the San Juan Chama Project is included in modeling supporting the hydrology, hydraulics and ecosystem restoration aspects of this study.

1.8.1.1 Heron Dam and Reservoir

Heron Dam and Reservoir (Heron) on Willow Creek (a tributary to the Rio Chama) in northern New Mexico was built in the late 1960s and is the principal storage reservoir for SJC Project water from the San Juan River system of the upper Colorado River Basin (Reclamation 2013). Only imported SJC Project water may be stored in Heron Reservoir requiring all native flows to be bypassed; therefore, Rio Grande Compact requirements do not apply.

1.8.1.2 Nambe Falls Dam

The Pojoaque Tributary Unit, a component of the SJC Project, stores water at the Nambe Falls Dam and Reservoir (Reclamation 2013). The dam is located on the Rio Nambe, which is a tributary to the Rio Grande, and provides approximately 1,030 AF of Supplemental Water for about 2,768 acres of irrigated lands. About 34% of the irrigated lands are Indian lands located on the Nambe, Pojoaque, and San Ildefonso Pueblos.

1.8.2 **Abiquiu Dam and Reservoir**

1.8.2.1 Flood regulation

The Abiquiu Dam and Reservoir project is situated on the Rio Chama about 32 river miles upstream from its confluence with the Rio Grande. The project was authorized for construction by the Flood Control Act of 1948, (Public Law [P.L.] 80-858) and the Flood Control Act of 1950 (P.L. 81-516). Construction of Abiquiu Dam was initiated by USACE in 1956 and the project was completed and placed into operation in 1963. The dam is a rolled earth fill structure with a crest length of 1,800 feet, and the maximum height above the stream bed is approximately 341 feet. The drainage area contributing flow to Abiquiu Reservoir comprises 2,146 square miles. Inflow to Abiquiu Reservoir is, in part, regulated by Heron and El Vado dams, which are operated by the BOR.

Abiquiu Dam was initially authorized to be operated solely for flood and sediment control. Subsequent legislation added authority for water supply storage (specifically, San Juan-Chama Project water storage). The reservoir's storage allocations include 502,000 ac-ft for flood control and 77,039 ac-ft for sediment retention. At the end of 2009, an estimated 40,616 ac-ft of the initial 77,039 ac-ft sediment reserve space remained unfilled. Storage of San Juan-Chama water occurs within the flood-control space and unused portion of the sediment reserve space.

Under current operating procedures, Rio Grande basin flow and releases from El Vado Reservoir upstream are passed through Abiquiu Reservoir without regulation. The only situation in which USACE would take any action would be to maintain the safe channel capacity downstream. Due to reach-specific safe channel capacity constraints, releases from Abiquiu Reservoir are restricted to 1,800 cfs directly below the dam; 3,000 cfs at the Chamita gage for the Rio Chama downstream from the dam; and 10,000 cfs at the Otowi gage (southern boundary of San Ildefonso) for the Rio Grande main stem. At the Chamita and Otowi locations, the Rio Chama and Rio Grande channels carry flow from sources other than Abiquiu Dam. USACE limits releases from Abiquiu Dam such that those releases, in combination with current in stream flows, do not exceed any of the three safe channel capacity limits.

1.8.3 **The Bureau of Reclamation’s Middle Rio Grande Project**

The Middle Rio Grande Project was authorized by the Congress to improve and stabilize the economy of the Middle Rio Grande Valley by rehabilitation of the Middle Rio Grande Conservancy District facilities and by controlling sedimentation and flooding in the Rio Grande. The Bureau of Reclamation (Reclamation) and USACE jointly planned the comprehensive development of the project.

The Reclamation project extends along the Middle Rio Grande Valley from Cochiti Dam south to the backwaters of Elephant Butte Reservoir. It includes maintenance of the Rio Grande in the vicinity of Truth or Consequences, New Mexico.

Built originally by the Middle Rio Grande Conservancy District, the irrigation features of the project divert water from the river to irrigate up to 89,652 acres of irrigable land between Cochiti and Elephant Butte dams. There are 30,000 acres of Indian water right lands within the project. Construction features rehabilitated by Reclamation in addition to El Vado Dam are Angostura, Isleta, and San Acacia Diversion Dams (Reclamation, 2009). Only El Vado Dam is relevant to this study as it is the only feature which lies upstream of the study area.

1.8.3.1 El Vado Dam and Reservoir

MRGCD initiated construction of El Vado Dam in 1929 and completed it in 1935 (Reclamation 2013). Reclamation operates El Vado Dam and Reservoir pursuant to the 1951 contract with the MRGCD. The total maximum storage of El Vado Reservoir is about 196,000 AF, though sediment and operational restrictions have reduced its effective capacity to about 180,000 AF. El Vado is used to store native Rio Grande and SJC Project water for MRGCD and to store native flows to ensure there is sufficient supplies for the prior and paramount lands of the Six MRG Pueblos pursuant to the “Agreement: Procedures for the Storage and Release of Indian Water Entitlement of the Six Middle Rio Grande Pueblos,” approved by the Secretary of the Interior, December 28, 1981, (1981 Agreement) (discussed below). MRGCD is not a party to the 1981

Agreement. When space is available, Reclamation and MRGCD may store SJC Project water in El Vado Reservoir for other users and other purposes. Storage of large volumes of SJC Project water may take place for extended periods of time.

Consistent with Article XVI9 of the Compact, water is held in El Vado each year regardless of Article VII restrictions, to ensure that water can be provided to meet the demand for the Six MRG Pueblos, which is tracked separately with a daily accounting model and released to specifically meet the demand for the Pueblos. Pursuant to the 1928 Act, the Pueblos have the prior and paramount right to divert Rio Grande natural flow; but due to diversions by others, sufficient natural flow may not always be available to the Pueblos when needed. Consequently, the Secretary of the Interior designates space in El Vado Reservoir to ensure that water is available for prior and paramount lands of the Six MRG Pueblos should the natural flow prove insufficient. This water can be released to meet irrigation demand for prior and paramount lands, as discussed below.

2 - Existing and Expected Future Without-Project Conditions*

Existing conditions are defined as those conditions that exist within the study area at the time of the study. The expected future without-project condition, which is the same as the “No Action” alternative, is a projection of how these conditions are expected to change over time if no USACE plan is implemented and forms the basis against which alternative plans are developed, evaluated, and compared. The term baseline is also used to refer to the existing conditions at the time of a measurement, observation, or calculation and may be used occasionally throughout this report.

The expected future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project. Proper definition and forecast of the expected future without-project condition are critical to the success of the planning process. The expected future without-project condition constitutes the benchmark against which alternatives are evaluated. Forecasts of the expected future without-project conditions shall consider all other actions, plans and programs that would be implemented in the future to address the problems and opportunities in the study area in the absence of a USACE project. Forecasts should extend from the base year (the year when the proposed project is expected to be operational) to the end of the life of the project.

2.1 Hydrology, Hydraulics and Sediment Transport*

2.1.1 Hydrology

Hydrology investigates the relationship between rainfall, runoff, and stream flows within watersheds. The hydrologic analyses for this project included a standard flood risk analysis and an environmental features analysis. The flood risk analysis was performed with statistical methods using U.S. Geological Survey (USGS) river gage data and watershed modeling using HEC-HMS. The flood flows for eight risk levels were determined. The hydrology for the ecosystem restoration measures for two tributaries and the Rio Grande was solely based on USGS gage data. This hydrologic analysis was completed with HEC-EFM for two target species: willows and cottonwoods (Appendix A).

The annual chance exceedance (ACE) (0.2%, 0.5% 1%, 2%, 5%, 10%, 20%, and 50%) refer to the probability of a particular flow event being exceeded in any one year. Therefore, the previous nomenclature of the “100-year flood” is more properly defined as the flood having a 1% chance of being exceeded in any one year. Similarly, the 5% ACE flood was previously called the “20-year” flood, the 2% ACE flood was previously called the “50-year” flood, and the 0.2% ACE flood was called the “500-year” flood (Appendix A, Attachments 1 and 3).

2.1.1.1 Historic Conditions

The Rio Grande and Rio Chama are regulated systems whose flows are strongly impacted by irrigation withdrawals, water storage reservoirs, and downstream water deliveries. Flow reductions of 40-70% on the Rio Grande due to upstream irrigation withdrawals (National Resource Commission, 1938) have resulted in reduced meander wavelength, increased channel sinuosity, reduction in multiple-channel reaches and increased channel stability in the Upper Rio

Grande Basin. Upper basin water resource development projects probably had little impact on the annual sediment loads of the Rio Grande, since historically, the sediment delivery to the Española Valley reach from the Upper Basin was low.

Flow changes on the Rio Chama have been more profound. Closure of Abiquiu Dam in 1963 resulted in the capture and storage of winter runoff, resulting in significant reductions in peak spring runoff flows in the lower Chama. These changes have also reduced spring runoff flows on the Rio Grande below the confluence, since historically a large fraction of these flows originated on the Rio Chama. In addition, during major precipitation events, reservoir releases from Abiquiu Dam are scheduled to not coincide with peak flows on the Rio Grande, significantly reducing peak flows downstream of the confluence. Finally, Abiquiu Dam captures sediment from the Rio Chama that historically would have been the major source of sediment transported by the rivers through the Española Valley. Additionally, Heron Lake, a smaller storage reservoir upstream of Abiquiu, also retains spring runoff. Both Abiquiu and Heron release stored water for irrigation during the summer months, augmenting base flow. Much of this water transits the study area on its way to users downstream.

The Colorado River compact has led to increased summer flows along the Rio Chama and Rio Grande. Since completion of the San Juan-Chama project in 1971, approximately 110,000 ac-ft of water is diverted annually from the Colorado Basin, stored in reservoirs along the Rio Chama upstream of the study area, and released to irrigators downstream of the study area during the summer and early fall.

Thus water storage on the Rio Chama has had the effect of both reducing spring runoff flows and increasing summer base flows throughout the study area. In addition, sediment is trapped behind storage dams, resulting in downstream flows that are sediment-starved compared to historic flows, with significant impacts to channel form and function.

2.1.1.2 Existing Conditions

The Rio Grande originates in the San Juan Mountains of southern Colorado at an elevation above 14,000 ft, and flows through the San Luis Valley before turning south to enter the Rio Grande Gorge near the Colorado-New Mexico state line. The Rio Grande emerges from the canyon near the town of Embudo at the northern end of the Española Valley. Through the Española Valley, about 30 miles in length, the Rio Grande receives runoff from high mountains and foothills (Sangre de Cristo Mountains) to the east and lower mountains and plateaus (Jemez Caldera) to the west (Figure 3). The Rio Grande exits the Española Valley through White Rock canyon, at the head of which is Otowi Gage at an elevation of approximately 5,488 ft.

The Rio Chama originates along the south side of the San Juan Mountains at an elevation above 12,000 ft and flows generally southeast towards its confluence with the Rio Grande at an elevation of 5,615 ft 15 miles downstream of Embudo. Dams along the Rio Chama have significantly affected stream flow (see Historic Condition section above, and Appendix A).

Four additional tributaries are included in this assessment (Figure 3). The Rio Pojoaque and the Arroyo Guachupangue, the largest and smallest of these four tributaries respectively, are arroyos with ephemeral flows. The remaining tributaries, Santa Clara Creek and the Santa Cruz River have flows year round. While locally important water sources, these tributaries' flows are small compared to those the Rio Grande and Rio Chama.

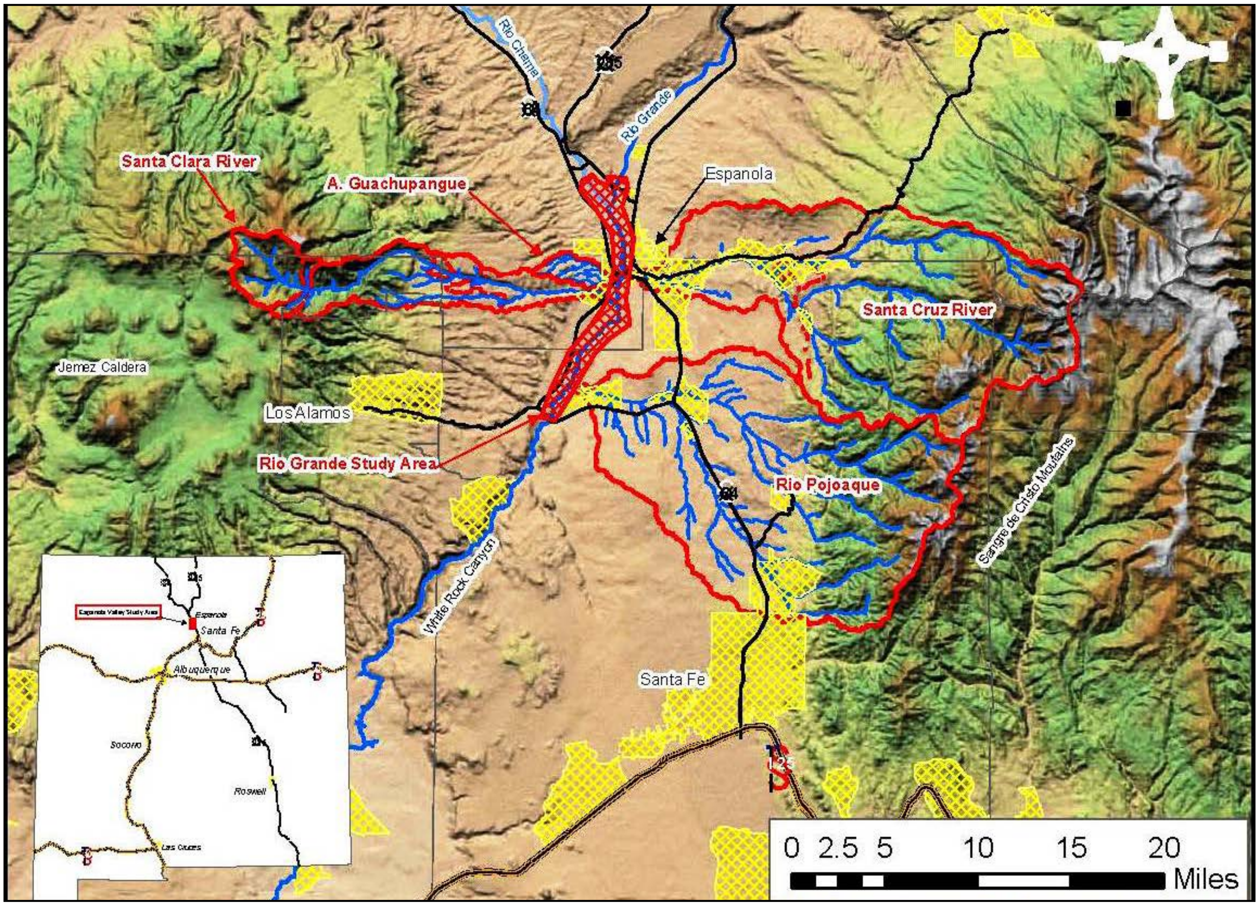


Figure 3 Map showing locations of Rio Grande and its tributaries in relationship to the study area.

Peak discharges are developed so that the risk of flooding can be estimated in the floodplains. The peak discharge is the flood flow that produces the highest flood stage and maximum extend of flood inundation.

Two watersheds were modeled using HEC-HMS v.3.1.0 and Environmental Systems Research Institute (ESRI) ArcMap 9.1 with the HEC-GeoHMS add-ons. Then USGS gage data was used for the other four waterways (Table 1) (Figure 4).

Table 1 Summary of peak discharges for the Rio Grande and its tributaries.

		Estimated Peak Discharge per ACE (cfs) at confluence							
	Drainage Area (sq. mi.)	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.5%**	**0.2%**
Rio Grande (Otowi Bridge)	11,360	6,525	10,450	13,100	15,700	19,050	21,600	24,200	27,650
Rio Chama	3,159	2,550	3,225	3,700	4,375	5,250	6,000	6,975	8400
Arroyo Guachupangue	4.9	2,50	820	1,240	1,830	2,300	2,800	3,300	3900
Santa Clara Creek	50	200	840	1,580	2,700	3,600	5,200	9,300	15900
Santa Cruz River	183	550	1,920	3,200	4,800	6,100	8,000	10,500	16000
Rio Pojoaque	195	250	4,300	8,070	12,500	16,900	22,200	28,200	37800

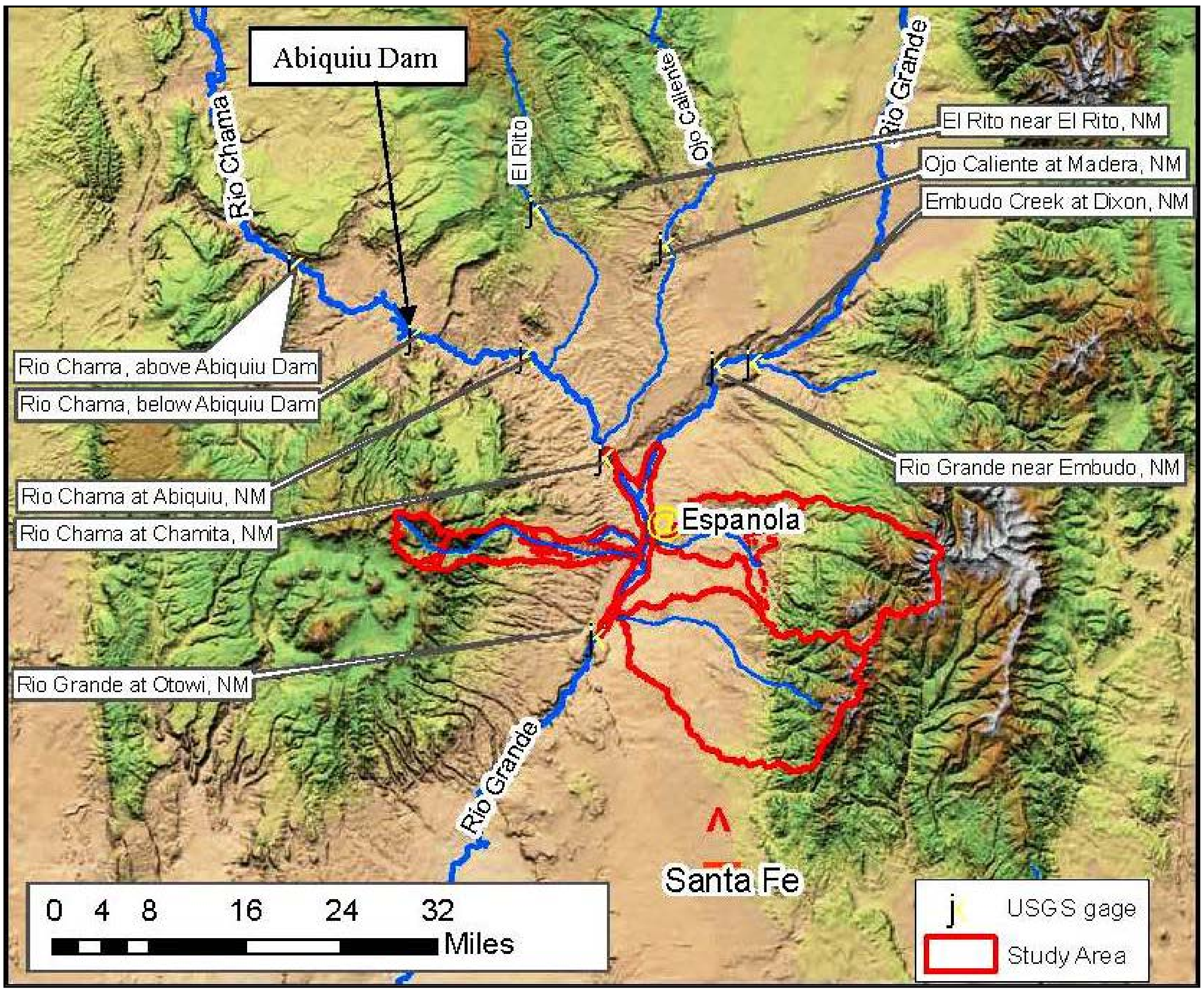


Figure 4 Map of USGS gage locations in relationship to the study area and Abiquiu Dam.

2.1.1.3 Expected Future Without-Project Condition

Although the stream gage record is considered extensive on this section of the Rio Grande, 120 years is not enough time to accurately estimate the full suite of potential peak flows for the expected future without-out project condition. The average and variability of flows at gages in the study area mask large changes in actual flow over the gaging period of record, including a wet period without historic precedent and two droughts.

The expected future without-project hydrology is anticipated to remain largely unchanged as there are no plans for additional flood risk management or water conservation storage structures on either the Rio Grande or the Rio Chama. There are currently no plans to alter how these structures are operated and no plans to change the schedule for downstream water delivery. Land use and land cover are also not anticipated to change significantly from their current condition.

Climate models project long term warming throughout the Upper Rio Grande basin (Melillo et al 2014), including in the winter at higher elevations across the southwest , including the Sangre de Cristo and Jemez Mountains (Gutzler 2006). This is likely to reduce the amount of precipitation falling as snow and therefore reduce spring runoff volumes and summer base flows on the Rio Grande and its tributaries (Reclamation 2013), including those in the study area. For more information on climate change impacts to the study area, see Appendix G.

2.1.2 **Fluvial Geomorphology**

An understanding of river and stream channel responses to human-caused and natural occurrences is necessary to formulate appropriate measures to address FRM and ecosystem restoration issues of management, conservation and restoration. The study of past effects is necessary to intuit future changes.

The geomorphic investigation primarily focused on the Rio Grande from the upstream (northern) boundary of the Ohkay Owingeh Pueblo downstream into the White Rock Canyon, which is located on the San Ildefonso Pueblo just downstream of Otowi Bridge (about 20 miles) and the Rio Chama from about one mile upstream of the Ohkay Owingeh Pueblo boundary to its confluence with the Rio Grande (Appendix A, Attachment 2).

2.1.2.1 Historic Conditions

Expansion of irrigated agriculture in the post-Spanish period probably resulted in a significant reduction in the native bosque vegetation, but it is unlikely that there were significant impacts to the river channels. Overgrazing of the watersheds by sheep and cattle led to a significant increase in watershed sediment yield and subsequent aggradation of the Rio Grande streambed and the floodplain.

Large flood flows in 1941 and 1942, and the aggraded nature of the Rio Grande in the Española Valley, led the New Mexico State Engineer to construct non-engineered spoil banks in 1949. The May-June flood in 1952 caused significant damage to these spoil banks, and as a result, the BOR straightened and channelized the river, rebuilt the spoil banks using dredged material between 1955 and 1957. Excess spoil from dredging was used to fill in old Rio Grande meanders.

Channel maintenance and bank stabilization activities by the BOR were conducted as necessary to maintain the channel capacity into the 1980s.

Unlawful sand-and-gravel mining occurred in the Rio Grande and on the floodplain/terrace in the lower reaches of the Ohkay Owingeh Pueblo in the 1980s. Approximately 10 feet of material was removed from the bed of the river and this has led to both vertical instability and increased rates of lateral erosion of the over-heightened banks. Although the mining has stopped, the combined effects of the channelization and the sand-and-gravel mining caused the upstream migration of channel bed head-cuts that caused incision that varies from over 10 feet at the downstream end of the reach to about 2 to 3 feet at the upstream end of the Ohkay Owingeh Pueblo reach.

There are few data available to characterize the historical channel conditions in the Rio Chama or the major tributaries within the project reach.

2.1.2.2 Existing Conditions

The combined effects of reduced peak flows, channelization and spoil piles, channel incision and the extensive presence of bank-reinforcing non-native vegetation (primarily Russian olive and tamarisk) have resulted in a 68-84% reduction in channel width and a reduction in active floodplain width for both the Rio Grande and Rio Chama. In conjunction with channel incision and a 50% decrease in sedimentation due to upstream dam construction, the reduced peak flows have effectively disconnected the rivers from their floodplains. The bed is currently stable (neither aggrading nor degrading). From a geomorphic perspective, the historical floodplains located along the Rio Chama and Rio Grande within the project boundaries under existing conditions should probably be classified as "terraces." A much wider and more densely vegetated bosque has developed compared to the bosque shown in 1935 aerial photographs as a result of colonization of inactive portions of the floodplain that were active in 1935. On both rivers, flows in excess of the 20% ACE peak flow are now required for floodplain inundation. Overbanking and the disturbance created by active channel meandering are critical functions that formerly affected hydration of the overbank, nutrient cycling, plant (especially cottonwood) regeneration and establishment of new habitat types or age class plant communities. The loss of these functions has greatly contributed to loss of habitat diversity and lower overall habitat values.

2.1.2.2.1 Rio Grande

Channel sinuosity (the ratio of the channel length to the straight line valley length) for the individual sub-reaches of the Rio Grande and Rio Chama was determined from the 2007 aerial photography of the project reach. Under existing conditions, the Rio Grande, regardless of reach, is a very low sinuosity river. In 1935, the Rio Grande also had very low sinuosity and the channel, in certain reaches, was braided or wandering. In the Santa Clara and San Ildefonso Pueblo reaches, there is evidence of lateral migration, and if this is allowed to continue, there will be an increase in channel sinuosity over time. Comparison of the active channel and floodplain widths on the 1935 and 2007 aerial photographs indicates that the active channel width on the Rio Grande has been reduced by about 80 percent.

2.1.2.2.2 Rio Chama

The combined effects of the reduced peak flows and reduced sediment supply, since the construction of Abiquiu Dam, should result in a channel with increased sinuosity. Although the sinuosity of the Rio Chama is slightly higher than that of the Rio Grande, it is still a low sinuosity river. However, in the lower reaches approaching it's confluence with the Rio Grande, there is an indication that the sinuosity is increasing.

On the lower Rio Chama, there is some lateral migration of the river, and the sinuosity of the river has increased over time.

2.1.2.3 Expected Future Without-Project Conditions

The mobile boundary sediment-transport models were executed over a 26-year simulation period to estimate the amount of aggradation or degradation and associated changes in channel geometry. The simulation period was based from WY1980 to WY2005 rainfall data from the City of Espanola. This rainfall was modeled in HEC-HMS for the two tributary watersheds to obtain flow hydrographs.

Results from the 26-year simulations are generally consistent with the results from the simulations for the eight individual flood hydrographs (Appendix A, Attachment 4, Sections 3.2 in both reports) and show little change from the existing conditions geomorphology.

2.1.3 **Hydraulics**

Water in a wetland, lake or a river is called surface water, and is lost by evaporation, infiltration, transpiration, and discharge to the oceans. The total quantity of water available in any system is dependent upon the storage capacity of any reservoirs, the permeability of the soil, the overflow characteristics of the watershed, precipitation, and the rate of evaporation and transpiration. The quantity of water consumed fluctuates over a time to which appropriate measures are sometimes necessary to manage natural resources.

The Rio Grande and its tributaries were hydraulically modeled using HEC-RAS v. 3.1.3. The model geometry was based on a variety of data including information from a 2007 survey of the main channel, previous cross-section surveys, and LiDAR-based mapping of the study reach. HEC-GeoRAS v. 4.1 and ArcGIS 9.2 were used to delineate the inundated area for each of the modeled flows (Appendix A, Attachments 3 and 5).

2.1.3.1 Existing Conditions

2.1.3.1.1 Rio Grande

For hydraulic modeling purposes, the river was divided into 2 reaches with reach 1 beginning upriver of the northern border of Ohkay Owingeh and going downstream to the confluence with the Rio Chama. Reach 2 starts at the confluence with the Rio Chama and goes downriver 4,030 feet beyond Otowi Bridge towards the southern boundary of San Ildefonso. The hydraulic depth varies significantly in the Rio Grande (3.7 feet to 13.7 feet); with relatively shallow depths upstream of its confluence with the Rio Chama and large depths in the Española reach. Floodplain mapping indicates that the widest flooding occurs in the reach of the Rio Grande between Santa Clara Creek and the Santa Clara / San Ildefonso boundary because of the many floodplain constrictions (bridges). Significant wide flooding at the higher peak flows also occurs upstream from the NM Highway 74 Bridge (Ohkay Owingeh) through the City of Española, and downstream from the Rio Pojoaque (San Ildefonso) (Table 2).

In both the Rio Grande and Rio Chama, very little overbank flooding is indicated at the 50% ACE event, and relatively minor flooding occurs at the 20% ACE. The spoil piles in the vicinity of the City of Española generally contain flows up to the 10% ACE, with localized flow breakouts that cause relatively minor flooding at lower flood levels. Moderate flooding occurs at the 4% ACE due to overtopping of the spoil banks at numerous locations. The spoil banks do not contain flows that equal or exceed the 2% ACE resulting in significant flooding at larger flood flows (Appendix A, Attachment 5).

Table 2 Acres inundated within each sub-reach at designated ACE.

	Acres inundated by ACE							
Sub-Reach	50%	20%	10%	4%	2%	1%	0.50%	0.20%
Rio Chama								
Ohkay Owingeh	109.2	161.1	216.6	279.2	400.7	472.1	523.3	504.6
Rio Grande								
Ohkay Owingeh	109.2	161.1	216.6	279.2	400.7	472.1	523.3	504.6
Santa Clara	218.4	322.2	433.2	558.4	801.4	944.2	1046.6	1009.2
San Ildefonso	327.6	483.3	649.8	837.6	1202.1	1416.3	1569.9	1513.8
Total	**764.4**	**1127.7**	**1516.2**	**1954.4**	**2804.9**	**3304.7**	**3663.1**	**3532.2**

2.1.3.1.2 Rio Chama

For modeling purposes, the Rio Chama was divided into a single sub-reach. The hydraulic depth in this reach varies in the Rio Chama from 3.6 feet to 8.6 feet (Table 2). As expected, the largest flow depths in the Rio Chama are indicated in sub-reach 1 due to the backwater effects of the Chamita/Hernandez Irrigation Diversion (Appendix A, Attachment 5).

2.1.3.1.3 Other Tributaries

Existing conditions for Santa Clara Creek, the Santa Cruz River, Rio Pojoaque, and the Arroyo Guachupangue are described in Appendix A.

2.1.3.2 Expected Future Without-Project Conditions

A USACE contractor performed hydraulic, geomorphic, and sediment-transport analyses of the study reaches of the Arroyo Guachupangue and the Rio Pojoaque. The specific purposes of the analysis were to assess potential flooding conditions in the study area under existing and future without-project conditions, evaluate the stability of the channels and provide estimates of the sediment supply to the Rio Grande.

The study reaches of the two tributaries are as follows:

- Arroyo Guachupangue: Approximately 1,000 feet upstream from the residential neighborhood at the western limit of the City of Española, NM to the confluence with the Rio Grande (about 1.2 miles).
- Rio Pojoaque: Eastern boundary of the San Ildefonso Pueblo to the confluence with the Rio Grande (about 3.6 miles).

The future without-project analysis was performed by developing floodplain delineation mapping of the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and the 0.2% ACE for steady-state peak flows. The channel geometry at the end of the 52-year simulation was imported into of the hydraulic models that were initially used to delineate the existing conditions. Results from the above model runs were used to delineate the flood boundaries for each of the modeled ACE (see Appendix A for results).

2.1.4 **Sediment transport**

Precipitation events and snow melt provide water to arroyos, streams and rivers as overland flow. This overland flow may pick up and move soils, rocks and debris to down slope waterways. The soils, rocks and debris are called sediment and their movement is called sediment transport. Analysis of sediment transport is necessary to properly formulate appropriate FRM and ecosystem restoration measures (Appendix A, Attachment 4).

In the analysis of FRM and ecosystem restoration measures, knowing the capacity of the river channels to convey flows is very important. Future trends in incision or aggradation of the channels may change channel capacity and therefore the extent of flooding outside of the channels. Flooding that reaches structures or infrastructure may cause damage. Conversely, overbank flows are a critical function in the riparian ecosystem. These flows facilitate nutrient cycling, seed dispersal and plant regeneration.

The analyses were performed using a sediment-routing model that was developed using the mobile bed sediment-transport feature HEC-RAS v. 4.0. The model geometry and basic structure were taken from the hydraulic model that was developed for the floodplain delineation mapping of the arroyo. In-channel bed-material information was developed from bed-material samples collected during the October 2007 field surveys.

2.1.4.1 Existing Conditions

2.1.4.1.1 Arroyo Guachupangue

Modeling results indicate that very little aggradation or degradation occurs under average annual conditions and during the 50% ACE. At the larger flood events, the majority of the reach is slightly degradational, with less than 1 foot of degradation at flows less than the 1% ACE (Figure 5). This suggests that channel capacity is relatively stable.

At the downstream limit of the model, slight degradation occurs at flows up to the 10% ACE event, but moderate aggradation is indicated for the less frequent floods. The average annual total bed material volume delivered to the Rio Grande is about 1,740 tons, and ranges from about 620 tons during the 50% ACE event to about 12,830 tons during the 0.2% ACE event. The average annual unit bed material volume delivered to the Rio Grande is about 0.7 tons/acre, and ranges from about 0.2 tons/acre at the 50% ACE to about 4.1 tons/acre at the 0.2% ACE event (Appendix A, Attachment 4).

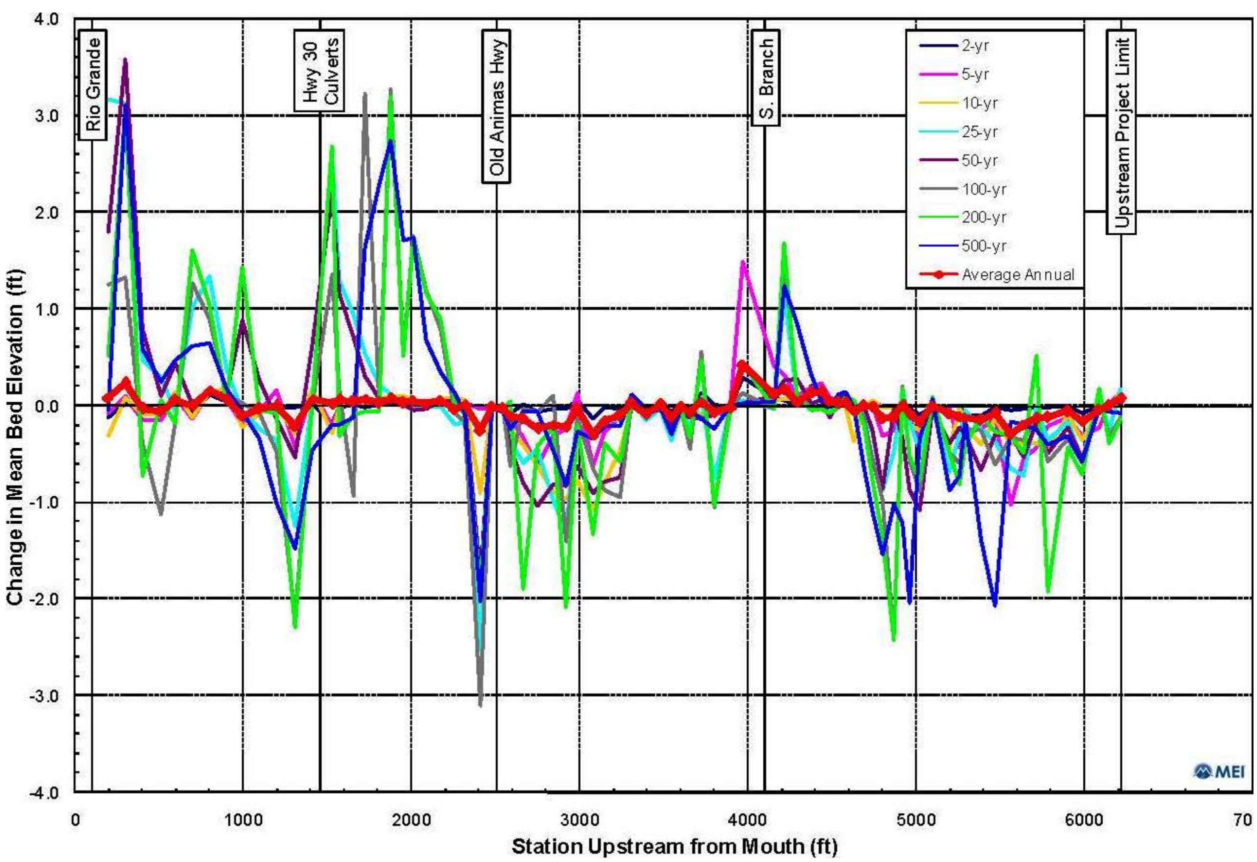


Figure 5 Modeled change in bed elevation in Arroyo Guachupangue.

2.1.4.1.2 Rio Pojoaque

Modeling results indicate that the overall project reach is roughly in equilibrium with the upstream and tributary sediment supplies, with generally small changes in elevation (less than 2 feet of aggradation or degradation at most cross sections for events up to the 1% ACE event), and average annual changes elevation at individual cross sections of less than 0.4 feet (Figure 6). Relatively little aggradation or degradation occurs under average annual conditions or during each of the flood hydrographs (Appendix A, Attachment 4).

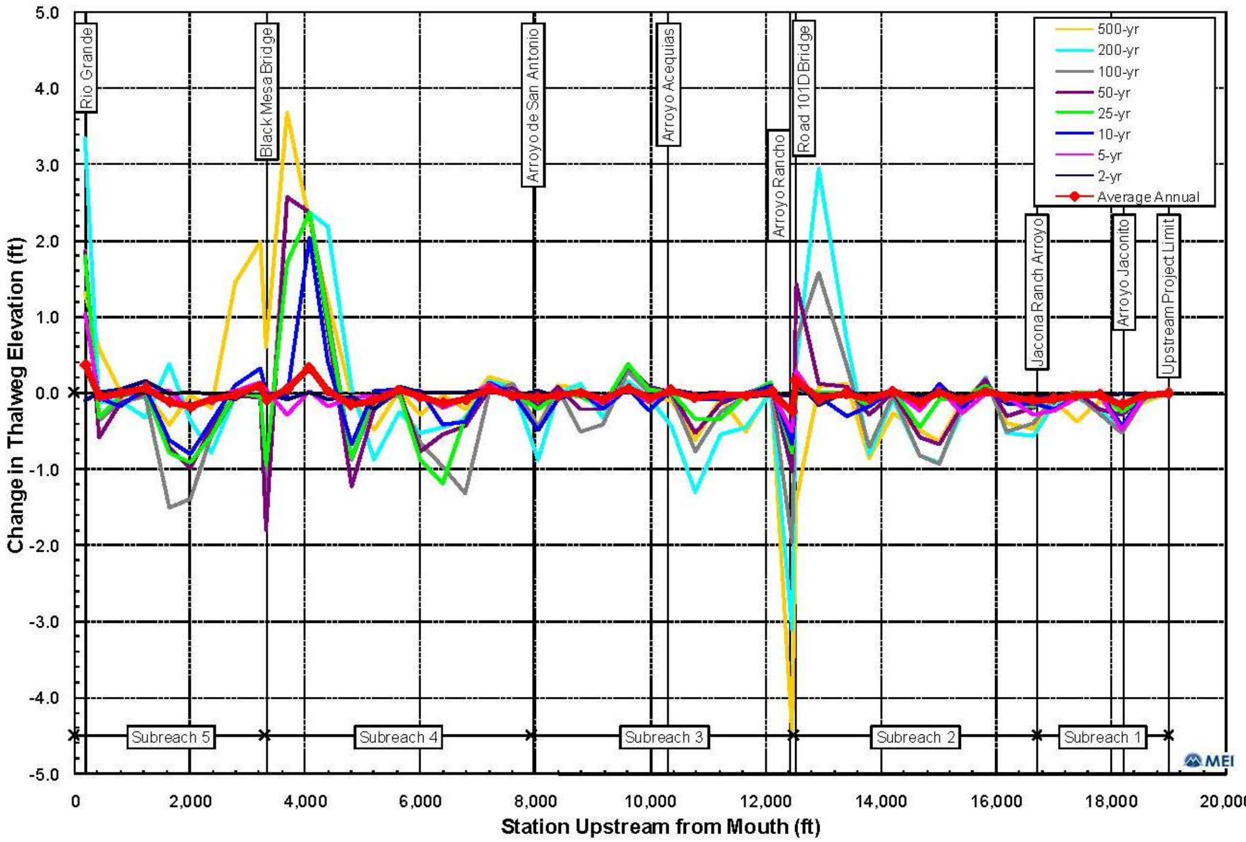


Figure 6 Modeled change in bed elevation in the Rio Pojoaque.

2.1.4.2 Expected Future Without-Project Conditions

The mobile boundary sediment-transport models were executed over a 26-year simulation period to estimate the amount of aggradation or degradation and associated changes in channel geometry. The simulation period was based from WY1980 to WY2005 rainfall data from the City of Espanola. This rainfall was modeled in HEC-HMS for the two tributary watersheds to obtain flow hydrographs.

Results from the 26-year simulations are generally consistent with the results from the simulations for the eight individual flood hydrographs (Appendix A: Attachment 4: Sections 3.2 in both reports) and show little change from the existing conditions geomorphology.

Results from the above model runs were used to delineate the flood boundaries for each of the eight modeled floods, and the delineations compared to the existing conditions flood boundaries to determine the potential effects of aggradation and degradation on the extent of flooding. Little change in channel capacity and therefore flooding extent or frequency is shown for the two tributary rivers in the future condition.

2.1.4.2.1 Arroyo Guachupangue

For the Arroyo Guachupangue, the predicted change in mean bed elevation is generally less than 1 foot (Figure 5). Local conditions result in about 3 feet of aggradation upstream from the South Branch confluence, under a foot of aggradation throughout the South Branch of Arroyo Guachupangue reach, and up to 1.4 feet at a construction. The remainder of the Arroyo Guachupangue reach is moderately degradational, except for localized incision downstream from the culverts (Appendix A, Attachment 4).

2.1.4.2.2 Rio Pojoaque

Except for 3.2 feet of aggradation for about 1,000 feet upstream of the Road 101D bridge, some degradation immediately downstream of this bridge, and approximately 0.8 ft of degradation just upstream of the confluence with Jacona Ranch Arroyo, very little change is indicated on the Rio Pojoaque within the study reach (Appendix A, Attachment 4).

2.2 Water Depletions*

The Rio Grande Compact, in effect, limits the amount of surface water than can be depleted in the Middle Rio Grande based upon the natural flow of the river measured at the Otowi gage downstream of the project area (Rio Grande Compact, 1939). In addition, the New Mexico State Engineer has determined the Middle Rio Grande to be fully appropriated. Therefore, any increase in water use in one area of the river must be offset by a reduced use in another area of the river. The State Engineer requires that increases in water use from new habitat restoration projects must be offset by purchased or leased water rights. Work performed within the river channel within the Rio Grande Floodway is exempt from this policy (NMISC, 2007). The definition of ‘Floodway’ in this case is a 600-foot corridor centered on the midline of the river. Therefore, water use within this 600-foot corridor is not deemed an ‘increase in water use’ and does not require offsetting, but increases in water depletions from any part of a habitat restoration project that falls outside of the 600-foot floodway must be offset. The New Mexico State Water Plan (Office of the State Engineer/Interstate Stream Commission, 2003) further states “State Engineer permits are required for all habitat restoration activities that result in increased depletions of water.” However, the New Mexico State Engineer “maintains that habitat restoration projects implemented by the Bureau of Reclamation, Army Corps of Engineers, or ISC in the Middle Rio Grande floodway do not require water rights permits because of those agencies’ respective flood control and compact delivery statutory roles” (NMISC, 2007).

There would be no change to Water Depletions under the future without project.

2.3 Environmental Resources*

The Rio Grande is the 5th longest river in North America, and one of the top ten endangered rivers in the world (Wong et al. 2007). The Rio Grande in New Mexico comprises 484 miles (26% of total length). Riparian corridors comprise less than one percent of New Mexico's landscape (USEPA and NMED 1998), yet they are the most important ecosystems in the state (Roelle and Hagenbuck 1995).The Rio Grande floodplain contains patches of undeveloped bosque consisting of cottonwood and willow riparian habitat. Historically, flooding and scour were the basic processes that created and maintained a patchwork of variable age class forest stands in the bosque (Crawford et al. 1993; Scurlock 1998). The surface area of wet meadows, marshes, and ponds has decreased by 73% along 250 miles of the Rio Grande floodplain in New Mexico.

Forty percent of the Rio Grande floodway in New Mexico is managed by the U.S. Bureau of Reclamation in cooperation with the Middle Rio Grande Conservancy District (MRGCD). The majority of the riparian forest (bosque) managed by these two agencies is downstream of Isleta Pueblo which includes aggrading and incised sub-reaches of the river. Ecosystem restoration in this area must be balanced with irrigation demand and flood damage reduction.

Approximately 10% of the Rio Grande in New Mexico is managed by other federal and state agencies other than USBR and MRGCD. The 150 miles (~31%) of the Rio Grande floodway downstream of Elephant Butte Reservoir is constrained by agriculture. Pueblos manage about ~60 miles (12%) of the Rio Grande in New Mexico.

2.3.1 **Combined Habitat Assessment Protocols (CHAP) to Estimate Habitat Value**

The Combined Habitat Assessment Protocols (CHAP) are a habitat-based approach to assess ecosystems and provide a mechanism for quantifying changes in habitat quality and quantity over time under proposed alternative scenarios. The three primary components of CHAP for estimating the habitat values (per acre) of proposed measures are the species function, habitat field inventory, and the invasive species factor.

The CHAP system tabulates the Key Ecological Functions (KEFs) values using the Biota Information System of New Mexico (BISON-M, 2010) species list for each polygon. The KEFs are the number of interactions between vertebrate species, their habitat, and functions as a component of calculating habitat units. These interactions have been tabulated in the Interactive Biodiversity Information System (IBIS).

The Key Environmental Correlates (KEC) values in CHAP are tabulated from the field inventory data for each polygon. Field data forms support consistent identification and recording of all potential functions present for each polygon. Calculating the relative habitat value based on KECs (field inventory) and KEFs (database) provides an estimate based on observed habitat complexity and how species utilize the area. The relative polygon values are multiplied by the baseline acreages to generate habitat units for additional analyses.

The Invasive Species Factor (ISF) is a value between 0.0 and 1.0 that adjusts overall habitat values as a function of the coverage of invasive plants. The CHAP field inventory estimates the vegetative cover for invasive herbaceous, shrubs, and trees. High ISF values indicate low invasive species cover, and low ISF values indicate high invasive species cover. Vegetation management measures to remove invasive plants and support native species would increase the ISF, producing a higher corrected per acre value.

The site-specific CHAP methodology is projected into the future through several variables. First, anticipated trends for invasive plant coverage (herbs, shrubs, and trees) are estimated for recalculation of the ISF. Invasive plant species would increase the percent coverage under the no management scenario, reducing the ISF which decreases the corrected per acre value (decreased coverage of native species). Second, the KEFs are recalculated based on removal of a percentage of the uncommon species at the 25 and 50 year time horizons. CHAP randomly removes half of the uncommon species at the 25 and 50 year milestones to evaluate the effects of changing habitat for KEFs. Removing a species during these time period(s) has the effect of changing the functional profile and resiliency of the system because they no longer contribute their ecological functions. These functions are removed from the 25 and 50 year runs because these species are not expected to have viable populations within the project boundary. Calculation of habitat units using the adjusted values for ISF and KEFs results in a decrease in habitat value and units for the temporal milestones.

GIS mapping shows individual habitat patch values across the landscape in relation to hydrology, topography, land management, and other factors. This allowed the habitat team to identify areas to protect and maintain the ecosystem, and other areas that would benefit from specific measures.

2.3.2 **Floodplains and wetlands**

Executive Order 11988 (Floodplain Management) provides Federal guidance for activities within the floodplains of inland and coastal waters. Federal agencies are required to "ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management." Removal of the non-native vegetation may allow the active floodplain to expand. Preservation of the natural values of floodplains is of critical importance to the nation and the State of New Mexico. These natural values include preservation of wetlands.

Wetlands consist of marshes, wet meadows, and seasonal ponds that typically support hydrophytic plants such as cattails, sedges and rushes. Wetlands are a critical component of bosque diversity. Wet meadows were the most extensive wetland habitat type in the Rio Grande valley prior to irrigation. The construction of the MRGCD drains and ditches led to substantial decreases in wetland habitat: 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 its 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 is the preservation of existing wetlands and expansion or creation of additional wetlands (Crawford et al., 1993).

Wetlands are lands transitional between terrestrial and aquatic ecosystems where the water table is at or near the surface (Figure 7) or the land is covered by shallow water (Cowardin et al. 1979). 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 may 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 wandered widely throughout its floodplain and abandoned channels often contained sufficient ground water 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 reach has been significantly reduced. The ground water elevation throughout the valley was significantly lowered by the construction of the MRGCD drains in the 1930s. 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 Section 404 of the Clean water Act) do occur in the Recommended Plan 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.

Scurlock (1998) has summarized trends for historic Rio Grande riparian communities over the last 150 years (Appendix C). The riparian ecosystem has changed with the decline of cottonwood gallery forest, encroachment of upland junipers, and invasion of salt cedar (*Tamarix ramosissima*), Russian olive (*Elaeagnus angustifolia*), and Siberian Elm (*Ulmus pumila*).

The existing ecosystem condition is the result of the severe channel degradation and reduced floodplain connectivity along the Rio Grande and its tributaries (Appendix C). Gravel extraction, which was halted in the 1980s, downstream of Ohkay Owingeh has created a headcut that has exacerbated channel incision, reducing water availability for riparian vegetation (Sparks and Spink 1998; Appendix I). The future without project condition has the headcut extending further upstream on the Rio Chama and Rio Grande, further reducing floodplain connectivity in the project area.

In the future, continued isolation of riparian vegetation in the study area from fluvial geomorphic processes will eventually result in complete dominance of the plant communities by non-native plant species including salt cedar, Russian olive, Siberian elm, and tree of heaven. Current vegetation management techniques such as understory clearing and planting of native species may 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. As stated above, some maintenance activities would likely continue by Pueblo staff. Some areas have been planted with native shrubs and trees through other projects. This native vegetation will continue to grow and provide some additional habitat for wildlife.

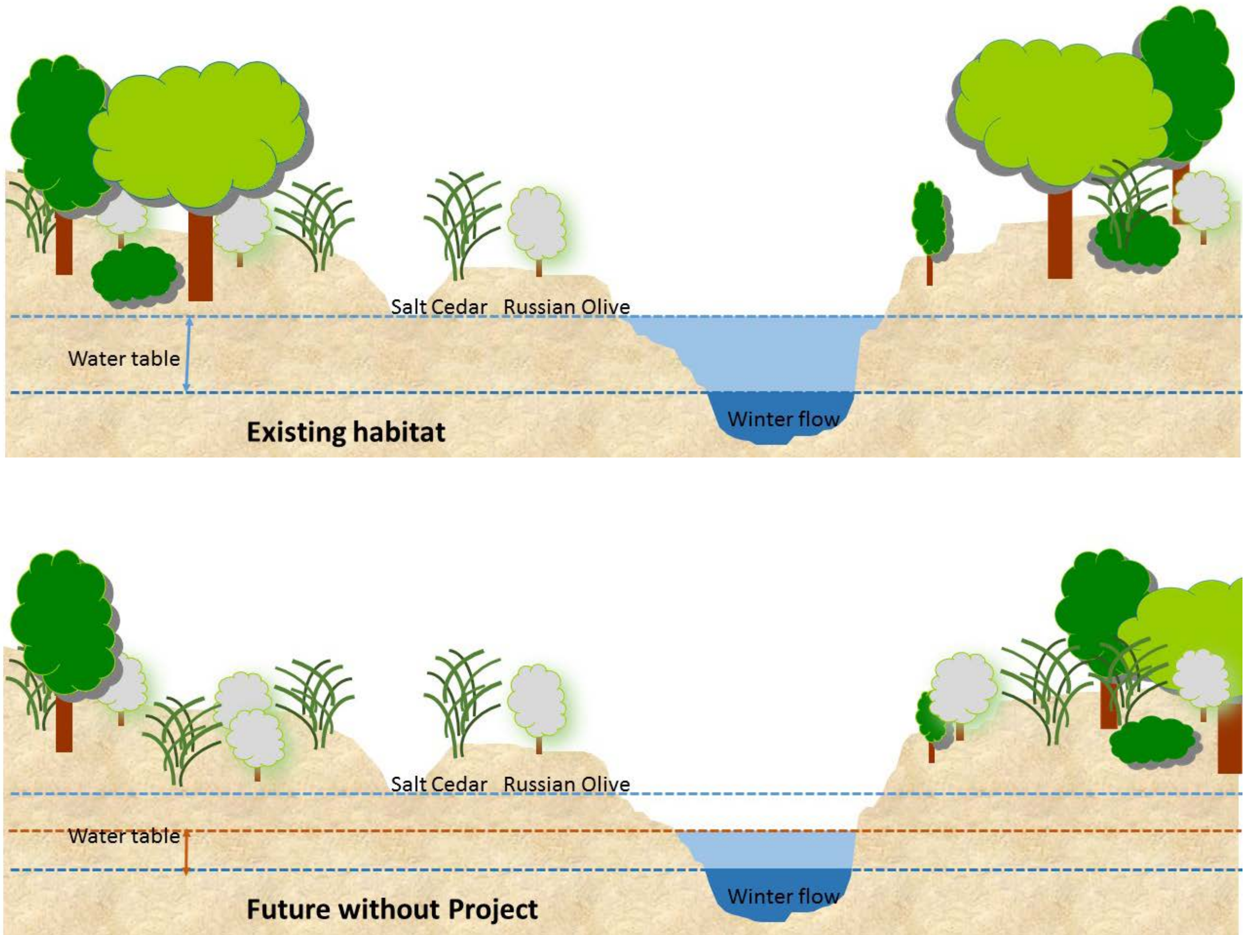


Figure 7 Topographical cross-section illustrating the existing and future without project conditions with a sinking water table as the riparian cottonwoods are replaced with invasive salt cedar and Russian Olive.

2.3.3 **Vegetation communities**

The naturally functioning bosque ecosystem was structured largely by fluvial geomorphic processes (cf. Déscamps et al., 1988). Loss of 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-1970s, 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, reduce sediment supply in downstream reaches, and cause channel incision and narrowing of the floodplain (Williams and Wolman, 1984).

A major change in vegetation dynamics in the bosque ecosystem has been loss of meander cut-off, meander migration, and flood scour processes, which were a driving force in the dynamics of the naturally functioning system. These processes removed existing vegetation and created new sites for founding of plant communities. Meander cut-off and lateral meander migration no longer occur. Bare soil sites are now created primarily through mechanical disturbance; typically in areas no longer subject to periodic inundation and with relatively dry soil moisture regimes. The existing bosque is becoming senescent due to the lack of flooding events for creating new stands of cottonwood gallery forest.

The frequency and duration of inundation, in addition to moisture requirements for establishment and persistence, also influences the structure of riparian vegetation (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 (Hughes, 1990). 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-particle 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 levees, and in oxbows (Hughes, 1990).

Soil moisture levels and depth to ground water on floodplain sites are influenced primarily by surface topography, the variation of which is created through fluvial-geomorphic processes (Malanson, 1993). The limits of riparian vegetation are controlled by depth to the water table (Hughes, 1990). Moisture in upper soil layers is a primary influence on establishment of tree species while ground water levels are important for their persistence (Dawson and Ehleringer, 1991). Soil moisture has a major influence on seed germination and seedling survival of cottonwood (Moss, 1938; Bradley and Smith, 1986; Mahoney and Rood, 1993) and willow (Taylor et al., 1999; Dixon, 2003).

Classification of Rio Grande riparian vegetation relies on plant community designations (Figures 8-10) developed by Hink and Ohmart (1984) and mapping by Sivinski and others (1990). Hink and Ohmart (1984: 37-39) defined six structure types based on vertical foliage density. Structure Type I consists of tall trees – at least 50 ft (15.2 m) with a relatively dense understory of saplings and shrubs (I). Type II structure is also composed of tall trees but with little or no sapling and shrub understory (II). Type III structure consists of mid-size trees (less than 30 ft [9.1 m]) and dense understory vegetation (III). Type IV structure is characterized by open stands of mid-sized trees with widely scattered shrubs and sparse herbaceous growth (IV). Type V structure is dense, short-stature trees and saplings, to about 15 ft (4.6 m) height, often with dense herbaceous growth (V). Type VI structure is scattered plant growth with foliage not exceeding about 5 ft (1.5 m) in height above the ground (VI).

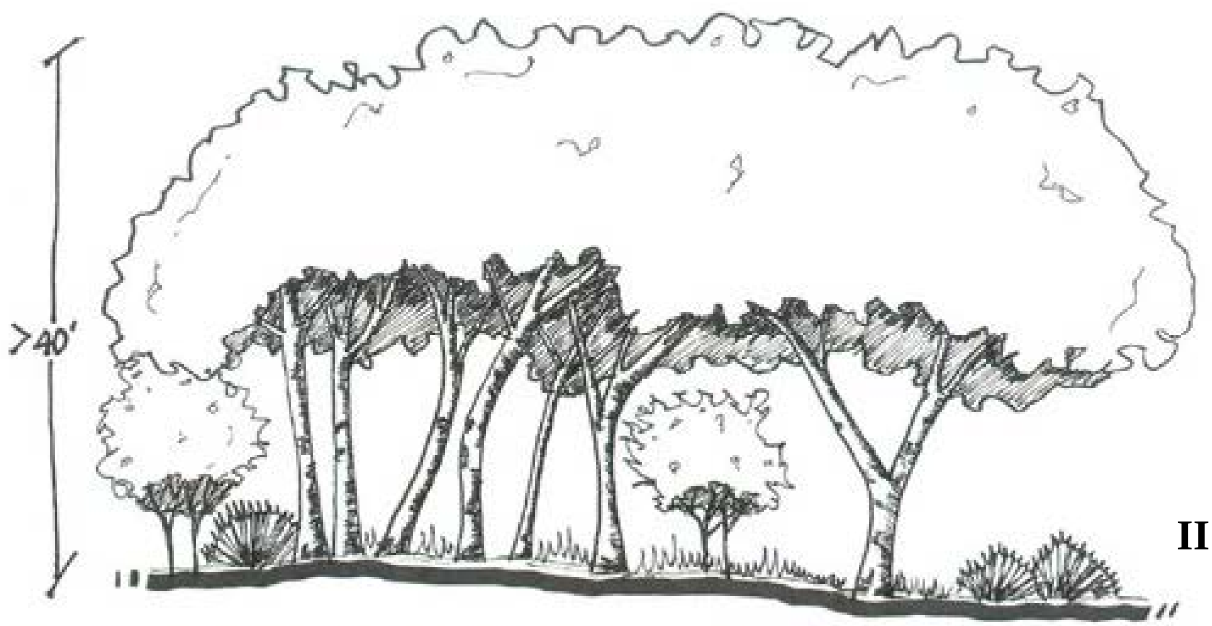
The Combined Habitat Assessment Protocols (CHAP, Appendix C) were used to estimate habitat value for the bosque on Ohkay Owingeh (

Figure 11) and Santa Clara Pueblos (Figure 12). The future without project condition assumes no additional habitat management by the sponsors. These figures show the relative CHAP value per acre for habitat patches values across the landscape in relation to hydrology, topography, land management and other factors.

The existing vegetation conditions indicate a decline in riparian vegetation due to decreasing floodplain connectivity. The lack of scouring and flood events for generating new stands of riparian cottonwoods and willows are expected to continue into the future. The future without project is anticipated to continue the decline of riparian vegetation along the Rio Grande and Rio Chama, with decreasing habitat value.

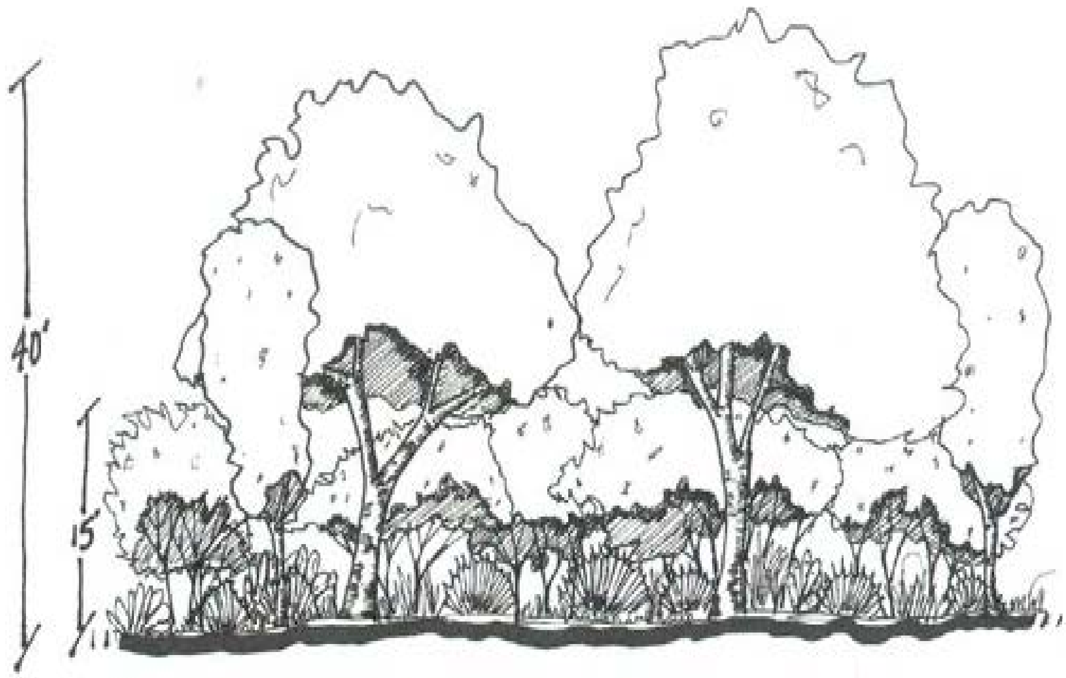
Existing vegetation mapping was used to quantify the condition and value of existing habitat in the study area. Table 3 lists the existing area (acres) of Hink and Ohmart structure type within defined riparian habitat plant communities. For instance, C/CW4 in the table refers to a habitat dominated by cottonwood and coyote willow that exhibit a structure type IV from Figure 11 above. The vegetation classification “C/CW with Russian Olive” denotes the presence of non-native Russian Olive trees and therefore lower value.

Hink and Ohmart Type I Vegetation - – Mature Riparian Forest with trees 50-60 ft; closed canopy, established understory



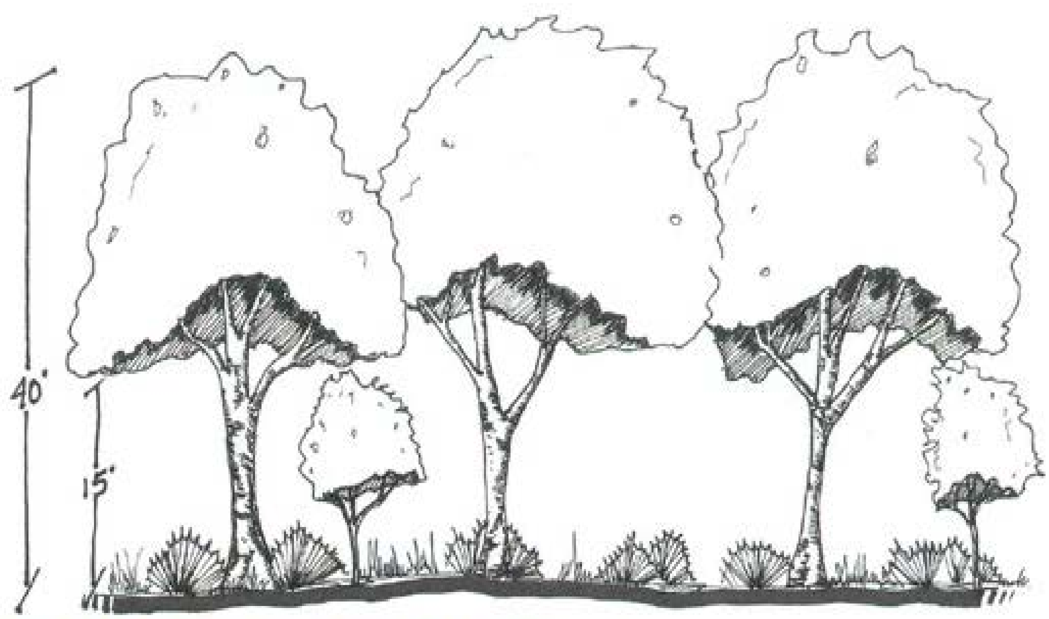
Hink and Ohmart Type II Vegetation – Mature Riparian Forest with trees over 40 ft; nearly closed canopy, limited understory

Figure 8 Hink and Ohmart vegetation classes I and II.



III

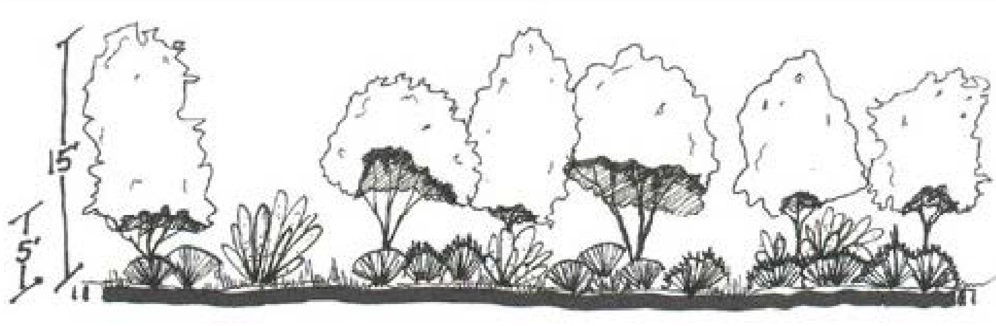
Hink and Ohmart Type III Vegetation - Intermediate aged riparian woodland; closed canopy; dense understory



IV

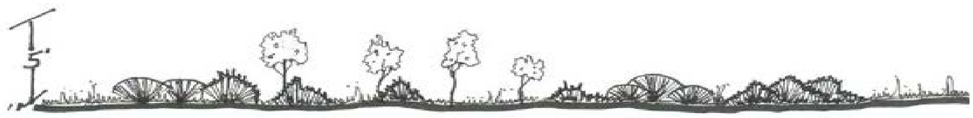
Hink and Ohmart Type IV Vegetation - Intermediate aged riparian woodland/savannah; broken canopy; mostly grass understory

Figure 9 Hink and Ohmart vegetation classes III and IV.



V

Hink and Ohmart Type V Vegetation – Riparian Shrub up to 15 ft; dense vegetation but no tall trees



VI

Hink and Ohmart Type VI Vegetation - Sparse vegetation with short shrubs, seedlings and grasses; open areas

Figure 10 Hink and Ohmart vegetation classes V and VI.

Table 3 Summary of baseline habitat and affected vegetation in the proposed project.

Vegetation communities are denoted in the table and associated with a habitat type (number) so that C/CW2 signifies a Cottonwood/Coyote willow community with a habitat structure type II as shown in Figure 8, above. Communities exhibiting the structure type 5 are considered “shrub” forms of those plants.

C/CW - Cottonwood/Coyote willow)
C/NMO - Cottonwood with New Mexico olive

Native vegetation	Existing acres	
C/CW1	71.0	
C/CW2	70.5	
C/CW3	196.8	
C/CW4	92.2	
C/CW5 (Shrub)	250.9	
C/NMO5 (Shrub)	527.9	
C/CW6 (meadow with Tree willow)	231.0	
Marsh (6)	369.7	
Native vegetation subtotal	1810.1	49.7%

Mixed gallery forest / shrubs (1-5)	Existing acres	
C/CW with Russian Olive	234.5	
C/CW with Salt Cedar	131.8	
Mixed invasive forest	938.9	
Russian Olive dominated forest	131.9	
Salt Cedar dominated forest	31.5	
Mixed gallery forest subtotal	1468.5	40.3%

Other land classifications	Existing acres	
Unclassified open area	365.1	10.0%
Total Area	3643.0	

2.3.4 Noxious weeds and invasive species

The majority of non-native species within the project area are plants. Though some non-native fish and other wildlife may exist, they are not of major concern. The invasive tree species of concern include salt cedar, Russian olive, and Siberian Elm. These species outcompete the native species and can eliminate the native riparian bosque resulting in a drier, more upland habitat.

Executive Order 13112 directs Federal agencies to prevent the introduction of invasive (exotic) species and provides for their control to minimize the economic, ecological, and human health impacts that invasive species cause.

In addition, the State of New Mexico, under administration of the United States Department of Agriculture, designates and lists certain weed species as being noxious (Nellessen 2000). “Noxious” in this context means plants not native to New Mexico that may have a negative impact on the economy or environment, and are targeted for management or control. Class C listed weeds are common, widespread species that are fairly well established within the state. Management and suppression of Class C weeds is at the discretion of the lead agency. Class B weeds are considered common within certain regions of the state but are not widespread. Control objectives for Class B weeds are to prevent new infestations, and in areas where they are already abundant, to contain the infestation and prevent their further spread. Class A weeds have limited distributions within the state. Preventing new infestations and eliminating existing infestations is the priority for Class A weeds. In order to prevent this, all equipment would be cleaned with a high-pressure water jet before leaving an area and entering a new area.

Salt cedar is now 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 therefore colonizes bare, moist-soil sites throughout the summer. Cottonwood, on the other hand, produces seed only for a short time in the spring and seed remains viable for only about a month and a half under ideal conditions (Horton et al., 1960). The flowering and fruiting phenology of salt cedar allows seedlings to establish on 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.

Russian olive 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 also 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 (Sivinski et al., 1990).

Salt cedar and Russian olive are established throughout the project area. The decreasing floodplain connectivity supports expansion of these invasive trees as the riparian vegetation declines. The future without project is based on the expanding presence of salt cedar and Russian olive.

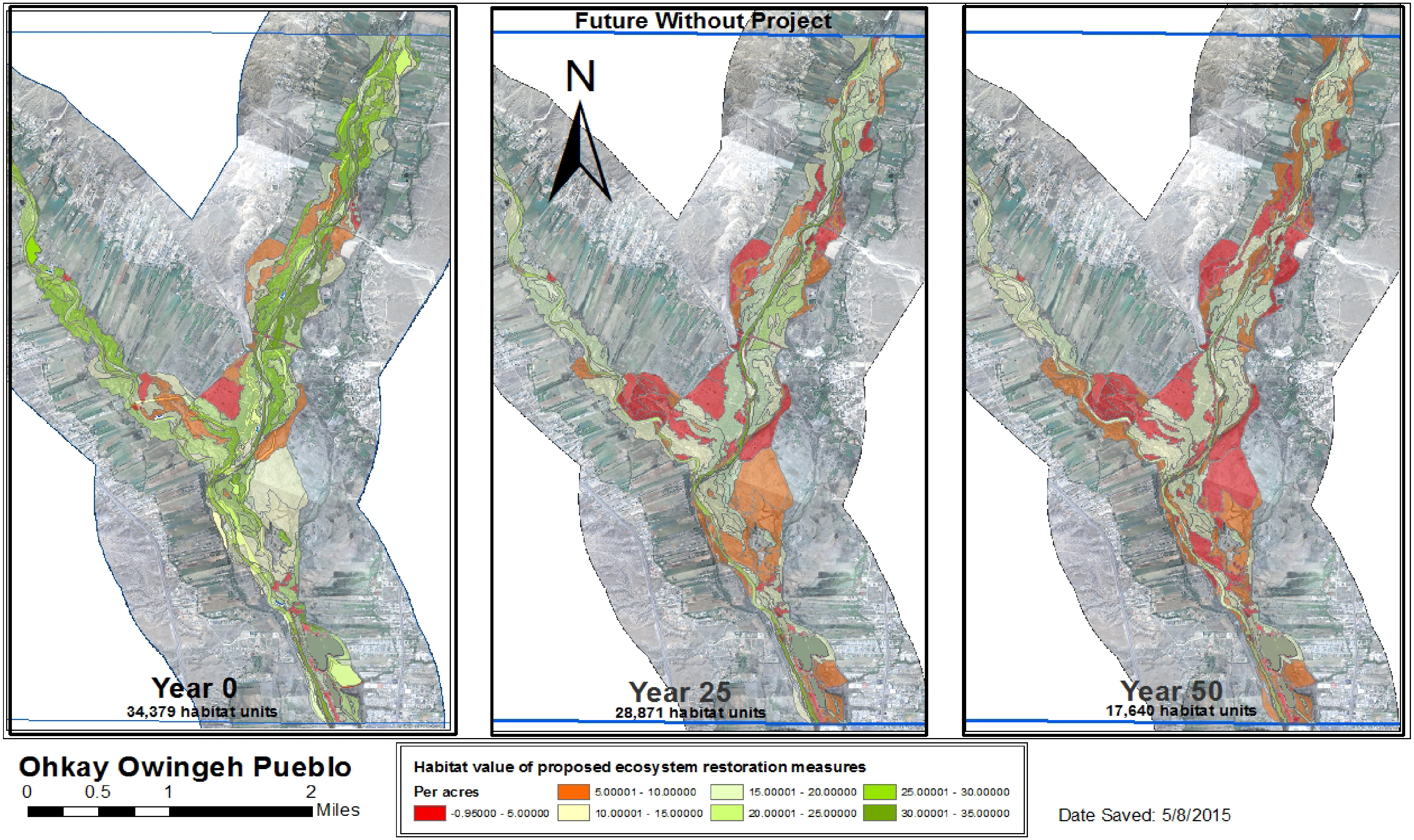


Figure 11 Change in habitat unit values per acre on Ohkay Owingeh Pueblo.

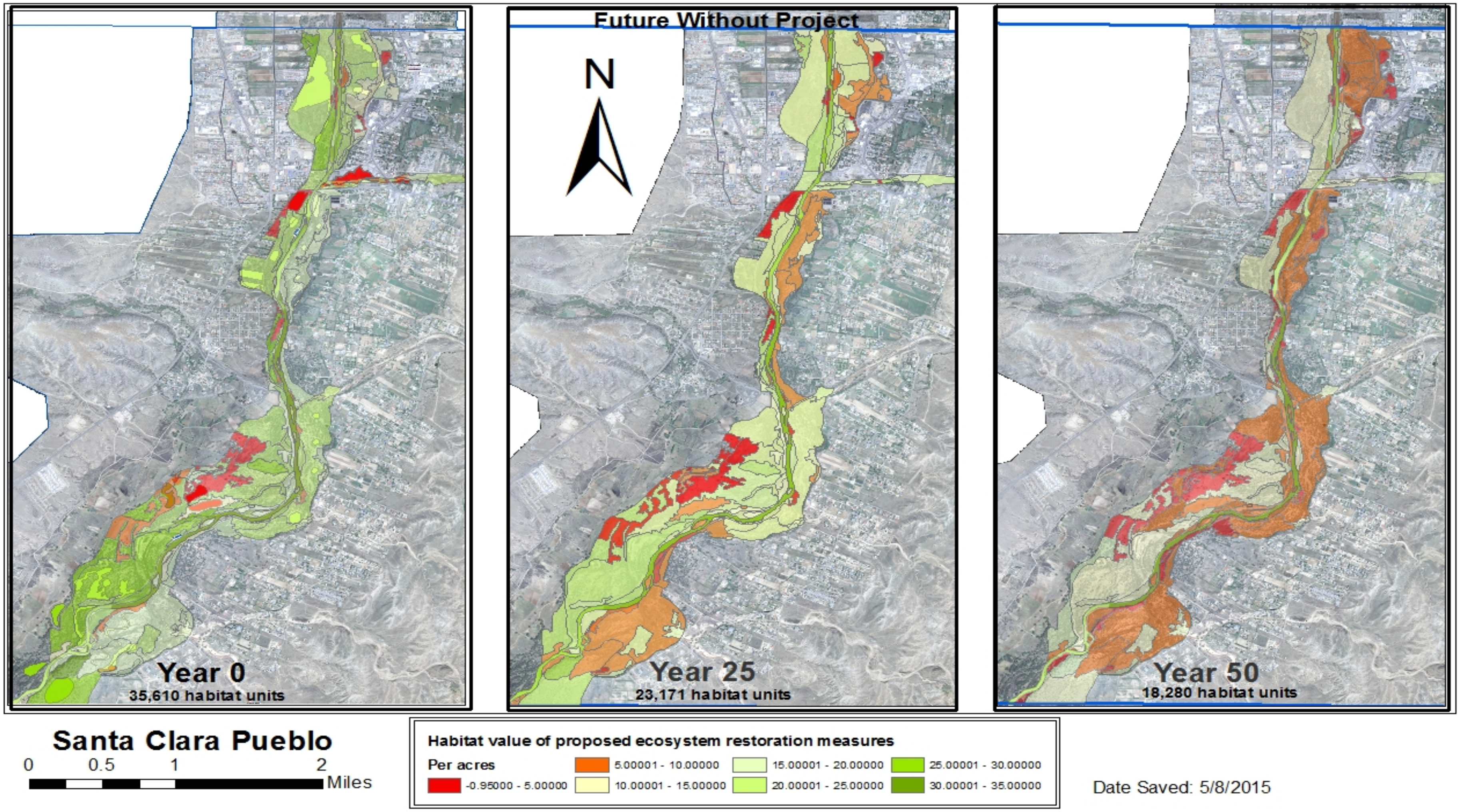


Figure 12 Change in habitat unit values per acre on Santa Clara Pueblo.

2.3.5 Fish and wildlife

The loss of riparian habitat is an important conservation issues in the arid southwest due to its rarity. The bosque ecosystem supports 276 vertebrate species, including birds (167), mammals (54), fish (31), amphibians (8 species), reptiles (14 species) (BISON-M, accessed August 2009; Appendix C).

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 (1984) did describe 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*), many-lined skink (*Eumeces multivirgatus epipleurotus*), black-necked garter snake (*Thamnophis cyrtopsis*), and western painted turtle (*Chrysemys picta bellii*).

The study area provides habitat for about 50 species of mammal at the transition from mountains, canyons, and river floodplain. The endangered New Mexico Meadow Jumping Mouse is dependent on rare wetland habitat historically found in the study area. Maintaining habitat corridors support used by large herbivores and a suite of predators is important for connecting populations. 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). Dominant species differed between various habitat types however, so that a variety of habitats increases the diversity of small mammals in the study area.

More than 160 bird species, which are federally protected under the Migratory Bird Treaty Act, are found locally in the Española Valley study area. Since 2001, 152 bird species have been observed at the Los Luceros Important Bird Area (IBA, Audubon Society) upstream of Ohkay Owingeh on the Rio Grande. Habitat managed by the two pueblos exceeds the area and diversity of the 130 acre Los Luceros IBA. Restoration of large patches of riparian habitat could support special status species (section 2.3.5), along with a variety of wading birds, ducks, and songbirds.

Hink and Ohmart (1984) recorded 277 species of birds in the bosque ecosystem. Highest bird densities and species diversity were found in edge habitat vegetation with a cottonwood overstory and an understory of Russian olive (Hink and Ohmart 1984). Studies done by Finch and Hawksworth (2006) indicate 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 reduces 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, it 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.

The Rio Grande is a major migratory flyway for avian species (Yong and Finch, 2002). The peak nesting season for birds is April 15 through August 15. The Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703, et seq.) is the primary legislation in the United States established to conserve migratory birds (USFWS, 2004). The list of the species protected by the MBTA appears in title 50, section 10.13, of the Code of Federal Regulations (50 CFR 10.13). The MBTA prohibits taking, killing, or possessing of migratory birds unless permitted by regulations promulgated by the Secretary of the Interior. The U. S. Fish and Wildlife Service (USFWS) and the Department of Justice are the Federal agencies responsible for administering and enforcing the statute.

The Memorandum of Agreement (MOA) between the Federal Aviation Administration, the U.S. Air Force, the U.S. Army, the U.S. Environmental Protection Agency, the USFWS, and the U.S. Department of Agriculture to Address Aircraft-Wildlife Strikes was signed by the Department of the Army in 2002. The agreement was signed in reference to Advisory Circular (AC) 150/5200-33 (1997). Criteria were developed for siting wildlife attractants for a distance of 5,000 feet for airports serving piston-powered aircraft and 10,000 feet for airports serving turbine-powered aircraft. The project area is approximately 6,800 feet from the Ohkay Owingeh airport east of the project boundaries.

The existing conditions have a trend towards dominance of invasive plant species at the expense of overall diversity in the bosque (Appendix C). Those wildlife 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. The lack of connectivity between the river and floodplain favors upland wildlife species that are fairly common in the region while the less common floodplain species would remain scarce.

The future without project would be a less heterogeneous habitat favoring only a portion of the existing animal species. If native bosque vegetation patches became smaller and distances between patches increase, then some wildlife species may be lost to the area altogether (Appendix C). Likewise migratory species relying on varying age stands of cottonwood bosque, wetlands, or open meadow would be forced to travel farther possible bypassing the bosque around Española to find suitable habitat.

2.3.6 **Special status species**

Three agencies have a primary responsibility for the conservation of animal and plant species in New Mexico: the U.S. Fish and Wildlife Service (Service), under the 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 / or plant species that have been classified or are candidates for classification as endangered or threatened based on present status and potential threat to future survival and recruitment (Appendix C).

There are three Federally listed species identified by the U.S. Fish and Wildlife Service (Consultation code 02ENNM00-2014-SLI-0436, 12 Jan 2015) that either occur in the action area and/or have proposed critical habitat in the action area. The species are the Southwestern Willow flycatcher (*Empidonax traillii extimus*) (flycatcher), the Western Yellow-billed Cuckoo

(*Coccyzus americanus occidentalis*) (cuckoo), and the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) (mouse). The other species of interest identified by the U.S. Fish and Wildlife Service (Consultation code 02ENNM00-2014-SLI-0436, 12 Jan 2015) do not meet the criteria for further analysis because there is no critical habitat in the action area, the lack of suitable habitat for the species or primary constituent elements (PCEs), or the species is unlikely to occur in the action area.

2.3.6.1 Southwestern Willow Flycatcher

Within the action area, critical habitat for the Southwestern Willow Flycatcher (*Empidonax traillii extimus;* flycatcher) has been designated outside pueblo lands in the vicinity of Ohkay Owingeh and Santa Clara Pueblos.

2.3.6.2 Yellow-Billed Cuckoo

The Western Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*; cuckoo) was listed as a threatened species on October 3, 2014 (USFWS 2014c). Critical habitat for the cuckoo has been proposed along the Upper and Middle Rio Grande Units (New Mexico) on lands owned by Ohkay Owingeh, San Ildefonso and Santa Clara Pueblos (USFWS 2014c). These units are occupied by cuckoos, and provide a corridor for cuckoos moving north.

2.3.6.3 New Mexico Meadow Jumping Mouse

The New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*; mouse) was listed as endangered on the June 10, 2014 (USFWS 2014). Proposed critical habitat for the mouse includes two marshes on Ohkay Owingeh Pueblo (USFWS 2013), but this habitat is believed to be unoccupied. Edge habitat along wetland measures may create suitable habitat for the mouse.

2.3.7 **Water quality**

The Pueblos of Ohkay and Santa Clara have developed their own water quality standards that meet Section 303(d) of the Federal Clean Water Act, and said standards have been accepted by the U.S. Environmental Protection Agency, Region 6. However, the U.S. Environmental Protection Agency has declared the Rio Chama within the boundaries of Ohkay Owingeh as currently impaired for turbidity and fecal coliform (Charles Lujan, pers. comm.).

According to the New Mexico Surface Water Quality Bureau 2008-2010 Clean Water Act Integrated §303(d)/ §305(b) List of Assessed Surface Waters, the Rio Chama from Abiquiu Dam to the Ohkay Owingeh boundary is classified as fully supporting all designated and existing uses. The reach of the Rio Grande between Embudo Creek and the Santa Clara boundary is not supporting of marginal coldwater aquatic life and warm water aquatic life. Probable causes of impairment are polychlorinated biphenyls (PCBs) in fish tissue, turbidity, and unsatisfactory benthic-macroinvertebrate bioassessments. Probable sources of impairment are: atmospheric deposition of toxics; contaminated sediments; highway/road/bridge runoff (non-construction related); inappropriate waste disposal; irrigated crop production; loss of riparian habitat; natural sources; rangeland grazing; and unknown sources.

The segment of the Rio Grande from the San Ildefonso Pueblo boundary to Cochiti Reservoir is classified as not supporting warm water or marginal coldwater aquatic life. The chemical PCB in fish tissue for this reach is the basis for impairment, and probable sources are atmospheric deposition of toxics, contaminated sediments, inappropriate waste disposal, natural sources, and/or unknown sources.

Under the No Action alternative, there would be no potential improvement to water quality through the creation of wetlands. The potential wetland, pond and willow swale habitats would also assist with water quality that may have increased issues due to an increase in human population. Native plants could assist in removing nutrients having a negative effect on water quality due to an increase in non-point source pollution as well.

2.3.8 Air quality

The action area is primarily located in Rio Arriba County, New Mexico. The area is an attainment area for all criteria air pollutants. Non-criteria pollutants, such as those from Los Alamos National Lab and tailpipe emissions from ever increasing traffic on/through San Ildefonso Pueblo, will continue to be air quality issues. Adjacent to San Ildefonso Pueblo, Bandelier National Monument is a Class I Federal air quality area. Future actions within the study area must account for and avoid potential degradation of the air quality at Bandelier.

There are no documented air quality non-attainment issues in Rio Arriba County, New Mexico (Appendix I). The Santa Fe County Air Quality Control Region is an attainment area for all criteria air pollutants identified in the National Ambient Air Quality Standards (NAAQS). Bandelier National Monument (southwest of the study area) is a Class I Federal air quality area. Future actions within the project study area must account for and avoid potential degradation of the air quality at Bandelier. The future air quality without project is expected to remain unchanged.

2.3.9 Noise

The Pueblos generally are quiet, rural settings, with only limited background noise from major highways, aircraft flyovers, sirens, or other urban noise (Appendix I). Santa Clara Pueblo may receive a somewhat higher level of urban background noise due to its proximity to the City of Española. Background noise levels are not expected to change under the without project conditions (Appendix I).

2.3.10 Aesthetics

The National Environmental Policy Act (NEPA) and Council on Environmental Quality (CEQ) regulations identify aesthetics on one of the elements that must be considered in determining the effects of a project. Aesthetics include the presence and appearance of landforms, water surfaces, vegetation and human created features relative to the surroundings and settings of the area. These features are primary characteristics of an area or project that determine visual character and the manner in which people view the setting. Aesthetics analysis considers the existing and future appearance, or perception of views, of the project site and areas surround the site, as well as viewer sensitivity.

The aesthetics of the bosque areas along the Rio Grande are internally defined by the three pueblos with a landscape perspective. The pueblos consider the aesthetics to be medium to high in areas where the bosque is functioning as a healthy ecosystem (Appendix I). They consider mature stands of cottonwoods with native understory vegetation as the target condition. Currently, the pueblos have characterized the aesthetics of the bosque and other riparian areas as ranging from poor to high. In areas where fires have occurred and burn restoration has not been implemented, the aesthetics would be considered poor as the bare, burned ground and vegetation dominates the view. Similarly, areas where concentrations of litter have accrued or illegal dumping has occurred, the aesthetics of such sites would be considered poor. In areas where non-native vegetation has been thinned and replanted with native vegetation, the pueblos characterize the aesthetics as medium to high. The goal of returning the river and bosque to pre-flood control conditions was a common theme.

The existing condition for the aesthetics of the bosque and other riparian areas ranges from poor to high. The future without-project conditions are expected to remain unchanged.

2.3.11 **Land Use and Classification**

The Pueblos have seen the effects of increasing intensity of land use along the Rio Grande and Rio Chama (Appendix I). Land use within the pueblos includes hunting, fishing, trapping, gathering, traditional ceremonies, grazing, timber harvest, and agriculture. Aerial photography can delineate several types of land use based on vegetation type. Table 4 summarizes the area of land used for agriculture, range (grazing), and commercial development (urban) by pueblo.

Table 4 Acres of intensively managed lands outside the riparian study area.

	1935	**1989**	**2002***
Agricultural	2399.2	1861.6	1861.6
Range	1165.7	2039.1	2039.1
Urban	191.4	777.1	777.1
Overall	**3756.3**	**4677.7**	**4677.7**

These lands were outside the boundaries of the General Investigations Study and the vegetation mapping during the 2002 URGWOP's study.

Much of the bosque has been converted to farmlands with a large portion in fee title ownership (Appendix I). Farmland on Santa Clara Pueblo has decreased about 33% from 1935, while on San Ildefonso Pueblo farmland has been converted into rangeland. Livestock grazing is an economically important activity for Tribal members that pueblos are working to balance with ecosystem goals. Grazing has doubled on two of the three pueblos since 1935, but remained nearly steady on Santa Clara Pueblo. Most of the bosque on Ohkay Owingeh is closed to grazing (Appendix I). Santa Clara Pueblo allows grazing in many areas of the Rio Grande bosque riparian corridor within the project study area (Appendix I). San Ildefonso Pueblo excludes grazing from the bosque and within 200 feet of the Rio Grande to prevent injury to riparian habitat.

Many native bosque plants are used intensively by pueblo members for food, fuel, fiber, pigment, medicine, and ceremonial uses (Appendix I). Shrubs like willow or Apache plume are pruned and harvested for baskets and other uses. Yerba manza (*Anemopsis californica*) and other plants were valued and propagated. Ancestral Pueblo agriculture cultivated food plants (corn, beans, and squash) in small plots along with propagating and harvesting native plants in the bosque. Restoration and production of cattails, willows and other forest products for cultural uses is a priority (Appendix I).

Timber is a limited resource the Pueblos manage for the benefit of their Tribal members. Gooding's willow is used for bows while cottonwood trees have been heavily utilized for ceremonial drum construction and carvings (Ohkay Owingeh 2008). Coniferous trees are generally preferred for firewood, though cottonwood and willow may also be used for fuel, (Appendix I). No cutting of native trees is allowed in Ohkay Owingeh riparian areas, while non-native trees can be harvested as part of bosque restoration efforts (Ohkay Owingeh 2008; Santa Clara 2000). Ohkay Owingeh has implemented fuel and non-native vegetation reduction on about nine hundred acres as partial restoration on the Rio Grande and Rio Chama floodplains community (Appendix I).

There are substantial educational opportunities in the bosque that involve Tribal members (Appendix I). Successful educational programs include the Youth Conservation Corps, Ohkay Owingeh Boys and Girls Club summer programs, and the Bosque Ecosystem Monitoring Program (BEMP) (Appendix I). Currently, Tribal members conduct vegetation monitoring, vegetation management, and bird monitoring programs. Nature trails and bosque educational activities would enhance Tribal connections to the bosque.

The future without project land use is expected to change as riparian vegetation declines. Cultural use of native plants would likely to decrease as a function of availability. More upland vegetation would increase pressure to open the bosque for grazing.

2.3.11.1 Recreation

Recreation within the bosque has generally focused on hunting, gathering, fishing, and trapping as culturally important activities for many Pueblo members. Improving fish and wildlife habitat through ecosystem management is a priority for Ohkay Owingeh and Santa Clara members (Appendix I).

2.4 Cultural Resources*

The bosque is more than simply a location; it is a place of deep cultural importance to the people of Ohkay Owingeh, Santa Clara, and San Ildefonso. Along with the Rio Grande and its tributaries, the bosque is an integral part of the cultural landscape and its health and the health of the rivers are fundamentally intertwined with significant cultural practices. For most tribes, the landscape is an essential part of constructing social identity and the transmission and survival of historical and cultural knowledge and practice. People define themselves in relation to the landscape, and the landscape is an interface where the past gives meaning and context to the present. Loss of the bosque is more than simply the loss of plants and animals; it presents a real threat to customs, beliefs, and practices essential to the cultural identity and continuity of the people of Santa Clara, Ohkay Owingeh, and San Ildefonso. As such, the bosque itself is a vital cultural resource, and the protection of that cultural resource is one of the foundations of this restoration effort.

Section 106 of the National Historic Preservation Act [54 U.S.C. § 300101 et seq.] (NHPA) and its 36 CFR Part 800 implementing regulations 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," must "possess integrity of location, design, setting, materials, workmanship, feeling, and association," *and* must 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 examples of historic properties, including archaeological sites, historic buildings, traditional cultural properties (TCPs), and historic districts.

Consultation is an important part of the Section 106 process. All of the acreage for the proposed project is located on Tribal land. Tribal partners, in this case Ohkay Owingeh and Santa Clara, are consulting parties. Section 106 mandates that the State Historic Preservation Office (SHPO) be a consulting party for any undertaking, except those taking place under the jurisdiction of a Tribe with a Federally recognized Tribal Historic Preservation Officer (THPO), in which case the THPO may assume the role otherwise played by the SHPO in the consultation process. As of 2014, Santa Clara Pueblo has an official THPO in place; therefore, all consultation for work on Santa Clara took place with the Santa Clara THPO. For work at Ohkay Owingeh, the New Mexico SHPO was also a consulting party. The USACE made determinations of NRHP eligibility and effect of the proposed project and consulted with the SHPO and the Santa Clara THPO on those determinations. This process is further discussed below.

2.4.1 **Existing conditions analysis**

USACE's analysis of existing conditions for cultural resources within the proposed project area included an initial broad-scale analysis of information available for resources on three pueblos covering a broad 35,000-acre area (available via the New Mexico Cultural Resources Information System [NMCRIS]), followed by focused studies within the likely areas of potential effect (APE) for planned measures associated with the selected plan on both Santa Clara and Ohkay Owingeh. This section reviews the results of data investigations using the NMCRIS database to identify known cultural resources within the original study area. National and State listed properties are identified.

2.4.1.1 Summary of Initial NMCRIS database analysis

At the time of the initial analysis in 2009, there had been a total of 176 cultural resources surveys documented in the study area, covering approximately 3,200 acres of land, or 9.06 percent of the original study area. As a result of these surveys, a total of 103 archaeological sites were recorded. This information is summarized in Table 5 and an overall summary of temporal trends in occupation of the study area is shown in Figure 13.

Table 5 Summary of previous cultural resources surveys in the study area.

Area	Total Acres	Acres Surveyed	Sites Recorded on Survey	Site Centers in Study Area	Sites/100 Acres	Total Recorded Sites	Percent Surveyed	Extrapolated Total Sites in Entire Study Area
Ohkay Owingeh	7,973	554	16	8	1.44	25	6.9	115
Santa Clara	15,573	1,735	47	36	2.07	88	11.1	323
San Ildefonso	7,848	572	25	19	3.32	57	7.3	261
Non-Tribal	3,913	339	15	10	2.95	20	8.7	115
Total	35,307	3,200	103	73	2.28*	190	9.1*	814

**These totals are calculated for the entire study area, and are not sums of the rows above them.*

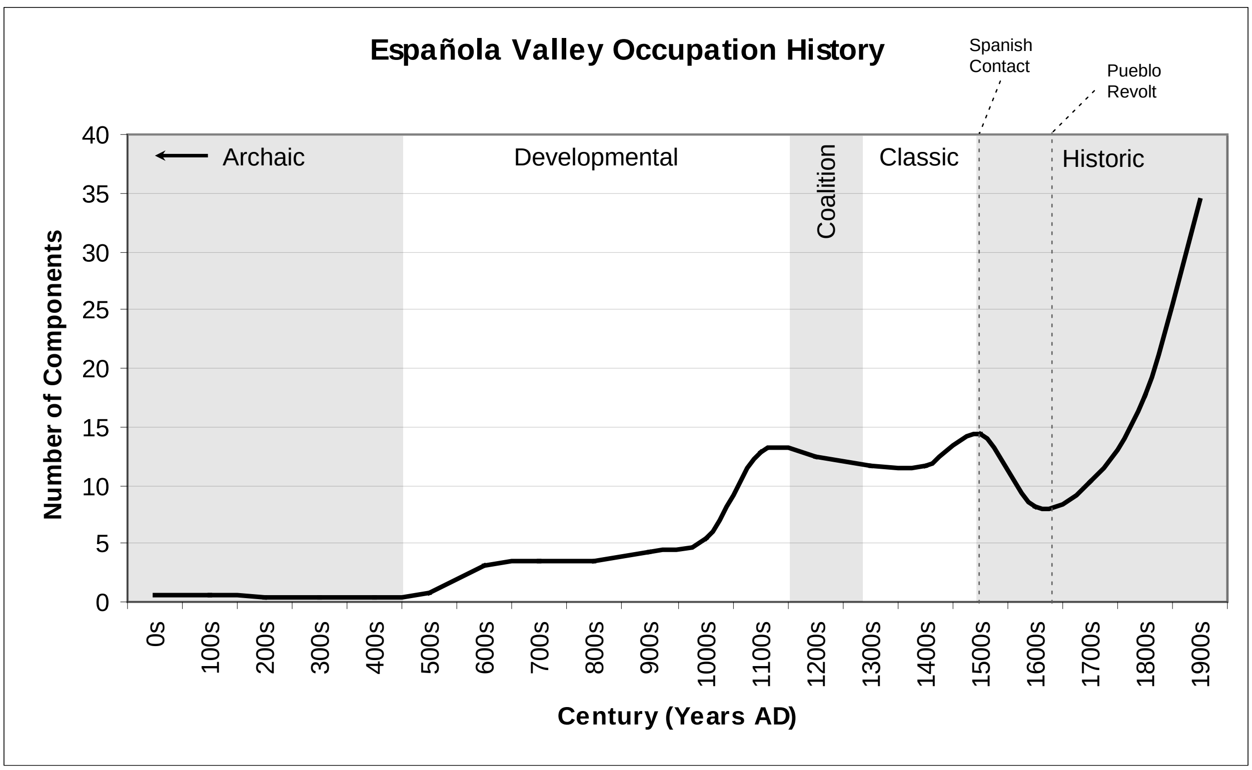


Figure 13 Occupational history of the Española Valley study area, expressed as the number of identified archaeological components over the last 2,000 years, based on available ARMS records.

These figures provide a rough indication of the potential density of sites in the project area based on surveys that have been performed. While the entire study area (over 35,000 acres) cannot be surveyed, the smaller subset of area included in any recommended plan will be. This indicates that the likelihood of encountering cultural resources in the project area is fairly high.

There is no documented Paleo-Indian presence in the overall study area (Figure 13), and only meager definitive evidence of Archaic-period occupations (three out of 221 components). However, there are a substantial number of components containing chipped-stone artifacts that have not been assigned to a time period, and it is likely many of these artifacts date to the Archaic period. The trend demonstrates a substantial increase in archaeological components beginning approximately 1,500 years ago, which is consistent with overall trends for the Rio Grande Valley as described in the culture history in Appendix D. Cultural use of the Española Valley begins to increase during approximately the AD 600s, or the beginning of the Developmental period. The rate of increase accelerates during the AD 1100s, right at the end of the Developmental and the beginning of the Coalition periods. This is consistent with trends throughout the northern Rio Grande, as populations from the north and west (including the Chaco Canyon and Mesa Verde areas) likely migrated to the Rio Grande during this period. Overall cultural use of the area peaks slightly at the end of the Developmental period, dips slightly, and then peaks again at the end of the Classic period.

There is a dramatic shift with Spanish contact, however. Between initial Spanish contact in 1540 and the Pueblo Revolts of 1680 and 1696, the number of cultural manifestations in the study area dropped by approximately 50 percent. The number of documented components then increases steadily again beginning in the 1700s and continuing to the present.

The analysis (Appendix D) suggests an overall growth in cultural use of the Española Valley through time, accompanied by increases in the relative proportions of sites in lowland areas, and an increase in the number of large sites. Cultural use of the Española Valley increases again after the Revolt period.

2.4.1.2 Traditional Cultural Properties

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 or a landscape. Indeed, the Rio Grande bosque throughout the proposed project area is an area of deep and ongoing cultural importance and meaning, and has the characteristics of a TCP. The health of the bosque ecosystem is deeply intertwined with past, present, and ongoing cultural practice, and the goals of this project – developed with ongoing involvement of and consultation with the Tribal sponsors – would provide positive benefits in supporting the future survival of those practices. In addition, Black Mesa, located on the northeast portion of San Ildefonso Pueblo and near the southern end of the proposed project area, was a stronghold of Tribal resistance to Spanish rule during the Pueblo Revolts of 1680 and 1696. Due to Black Mesa's importance in the Pueblo Revolt and its continued cultural importance in the lives of Tribal members, Black Mesa can be considered a Traditional Cultural Property, and it is also listed on the State Register for its association with important events in history (the Pueblo Revolt).

Tribes are the best source of knowledge on TCPs. However, the often deep religious and cultural significance of these properties require great care against widespread sharing of specific information about them. By working closely with Tribal partners, this project has been designed to provide positive benefit to the culturally vital bosque, while minimizing or avoiding negative impacts to TCPs and protecting the confidentiality of traditional knowledge.

2.4.1.3 Cultural Resources Inventory and Consultation

With the selection of a recommended plan, and for the purposes of Section 106, an APE must be designated. According to 36 CFR 800.16, the APE for an undertaking is defined as “the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist.” For this project, the APE is defined as those areas containing the footprints of any proposed construction features, as well as those areas within which any ground-disturbing activity (including but not limited to vehicle movement, earth moving, excavation, clearing, grubbing, materials laydown and storage, staging, additional inundation, etc.) might occur.

The currently-defined APE for this project is shown in Figure 14. The features proposed for Santa Clara include high-flow channels, vegetation management, terrace lowering, and the creation of swales; as such, the defined APE for these measures are drawn widely in order to provide adequate buffers for potential movement of personnel and equipment. At Ohkay Owingeh, the proposed features are generally more closely confined to the channel, and include (in addition to vegetation management and terrace lowering) channel stabilization and grade reduction features. For these proposed features, the currently understood APE includes both the footprints of the eventual features and areas of potential ground disturbance, as well as adjacent areas that might experience modification due to the need to reroute water flow during construction.

Access routes for equipment and staging areas have not yet been selected. When these are chosen, locations and routes will be taken into account to avoid any cultural resources known to be in the vicinity, and the USACE will complete full Section 106 consultation on those routes and locations before any construction begins.

Characteristics of the expected APE are as follows:

- The expected APE for the proposed project totals approximately 1,419 acres (925 acres within Santa Clara Pueblo, and 494 acres within Ohkay Owingeh).
- The entirety of the expected APE for this project falls within what would be categorized as “floodplain” or “lowland” areas in the above analysis

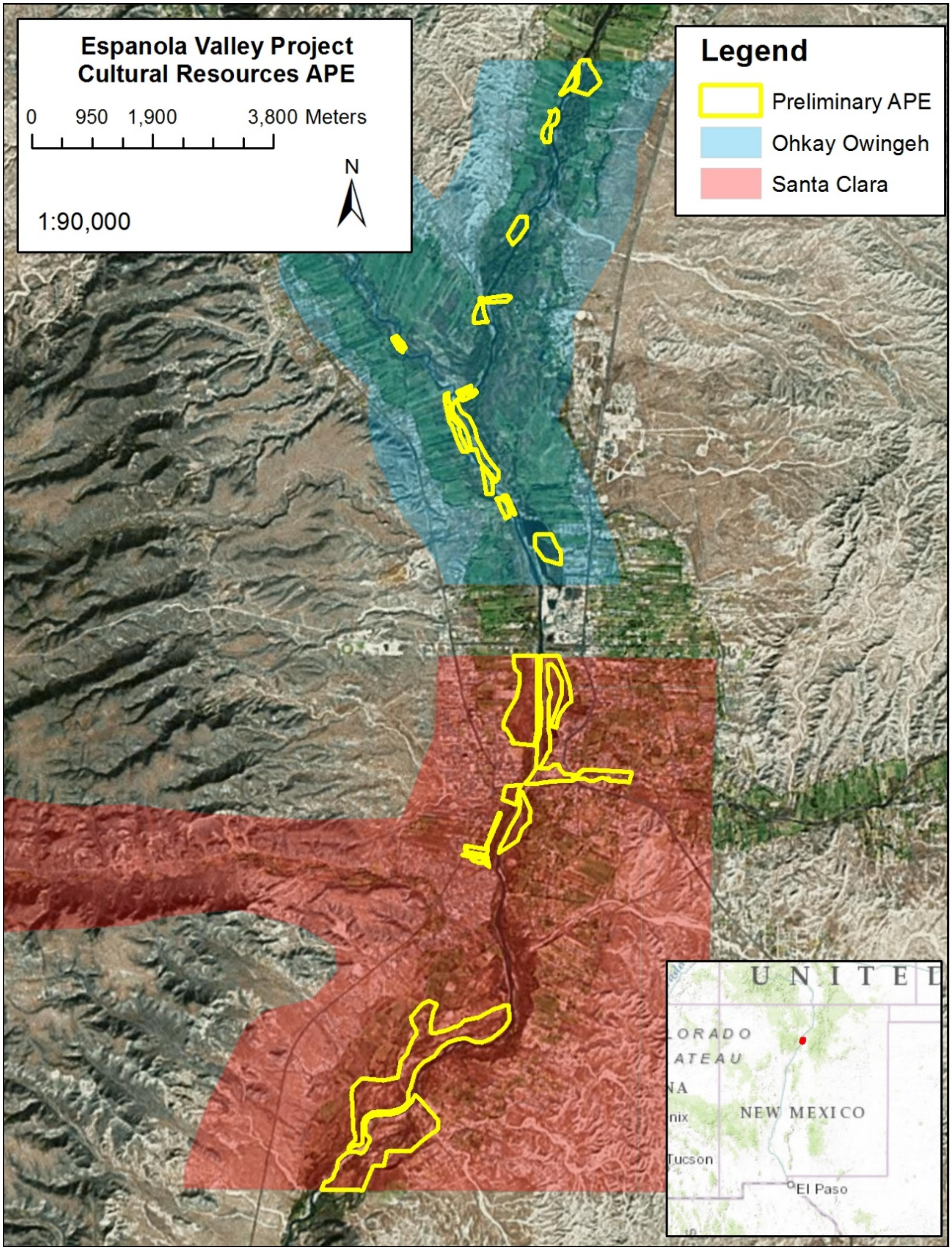


Figure 14 Preliminary Area of Potential Effect for cultural resources for proposed project.

2.4.2 Identification and Consideration of Historic Properties

Upon identification of the project APE, the Section 106 process mandates that the agency attempt to identify historic properties within the APE; to make determinations of National Register of Historic Places (NRHP) eligibility for any historic properties identified; and to make determinations of effect for the proposed project on those historic properties. The agency then consults with the SHPO and/or THPO on those determinations.

For the portions of the project on Santa Clara land, the USACE coordinated closely with the Santa Clara THPO in the identification of historic properties within the APE. A cultural resources survey was conducted within the Santa Clara portion of the APE, which identified no prehistoric artifacts, features, or archaeological sites. Several isolated occurrences and relatively recent landscape features were identified, including portions of acequias (irrigation channels). The USACE determined that the acequias were eligible for NRHP listing, but would be completely avoided by the proposed project. The USACE therefore determined that the proposed project would result in *no historic properties affected,* and the Santa Clara THPO concurred with these determinations on August 4, 2016. Copies of consultation correspondence are included in Appendix D.

For the portions of the project on Ohkay Owingeh land, the USACE coordinated closely with both Ohkay Owingeh and the SHPO on appropriate methods for identifying historic properties. Because of the bosque's cultural importance and the extremely sensitive nature of cultural information for the Pueblo in this area, the Pueblo of Ohkay Owingeh elected not to allow a traditional archaeological survey of the APE. The Pueblo did compare the proposed APE and proposed project measures to internal information and determined that the proposed project would not have adverse impacts to any cultural resources in the area. The Pueblo also expressed its determination to assume responsibility for protecting its cultural resources, including monitoring all construction toward that end. These decisions are documented in an Ohkay Owingeh Tribal Council Resolution (see Appendix D).

Because the measures proposed for the Ohkay Owingeh portion of the project are mostly within the recent floodplain and close to (or within) the active river channel, the USACE conducted an independent analysis using publicly-available historic aerial imagery of the APE for the 1930s, 1940s, 1950s, 1960s, and 1970s, to determine how much of the proposed APE has recently been within the active river channel. Any areas recently within the active channel would have experienced significant fluvial impacts, significantly reducing the likelihood of any intact archaeological sites or historic properties within those areas. This analysis corroborated and supported the Pueblo's statement that the proposed project would not adversely affect historic properties.

The USACE also considered publicly-available information about known historic properties in proximity to the project APE. The USACE identified two NRHP-listed historic properties adjacent to, but not within, the APE within Ohkay Owingeh lands: San Gabriel de Yunque-Ouinge, and the Rio Grande Bridge at San Juan Pueblo. San Gabriel de Yunque-Ouinge is the location of Juan de Oñate's first capital in New Mexico. It is located above the west bank of the Rio Grande approximately 100 meters from the current river channel, and 250 meters from a proposed high-flow channel. San Gabriel de Yunque-ouinge is a National Historic Landmark and is listed on the National Register (NR #66000482) and State Register (SR #25). This property is extremely significant both historically and archaeologically. However, the USACE determined using publicly-available information about San Gabriel that the distance and topographic separation between this property and the proposed work is such that there would be no adverse effect to San Gabriel from the proposed project.

The Rio Grande Bridge is listed on both the State and National Registers (SR #1669, NR #97000738). All construction activities for this measure will avoid impacts to the bridge itself, but one measure would result in modification and/or removal of an abandoned road bed leading to the bridge. The USACE determined that the road bed was not in itself eligible for NRHP listing, and was not a contributing element to the significance of the Rio Grande Bridge. The USACE determined that the proposed project would have no adverse effect to the Rio Grande Bridge.

In addition, the USACE identified that the diversion for the Aceqiua de los Vigiles, an irrigation ditch system, was within the APE and would be impacted by a proposed GRF. The Corps determined that the overall acequia system is an NRHP-eligible property. However, the USACE determined by use of recent and historic aerial imagery that the existing diversion structure is of recent age (constructed within the last 20 years), and is not itself a contributing element to the acequia's significance. The USACE therefore determined that the project would not constitute an adverse effect to the acequia.

More broadly, the USACE determined that the bosque itself is a historic property with the characteristics of a Traditional Cultural Property, and is eligible in its own right. However, given the goal of the proposed project to benefit the health and survival of the bosque, the USACE determined that the proposed work would not have an adverse effect on the bosque itself.

In sum, based on the Ohkay Owingeh Tribal Council resolution, the historic aerial imagery analysis, and an independent assessment of the likelihood of intact archaeological materials within the Ohkay Owingeh APE, the USACE determined that the proposed project would have *no adverse effect to historic properties*. The USACE conveyed these determinations to the SHPO, and SHPO concurred with these determinations on February 2, 2017 (see Appendix D for copies of correspondence).

2.4.3 **Expected future without project conditions**

Without the proposed 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 imperiled or undergoing active change at the present time. More broadly, however, the cultural benefits related to cultural practices and the bosque's health would not be realized in the event that the project does not go forward.

2.5 Hazardous, Toxic, and Radioactive Waste (HTRW)*

This section documents the existing conditions observed during the 2009 preliminary assessment. It also describes the future without-project scenario and its impact to HTRW. USACE anticipates minimal impact of the project on HTRW.

This study has recently reached the stage where specific study areas have been selected for intensive investigation. Existing, future with- and future without-project conditions, of that smaller subset of the initial study area, will be examined in significant detail. A new Phase I Environmental Site Assessment (ESA) will be contracted to determine the likelihood of the existence of Hazardous, Toxic & Radioactive Waste (HTRW) concerns; specifically, ASTM 2247-02, Phase I ESA Assessment for Forestland or Rural Property.

If there are any HTRW issues identified USACE will inform the project manager, project delivery team, and local sponsor(s). USACE will follow USACE Engineering Regulation, HTRW Guidance for Civil Works Projects (ER 1165-2-132).

2.5.1 **Water quality**

Water quality in the study area would continue to be affected by input from storm water sewer outfalls including solid waste, fecal coliform, nutrients, and organic compounds. Other aspects and characteristics of water quality would remain unchanged from the existing condition without implementation of the proposed project.

Section 404 of the Clean Water Act provides for the protection of waters of the United States" from impacts associated with irresponsible or unregulated discharges of dredged or fill material in aquatic habitats, including wetlands as defined under Section 404(b)(1). In New Mexico, permitting for placement of fill in such areas is the responsibility of the U.S. Army Corps of Engineers, Albuquerque District.

2.6 Geology and Soils*

2.6.1 **Regional geology**

The study area lies within the Española Basin, a sediment filled asymmetric west-tilted half-graben that formed as part of the Rio Grande Rift. The Rio Grande Rift created a series of north-south trending faults that resulted in uplifted mountains, widespread volcanism and large sediment filled basins. The Española Basin is bounded by the Sangre de Cristo Mountains to the east, the Jemez Volcanic Field to the west, the San Luis Valley and Chama Basins to the north and the Albuquerque Basin to the south-southwest (Appendix F – Geotechnical Engineering).

2.6.2 **Subsurface**

Subsurface information specific to proposed construction sites is currently not available. Depth to bedrock is unknown but not expected to be within the proposed limits of foundations. A subsurface investigation was not conducted. As the project alternatives are developed in greater detail, a subsurface investigation will be planned to investigate the subsurface conditions at those specific locations. Subsurface information from the proposed Los Vigiles Grade Reduction Facility (GRF), Española, New Mexico; is provided in Appendix F. This information was obtained in the general vicinity of this project and in 2007.

2.6.3 Future Without Project Geology and Soils

No changes are anticipated in site geology and soils over the life of the project.

2.7 Climate*

This section provides information on the existing climate in the study area, and on projected changes in future climate conditions. A detailed discussion of regional climate and climate change, along with an assessment of climate impacts to regional hydrology, riparian and aquatic ecosystems, and project features can be found in Appendix G.

2.7.1.1 Existing Climate

Based on data from the Alcalde National Weather Service Cooperative Observer station (Station 290245) along the Rio Grande northeast of Ohkay Owingeh Pueblo, 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 with daytime temperatures averaging 87°F; July is the hottest month, with an average of 16 days with temperatures above 90°F. Winters tend towards cool and humid, with most days above freezing and overnight temperatures averaging 17°F. Precipitation averages 10.01” 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 1.37”, August 1.89”, and September 1.26”. Precipitation may fall as snow from October through April, with average monthly snowfall peaking in December at 2.8”. Spring and fall tends towards warm and dry.

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. Over the last 90 years, annual maximum flows at the gage Rio Grande at Otowi Bridge, NM (08313000) have exhibited a statistically-significant downward trend in annual maximum daily discharge (Climate Hydrology Assessment Tool: annual maximum discharge = (-38.4677*Water Year) +81405.9, p-value = 0.0188521) probably as a result of the development of water supply and flood risk management infrastructure along the Rio Chama rather than changes in precipitation (see Appendix G Climate Change). No significant nonstationarities in this time series were detected.

Climate and Climate Change: Future Without-Project Conditions

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 21st Century of 5-7°F by 2100 as compared to late 20th 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 features 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.

2.7.2 **Future Without-Project Climate Conditions**

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 features, sedimentation within the features, and potentially reduced water quality (see Appendix G Climate Change).

2.8 Socioeconomics*

The majority of the study area and affected populations is in Rio Arriba County, New Mexico. The population of Rio Arriba County has decreased slightly from 41,190 in 2000 (U.S. Census Bureau 2014). The majority of the surrounding project population is Hispanic/Latino followed by White (not Hispanic), Native American, Black and Asian. The poverty level is slightly higher than the state average as is the Census Data Population (CDP) of Ohkay Owingeh. Poverty levels for Santa Clara and San Ildefonso are below the state average.

The leading employment sectors in Rio Arriba County are education, health care, and social services (20.9 percent) and public administration (16.4 percent). Agriculture employs about four percent of the county's workers, while hospitality services and construction, each employs more than 10 percent of the workforce.

Table 6 Española Valley 2015 population statistics.

Española Valley	Total Population (individuals)	Race and Ethnicity				
		White, not Hispanic	Hispanic / Latino	Native American	Black	Asian
New Mexico	2,065,826	39.4%	47.3%	10.4%	2.5%	1.6%
Rio Arriba County	40,371	13.2%	71.4%	18.0%	0.9%	0.8%
Santa Fe County	144,532	43.5%	51.1%	4.0%	1.1%	1.4%
Ohkay Owingeh CDP	1,143	1.9%	19.7%	76.8%	0.09%	0.2%
Santa Clara CDP	1,018	2.8%	23.6%	71.9%	0.3%	0.3%
San Ildefonso Pueblo CDP	524	9.4%	31.9%	57.4%		

** Respondents may have multiple answers to census survey resulting in numbers greater than the total population.*

Table 7 Española Valley 2015 population and poverty statistics.

Española Valley	Total Number	Age			Below Poverty Level	
		0-17 years	18-64 years	65 and older	Under 18 years	All ages
New Mexico	2,065,826	265,580	145,523	93,680	7.3%	21.2%
Rio Arriba County	40,371	6,466	573	1,697	7.8%	24.5%
Santa Fe County	144,532	12,412	775	6,025	5.4%	18.2%
Ohkay Owingeh CDP	1,143	334	673	136		25.7%
Santa Clara CDP	1,018	251	631	136		15.3%
San Ildefonso Pueblo CDP	524	138	311	75		11.9%

2.8.1 Environmental justice

Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (11 February 1994) was designed to focus the attention of Federal agencies on the human health and environmental conditions of minority and low-income communities. It requires Federal agencies to adopt strategies to address environmental justice concerns within the context of agency operations and proposed actions. The 1995 Environmental Protection Agency (EPA) guidance document, Environmental Justice Strategy: Executive Order 12898, defines the approaches by which the EPA will ensure that disproportionately high environmental and/or socioeconomic effects on minority and low-income communities are identified and addressed. Further, it establishes agency wide goals for all Native Americans with regard to environmental justice issues and concerns.

The goals expressed by the Pueblos of Ohkay Owingeh and Santa Clara have included local Native American environmental justice issues and concerns.

2.8.2 Future with-out project condition

No significant changes to socioeconomic trends or to environmental justice are expected within the analyzed life of the project (Appendix I, Section 5.6).

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3 - Plan Formulation and Evaluation for Ecosystem Restoration

The USACE iterative six-step planning process was used to develop, evaluate, and compare the array of management measures and alternative plans that have been considered. As discussed in Section 1.7, the six steps used in the plan formulation (Figure 15) process include:

1. **Identifying Problems and Opportunities**
2. **Inventorying and Forecasting Resources**
3. **Formulating Alternative**
4. **Evaluating Alternative Plans**
5. **Comparing Alternative Plans**
6. **Selecting the Recommended Plan**

In section 1.7 we discussed the problems and opportunities. Chapter 2 discussed inventory of existing conditions and forecasting of future conditions. In this chapter we present steps 3 through 6 of the planning process.

In the initial study phase, the team developed measures to alleviate the ecosystem problems identified by the PDT and sponsors (Section 1.7.2). The objectives were used to guide the formulation of measures and will be used later to evaluate the effectiveness of alternative plans. Development of ecosystem restoration plans for the Española Valley, Rio Grande and Tributaries, New Mexico Study involved evaluation of successive iterations of alternative solutions to address the ecosystem degradation issues. The underlying key to long-term success for the study is to reconnect rivers and their floodplains. Once this key function is restored the vegetation and habitat enhancements can flourish and maintain a competitive edge on non-native plant invaders.

Development of alternatives for riparian and aquatic ecosystem restoration involves successive iterations of development of alternative solutions then screening of those alternatives using study objectives and other evaluations criteria. The solutions to be formulated should address the problems and opportunities. For this study, alternative plans are made up of smaller components called measures. A measure is a single action at a certain location such as creating a 2 acre wetland in a location where there is a natural depression.

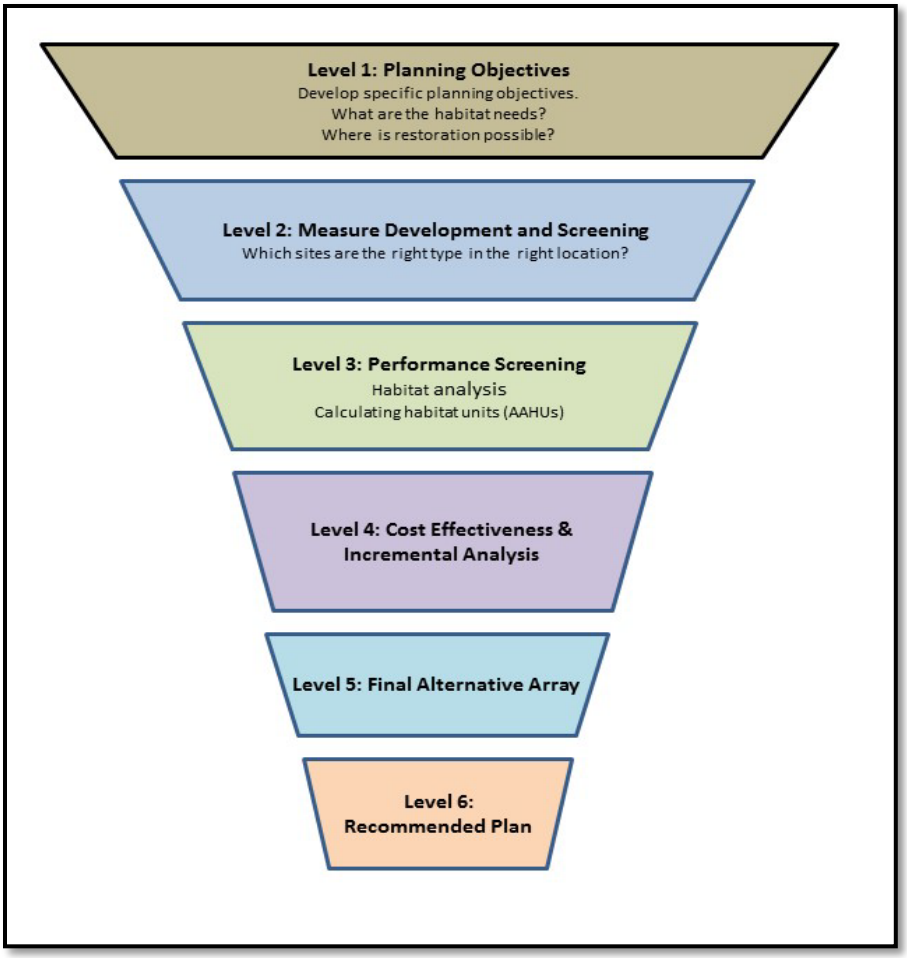


Figure 15 Generalized plan formulation process for developing the recommended ecosystem restoration plan.

Multiple alternatives were identified that would meet specific planning objectives, although to varying degrees (Figure 18, Figure 19, Figure 20). Details on the development of measures is described in section 4.3.

Selection of the recommended restoration plan, or National Ecosystem Restoration (NER) plan, is based on identification of a plan that meets Federal and study objectives, while reasonably maximizing ecosystem restoration benefits compared to costs. The economic comparison of cost per unit of ecosystem output will provide a metric to eliminate alternative plans that are inefficient. The ultimate identification of an NER Plan is based on objectives criteria. In addition to considering ecosystem benefits and costs, selection of a recommended plan was informed by criteria that cannot be readily quantified, such as environmental significance and scarcity, socioeconomic impacts, and traditional cultural values.

3.1 Planning Objectives

3.1.1 Specific Planning Objectives

Evaluation of measures and then combinations of measures that make up alternative plans is performed through comparison of the plans as they meet planning objectives and objectives criteria. The study objectives are:

1. Reconnect the Rio Grande and its tributaries to their floodplains within the study area for the through the period of analysis and beyond.
2. Increase the amount and quality of valuable Bosque habitat in the study area through the period of analysis and beyond.
3. Increase the diversity of riparian habitat types in the study area through the period of analysis and beyond.
4. Provide recreational and traditional cultural opportunities to the public, in the study area, through the period of analysis.

3.1.2 Objectives Performance Criteria

General feasibility criteria must be met for ecosystem restoration alternatives. These are:

- **Completeness –** Does the plan include all necessary parts and actions to produce the desired results?
- **Effectiveness –** Does the alternative substantially meet the objectives? How does it measure up against constraints?
- **Efficiency –** Does the plan maximize net NER and/or NED benefits?
- **Acceptability –** Is the plan acceptable and compatible with laws and policies?

Specific planning objectives that address identified problems were discussed in section 1.7 but are revisited here with more detailed discussion of how those objectives will be met and how success can be determined. The study measures and alternatives were developed to contribute to study objectives and can be evaluated using the following criteria.

Objective 1. Reconnecting the Rio Grande floodplain could most efficiently be accomplished by: a) applying measures to halt the headcut (see section 3.3.5 for discussion), while b) increasing the number of acres inundated during annual spring runoff and summer high flows. The number and placement of structures installed to halt the headcut should limit future incision, while managing channel slope to a degree allowing movement of fish through the project area. Measures applied should also increase floodplain inundation and expand riparian habitat. Accomplishment of these floodplain restoration requirements, in sum, is a necessary foundation to achieve the rest of the objectives.

Objective 2. The quality of existing Bosque habitat is projected to decrease over the 50 year period of analysis due to increasing densities of invasive species. Habitat quality can be increased using features that increase native plant diversity and habitat complexity, which changes a lower value habitat to a higher value habitat. Habitat restored is a function of the number of acres or footprint of restored habitat combined with their improved restored riparian habitat values; combined as habitat units. Measures were also screened to ensure a threshold value for habitat diversity created or restored was achieved. This threshold was determined to be double that of the without project baseline condition over the 50 year period of analysis. The Habitat team determined that this amount of restored riparian habitat mimics historic conditions of habitat diversity. This habitat value equates to restoration or creation of a minimum of 200 acres of diverse riparian.

Objective 3. Increased diversity of habitat types, to achieve a sustainable mosaic, was measured based on: a) the distribution of measures across the project area; and b) achieving a balance of for each pueblo or project reach. Individual restoration measures should be distributed all along and across the riparian corridor, to produce a mosaic of restored vegetation patches in combination with existing riparian habitat.

3.2 Planning Constraints and Considerations

Water delivery policies and regulations will affect water availability for ecosystem restoration measures. Water oriented legislation and policies include the Rio Grande Compact and New Mexico State Engineer's Regulations. This project is being designed, in turn, to ensure it can be sustained with existing water flows.

The Rio Grande Compact, in effect, limits the amount of surface water than can be depleted in the Middle Rio Grande based upon the natural flow of the river measured at the Otowi gage downstream of the project area (Rio Grande Compact, 1939). In addition, the New Mexico State Engineer has determined the Middle Rio Grande to be fully appropriated. Therefore, any increase in water use in one area of the river must be offset by a reduced use in another area of the river. The State Engineer requires that increases in water use from new habitat restoration projects must be offset by purchased or leased water rights. Work performed within the river channel within the Rio Grande Floodway is exempt from this policy (NMISC, 2007). The definition of 'Floodway' in this case is a 600-foot corridor centered on the midline of the river. Therefore, water use within this 600-foot corridor is not deemed an 'increase in water use' and does not require offsetting, but increases in water depletions from any part of a habitat restoration project that falls outside of the 600-foot floodway must be offset. The New Mexico State Water Plan (Office of the State Engineer/Interstate Stream Commission, 2003) further states "State Engineer permits are required for all habitat restoration activities that result in increased depletions of water." However, the New Mexico State Engineer "maintains that habitat restoration projects implemented by the Bureau of Reclamation, Army Corps of Engineers, or ISC in the Middle Rio Grande floodway do not require water rights permits because of those agencies' respective flood control and compact delivery statutory roles" (NMISC, 2007).

Formulation of restoration measures within the floodway were limited to the 600-foot corridor.

Restoration measures were developed in coordination with the Interstate Stream Commission and the New Mexico State Engineer's office to minimize water depletions through the implementation of the restoration project. Restoration measures were formulated such that there would be no change to Water Depletions under the future without project. A final evaluation of plans and designs will be completed during project design to verify that the measures do not result in depletions.

Each of the two non-Federal sponsors interested in ecosystem restoration is an individual, dependent sovereign nation with its own government and Tribal legislation. Per Tribal policy, management measures were reviewed by each Tribal council prior to alternative formulation. This does not present a constraint to plan formulation but a step in the process. The sponsors provided invaluable information regarding traditional cultural practices and local knowledge of the study area.

Table 8 Floodplain area by sponsor based on inundation frequency.

Inundation Frequency	Ohkay Owingeh Pueblo (acres)	Pueblo of Santa Clara (acres)	Floodplain (total acres)	Cumulative (acres)
0.500	314.3	420.7	735.0	735.0
0.200	312.4	554.5	866.9	1601.9
0.100	432.7	481.6	914.3	2516.2
0.040	157.6	223.1	380.7	2896.9
0.020	190.6	212.5	403.1	3300.0
0.010	125.2	54.0	179.2	3479.2
0.005	60.1	18.7	78.8	3558.0
0.002	165.6	162.3	327.9	3885.9
	1758.5	2127.5	3886.0	

3.3 Measure Development and Evaluation Process*

3.3.1 Local Involvement in Plan Development

A habitat team was formed for guiding development and analysis of habitat restoration measures for the Española Valley Study. The interagency habitat team was convened with members from the Pueblos of Ohkay Owingeh, San Ildefonso, and Santa Clara, and representatives from the U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), New Mexico Department of Game and Fish (Game and Fish), the U.S. Forest Service (USFS), and the U.S. Bureau of Indian Affairs (BIA), La Calandria Consultants, and the Audubon Society. The habitat team first assisted with refining the data for the conceptual habitat models to estimate habitat values. They later provided input on variables identified for habitat evaluation and application of the CHAP protocols. The team also provided input to sponsors and USACE on preliminary habitat restoration measures for possible, and assisted with identification of screening measures, supporting the planning process.

3.3.2 Development of Ecosystem Management Measures

The habitat team developed preliminary ecosystem management measures during brainstorming sessions based, in part, on experience with previous Middle Rio Grande projects conducted by Federal and State agencies (USBR 2012; USACE 2011). The team focused on measures that have proved effective and sustainable for restoring ecological processes in the unique Rio Grande hydrologic and geomorphologic regime. The habitat team recognized that the proposed measures would require variable implementation across project reaches to support development of a habitat mosaic. The suitability and effectiveness of a suite of measures at a given site are a function of the inherent properties of the method, and the physical characteristics of each reach and/or site. The measures also were adapted to suit local conditions in the Española Valley Project area.

In general, the habitat team sought to identify potential ecosystem measures that would that mimic historic, natural conditions in the project area. These included restoration of gently sloping banks with backwater areas, overbank flooding, and off-channel wetlands to facilitate water infiltration, native plant regeneration and nutrient cycling in the reconnected floodplain. After invasive species control, existing vegetation communities would be enhanced with riparian, wetland and other supplemental plantings now rare in the Bosque. The restored habitat should improve vegetation structure, and promote an increase in the number and diversity of wildlife species in the area. This approach to habitat restoration focuses on rebuilding community functions based on restoration of geomorphological and hydrological processes combined with managing vegetation. This is intended to redirect future trends away from further habitat degradation to a more natural, sustainable system that will uphold or increase in habitat value.

3.3.3 **Categories of Management Measures**

Ecological management strategies are based on a variety of techniques depending on local river conditions, project goals, and environmental effects. The applicable measures for the Española Valley are based on the U.S. Bureau of Reclamation (USBR) *Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide Appendix A: Middle Rio Grande Maintenance and Restoration Methods* (2012). These methods are organized into categories with similar measures and objectives, and can be combined at project locations to improve the benefits for aquatic and riparian habitat restoration. The suitability and effectiveness of a suite of methods at a site are a function of the inherent properties of the method, and the physical characteristics of each reach and/or site. Each method or measure was rated with a level of confidence (I, II, III) for achieving the desired geomorphic, and habitat effects (USBR 2012). The methods have been adapted here for local conditions in the Española Valley Project area.

These measures (Table 9) include activities to reconnect floodplains with the river, manage habitat management along channel perimeters, install in-channel structures to deflect flow, modify sediment supply in the river, control invasive plant species, and manage riparian vegetation (USBR 2012).

Table 9 Types of ecosystem measures considered by the habitat team.

Ecosystem Measure	Function
Boulder Weirs	Manage channel incision by controlling the bed elevation to improve or maintain current flood plain connectivity
Grade Restoration Facilities (GRFs)	Manage channel incision by controlling the bed elevation to improve or maintain current flood plain connectivity
Deformable Riffles	Manage channel incision by controlling the bed elevation to improve or maintain current flood plain connectivity
Rock Sills	Manage channel incision by controlling the bed elevation to improve or maintain current flood plain connectivity

Riprap Grade Control	Manage channel incision by controlling the bed elevation to improve or maintain current flood plain connectivity
Low Head Stone Weirs	Manage channel incision by controlling the bed elevation to improve or maintain current flood plain connectivity
Terrace Lowering	Increase floodplain connectivity by excavation of islands, bars, or terraces to create lower floodplain surfaces
High-Flow Channels	Increase floodplain connectivity by excavation of channels across terraces or abandoned river channels.
Willow Swale / Wetlands / Ponds	Increase native riparian vegetation by excavation to ground water and replanting with native species
Bank Line Embayment	Increase floodplain connectivity by excavation of features adjacent to the river channel
Bendway Weirs	Increase slack water habitat and protect bank line features
Boulder Groupings	Increase complex aquatic habitat with variable depth and velocity
Bioengineering, Large Woody Debris and Root wads	Increase complex aquatic habitat with variable depth and velocity
Change Sediment Supply	Manage channel incision by adding sediment into the river
Invasive Species Control	Increase native riparian vegetation and reduce invasive plant species using multiple control techniques
Riparian Vegetation Re-Establishment	Increase native riparian vegetation by replanting with native plant species following excavation or invasive plant species control
Vegetation Management For Dynamic Bank Formation	Increase native riparian vegetation and floodplain connectivity for sediment retention

3.3.4 **Measures to Restore Floodplain Connectivity**

The key to long-term success for Española Valley Project riparian restoration is to reconnect the rivers with their floodplains. A combination of two techniques may be implemented to improve floodplain connectivity. First, structures could be constructed to raise water surface elevations at select locations in the river and arrest further down-cutting, which together would raise the water surface elevation in the river channel. These measures also prevent down cutting in the future. Second, swales could be excavated into the overbank habitats to reintroduce surface flows back into the Bosque. Swales would then flood during high flows or fill from the rising groundwater. Improving floodplain connectivity, in this manner, would increase the area and quality of wetland and native riparian habitat in the bosque, and allow some degree of point bar deposition and soil scour so that new vegetation could become established. These measures are then combined with vegetation management by removing invasive tree species and planting native trees, shrubs, and herbaceous plants to accelerate successful establishment of the riparian vegetation and prevent reinvasion by invasive species.

3.3.5 **Measures to Increase Channel Bed Elevation**

The objective of river spanning measures is to control the channel bed elevation or grade, improve or maintain current flood plain connectivity, and stabilize ground water elevations. Structures like boulder weirs, riffles, or grade restoration facilities (GRFs) are intended to manage channel incision while raising the riverbed level in relation to the surrounding floodplain to reduce the elevation difference between the river in its current channel and the abandoned channels in the bosque (USBR 2012). GRFs are engineered structures that are designed to control river channel grade while maintaining the river perpetually in its current location. Weirs or riffles are designed to encourage river flow into former channels that over time may allow the river to avulse entirely into former channels, eventually leaving the boulder weir behind.

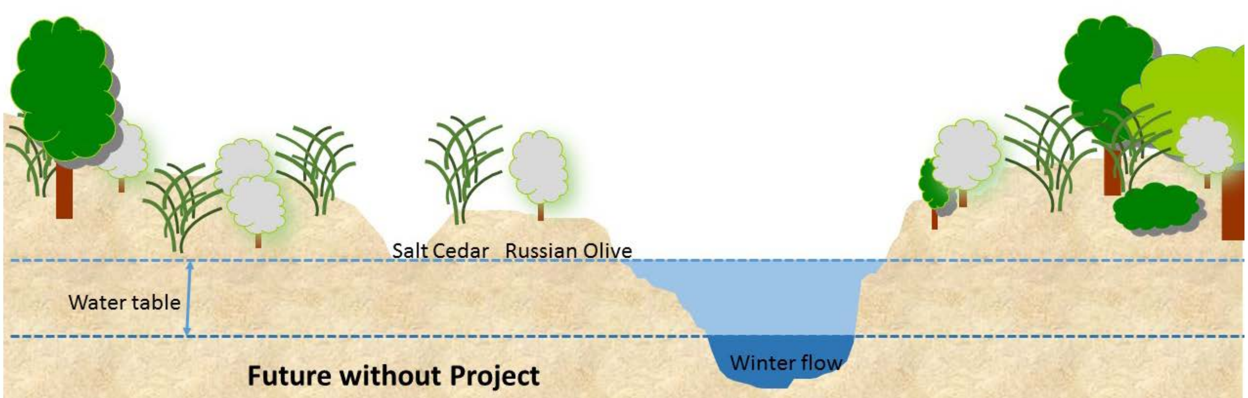
3.3.5.1 Grade Restoration Facility (Retained)

Grade restoration facilities (GRF) are engineered structures that are designed to control river channel grade while maintaining the river perpetually in its current location. This method raises the river bed about 1-2 feet, and has a long low slope downstream apron to dissipate water velocity. GRFs consist of an upstream sheet pile wall, with a variably sized rock section, and a downstream sheet pile wall. Scour protection is often added to protect the downstream sheet pile wall. GRFs are designed to replicate long, low slope riffles and to raise the river bed up to improve flood plain connectivity. These low structures can raise the water surface during lower flows and generally do not raise the water surface as much during higher flows (Figure 16, Figure 19).

Grade restoration facilities would be utilized at designated locations in the cross section of the river. The structures are designed to hold the bed of the river channel at a constant elevation, i.e. the structures prevent further incision (lowering) of the river bed. In addition, the structures can provide a local increase in water surface elevations when the top of the structure is placed above the existing bed elevation. By raising the bed elevation there is a local increase in the water surface elevation that in turn increases overbank flooding.

The proposed GRFs are the primary structures considered for increasing the bed elevation because of their greater effectiveness for stabilizing the channel bed. They are large, permanent structures that would lock the channel in place where channel migration or avulsion would be undesirable. The structure would be entirely submerged at all river flows, which is culturally important for because the sponsor prefers that no constructed river measures extend above the water surface.

A number of in-channel features, such as deformable riffles, rock sills, riprap grade restoration facilities and low head stone weirs were considered during initial alternative development. These measures were screened out (sections 4.3.4.2 – 4.3.4.8) because they are not considered as effective as the GRFs for stabilizing the channel bed in this reach of the Rio Grande.



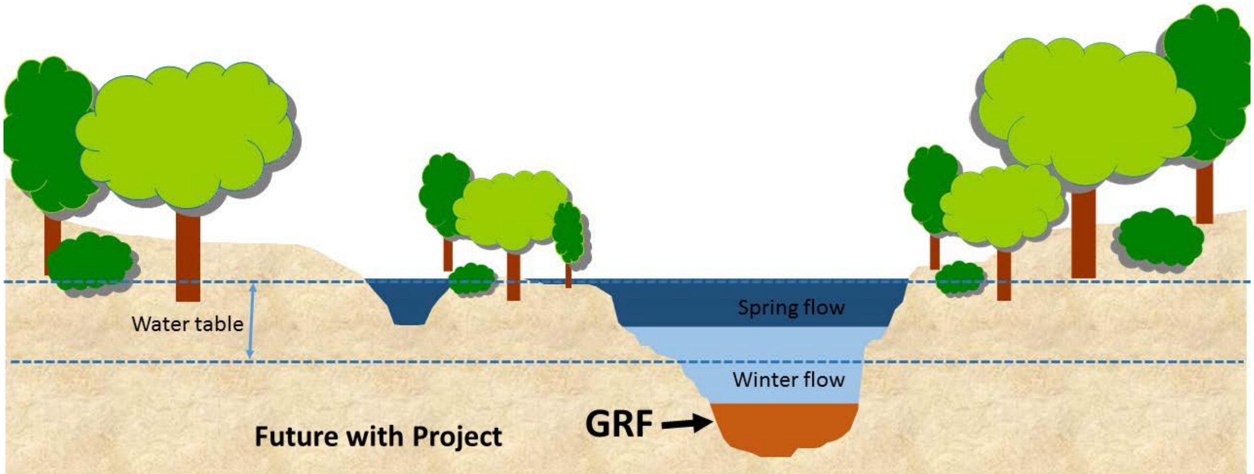


Figure 16 Conceptual diagram showing the hydraulic benefit of implementing grade restoration facilities for increasing floodplain connectivity.

3.3.5.2 Deformable Riffles (Screened Out)

Deformable riffles are a recent (and untested) measure to establish a channel with a stable grade, allow some vertical channel bed movement, and supplement the bed material load (USBR 2012). Deformable riffles consist of a trench excavated across the channel and filled with rock that would be stable during most flows. The length of a deformable riffle in the downstream direction should approximate the length and slope of typical stable riffles. Local natural riffles may be used to determine the appropriate shape and rock size based on information about the flow range for bed mobilization.

Multiple riffles could be constructed in series along the river about five to seven river widths apart. Riffles would contain a supply of rock to be mobilized during subsequent 5- to 10-year flow events, while allowing some erosion of the riffles to occur.

3.3.5.3 Rock Sill (Screened Out)

Rock sills involve placing large stones directly on the streambed that resist erosion in an incising river zone (USBR 2012). Rock sills are constructed of larger, less mobile rocks, while deformable riffles have smaller rock that are differentially transported during high-flow events. The rock sill would deform as the channel establishes small pools and scour between each sill.

3.3.5.4 Riprap Grade Control (Screened Out)

Rock grade control structures are constructed by excavating a trench across the streambed which is filled with large rock, with the top elevation being the river bed (USBR 2012). As the channel degrades and downstream scour occurs, a portion of the variably sized rock in the trench will be transported downstream.

3.3.5.5 Low Head Stone Weirs (Screened Out)

Low head stone weirs are used to protect banks, stabilize the bed of incising channels, activate side channels, reconnect flood plains, and create in-channel habitat (USBR 2012). The structures are constructed across the river with individual stone (or smaller variably sized rock) placed in lines forming “U,” “A,” “V,” or “W” shapes. During low flows, the water surface elevation changes through the structures. Stone weirs can be oriented to direct flow toward the center of the channel, creating a pool while limiting bank erosion.

3.3.5.6 Transverse Measures or Flow Deflection Techniques (Screened Out)

Transverse measures are structures that extend into the river channel to redirect flow away from the bank line to reduce erosion (USBR 2012). These measures can be constructed using boulder groupings, rootwads, large woody debris or bioengineering techniques. Flow deflection structures also include vanes, baffles, or j-hook weirs extending out into the river from one bank. These structures can also raise the water level to direct flow into a reconnected side channel, and towards the opposite bank for the formation of meander bends. Channel meandering encourages natural erosion and deposition, which benefits the bosque and wetland ecological communities. As deposition occurs, vegetation begins to establish, stabilizing the newly formed point bar.

3.3.5.7 Bendway Weirs (Screened Out)

Bendway weirs are rock measures that are designed to be angled upstream from the bank line into the flow in order to direct flow away from the bank line, thereby reducing bank erosion and creating slackwater habitat (USBR 2012). During low river discharges, the flow is directed to the center of the channel, while at high flows, secondary currents reduce water velocity near the bank. They also re-align or relocate the river thalweg through the weir field and downstream.

3.3.5.8 Boulder Groupings (Screened Out)

Boulder groupings are designed to increase or restore structural complexity and variable depth and velocity habitat (USBR 2012). Boulder groupings can be constructed to improve aquatic habitat diversity. High-flow events interacting with boulder groupings create and maintain downstream scour pools and provide bed sorting.

3.3.6 **Measures to Decrease Floodplain Surface Elevation**

Varied channel perimeter modifications can be used to manage river channels for floodplain restoration (USBR 2012). Connecting remnant channels, historic irrigation channels, and natural depressions with river flows can create a variety of diverse floodplain and wetland conditions. New vegetation established in deep former river channels can reactivate the geomorphological disturbance environment needed for a healthy and sustainable riparian ecosystem in the floodplain. Shallow ponds, wet meadows, backwaters, and saturated soil will all develop around and between these flowing channels as essential components of a healthy floodplain ecosystem.

3.3.6.1 Terrace Lowering (Retained)

Terrace lowering consists of excavation of islands, bars, or adjacent areas to lower the ground surface elevation to create habitat measures (terraces, Figure 17, Figure 20). The lower surfaces increase floodplain inundation during spring runoff or storm events, and support vegetation requiring increased groundwater connectivity (swales). Willows and cottonwoods are commonly planted in the excavated terraces and swales. Excavated materials can be placed here for downstream sediment transport (sediment enrichment), or to manage flow across islands and bars for habitat diversity.

3.3.6.2 Swales (Retained)

Willow swales are depressions constructed by removal of vegetation (Figure 17, Figure 20), dumped debris and soil to provide microenvironments in which native plants can thrive due to the decreased depth to the water table and moist soils (USACE 2011). In certain areas of the bosque, the depth-to-water table is minimal and even slight excavations expose water. Willow swales also help create vegetative habitat where establishment of native plants or seed would otherwise be challenging due to soil type or depth to groundwater. 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 would thrive in these depressions.

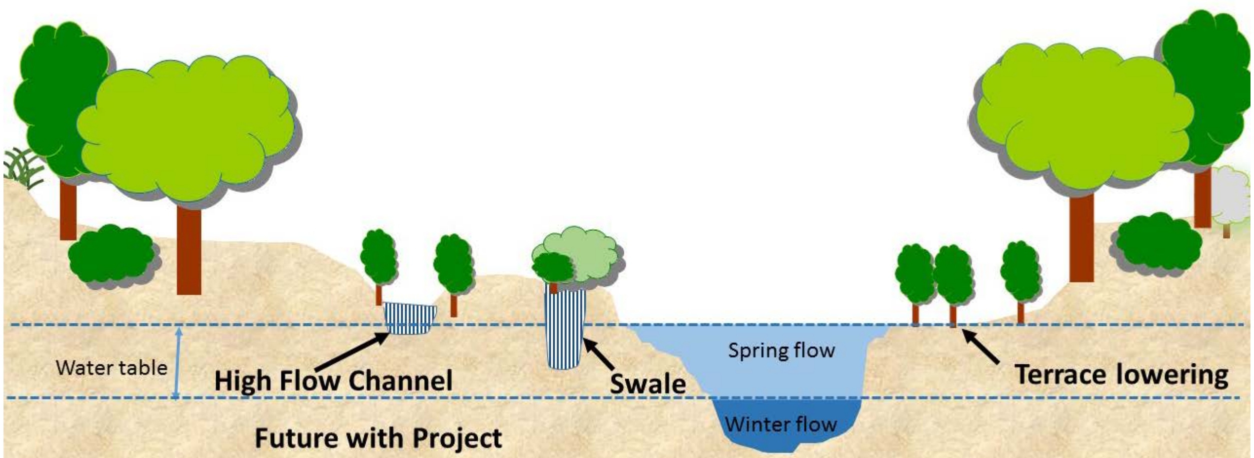


Figure 17 Conceptual diagram showing the benefit of floodplain connectivity measures for increasing inundation frequency.

3.3.6.3 Side Channels (High-flow, Perennial, and Oxbow Re-establishment) (Retained)

Side channels consist of channels that can be inundated by higher river flow during spring runoff or storm events, which are adjacent to the main river in the flood plain, bars, and islands (Figure 17, Figure 20). Excavation can consist of creating completely new side channels or enlarging natural topographic low areas on bars or abandoned flood plains when the channel has incised. Side channels can be created by excavating the entire feature or reconnecting abandoned river channels or topographic low areas. Side channels in combination with a boulder weir or similar structure that controls channel incision would increase the effectiveness of the technique.

3.3.6.4 Wetland Restoration (Retained)

Wetland restoration measures focus on development of open water wetlands, marsh wetlands, or wet meadows (USACE 2011). Such wetlands provide open water habitat for migrating and local waterfowl and aquatic habitat for numerous species (Figure 20). A marsh wetland would have fluctuating water levels (usually 1-5 feet) and various vegetative species. These areas can be created by lowering the ground surface level below the local water table.

A wet meadow habitat is similar to a marsh wetland, but has much shallower standing water, and is created by allowing flow from a deeper wetland area (such as an open water wetland) to flow out into an existing dry area or by lowering an area to the shallow groundwater table. This creates marshy or moist soil habitat, usually only about 6 inches deep with water.

3.3.6.5 Bank Line Embayment (Screened Out)

Bank line embayments (including shelves, scallops, inlets, and backwater areas) may be excavated into bank lines at various elevations to create slackwater habitat during spring runoff and summer thunderstorms. The measures are designed with sufficient width and distance to created areas of very low water velocity habitat, while allowing flow through the feature. These measures provide fish habitat when inundated and are suitable for natural recruitment of willow and cottonwood seedlings on the descending hydrograph.

3.3.6.6 Bioengineering, Large Woody Debris and Rootwads (Screened Out)

Bioengineering treatments may be constructed to replace “hardened” rock measures revetments with more esthetically pleasing and wildlife-friendly designs (USBR 2012). Techniques include piles of woody materials, rootwads, brush mattresses, vertical bundles, and brush or tree revetments that use live and/or dead plant materials in combination with support materials. Bioengineering treatments can be as durable and protective as simple rip-rap while providing soil improvement, water shading, cover for fish, and habitat for birds.

Large woody debris (LWD) structures are constructed from cut trees to redirect, deflect, or dissipate erosive flows (USBR 2012). LWD can be used in combination with other measures to enhance the effectiveness and mitigate the impacts of channel spanning or transverse features. Downstream scour can create perennial pools and variable depth and velocity habitat conditions. Rootwads are LWD measures embedded into the banks or bed of the channel to redirect flow, especially when placed close together (USBR 2012). Engineered logjams are larger LWD structures constructed for sediment deposition onto in-channel bars (NRCS 2007; Shields et al. 2004). All woody structures provide additional habitat value as substrate for many aquatic insects, scour perennial pools, sort gravel substrate, and create variable velocity habitat.

Planting willows and cottonwood poles, willow bundles and/or willow mats / along the bank line can reduce erosion there. Vegetation has low erosion resistance, with plantings requiring time to establish (USBR 2012). Biodegradable fabrics, wattles, mats, Bio-D Blocks, etc., may be used to assist with plant growth and bank stability until vegetation becomes well established (Fischenich 2000). The use of living vegetation as a bank protection material is generally limited to the bank elevations above a base flow where natural vegetation grows in the river system. Most bioengineering measures include some longitudinal toe protection component.

3.3.7 **Measures to Increase the Quantity and Quality of Riparian Habitat**

Successful riparian vegetation management relies on creating the appropriate hydrologic conditions, effective long-term control of invasive plants and the presence or reinstallation of native plants. The previously discussed river restoration and floodplain reconnection techniques should provide the foundation hydrological and groundwater conditions for successful revegetation using native plants.

3.3.7.1 Invasive species control (Retained)

Managing invasive plant species is an essential element for successful Southwestern riparian ecological restoration. Russian olive, salt cedar and Siberian elm are the most common woody invasive plants that have become established in the bosque. There are many herbaceous species that should also receive substantial control effort. The key to invasive plant species control is application of multiple integrated strategies to both remove the species and create an environment where native plants can thrive (Figure 21). This includes replanting areas with native species, in concert with re-establishing (where possible) the preferred soil, hydrology and groundwater conditions to support competition by native species against non-native invaders.

Invasive tree species include Russian olive, salt cedar, Siberian elm, and tree-of-heaven. These species may predominate in large, dense monocultures that can be effectively cleared using cutter-mulchers. Other situations require hand-clearing with chain saws, followed immediately by herbicide application (using a hand-operated sprayer) to the cut stump. Resprouts are cut by hand using machetes, hatchets, powered weed cutters or chainsaws if there is significant new growth, and the cut faces of the sprouts immediately treated with herbicide. Successful herbicide control of resprouts usually requires two to three additional growing seasons after the initial treatment is completed.

Invasive (noxious) herbaceous weed species are an increasing threat to Southwestern riparian ecosystems. Many of these species become established in disturbed areas, such as newly excavated or bladed areas, spoil piles or where invasive trees have been removed. Revegetation activities should include a systematic invasive weed survey, with appropriate control efforts to prevent the spread of invasive weeds.

3.3.7.2 Riparian Vegetation Reestablishment (Retained)

Installation of native vegetation may follow any excavation activities or invasive plant species control, or as an independent management action. Its success depends on providing vigorous native plant revegetation. Many areas will naturally revegetate on their own from the soil seed bank or nearby seed sources. Planting container plants, locally harvested transplants, seeds or other plant parts (poles), however, will accelerate the revegetation process and suppress undesirable invasive species at the restoration site (Figure 21).

Native plants can be propagated either through stem cuttings (willows and cottonwoods especially), root wads (willows and many wetland grasses and sedges), seeds (most species), and whole plants. Often local plant materials are better. Transplanting local, dormant or semi-dormant willow root wads or herbaceous wetland species has several advantages: a) It guarantees that the plants will be adapted to the area; b) It prevents accidental introduction of new, undesirable species to the bosque; c) It maintains and promotes the local genetic composition of the species; d) the survivorship following transplant is better; and e) the costs are lower than commercially available material. Although seed can also be collected seasonally from the bosque, this can be a difficult and time consuming activity.

Species lists of appropriate bosque plants for the study area are available from the New Mexico Natural Heritage Program. A plant list has been developed that includes a total of 57 species recommended for transplant into restoration sites. The surviving gallery forest still has sufficient Rio Grande cottonwoods for seed production, such that every spring with barren, saturated soil in full sunlight, abundant seedlings will sprout.

In addition to transplanted material, reseeding an area with a vigorous and competitive mix of native grasses and forbs is commonly used to accelerate revegetation of disturbed areas (excavated) and provide a long-term control strategy to restrain the colonization of non-native plants. A typical seed mix for dryer or more “upland” areas is a starting point for post-treatment revegetation in order to prevent a quick reinvasion of undesirable species. Revegetation of wetland areas should use rooted aquatic plant material for transplant instead of seeds.

3.3.8 Measures to Increase the Diversity of Riparian Habitat (Retained)

Potential ecosystem measure locations were distributed across the project area landscape during the brainstorming phase of plan formulation. The habitat team recommended that alternatives should create a mosaic of habitat across the project area.

3.3.9 Measures to Modify Sediment Supply (Screened Out)

Sediment supply and transport vary within a river system as a function of discharge over time and space. The sediment supply in the project area has been reduced by Abiquiu Dam (USACE 2007) and gravel mining that stopped in the 1980s. The result has been channel incision, narrowing, and deepening. Sediment augmentation (adding sediment) to the river may reduce the effects of channel incision. Sediment from excavation of other project measures (bank/bar/island clearing, terrace lowering, floodplain channels, and etc.) can be used to augment sediment in the river. Construction of downstream LWD measures to capture sediment would increase the habitat value of both project features, but would increase operational costs.

3.3.10 Vegetation Management for Dynamic Island and Bank Formation (Screened Out)

A reciprocal technique to bar and island destabilization to improve floodplain connectivity entails combining native plant revegetation with engineered logjams or channel management techniques. The combination of engineered measures with plants would increase sediment retention from the river.

3.3.11 **Preliminary Management Measures Eliminated From Further Study**

The habitat team completed several iterations of the ecosystem restoration formulation process for the Ohkay Owingeh and Santa Clara Pueblos. During brain-storming sessions, the habitat team initially proposed about 200 individual measures (techniques and locations) for screening analysis including irrigation, acquisition of private land, zoning, trails and other recreation.

The team discussed the effectiveness of a number of channel stabilization measures (similar to a value-engineering analysis) for addressing the channel headcut. GRFs are established, widely used features with reliable design criteria (USBR 2012), making them the most effective habitat measure for halting the headcut. The other features considered in Table 10 lack the level of detail, design criteria, and reliability already established for GRFs for addressing critical channel stabilization (USBR 2012). The team eliminated the other proposed channel stabilization measures from further consideration that did not support the goals and objectives of the study from further consideration (Table 10). GRF's have been successfully constructed in the Middle Rio Grande, and address cultural requirements described by Ohkay Owingeh Pueblo.

3.3.12 **Measure Screening**

Restoration measures were screened to eliminate measures that would not meet objectives, specified success criteria, or targets; or that were not implementable or feasible based on the knowledge, experience, and judgment of the represented professional disciplines. The remaining management measures were evaluated in different combinations and scales to create alternative plans.

The PDT and sponsors conducted a preliminary screening of management measures to evaluate the applicability of each measure for each reach, and their potential to contribute to the planning objectives consistent with planning constraints. Initial screening also occurred based on acceptability for cultural practices and values.

Table 10 Preliminary ecosystem measures eliminated from consideration for further study.

Ecosystem Measure	**Reason for Excluding Measure from Consideration**
Boulder Weirs	Measure considered less effective than the GRFs with minimal contribution to floodplain connectivity
Deformable Riffles	Measure considered less effective than the GRFs with minimal contribution to floodplain connectivity
Rock Sills	Measure considered less effective than the GRFs with minimal contribution to floodplain connectivity
Riprap Grade Control	Measure considered less effective than the GRFs with minimal contribution to floodplain connectivity
Low Head Stone Weirs	Measure considered less effective than the GRFs, requiring a larger number of measures to match GRFs.
Bank Line Embayment	Habitat measure with minimal contribution to floodplain connectivity does not contribute to objectives

Bendway Weirs	Measure considered less effective than the GRFs with minimal contribution to floodplain connectivity
Boulder Groupings	Habitat measure produces minimal floodplain connectivity and does not contribute to objectives.
Bioengineering, Large Woody Debris and Root Wads	Habitat measure produces minimal floodplain connectivity and does not contribute to objectives.
Change Sediment Supply	Requires other measures to benefit from large volume of material
Vegetation Management for Dynamic Bank Formation	Habitat can be created by terracing with more predictable results

Proposed measures with external dependencies require action by the sponsors (irrigation, zoning), other local governments (zoning), or private individuals (land acquisition) prior to further consideration by the sponsors. Non-construction measures with external dependencies (land acquisition, zoning) were segregated from the initial screening, while recreation measures were evaluated separately.

3.3.13 **Retained Ecosystem Restoration Management Measures**

The habitat team members identified restoration measures that have been successfully implemented in the Middle Rio Grande (USACE 2014b). The team's focus on ecosystem measures with demonstrated success for increasing floodplain connectivity and supporting riparian vegetation (Table 16) improves the likelihood of successful implementation. Each type of measure contributes to the project objectives by performing one or more of the key functions for a sustainable Bosque ecosystem.

Table 11 Ecosystem management measures for alternative analysis.

Ecosystem Measure	Function
Grade Restoration Facilities (GRFs)	Manage channel incision by controlling the bed elevation and improve flood plain connectivity by elevating the water surface elevation. Maintain or increase the frequency and duration of overbanking flows.
Terrace Lowering	Increase floodplain connectivity by excavation of islands, bars, or terraces to create lower floodplain surfaces that are inundated during annual high flows.
High-Flow Channels	Increase floodplain connectivity by excavation of channels across terraces or abandoned river channels that are inundated during annual high flows.
Willow Swale / Wetlands / Ponds	Increase native riparian vegetation by excavation to ground water and replanting with native species to create lower floodplain surfaces that are inundated during high flows or rising water tables.
Native Vegetation Re-Establishment	Increase the density and diversity of native trees and shrubs through revegetation of native plant species and selective removal of invasive plants. New stands of native vegetation will be established to provide a diversity of different aged or structured habitat types.

3.3.14 **Recreation Management Measures**

Recreation is an incidental output and cannot be included as a feature of an ecosystem restoration plan until it has been established that the ecosystem restoration project is justified for construction. Santa Clara Pueblo expressed interest in including recreation measures in a small part of the study area. Neither Okay Owingeh nor San Ildefonso Pueblos expressed interest in recreation plans as part of the study.

The Santa Clara Pueblo recreation master plan was the basis for the following recreation management measures. Measures would include formalized gravel trails, informational kiosk and shade structures. The proposed recreation plan selected those amenities that complement the restoration measures without detracting from habitat. Where possible, gravel trails would follow existing primitive trails or access road alignments. Kiosks and benches would be placed at strategic locations along improved trails.

3.4 Initial Development of Alternatives*

Once the habitat team had identified the five types of measures to be included in the project, the habitat team evaluated locations to place these measures throughout the study area. Measures that included excavation, such as willow swales and terrace lowering, were placed in naturally low areas to minimize the amount of excavated soil. High flow channels were located along historic side channels and oxbows. Vegetation management was located in areas of particularly low existing habitat value. GRFs were located to successfully arrest the head cut as well as in locations to best support upstream habitat locations.

In all, 84 individual measures were located throughout the study area (Figure 27, Figure 28). The next step was to evaluate which of the measures were more effective and in what combination. Each type of measure at each location could contribute to one or more study objectives, however, only a number of individual measures in combination could achieve all study objectives to a degree that provides a complete and effective restoration alternative. Each combination of measures was considered an alternative plan.

The IWR Planning Suite was used to compare every possible combination of the 84 measures. 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 Section 4.9 and in Appendix B Economics.

In order to perform the CE/ICA each of the 84 individual measures requires a cost and an output. Costs for implementation of each measure was estimated using experience with similar constructed projects and nonparametric cost data. Each of the 84 measures consisted of specific environmental restoration features, 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 measure construction components to develop a consistent basis for costs, to avoid skewing the CE/ICA modeling process, and to support unbiased plan selection. For example, two high flow channels would only differ in cost such as the length (linear feet) of each channel and by the difficulty is access or distance for trucking of excavated soil.

Outputs from implementation of each measure were determined by the increase in value or quality of the habitat measured in Habitat Units (HU's). Therefore the difference between similar measures in different locations would be the difference in existing habitat value.

Existing baseline and future habitat values were estimated using CHAP (Appendix C). CHAP is an accounting and appraisal method based on a habitat evaluation framework (approved for this project January 16, 2014) that satisfies the requirements of Engineer Regulation 1105-2-100. CHAP uses an inventory of habitat, species, and functions (O'Neil et al., 2005) to assess habitat values at multiple scales.

The 2002 vegetation mapping (Hink and Ohmart 1984, USACE 2007) delineated distinct vegetation polygons based on species and structure for field surveys and analysis in GIS (Appendix C). The vegetation mapping was ground-truthed in 2010-2011 during the field inventory of key environmental correlate parameters for CHAP (Appendix C, 1.5.1).The habitat team reviewed the species list for habitat valuation using CHAP to estimate habitat value for existing vegetation types and project habitat value into the future without project. The habitat values were projected into the future based on observed trends of invasive plant species described by the habitat team. The habitat analysis is described in detail in Section 4.8 and in Appendix C Environmental Resources.

Once the cost and output of each of the 84 measures was assigned, the CE/ICA determined which combinations of measures 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 produced a smaller set of alternative plans that could be evaluated based on other criteria such as achievement of study objectives. This evaluation is described in Appendix B.

3.4.1 **Real Estate Considerations**

The majority of the Bosque within the study area occurs within tribal ownership. All proposed measures were located on lands owned by the sponsors since any measure proposed on non-sponsor (tribal) lands would include the cost of land acquisition as part of the implementation. The added cost was determined to make those measures inefficient relative to the measures proposed on tribal lands. Both sponsors have sufficient real estate with proximity to the Rio Chama and Rio Grande for floodplain inundation, and sufficient areas of riparian vegetation that an effective and complete restoration plan can be performed within tribal ownership and meet the objectives of the study.

3.5 Habitat Analysis and Performance Screening*

Evaluating the ecological benefits of proposed ecosystem restoration plans requires an assessment methodology that captures the complex ecosystem processes and patterns operating at both the local and landscape levels across multiple habitat types. 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". The proposed ecosystem restoration measures were evaluated for cost effectiveness and incremental benefits during the formulation process. The recommended plan provides a reasonable approach to maximize ecosystem restoration benefits relative to the construction costs.

3.5.1 Ecosystem Importance

The Rio Grande is the 5th longest river in North America, and one of the top ten endangered rivers in the world (Wong et al. 2007). The Rio Grande in New Mexico comprises 484 miles (26% of total length). Riparian corridors comprise less than one percent of New Mexico's landscape (USEPA and NMED 1998), yet they are the most important ecosystems in the state (Roelle and Hagenbuck 1995).The Rio Grande floodplain contains patches of undeveloped bosque consisting of cottonwood and willow riparian habitat. Historically, the Rio Grande and the Rio Chama supported substantial patches of cottonwoods, willows, New Mexico olives, shrubs, and wetlands (locally, these riparian communities are termed bosque) as the river meandered across the floodplain. Flooding and scour were the basic processes that created and maintained a patchwork of variable age class forest stands in the bosque (Crawford et al. 1993; Scurlock 1998).

The cottonwood bosque is the most extensive remaining gallery cottonwood forest in the Southwest, having survived the impacts of development. Over the past decade the value of riparian habitats to wildlife in this arid region has been widely recognized (Hubbard 1971, Carothers et al. 1974, Johnson and Jones 1977, Brown 1982, Ohmart and Anderson 1982). The riparian community supports a rich assemblage of vertebrate species, particularly birds. The highest wildlife densities and diversities were found in mature cottonwood/Russian olive stands and the intermediate-aged cottonwood/coyote willow stands. Areas with sparser vegetation had lower densities and numbers of vertebrate species.

The Española Valley study area extends nearly 20 miles (4% of the Rio Grande in New Mexico) in a separate sub-basin from the rest of the river valley. Its separation from other sub-basins by upstream and downstream canyons increases the value of the riparian ecosystem. The bosque of the Española Valley study area 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.

The importance of the Rio Grande as a wildlife habitat and cultural resource in the region and nation, as well as the impact on the bosque of earlier interventions by Federal agencies, indicates there is a Federal interest in restoration. The valley is an important corridor for terrestrial and avian species, providing 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. It also a critical travel corridor connecting Central and South America to North America along the Rio Grande Flyway. It has been estimated that up to 70 percent of bird species in the arid Southwest are riparian-dependent during some part of their life cycles (Krueper 1993). As a direct consequence of the loss and degradation of riparian habitat, the area has experienced a major reduction in bird species diversity and in the populations of remaining species. In addition, destruction of native riparian habitat facilitates an increase in invasive plant species that are more tolerant of disturbed conditions.

Water resources development, by limiting flood magnitudes and mitigating stream scour, have contributed significantly to bosque loss through the region and in the project area. In addition, channelization activities, unlawful gravel mining and non-engineered spoil banks have modified the channel geomorphology, thereby changing floodplain connectivity and shifting plant composition from the native bosque plant species to increasing invasive plant species. Surface/groundwater interactions and sedimentation dynamics that are important for sustaining and regenerating bosque vegetation have been negatively affected by changes in river morphology and hydrology. Although unlawful gravel mining activity has been stopped, the combined effects of the channelization and the sand-and-gravel mining caused the upstream migration of channel bed head-cuts that caused incision (stressor) that varies from over 10 feet at the downstream end of the reach to about 2 to 3 feet at the upstream end of the Ohkay Owingeh Pueblo reach. These changes in vegetation are anticipated to decrease wildlife habitat values.

Loss of riparian habitat is an important conservation issue in the arid Southwest. Riparian habitat comprised approximately 720,000 acres in the 1780s of what would later become the State of New Mexico (only 0.9 percent of New Mexico). As of 1998, approximately 33 percent of the riparian habitat had already been lost in New Mexico (USEPA and NMED 1998). The surface area of wet meadows, marshes, and ponds has decreased by 73% along 250 miles of the Rio Grande floodplain in New Mexico. This combination of riparian, wetland, and fringe habitat is extremely valuable due to its rarity. The Nature Conservancy lists desert riparian woodland as a very rare although significantly important cover type and describes restoration of wetland and riparian systems as critical (Marshall et al 2000).

This project unique partnership between USACE and the two pueblos proposes to address floodplain connectivity for restoring riparian habitat. Previous experience with riparian habitat restoration in the Middle Rio Grande provides a solid foundation for success.

3.5.2 **Conceptual Rio Grande Riparian Ecosystem Model**

The habitat team identified appropriate inputs for estimating habitat units and possible measures for achieving ecosystem restoration objectives. The habitat team identified primary drivers of ecosystem change in the project area (Figure 18). These ecological drivers produce multiple inter-related stressors that affect the riparian habitat (Figure 18).

Model drivers are based on the long-term current and historical processes identified as adversely affecting the riparian ecosystem. The model stressors are measureable parameters indicative of the adverse effects on the riparian habitat. Model effects are the ongoing processes that the proposed management measures are expected to alter for successful riparian and aquatic habitat restoration. Changes to the Key Environmental Correlates and the Invasive Species Factor provide initial data for comparing existing condition with post-project effects of the management measures (Figure 18).

This report provides an overview of the baseline information for estimating habitat units, and the proposed ecosystem management measures to reconnect the Rio Grande with its floodplains, and increase the area, diversity and quality of the bosque on Ohkay Owingeh and Santa Clara Pueblos. Figure 7 illustrates the importance of hydrological connectivity between the river and the floodplain for supporting native riparian vegetation.

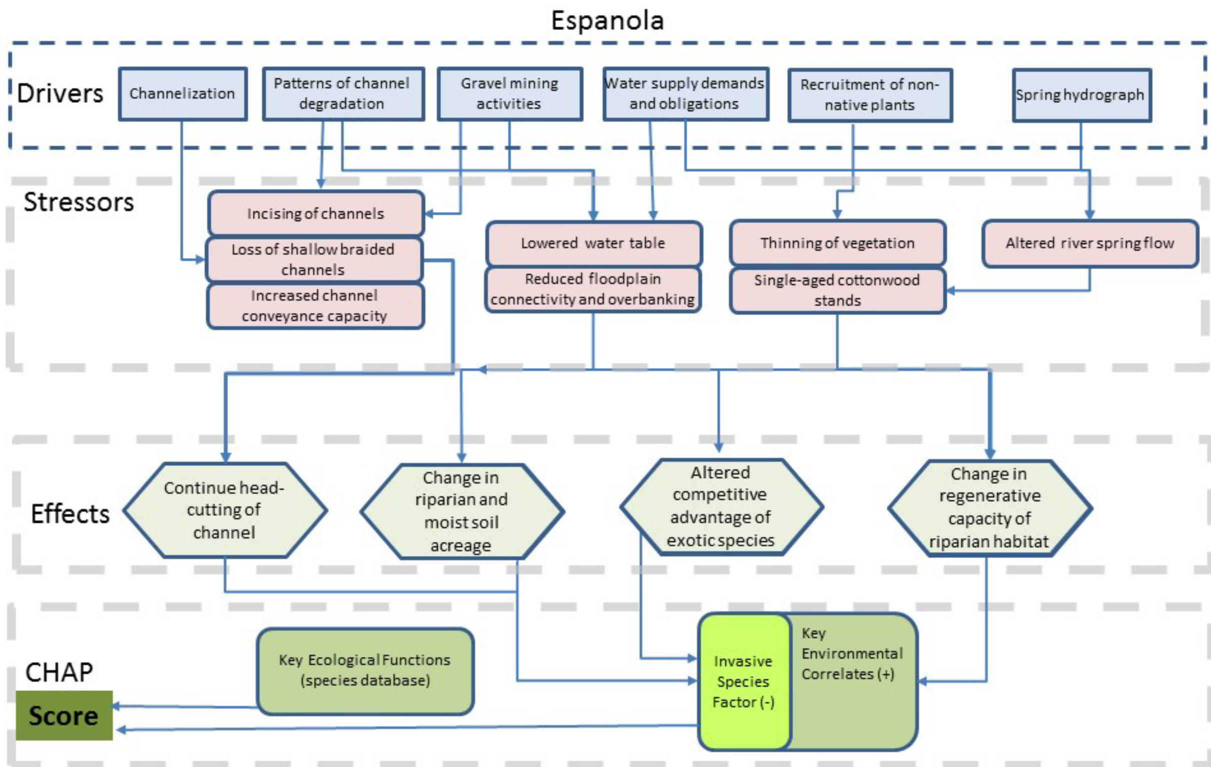


Figure 18 Conceptual model describing the interactions of drivers and stressors that affect floodplain connectivity and riparian habitat.

The bosque of the Española Valley study area 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. The valley is an important corridor for terrestrial and avian species, providing 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. It also a critical travel corridor connecting Central and South America to North America along the Rio Grande Flyway. It has been estimated that up to 70 percent of bird species in the arid Southwest are riparian-dependent during some part of their life cycles (Krueper 1993). As a direct consequence of the loss and degradation of riparian habitat, the area has experienced a major reduction in bird species diversity and in the populations of remaining species. In addition, destruction of native riparian habitat facilitates an increase in invasive plant species that are more tolerant of disturbed conditions.

3.5.3 **Development of the Conceptual Riparian Ecosystem Model**

The habitat team followed a process similar to the US Fish and Wildlife Service's (USFWS) Ecological Service Manual series on HEP (USFWS 1980a-c), and the USACE Habitat Evaluation and Assessment Tools (HEAT) protocols developed by ERDC-EL (Brinson 1993;

Smith et al. 1995). The general steps involved in assessing an environmental restoration project are described in Burks-Copes et al. 2007.

3.5.3.1 Existing Conditions for the Española Riparian Ecosystem

Historical channel maintenance and bank stabilization activities by the U.S. Bureau of Reclamation (1950's to 1980s), are major drivers in the conceptual model (Figure 18) causing channel degradation such that spring snowmelt flows (hydrograph) no longer inundate the riparian areas (floodplain connectivity). Unlawful sand-and-gravel mining occurred in the Rio Grande and on the floodplain/terrace in the lower reaches of the Ohkay Owingeh Pueblo in the 1980s. Although unlawful gravel mining activity has been stopped, the combined effects of the channelization and the sand-and-gravel mining caused the upstream migration of channel bed head-cuts that caused incision (stressor) that varies from over 10 feet at the downstream end of the reach to about 2 to 3 feet at the upstream end of the Ohkay Owingeh Pueblo reach.

Drought has reduced the annual water volume, increasing the demands on the available water supply. Reduced floodplain connectivity (stressor, Figure 18) along the Rio Grande and its tributaries has decreased regeneration of the bosque, allowing invasive tree species to become established. Restricting the Rio Grande to single channel has allowed these patches to mature to senescence, but does not provide the process to remove and regenerate the patches.

The future without project condition has the headcut (stressor, Figure 18) extending further upstream on the Rio Chama and Rio Grande, further reducing floodplain connectivity in the project area (Figure 16). In the future, continued isolation of riparian vegetation in the study area from fluvial geomorphic processes will eventually result in complete dominance of the plant communities by non-native plant species including salt cedar, Russian olive, Siberian elm, and tree of heaven. 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.

3.5.3.2 Hink and Ohmart Vegetation Classification

The Hink and Ohmart (1984) classification delineated distinct Rio Grande riparian vegetation classes based on species and structure. Riparian woodlands have a canopy of Rio Grande cottonwood (*Populus fremontii var. wislizenii*), and, less extensively, Goodding's willow (*Salix nigra var. goodingii*) (Parametrix, 2008), with an understory of native shrub species composed primarily of coyote willow (*Salix exigua*) and seep-willow (*Baccharis salicifolia*). The majority of bosque has an understory dominated by invasive saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*).

The Hink and Ohmart (1984) study characterized the major types of riparian habitat, vegetation and terrestrial vertebrate communities along the Rio Grande. The major communities were composed of combinations of cottonwood, coyote willow, juniper, Russian olive, saltcedar, and cattail marsh. Six vegetation structure types were defined based on the overall height of the vegetation and the amount of vegetation in the lower layers.

The Española Valley Project Habitat Team decided to use the 2002 Hink and Ohmart (Burks-Copes et al. 2007, USACE 2007) habitat mapping for establishing study site conditions. The map layers provide classified homogenous polygons for field surveys and analysis in GIS. The use of the recent mapping (USACE 2007) accelerated the inventory of ecological functions for CHAP, and integrated the project into ongoing river management efforts.

3.5.4 **Ecosystem Restoration of the Española Valley Riparian Ecosystem**

The habitat team developed three objectives for developing ecosystem restoration measures. Reconnect the Rio Grande and its tributaries to their floodplains within the study area for the life of the project. Increase the amount and quality of valuable bosque habitat in the study area for the life of the project. Increase the diversity of riparian habitat types in the study area for the life of the project. The habitat team subsequently identified recreational opportunities for the public as an additional objective for the project.

3.5.4.1 Reconnect the Rio Grande floodplain

There are two general approaches for increasing connectivity of the floodplain with the river: 1) increase the elevation of the river channel bed to increase the local water surface elevation (Figure 16, Figure 19); and 2) excavate the floodplain to decrease the local surface elevation (Figure 17, Figure 20). Increasing floodplain connectivity provides the hydrological processes for supporting the bosque ecosystem by decreasing the depth to the lowered water table (stressor, Figure 18) from the floodplain surface, and increasing the frequency, area and duration of inundation from snowmelt runoff. GRF management measures (3.3.5.1) prevent habitat loss by headcutting (Figure 19, effect) and support local riparian habitat (effect). Floodplain management measures (Figure 20) increase connectivity that supports riparian habitat and increases KEC values. Better floodplain connectivity is essential for bosque health.

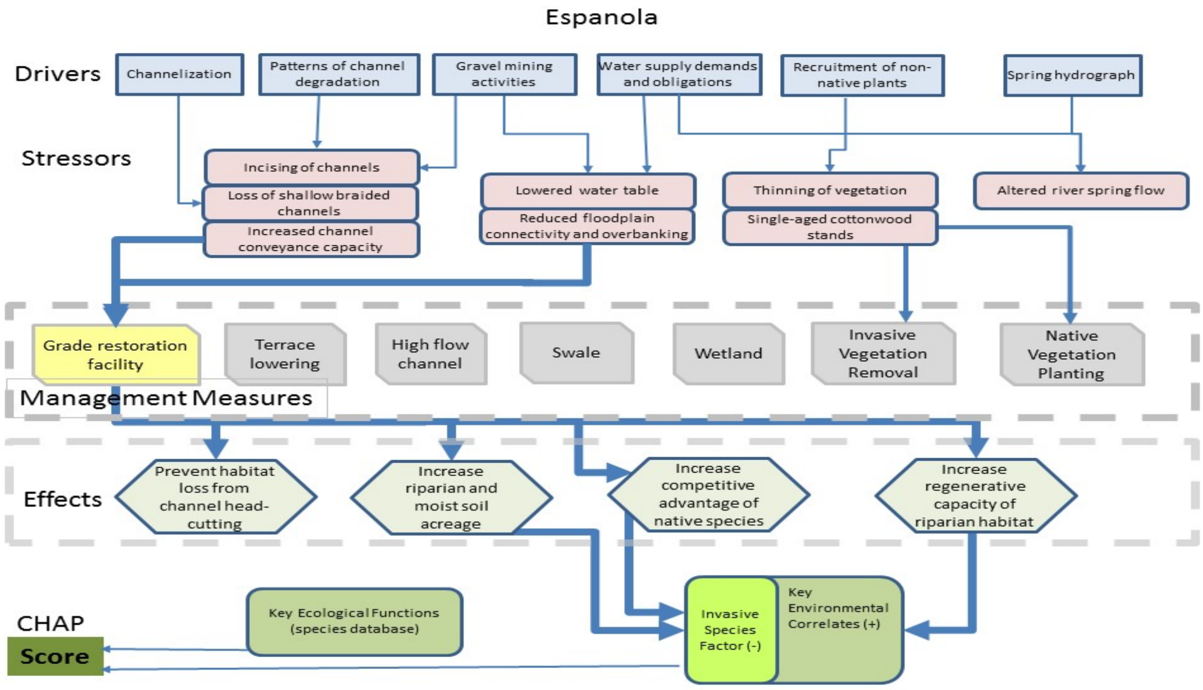


Figure 19 Conceptual model illustrating how grade restoration facilities contribute to the CHAP habitat evaluation.

3.5.4.2 Increase bosque habitat quantity and quality

With the increased floodplain connectivity, vegetation management for native riparian plant species becomes viable. Removal of invasive plants species directly decreases the Invasive Species Factor and allows native species to become established (Figure 21). Native species may become established through planting to accelerate development and through natural seeding during floodplain inundation, supporting an increase in KECs (Figure 21).

3.5.4.3 Increase bosque habitat diversity

The variable design and distribution of excavated measures creates patches of microhabitats that, in turn, create a vegetation mosaic across the landscape. These patches in combination with planting of native species increases the diversity of habitat within the bosque.

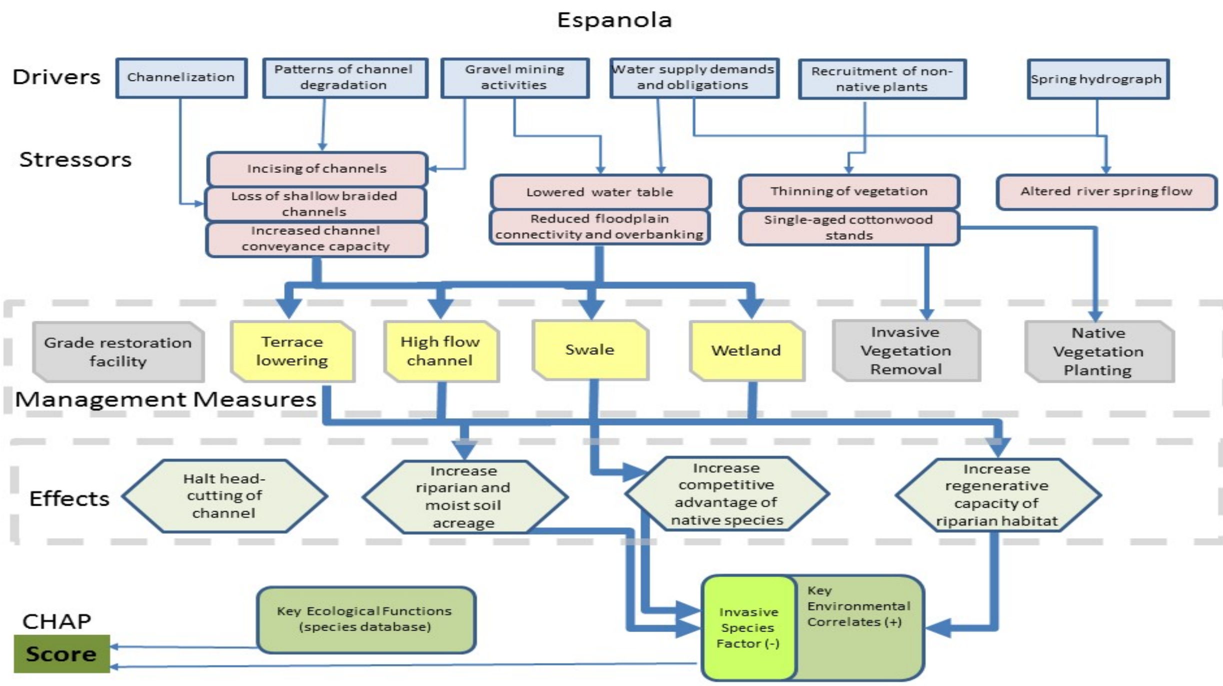


Figure 20 Conceptual model illustrating how floodplain connectivity measures support riparian vegetation, and contribute to the CHAP habitat evaluation.

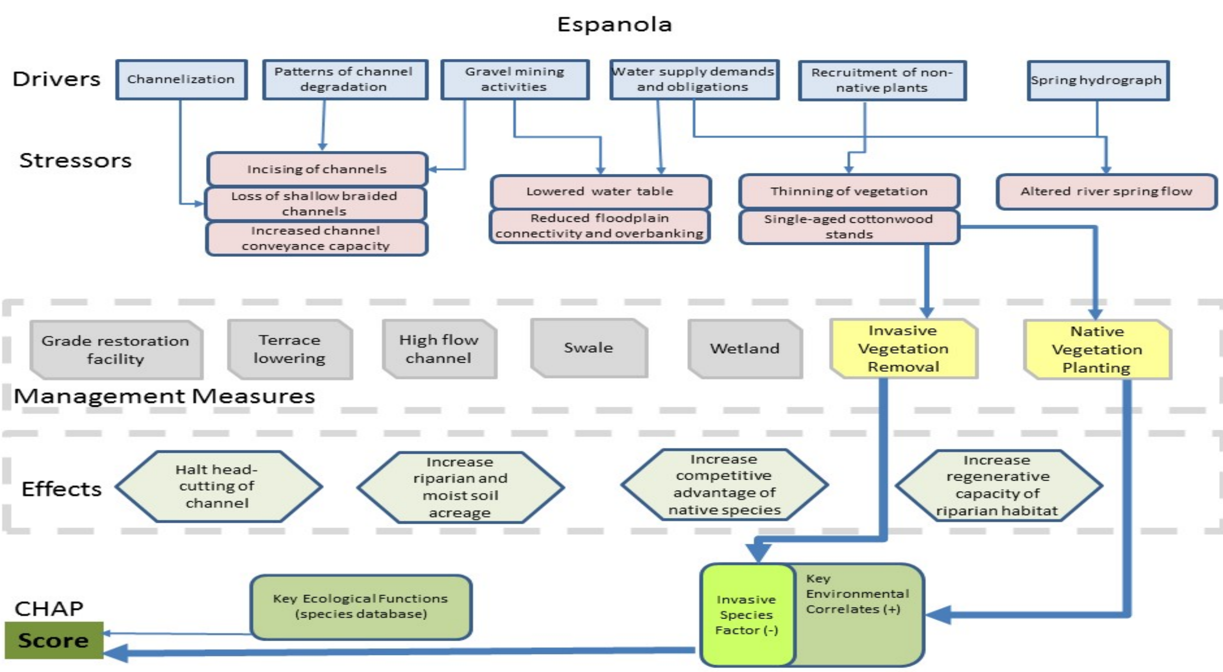


Figure 21 Conceptual model illustrating how invasive vegetation management and native vegetation re-establishment contribute to the CHAP habitat evaluation.

3.5.5 **Habitat Analysis –Conceptual Model and Methods**

The habitat team selected the Combined Habitat Assessment Protocols (CHAP) method to estimate habitat units for economic analysis (approved 16 Jan 2014). CHAP relies on GIS for visualizing individual habitat patch values across the landscape in relation to hydrology, topography, land management and other factors. CHAP is a habitat-based approach to assess ecosystems and provide a mechanism for quantifying changes in habitat quality and quantity over time under proposed alternative scenarios. CHAP uses an accounting and appraisal methodology based on a habitat evaluation framework. CHAP uses an inventory of habitat correlates and species functions (O'Neil et al. 2005) to assess habitat values at multiple scales. CHAP provides an objective, quantifiable, reliable and well-documented process to generate environmental outputs for all levels of proposed projects and monitoring operations in the natural resources arena. CHAP provides an impartial look at environmental effects, and delivers measurable products to the decision-maker for comparative analysis. The CHAP method calculates habitat units (HUs) by combining using an assessment of correlates by habitat type and multiple vertebrate species functions (NWHI 2013a, b). Use of GIS as the foundation for CHAP provides greater spatial resolution for calculating HUs. The spatial resolution supports a broader range of values for differentiation of habitat complexity. Though habitat complexity is generally associated species richness (more species per unit area), CHAP does not assign richness values to vegetation classes.

3.5.5.1 CHAP processes

The most recent Hink and Ohmart vegetation mapping (USBR 2002) was used for identifying coherent vegetation patches (polygons) supports conducting a more precise field inventory of key environmental correlates (KECs, Table 12) for CHAP. Patch size based on the 2002 Hink and Ohmart vegetation survey ranges from 0.15 to 150 acres, with an average size of 9.4 acres. The habitat value per acre by polygon represents the local conditions of the habitat mosaic in the riparian cottonwood forest. The inventory approach allows the habitat team to use CHAP for focusing on restoration measures at a broader range of scales. Table 2 shows the range of habitat values (per acre) for the Hink and Ohmart structural components.

The Key Environmental Correlates (KEC) values are tabulated from the field inventory data for each vegetation polygon. The field inventory was conducted at Ohkay Owingeh and Santa Clara Pueblos using recent vegetation mapping (USBR 2002). The data were compiled into a geospatial database linked to the Hink and Ohmart GIS shapefiles for processing. The field inventory identifies the percent coverage for canopy and understory vegetation, tree and shrub species, biotic, abiotic, anthropogenic, and other identifiable habitat components (NHI 2010; O'Neil et al. 2012). The inventory design supports a more detailed evaluation of habitat patches (particularly small patches) with rapid data acquisition. The polygons with a greater number of observed functions (higher KEC values) identify the suite of functions that produce greater habitat complexity and value. The high KEC value polygons can be used as reference sites (Burks-Copes *et al.* 2007; Burks-Copes and Webb 2009) representing possible target conditions for restoration. Measures that increase habitat complexity are anticipated to increase the KEC values in the habitat function matrix, and overall habitat value.

The Biota Information System of New Mexico (BISON-M) is an online database for all vertebrate wildlife occurring in New Mexico (including all threatened, endangered and sensitive species). The database was queried to provide the initial vertebrate species list for the Española Valley project. The list was reviewed by the habitat team to focus on species likely to occur within the project area boundaries. With the majority of species in the BISON-M list represented in the IBIS database (O'Neil et al. 2005), the Combined Habitat Analysis Protocol was able to use existing Key Ecological Functions (KEFs, Table 12). The KEFs are the number of interactions between vertebrate species, their habitat, and functions as a component of calculating habitat units that have been tabulated in the IBIS database.

3.5.6 **Calculating Habitat Unit Values**

CHAP provides a site-specific, standard methodology for quantifying areas (polygons) based on observable differences in habitat by tabulating ecological functions. The primary components of CHAP for estimating the habitat values (per acre) of proposed measures are the species function matrix (KEF) and habitat function matrix (KEC). The KEF matrix refers to the principal set of ecological roles performed by each species in its ecosystem. These roles include the primary ways organisms use, influence, and alter their biotic and abotic environments. Higher KEF values indicate greater ecological complexity which is a metric for higher value habitat. The KECs represent observed habitat elements (physical and biological) that influence a species distribution, abundance, fitness, and viability. Higher KEC values are a complementary indicator for increasing ecological complexity and higher habitat value.

An invasive species factor based on vegetation changes (effect) was developed with input from the Habitat Team to model the effect of decreasing floodplain connectivity (stressor) for the without-project conditions (Figure 18, Table 13). The Invasive Species Factor (ISF) is a value between 0.0 and 1.0 that adjusts overall habitat values as a function of the coverage of invasive plants (Table 13a). The CHAP field inventory estimates the vegetative cover for invasive herbaceous, shrubs, and trees. Table 13 has the conversion from percent cover to factor value (×) for each cover type. High ISF values indicate low invasive species cover, and low ISF values indicate high invasive species cover. Vegetation management measures to remove invasive plants and support native species would increase the ISF, producing a higher per acre habitat value.

3.5.7 **Habitat Analysis and Results for Projecting Future Conditions**

HUs were annualized by estimating the HUs at years 25 and 50 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.

The polygon-specific CHAP values are projected into the future through several variables. First, anticipated trends for invasive plant coverage (herbs, shrubs, and trees) are estimated for recalculation of the ISF (Table 13b). Invasive plant species would increase the percent coverage under the no management scenario, reducing the ISF which decreases the corrected per acre value (decreased coverage of native species).

Second, the KEFs are calculated at the 25 and 50 year time horizons based on removal of a percentage of the uncommon species. CHAP randomly removes half of the uncommon species (Table 13b) at the 25 and 50 year milestones to evaluate the effects of changing habitat for KEFs. Removing a species during these time period(s) has the effect of changing the functional profile and resiliency of the system because they no longer contribute their ecological functions. These functions are removed from the 25 and 50 year runs because these species are not expected to have viable populations within the project boundary. The removal of species at the 25 and 50 year intervals affects the calculations for these time periods (Table 13b). Calculation of habitat units using the adjusted values for ISF and KEFs (see Table 13b) results in a decrease in habitat value and units for the temporal milestones.

GIS supports detailed evaluation of each measure across the habitat polygons to calculate the without- and with-project habitat values. The proposed measures were mapped onto locations to estimate the area for each measure. The existing habitat values for each measure were assigned from the existing CHAP mapping for the current conditions. Habitat values were then interpolated across 50 years for each measure footprint based on the anticipated vegetation structure at 25 and 50 years post-construction from equivalent existing habitat. The lift in habitat value was then calculated for each measure footprint as the difference between the without and with-project habitat values. The habitat polygons with higher initial habitat values will have a lower lift during the economic analysis. Most of the future with-project habitat values were modeled as increasing the density of native vegetation.

These habitat values were transferred to the measure footprints using GIS to estimate the future without-project values. The future with-project habitat was forecast based on the Hink and Ohmart vegetation classification for each measure type, and habitat values were estimated. The future with-project habitat values were based on current habitat values for target vegetation types anticipated from implementation of the measures. The future habitat values (25 and 50 years) with and without projects were interpolated across years for each measure for the cost-effectiveness analysis.

Table 12 Examples of ecological functions and environmental correlates for the study area.

Key Ecological Functions (KEF) Example species for the project area from the IBIS database	New Mexico Spadefoot Toad	Willow Flycatcher	American Crow	Rock Squirrel	Meadow Jumping Mouse	Coyote
aquatic herbivore	X					
feeds on benthic substrate	X					
seed eater			X	X	X	
fruit eater		X	X	X		X
root feeder				X		
consume terrestrial invertebrate	X	X	X	X		
consume vertebrates			X	X		X
egg eater			X			
carrion feeder	X		X	X		X
prey for secondary or tertiary consumer	X	X		X	X	
supports nutrient cycling	X					
relationships with other organisms		X	X	X	X	X
creates large burrows						X
creates small burrows				X	X	
uses burrows dug by other species				X		X
uses runways created by other species						X
steals food from other species			X			
interspecific hybridization			X			
predation control of terrestrial vertebrate populations						X
disperses seed /& fruits			X	X		X
creates aerial structures			X			
interspecific nest host		X				
reservoir of vertebrate disease				X		
carrier of disease that affect humans				X		
affect soil	X			X		
physically improves soil by digging	X			X		

Polygon SC_009	**Observed Key Environmental Correlates (KEC)**
LIVE TREES	
1.1.14.3.2	Sapling/pole, 1"-9.9" (2.5-25cm)
1.1.14.3.3	Small, 10"-14.9" (25-38cm)
SHRUBS	
1.1.4.2	shrub canopy cover
1.1.4.1.1	Small, <20" (0.5m)
DOWN WOOD	
1.1.1.1.1	Hard [class 1, 2]
1.1.1.4.1	Small, </= 5" large end diameter
1.1.1.4.2	Medium, >5" to <20" large diameter
1.1.1.2	down wood in riparian areas
OTHER BIOTIC FOREST ELEMENTS	
1.1.2	Litter
1.1.6	Flowers
1.1.8	Forbs
1.1.13	presence of herbaceous layer
1.1.16	habitat edges
ABIOTIC FOREST ELEMENTS	
3.3.6	barren ground

Table 13 Española Valley Study Example Calculation.

a. Baseline HAB Calculation Worksheet Format:

Polygon Identification	Acres	Invasive Herbaceous Plants	Invasive Shrubs	Invasive Trees	Invasive Species Factor (ISF)	Species-Function Matrix (KEFs)	Habitat-Function Matrix (KECs)	Uncorrected Per Acre Value	Corrected Per Acre Value	Habitat Units (HUs)
SC_009	2.1	0.3	1	1	0.67	14.90	6.90	21.80	14.59	30.64
From CHAP mapping and GIS										

Invasive species cover	*X*
From observations in the field for each polygon	
0-10%	1
11-35%	0.9
36-65%	0.7
66-90%	0.5
>90%	0.3

Column	Explanation
Invasive Species Factor (ISF)	GEOMEAN accounts for a structural layer not being present within a polygon (e.g., no shrub layer in polygon)
Species-Function Matrix (KEFs)	Equals the sum of the species-function table divided by the number of functions (species-function table)
Habitat-Function Matrix (KECs)	Equals the sum of the habitat-function table divided by the number of functions (habitat-function table)
Uncorrected Per Acre Value	Equals the sum of the two matrices
Corrected Per Acre Value	Equals the uncorrected per acre value multiplied by the invasive species factor
Habitat Units (HUs)	Equals the corrected per acre value of the polygon multiplied by the area of the polygon (acres)

b. Calculated habitat units for future without-project condition at the 25 and 50 year milestones.

Polygon SC_009	Acres	Invasive Herbaceous Plants	Invasive Shrubs	Invasive Trees	Invasive Species Factor	Species-Function Matrix (KEFs)	Habitat-Function Matrix (KECs)	Uncorrected Per Acre Value	Corrected Per Acre Value	Habitat Units (HUs)
@ 25 years	2.1	*0.1*	*0.75*	*0.75*	*0.38*	13.23	6.90	20.15	*7.72*	*16.22*
@ 50 years	2.1	*0.1*	*0.65*	*0.65*	*0.35*	11.80	6.90	18.70	*6.51*	*13.69*

c. Calculated habitat units for future with-project condition at the 25 and 50 year milestones.

Polygon SC_009	Acres	Invasive Herbaceous Plants	Invasive Shrubs	Invasive Trees	Invasive Species Factor	Species-Function Matrix (KEFs)	Habitat-Function Matrix (KECs)	Uncorrected Per Acre Value	Corrected Per Acre Value	Habitat Units (HUs)
@ 25 years	2.1	*0.9*	*0.9*	*0.9*	*0.9*	14.90	x = 11.93	26.83	*24.15*	*50.71*
@ 50 years	2.1	*0.7*	*0.7*	*0.7*	*0.7*	14.90	x = 8.22	23.12	*16.18*	*33.99*

3.6 Cost Effectiveness / Incremental Cost Analysis

With the cost and the output in AAHU's identified for each of the measures, the potential restoration alternative plans were analyzed for cost effectiveness and incremental benefits gained. The plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, is selected and identified as the National Ecosystem Restoration (NER) Plan. Cost-effectiveness and incremental cost analysis (CE/ICA) is the technique used by the USACE to identify cost-effective restoration projects. Analysis of cost effectiveness, compares the relative costs and benefits of alternative plans and identifies those alternative that produce more output per unit cost. The most efficient plans that provide the greatest increase in output for the least increase in cost are called the best buys (BB). The least expensive best buy, which meets the study objectives, is usually chosen as the recommended plan.

Specifically, cost-effectiveness analysis compares the costs and expected environmental outputs among various alternative plans. If different alternative plans can produce the same level of output, only the least expensive (least-cost) choice makes economic sense for implementation. Economically *inefficient* alternative plans can be eliminated from further consideration. Similarly, if one alternative plan can produce a greater level of output for the same or less cost than others (cost-effective), only the greater output choice makes economic sense; economically *ineffective* alternative plans can be eliminated. After elimination of inefficient and ineffective alternative plans, there remain several least-cost, cost-effective alternative plans offering a range of output values from which to identify the means of meeting the ecosystem restoration objective.

3.6.1 Cost Effectiveness Analysis

The software package IWR-Plan suite is used to perform CE/ICA. Once a planning study comprised of variables, outputs, and attributes has been defined, the software can evaluate alternatives by combining and recombining attributes. In this study, ecosystem restoration measures were independently defined and the software was used to evaluate all possible combination of the measures. IWR-Plan displays generated sets of alternatives with the information needed to assist planners manage the alternative plans and keep the plans in context.

Due to the sheer number of management measures, three models were created to evaluate all possible combinations of the 84 management measures. The main model for the entire study area (Yellow box on the right of Figure 22) was separated into to two smaller sub-models corresponding to the tribal boundaries (red and blue boxes in the lower center of Figure 22). The sub-model for each Pueblo was further subdivided into smaller reaches (white circles). Only the best buys from each of the smaller sub-reaches were carried forward to the next tier of models.

The sub-model for Santa Clara Pueblo was subdivided into four reaches (white circles in lower half of Figure 22). The reaches are: Santa Cruz, Middle Rio Grande East Bank and Middle Rio Grande West Bank #1 and Middle Rio Grande West Bank #2. Results generated by the sub-models within Santa Clara Pueblo are as follows:

- Santa Cruz - 8 total plans, 4 are cost effective and 3 best buys;
- Lower Rio Grande East Bank – 267 total plans, 198 are cost effective and 16 best buys;

- Lower Rio Grande West Bank reaches #1 and #2 (combined) – 1,153 total plans, 635 are cost effective and 25 best buys.

The sub-model corresponding to the Santa Clara Pueblo resulted in 9,984 total plans, of which 833 were classified as cost effective and 40 were classified as best buys.

Similarly, one sub-model was created for the Ohkay Owingeh Pueblo (Blue box in the lower half of Figure 22). The sub-model for Ohkay Owingeh Pueblo was further subdivided into three reaches (white circles in upper half of Figure 22). The reaches are: Rio Chama East and West Bank and Middle Rio Grande. Results generated by the sub-models within Ohkay Owingeh Pueblo are as follows:

- Rio Chama East Bank – 8,192 total plans, 217 are cost effective and 14 best buys;
- Rio Chama West Bank – 524,288 total plans, 954 are cost effective and 20 best buys;
- Middle Rio Grande – 128 total plans, 50 are cost effective and 8 best buys.

The sub-model for the Ohkay Owingeh Pueblo resulted in 2,240 total plans, of which 394 were classified as cost effective and 40 were classified as best buy plans.

The best buy plans from sub-models corresponding to each pueblo were then loaded into the main and final model. The main model combined 40 best buy plans from Santa Clara and 40 best buy plans from Ohkay Owingeh Pueblo. In all, 1,638 plans were generated from the main model. Of those, 465 were deemed to be cost-effective and 78 were best buys. Figure 22 is a graphic representation of the nested model configuration used.

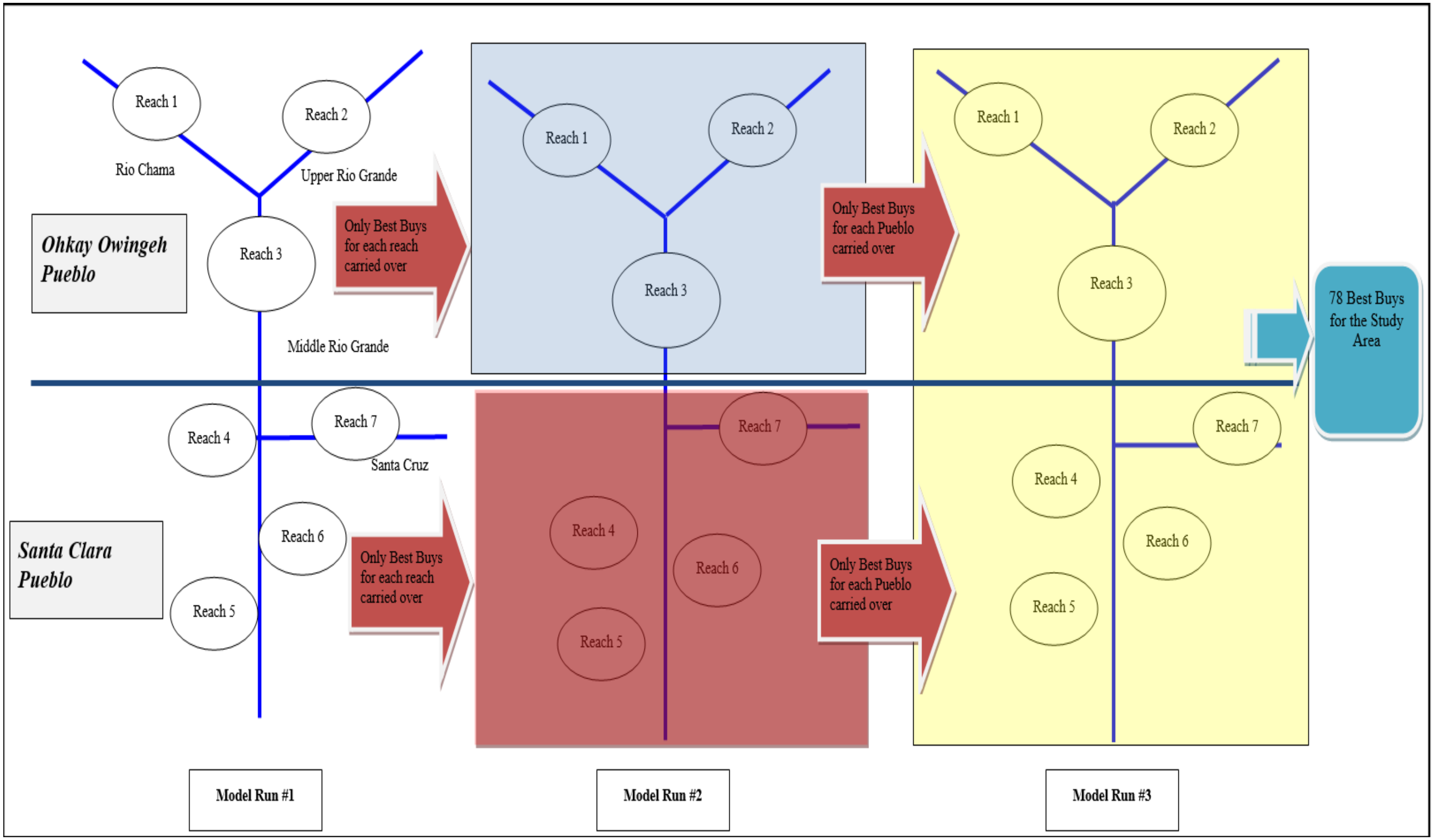
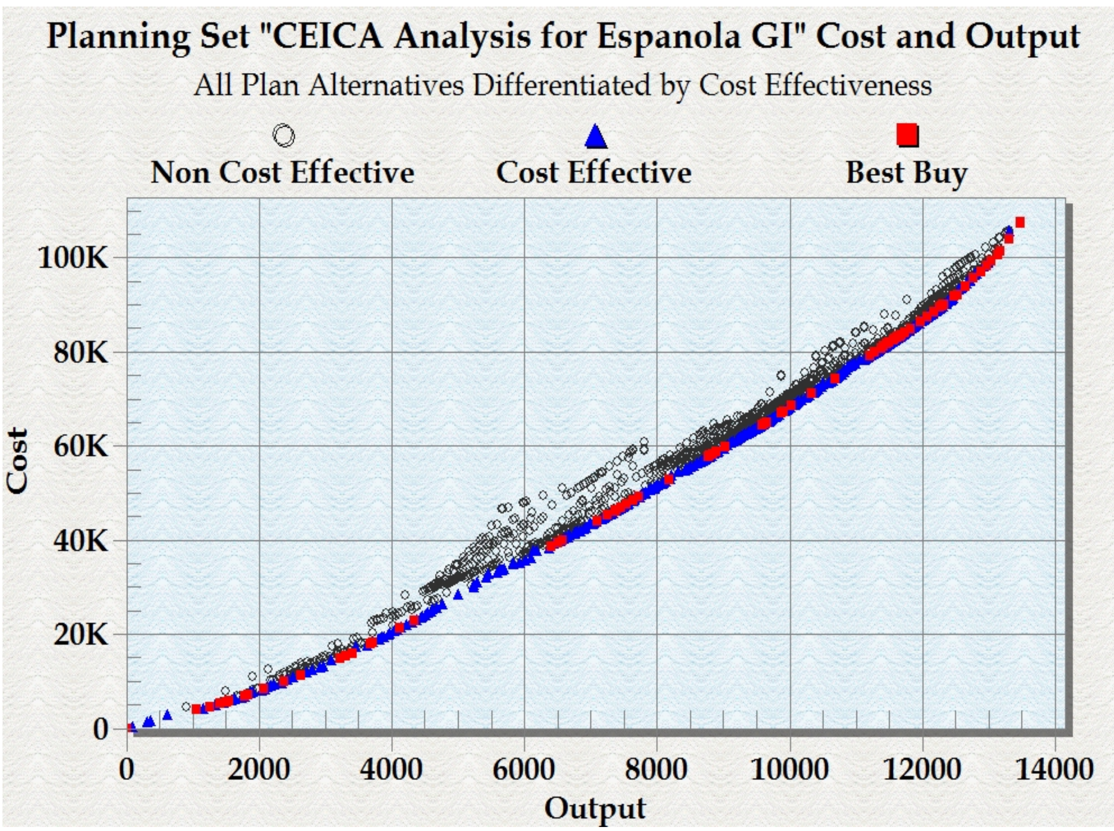


Figure 22 - Visual Representation of the steps in the CEICA process

Thousands of plans were generated and by focusing on the best buys, thousands of plans were identified as not efficient or cost effective and fell out from consideration. The main model (the combination of the two pueblo models), identified alternative plans that provide efficient and effect ways to generate output for the entire Espanola Valley.

The CE/ICA analysis yielded 78 Best Buy plans within a very wide range of both cost and output. The cost of the Best Buy Plans ranged from approximately $3.8 M to $108 M. Output, measured by the CHAP analysis in terms of increased average annual habitat units (AAHUs), range from 3488 AAHUs to 11,211 AAHUs. Figure 23 shows the results of the CEICA analysis. The 78 buys are shown in red dots, cost effective plans in blue and inefficient plans are shown in black circles.

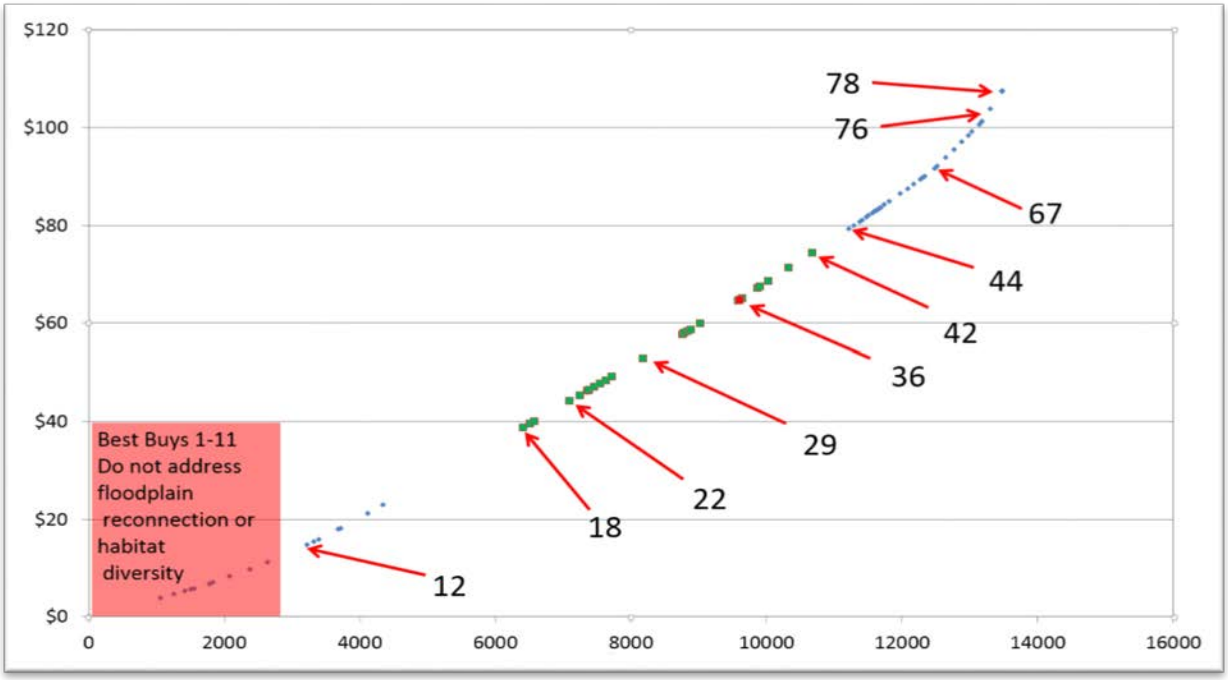
Figure 23 CEICA Cost and Output Graph Showing Best Buy Plans in Red, Cost Effective Plans in Blue and Inefficient Plans in Black.



3.6.2 **Incremental Cost Analysis**

Evaluation of the 78 best buys using the objectives performance identified those plans that would not meet minimum criteria for success. That is, bust buy plans 1-11 provide a minimal amount of vegetation management but do nothing to address floodplain connectivity or increase habitat diversity. Since they do not contribute to two of the three objectives, plans 1-11 were eliminated for further consideration and plan 12 represents the lower bound of the alternatives plans from which the NER plan can be chosen.

Within the remaining 67 best buy plans, nine plans stand out as having a higher incremental output (Figure 24). These nine plans represent break points where higher gains of output are achieved for relatively low incremental cost. The nine best buys constitute the final array of alternative plans (Figure 25) from which to identify the NER plan.



Cost (y-axis) = $ millions and Output (x-axis) = AAHU

Figure 24 – Plot of best buy plans calling out alternatives at break points of incremental cost per output.

The makeup of the final array of plans consists of the combination of measures included in Plan 12 and then for each larger plan includes one or more additional measures. Table 14 shows the rising costs of incremental costs per unit of output as plans increase in scope and Table 15 demonstrates the number and type of measure that is incrementally added to each larger plan.

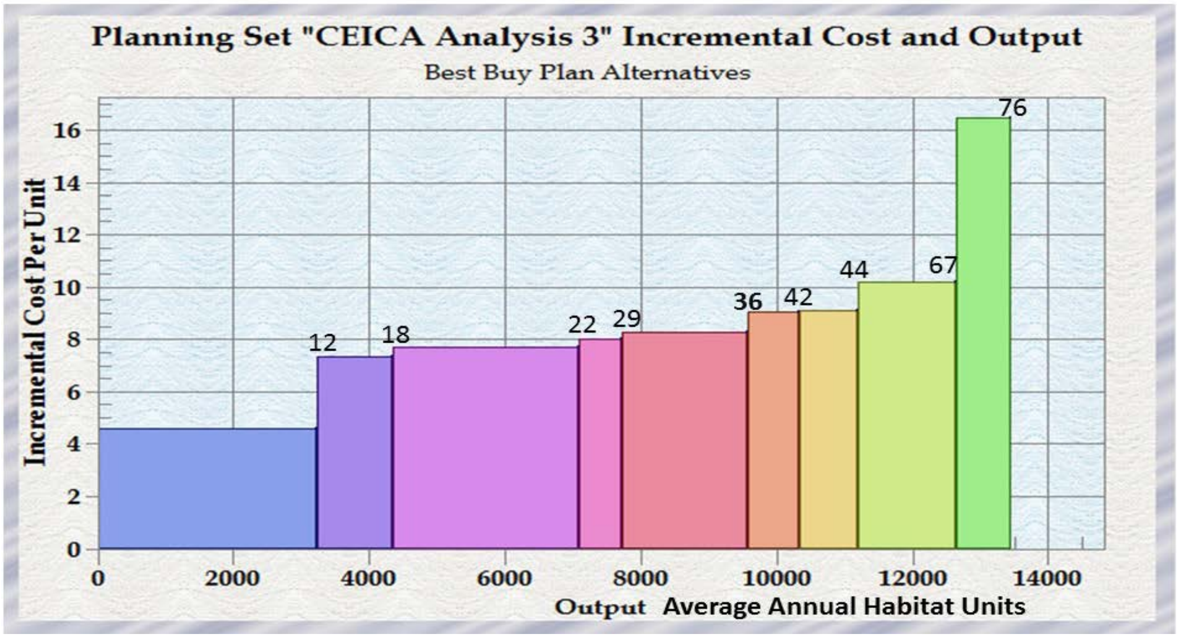


Figure 25 Bar graph showing the cost and output of the final array of alternatives.

Table 14 Incremental Cost per of Unit of Output.

Best Buy #	Output (HU)	Cost ($1000)	Avg. Cost ($1000/HU)	Incremental Cost ($1000)	Inc OutPut (HU)	Inc. Cost per Output
25	7,378.97	46,352.19	6.28	122.01	15.27	7.99
26	7,459.45	46,995.68	6.30	643.49	80.48	8.00
27	7,543.39	47,668.22	6.32	672.54	83.94	8.01
28	7,633.76	48,397.43	6.34	729.21	90.37	8.07
29	7,718.05	49,085.87	6.36	688.44	84.29	8.17
30	8,179.93	52,861.23	6.46	3,775.36	461.88	8.17
31	8,770.68	57,708.77	6.58	4,847.54	590.75	8.21
32	8,793.35	57,895.74	6.58	186.97	22.67	8.25
33	8,840.87	58,288.57	6.59	392.83	47.52	8.27
34	8,885.11	58,654.93	6.60	366.36	44.24	8.28
35	9,026.16	59,828.15	6.63	1,173.21	141.05	8.32
36	9,585.14	64,519.49	6.73	4,691.35	558.98	8.39
37	9,614.58	64,770.64	6.74	251.15	29.44	8.53
38	9,646.71	65,060.26	6.74	289.62	32.13	9.01
39	9,873.53	67,108.89	6.80	2,048.63	226.82	9.03
40	9,905.01	67,393.43	6.80	284.54	31.48	9.04
41	10,027.83	68,503.96	6.83	1,110.53	122.82	9.04
42	10,332.83	71,266.11	6.90	2,762.15	305.00	9.06
43	10,677.45	74,392.22	6.97	3,126.11	344.62	9.07
44	11,210.98	79,256.93	7.07	4,864.71	533.53	9.12
45	11,284.63	79,933.17	7.08	676.24	73.65	9.18

Table 15 Final array of plans showing the types of measures included in each successive plan.

Alt Plan		**Added measures on Santa Clara Pueblo**		***Added measures on Okay Owingeh Pueblo***
12	Basic vegetation	5 vegetation removal		*1 vegetation removal, 1 terrace, 1 grade restoration feature*
18	Plan 12 plus	1 vegetation removal, 3 bankline lowering	*Plan 12 plus*	*1 vegetation removal, 1 high flow channel, 1 grade restoration feature, 2 terrace lowering*
22	Plan 18 plus	2 high flow channels	*Plan 18 plus*	*3 grade restoration features, 1 bankline lowering*
29	Plan 22 plus	3 high flow channels	*Plan 22 plus*	*4 terrace lowering*
36	Plan 29 plus	2 high flow channels, 4 swales	*Plan 29 plus*	*1 terrace lowering*
42	Plan 36 plus	1 high flow channel, 2 swale/wetlands	*Plan 36 plus*	*3 high flow channels*
44	Same as Plan 36		*Plan 42 plus*	*2 high flow channels*
66	Plan 44 plus	1 high flow channel, 2 swales - 1 bankline lowering, -3 vegetation removal, -2 wetland	*Plan 44 plus*	*2 high flow channels, 1 terrace lowering*
76		Not translated*		Not translated*
78		Includes all measures		Includes all measures

* Although Plan 76 included additional measures on one or both Pueblos, the additional measures were not identified (not translated) for this table. It became apparent that Plan 76 would not be chosen as the recommended plan and therefore was not translated from the CEICA. See discussion below on evaluation of the final alternatives.

3.6.2.1 Evaluation of the Final Alternatives Array

To review, from the original 84 measures the CE/ICA software compared all possible combinations of measures. The cost effectiveness analysis screened out all alternative plans that were economically inefficient. From that of efficient alternatives 11 plans do not meet the objectives of the study even minimally and were removed from further consideration. Within the remaining 67 alternatives, incremental cost analysis identified nine alternatives that demonstrate a higher incremental gain of output for relatively low incremental cost. We are left with nine alternatives, the final array of alternatives, from which to choose the NER plan. Generally the “do all plan” is not considered since there is not a larger, more expensive plan to compare it with.

For the next evaluation the alternative plans were compared on the basis of how they meet the study objectives. The alternative plans from the final array achieve increasingly higher outputs through implementation of larger combinations of measures. The larger combinations of measures also achieve a greater number of objectives and to a greater degree. The next step in choosing the NER plan is to identify the least cost plan that meets all study objectives. For this we compare how each alternative plan contributes to the objectives and to what degree. The next section provides the rational for performance targets within each objective. Table 16 describes how measures affect vegetation.

Table 16 Proposed types of ecosystem restoration measures and their effect on vegetation.

Description	Action	Effect
Grade restoration facility (GRF)	Excavate/harden channel	Prevent loss of upstream floodplain connectivity, Increase proximal floodplain connectivity Increase cottonwood / willow density
High-flow Channel	Excavate, re-vegetate CW/W	Increase seasonal water connectivity Increase cottonwood / willow density
Pond	Excavate	Increase aquatic habitat
Vegetation Management	Remove exotic vegetation Re-vegetate with native species	Increase cottonwood / willow / native tree density
Willow Swale	Excavate , re-vegetate	Increase groundwater connectivity Increase cottonwood / willow density
Terrace Lowering	Excavate , re-vegetate	Increase groundwater connectivity Increase cottonwood / willow density
Wetland	Excavate , re-vegetate	Increase groundwater connectivity Increase wetland vegetation

3.6.3 Objectives Performance Targets

Objective performance targets describe specific ecological functions that revers stressors and address the drivers of declining habitat values. The objective performance targets for ecosystem restoration were met, or not met, by the best buy alternatives are discussed in Table 17. The array of best buy alternatives from the economic analysis were compared to the objectives of reconnecting the Rio Grande floodplain, increasing the amount of bosque habitat, and increasing the diversity of habitat types.

Table 17 Targets and Analysis per Objective.

OBJECTIVE 1: RECONNECT THE RIO GRANDE FLOODPLAIN	
Target	**Alternatives Analysis**
Increase the number of acres inundated during spring runoff.	Each of the best buy Alternatives 12 to 44 would meet this part of the objective.
Halt the headcut using appropriate and effective measures.	Each of the best buy Alternatives 22 to 44 would meet this part of the objective.
Floodplain Connectivity on Ohkay Owingeh Pueblo	
The terrace lowering measures produce greater floodplain connectivity and inundation during spring runoff by lowering floodplain surface elevations.	Terrace lowering increases inundation by lowering the floodplain elevation adjacent to the river. Alternative 18 has 1/3 of the potential acreage, doubling in Alternative 30. Most of the terrace lowering occurs on Ohkay Owingeh Pueblo.
The grade restoration facilities (GRFs) stabilize the channel bed through and upstream of the incised channel with constructed riffles.	The complete set of GRFS in Alternative 22 protect the upstream reaches on the Rio Chama and Rio Grande from channel incision. The GRFs increase local floodplain connectivity by raising the bed elevation.
Floodplain Connectivity on Santa Clara Pueblo	
The high-flow channels transport the river into the interior riparian areas during spring runoff.	Alternative 44 implements the most complete set of high-flow channels in the project area. Suitable topography for high-flow channels currently supports higher value habitat.
The willow swales and wetlands lower the ground elevation to increase groundwater connectivity to support thick stands of willows and cottonwoods.	Alternative 36 implements the majority of the willow swales / wetlands measures. These measures produce healthy patches of desirable willow and cottonwood bosque habitat with groundwater connectivity.
OBJECTIVE 2: INCREASE THE AMOUNT AND QUALITY OF BOSQUE HABITAT	
Target	**Alternatives Analysis**
Increase the number of acres and riparian habitat value (per acre).	Each of the best buy Alternatives 12 to 44 would meet this part of the objective.

Ohkay Owingeh and Santa Clara Pueblos	
The removal of invasive plants with subsequent planting of native species increase the structural complexity and quality of the bosque habitat patches.	The majority of invasive species removal across the project is achieved by Alternative 18. Stand-alone vegetation management is generally a highly effective low cost measure where groundwater / river connectivity is suitable for replanting riparian vegetation.
The planting of native plants on the floodplain connectivity measures increases the structural complexity and quality of the bosque habitat patches.	Re-establishing native plant species following excavation of floodplain connectivity measures accelerates development of the desirable vegetation. The measure increases with each of the floodplain connectivity measures that are implemented.
OBJECTIVE 3: INCREASE BOSQUE HABITAT DIVERSITY	
Target	**Alternatives Analysis**
Distribute ecosystem measures across the project area, and balance acreage for each sponsor.	Each of the best buy Alternatives 29 to 44 would meet this part of the objective.
Ohkay Owingeh and Santa Clara Pueblos	
The placement of the floodplain connectivity and vegetation management measures across lands for both sponsors produces a mosaic of different vegetation types at varying stages of structure.	The broad distribution of measures to produce a mosaic of quality riparian habitat patches across the project area would be achieved with Alternatives 36 to 44.

3.6.4 Comparison of the Alternatives and Selection of the Recommended Plan*

Project objectives targets described above were used to compare best buy alternatives generated by the CE/ICA analysis. Alternative plans are compared to determine the level to which each of the plans met the objectives (Effectiveness) and whether the plans include all the components necessary to achieve the stated outputs (Completeness).

Objective 1. Reconnect the Rio Grande and its tributaries to their floodplains within the study area for the life of the project. The progression of plans have increasing area of floodplain connectivity through a) the GRFs raising the channel and halting the headcut, and b) excavation to lower floodplain surfaces for terrace lowering, high-flow channels and willow swales. Plans 22 and higher have the complete set of GRFs for stabilizing the headcut (Objective 1a). Plans 36-44 increase floodplain connectivity using additional measures to satisfy Objective 1b.

Objective 2. Increase the amount and quality of valuable bosque habitat in the study area for the life of the project. Each of the measures contributes to an increase in habitat quality through removal of exotics, planting new native vegetation or reconnecting the river to the floodplain. Reconnection of the floodplain contributes indirectly to the quality of habitat by providing the hydraulic connection to water that invigorates vegetation and provide conditions for native plant recruitment. Plans 36-44 contain measures covering more than 200 acres that manage vegetation to increase native habitat types as well as a number of measures that increase habitat quality through reconnection of the floodplain (Objective 2a).

Objective 3. Increase the diversity of riparian habitat types in the study area for the life of the project. The measures in Plan 36 and higher are spatially distributed evenly across the entire project area (Objective 3a). Plan 36 and higher also provide a more balanced mix of each type of measure across the entire study area (Objective 3b). Plans 21 and higher produce a mosaic of vegetation patches within the future riparian habitat (Objective 3c).

3.6.5 **Summary**

Measures contained in the final array of alternatives each contribute to performance targets and therefore study objectives. The number, composition and distribution of measures in each alternative dictate how alternatives satisfy the performance targets

The GRFs increase local floodplain connectivity by raising the elevation of the river channel and the water surface closer to the elevation of the adjacent terraces. The GRFs also halt future channel incision by the headcut and would protect upstream riparian habitat and floodplain connectivity. The increase in riparian vegetation adjacent to the GRFs was modeled in CHAP, but not the protective value of the GRFs for upstream habitat.

Terrace lowering and high-flow channels require moderate excavation to achieve the objectives than willow swales or wetland ponds. Wetland ponds require deeper excavation to intercept the water table and significantly increase costs over terrace lowering, high-flow channels, and willow swales. Though wetland ponds are important, they are structurally simple ecosystem components relative to the surrounding riparian forest. This results in a lower CHAP habitat score than a qualitative assessment by wetland scientists would produce.

Evaluation of the final array of alternatives using performance targets point to those alternatives from 22 to 44 as contributing to all objectives to some degree. Alternatives 36 through 44 meet these objectives to a greater degree and with a more even distribution of measures across the study area than smaller alternatives. The next Section evaluates each of the final alternative on its ability to meet objectives in order to identify the one alternative that best meets the complete set of objectives and objective targets.

3.7 Description of the Final Array of Alternatives*

3.7.1 **The No Action Alternative***

Under the no action alternative (WOP in Table 20), there would no construction of any ecosystem restoration measures. For comparison with other alternatives, the 544 acre footprint for the complete suite of measures is evaluated for the future without project (Table 20). The current CHAP habitat value for the no action alternative footprint is 9201 HU, with the 50 year AAHU of 3489. The trend illustrated by the no action alternative is declining habitat unit values for the location of proposed habitat measures.

3.7.2 **Action Alternatives***

3.7.2.1 Minimal Floodplain Connectivity Alternative (Plan 12*)*

The Minimal Floodplain Connectivity Alternative produces minimal floodplain connectivity through terrace lowering and the one upstream GRF. This alternative includes the low-cost, stand-alone vegetation management measures, with one terrace lowering and one high-flow channel measure. This alternative does not meet the objective of increasing floodplain connectivity and only minimally meets the objective of increasing diversity of habitats.

3.7.2.2 Vegetation Management Alternative (Plan 18*)*

The Vegetation Management Alternative slightly increases the floodplain connectivity through terrace lowering and the two upstream GRFs on the Rio Chama and the Rio Grande. This alternative includes most of the low-cost, stand-alone vegetation management measures, and one-third of the possible terrace lowering acreage, with a single high-flow channel.

3.7.2.3 Headcut Stabilization Alternative (Plan 22)

The headcut Stabilization Alternative has the complete set of three GRFs which halt the upstream progression of the headcut, and increases floodplain connectivity. The acreage for the GRFs is based on direct increased floodplain connectivity. By halting the upstream incision caused by the headcut, the GRFs would protect an additional 644 acres of riparian habitat and floodplain connectivity. The number of high-flow channels increases in this alternative over plan 17 while vegetation management measures, and terrace lowering acreage remains the same.

3.7.2.4 Willow Swales Alternative (Plan 29)

The Willow Swales Alternative has the significantly increased floodplain connectivity that is included in plan 21 with increased acreage of high-flow channels and is the first plan to include willow swales. This represents the beginning of increased diversity but falls short including enough diversity to meet the objective.

*3.7.2.5 Habitat Diversity Mosaic Alternative (Plan 36 - *Recommended Alternative)*

Alternative 36 includes a relatively even distribution of habitat restoration measures across the study area. In fact, acreage of measures are balanced between the Pueblo of Ohkay Owingeh (149 acres) and Santa Clara Pueblo (165 acres). This Alternative 36 has increased acreage of willow swales over plan 30, close to the maximum area proposed. The swales significantly increase habitat diversity.

Alternative 36 includes a relatively even distribution of measures across the study area.

Table 18 Habitat restoration acreage compared to the existing floodplain for the recommended alternative, Plan 36.

Inundation Frequency	Existing Floodplain	Habitat Restored	Habitat Protected	Total Habitat	Percent Habitat
0.500	735.0	38.4	206.5	245.0	33%
0.200	866.9	36.9	179.5	216.4	25%
0.100	914.3	58.3	121.2	179.5	20%
0.040	380.7	26.8	47.9	74.8	20%
0.020	403.1	70.9	35.8	106.7	26%
0.010	179.2	15.0	28.4	43.4	24%
0.005	78.8	6.3	9.4	15.7	20%
0.002	327.9	44.5	12.9	57.4	17%
	3886.0	297.2	641.7	938.9	24%

3.7.2.6 Alternative (Plan 42)

Alternative 42 adds a secondary high flow channel in an important wetland area on Santa Clara Pueblo, and adds a 1.2 acres open water wetland. The plan provides an incremental increase in area for high flow channels, swales, and terrace lowering at sites with good existing riparian habitat.

3.7.2.7 High-Flow Channels Alternative (Plan 44)

The High-Flow Channels Alternative increases acreage of high-flow channels above the Habitat Diversity Mosaic Alternative (36). A larger number of high-flow channels were proposed through habitat with higher initial values, resulting in less habitat lift per unit cost. The acreage for the stand-alone vegetation management measures, the GRFs, terrace lowering, and willow swales is functionally unchanged from Habitat Diversity Alternative.

Table 19 Habitat restoration acreage compared to the existing floodplain for Plan 44.

Inundation Frequency	Existing Floodplain	Habitat Restored	Habitat Protected	Total Habitat	Percent Habitat
0.500	735.0	62.3	206.5	268.8	37%
0.200	866.9	104.1	179.5	283.6	33%
0.100	914.3	114.1	121.2	235.3	26%
0.040	380.7	43.5	47.9	91.5	24%
0.020	403.1	87.1	35.8	122.9	30%
0.010	179.2	17.9	28.4	46.3	26%
0.005	78.8	7.2	9.4	16.6	21%
0.002	327.9	49.8	12.9	62.6	19%
	3886.0	486.0	641.7	1127.6	29%

Coordination with the U.S. Fish and Wildlife Service reveals that potential habitat for the Southwest Willow Flycatcher occurs within the Okay Owingeh Pueblo. One of the added measures included in alternative 44 would cause an adverse effect on the habitat during implementation.

3.7.2.8 Alternative (Plan 67)

Alternative 67 increases the acreages for high flow channels, swales, and wetlands. Willow swales and high flow channels have been maximized in this alternative. Includes an adverse effect on SWWFC habitat.

3.7.2.9 Wetland Alternative (Plan 76)

Alternative 76 has a substantial increase for wetlands, maximizing the acreage over the previous alternatives considers (41.2 acres – Plan 67). Includes an adverse effect on SWWFC habitat.

3.7.2.10 Maximize Connectivity Alternative (Plan 84)

The Maximize Connectivity Alternative would construct all proposed ecosystem restoration measures. Comparison with the no action alternative illustrates the potential maximum for increasing habitat units over the period of analysis. All of the terrace lowering, high-flow channels, and willow swales would be constructed over the project area.

In Table 20 shows increasing acreage of measures for each of the alternatives in the final array. Moving from left to right through the alternatives, the acreages get larger due to the larger plan and an increasing number of types of ecosystem measures are added as well. The top row of Table 20 increase the amount and quality of valuable Bosque habitat" shows that vegetation removal reaches its maximum at plan 18. This suggests that the amount of habitat is relatively large but as discussed earlier, the other objectives will contribute to quality of habitat. Similarly, all the GRF measures are included in alternative 22 and above so that this method of reconnecting the river and floodplain is at its maximum.

Terrace lowering is included in small alternatives and reaches its maximum at plan 36. High flow channels are included in relatively small alternatives (22-36) and continue to increase in number of instances and acreage throughout all alternatives.

The measures that contribute to the last objective are swales and swale/wetlands and do not appear in any plan smaller than plan 36. Larger alternatives only add a few of these features.

Alternative 36 is the first plan to include measures to address all the objectives. While larger alternatives contribute to floodplain connection and habitat diversity to a greater degree there is not a large increase. As stated in the description of plan 44, this plan includes measures that impact habitat for endangered species. The first alternatives to meet all objectives and before negative impacts are realized appears in alternatives 36 and 42. While plan 42 includes additional measures that reconnect the river and floodplain, alternative 36 does contribute significantly to this objective. The PDT determined that the additional connectivity in Alternative 42 was beneficial, however, Alternative 36 includes enough of these measure to be effective and compete. Therefore the first alternative that meets the objectives is alternative 36 (Figure 26).

Table 20 Array of best buy measures.

Ecosystem Restoration Objectives	Ecosystem Measures	WOP[b]	Best Buys (acres of restored habitat)								
			12	18	22	28	29	36[c]	37	42	44
Increase the amount and quality of valuable bosque habitat	Vegetation Removal (Invasive plant species removal)	0	80.7	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0
Reconnect the Rio Grande and its tributaries to their floodplains	GRF	0	30.2	30.2	80.2	80.2	80.2	80.2	80.2	80.2	80.2
	Reduce habitat loss	0			643.5	643.5	643.5	643.5	643.5	643.5	643.5
	High flow channel	0	1.8	1.8	8.1	14.5	17.7	21.2	22.3	46.4	59.1
	Terrace lowering	0	1.7	24.2	43.4	56.5	56.5	57.4	57.4	57.4	57.4
Increase the diversity of riparian habitat types	Swale	0						47.5	47.5	47.5	47.5
	Swale / wetland	0						17.0	17.0	19.4	19.4
	Wetland	0								1.2	1.2
Measure Footprint (acres)		544	114	147	189	208	212	314	315	343	356
Total Habitat Restored (acres)		0	114	147	866	886	889	958	959	987	999
Project habitat units[a]		3488.9	2,577	3,467	17,300	17,830	17,913	19,781	19,810	20,529	20,873
Total Cost ($1,000's)			14,748	22,930	44,159	48,397	49,085	64,519	64,770	71,266	74,392

a. *AAHU for the total acres in the previous row.*
b. *WOP – without project*
c. *Recommended plan.*
d. *Acreage includes ponds with high costs and lower appraised habitat values.*

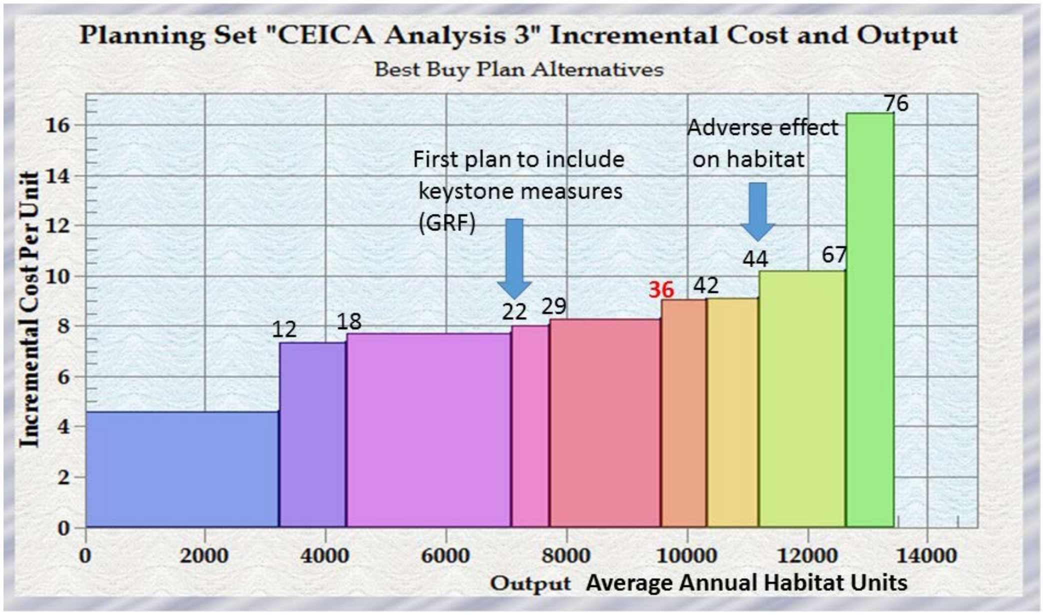


Figure 26 Incremental cost analysis graph from the IWR software suite.

3.8 Description of the Recommended Plan*

The Best Buy Alternative 36 was selected as the recommended alternative because it provides contributions to all of the study and Federal objectives (Figure 26). It is the least cost plan to meet all three objective targets while providing an even distribution and composition of measures across the entire study.

The recommended alternative (Best Buy 36) would construct an economically efficient subset of the proposed ecosystem restoration measures. Implementation of the recommended alternative will contribute to the customs, beliefs, and practices essential to the cultural identity and continuity of the people of Santa Clara, and Ohkay Owingeh. It will also meet the study objectives of reconnecting the Rio Grande and its tributaries to their floodplains, increase the amount and quality of valuable bosque habitat, increase the diversity of riparian habitat types in the study area.

Comparison with the no action alternative shows that this alternative increases habitat by 19,781 AAHU for the constructed measures. This alternative captures 63% of the potential habitat units in the alternative with all of the proposed measures (plan 78). The alternative is balanced for distributing the measures (by acres) for both sponsors and provides an even distribution of measures across the study area. It also provides a variety of types of measures. Alternative 36 implements all of the vegetation management measures, all of the GRFs, a significant number of high flow channels on the Santa Clara Pueblo and most of the terrace lowering and willow swale measures.

The recommended plan consists of 314 acres of ecosystem restoration measures to restore and protect 958 acres of the bosque within the study area. The measures are designed for a) improving hydrologic connectivity with the floodplain by constructing grade restoration facilities (GRFs), high-flow channels, terrace lowering, willow swales and wetlands, and b) restoring native vegetation and habitat through exotic species reduction, and by riparian forest re-vegetation with native plant species. Each of these proposed measure types will be discussed below. Work would be phased over eight to twelve years depending on expected funding streams with an initial construction phase potentially in the fall of 2020.

The proposed GRFs would halt upstream migration of channel incision, and provide additional floodplain connectivity. The GRFs to be constructed on Ohkay Owingeh Pueblo would improve floodplain connectivity for about 80 acres, and prevent the loss of approximately 644 acres by arresting the channel incision that would occur under the future without project. Terrace lowering would provide over 57 acres of connectivity with the river by excavating the banks. The proposed high-flow channels (21 acres) would transport much-needed water across the terraces to bosque vegetation and improve floodplain connectivity on both Pueblos. Willow swales (48 acres) provide microenvironments in which native plants can thrive due to the reduced depth to the water table and moist soils. The proposed swale/wetland measures (17 acres) focus on development of open water or marsh wetlands with fluctuating water levels and various vegetative species. These wetlands provide open water habitat for migrating and local waterfowl, and provide aquatic habitat for numerous species.

Vegetation removal and replanting is a component of most measures. Grubbing the sites is the initial step for the excavation measures, followed by planting with native plant species. Vegetation management measures are also proposed as standalone measures (91 acres). Removal of invasive plants and planting of native species removal increases the habitat value and enhances the aesthetic aspects of the bosque.

The proposed measures in Best Buy 36 provide a cost-effective strategy to mitigate channel degradation, while increasing habitat heterogeneity, function and value throughout both Ohkay Owingeh and Santa Clara Pueblos. These ecosystem restoration measures would reconnect the Rio Grande to the floodplains throughout the bosque on both Pueblos with GRFs, high-flow channels, terrace lowering, willow swales and wetlands. The six GRFs are essential for halting current and future channel degradation to address the loss of floodplain connectivity on Ohkay Owingeh Pueblo are measures in Best Buy alternatives 21 and higher. Achieving significant bosque ecosystem heterogeneity, function and habitat value depends on locating measures throughout the project area with Best Buy plan 36 and higher. Best Buy 36 includes a side-channel on Santa Clara Pueblo that contributes important wetland habitat consistent with costs for other measures. The incremental cost per habitat unit increases significantly with Best Buy alternatives 42 and higher. The measures proposed in Best Buy 36 provide the broadest distribution of cost-effective habitat features.

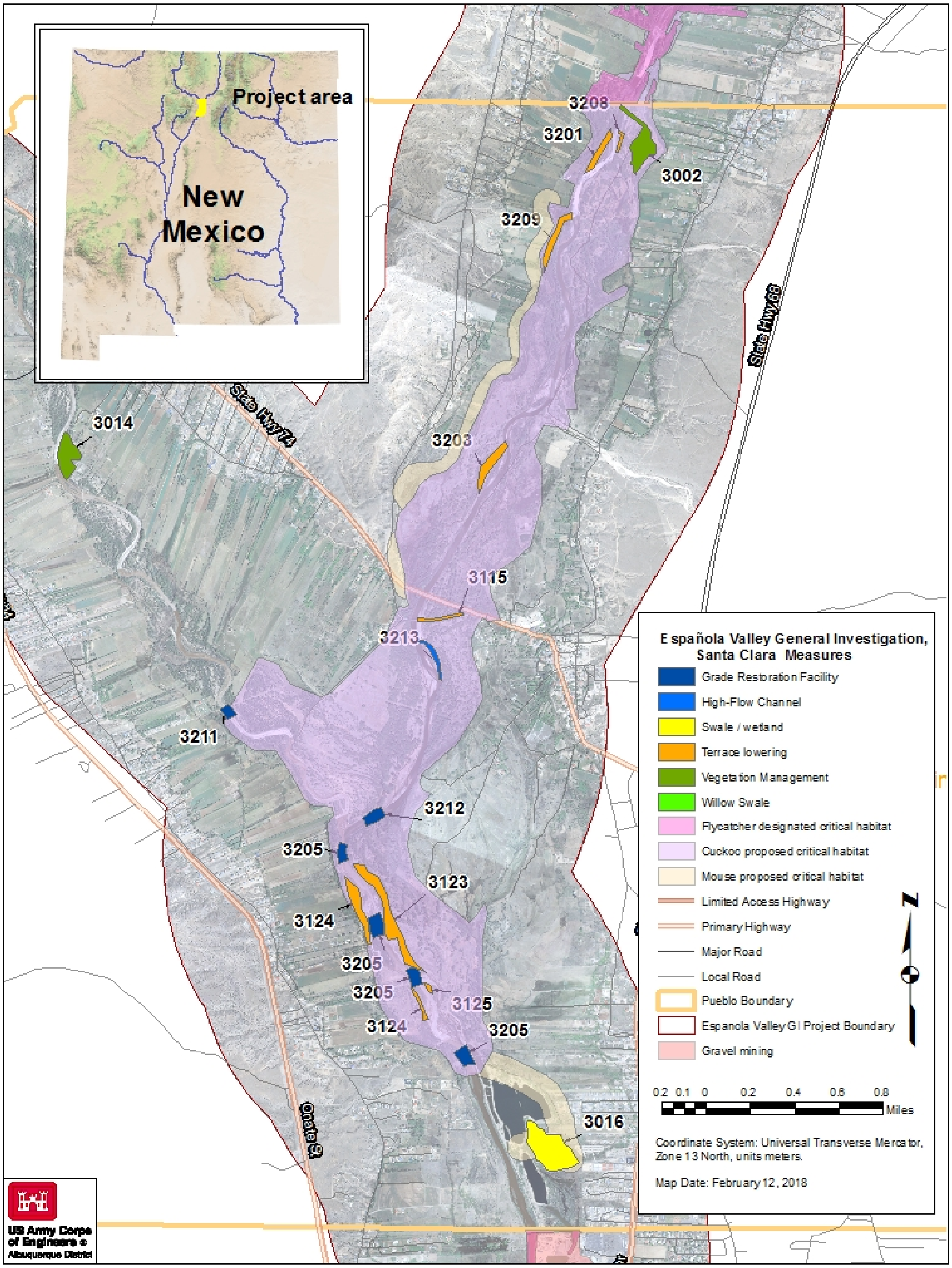


Figure 27 Location of ecosystem measures on Ohkay Owingeh Pueblo.

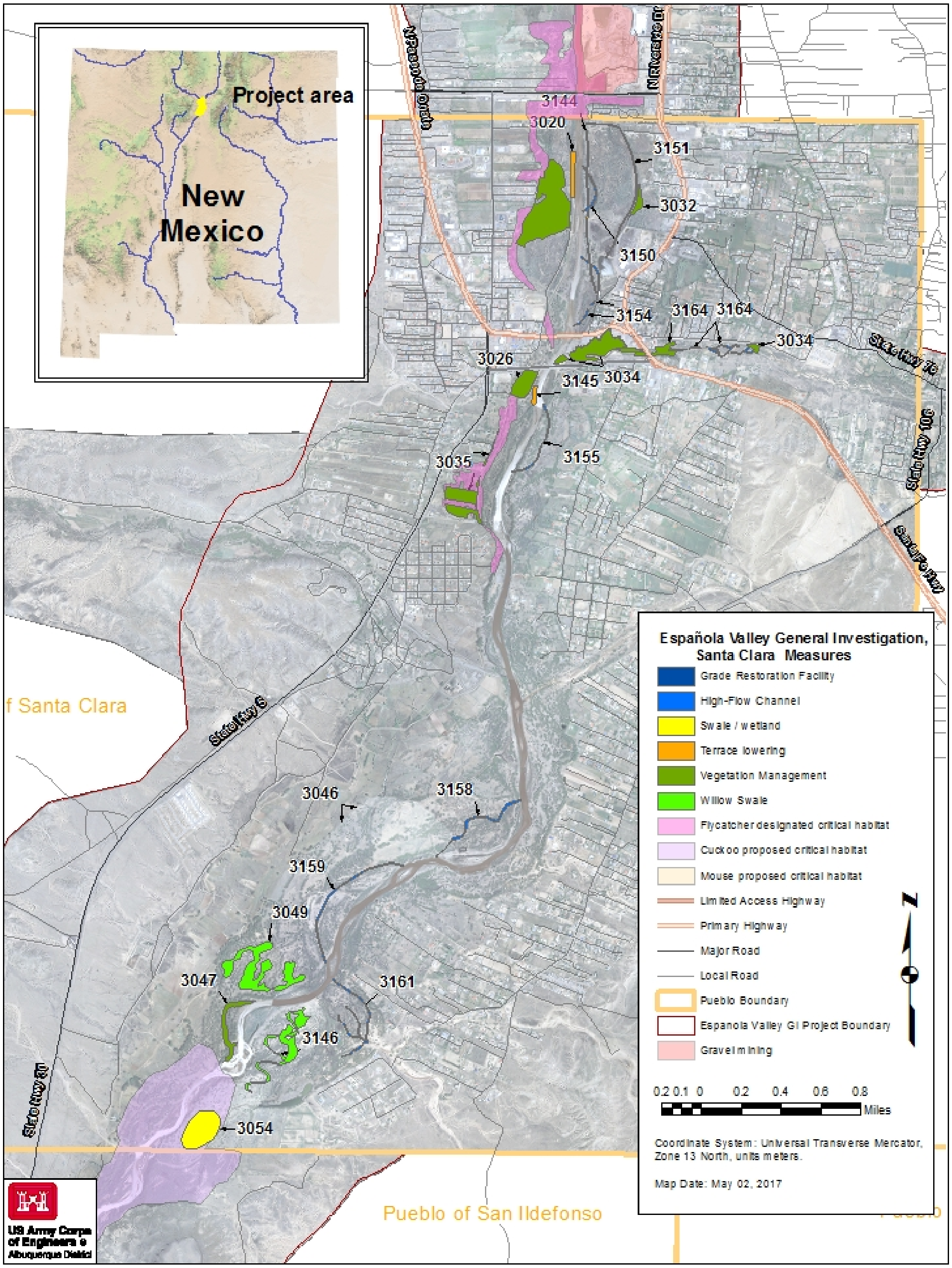


Figure 28 Location of ecosystem measures on Santa Clara Pueblo.

3.8.1 Contributions to the four Federal accounts

As discussed in Section 1.7, the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (March 10, 1983) establishes four accounts to facilitate the evaluation and display of effects of alternative plans. They are described in ER 1105-2-100, Planning Guidance Notebook, paragraph 2-3. The evaluation of the recommended plan against those accounts follows:

- The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services. The Espanola ecosystem restoration does not directly contribute to the NED account, however, indirect benefits gained from a healthy riparian ecosystem may be realized through flood attenuation and reduction in downstream flooding or sediment retention in this reach of river preventing sediment deposition in downstream flood and water supply facilities.

- The Environmental Quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans. The array of plans described have ecosystem restoration as their stated goal. The recommended plan was selected for efficiently providing EQ benefits while meeting planning objectives.

  All of the best buy plans would contribute to the EQ account by providing an increase in habitat and therefore benefits to the EQ account as quantified by AAHU's. Benefits to the EQ account increase with plan outputs as does the costs for the project and incremental costs for each AAHU. As described earlier only 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.

  Water Quality – Reconnection of the river channel to overbank area would provide some improvements to water quality through natural filtration in riparian areas. An increase in wetland area particularly those located at storm water outfalls would filter water and break down some pollutants through biologic processes.

  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 also acts as a heat sink during warmer months providing a corridor of shady, relatively moist environment that contrasts the urban asphalt and concrete.

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

  Essentially the larger the project is the more benefits to this account would be. This is quantified both in total AAHU and incremental costs per AAHU.

- The Regional Economic Development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment). This account is typically used to capture the regional impacts of a large capital infusion of project implementation dollars on income and employment throughout the study area through the use of income and employment multipliers. A recent study for the Nuclear Watch of New Mexico suggests that public sector multipliers tend to be below 1.5, while the Department of Energy claimed multipliers of 2.4 to 3.5 in fiscal year 1998. The important point to be made here is that a large infrastructure project (over $70 million) in the Española Valley will have a positive impact on local income and employment.

- The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. In most cases, impacts of proposed projects not covered in other accounts are described and evaluated here. Primary affects to OSE from the proposed restoration would benefit health, standard of living and education by providing a public area of improved aesthetics, air quality and providing recreational and educational opportunities. There would be significant benefits to the community from the facilities provided from the recreation component of the project, increase in quality of the recreational experience and educational opportunities within the project area.

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

  For the Pueblos, the bosque is an integral part of the cultural landscape and the improvements contribute to social identity and cultural practices. A healthy bosque ecosystem contributes to carrying out of customs, beliefs, and practices essential to the cultural identity and continuity of the people of Santa Clara, Ohkay Owingeh, and San Ildefonso.

3.8.2 Monitoring and Adaptive Management

Recent USACE guidance (*Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 – Monitoring Ecosystem Restoration*) requires that a plan be developed for monitoring the success of the ecosystem restoration. Due to the relatively recent emergence of restoration science and inherent uncertainty in some aspects of ecosystem restoration theory, planning and methods, success can vary based on a variety of technical and site-specific factors. Recognizing this uncertainty, it is prudent to allow for contingencies to address potential problems in meeting restoration goals that may arise during or after project implementation. A plan was developed for monitoring the success of the ecosystem restoration that includes 1) 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 use of restoration measures with demonstrated success in the Middle Rio Grande focuses monitoring on project-level implementation. Post-construction monitoring is an important component of the adaptive management process, as performance feedback may generate new insights on ecosystem response and provides a basis for determining the necessity or feasibility of subsequent design or operational modifications (GeoSystems Analysis 2014). Success should be measured by comparing post-project conditions to the restoration project purpose and pre-project conditions.

Monitoring also provides the feedback needed to refine established protocols and make adjustments where and when necessary to achieve the desired results. Monitoring of other Rio Grande restoration projects by the USACE and other stakeholders in the Middle Rio Grande Endangered Species Collaborative Program provides information that has been useful in developing goals and alternatives used in the formulation of the Espanola Valley Restoration project.

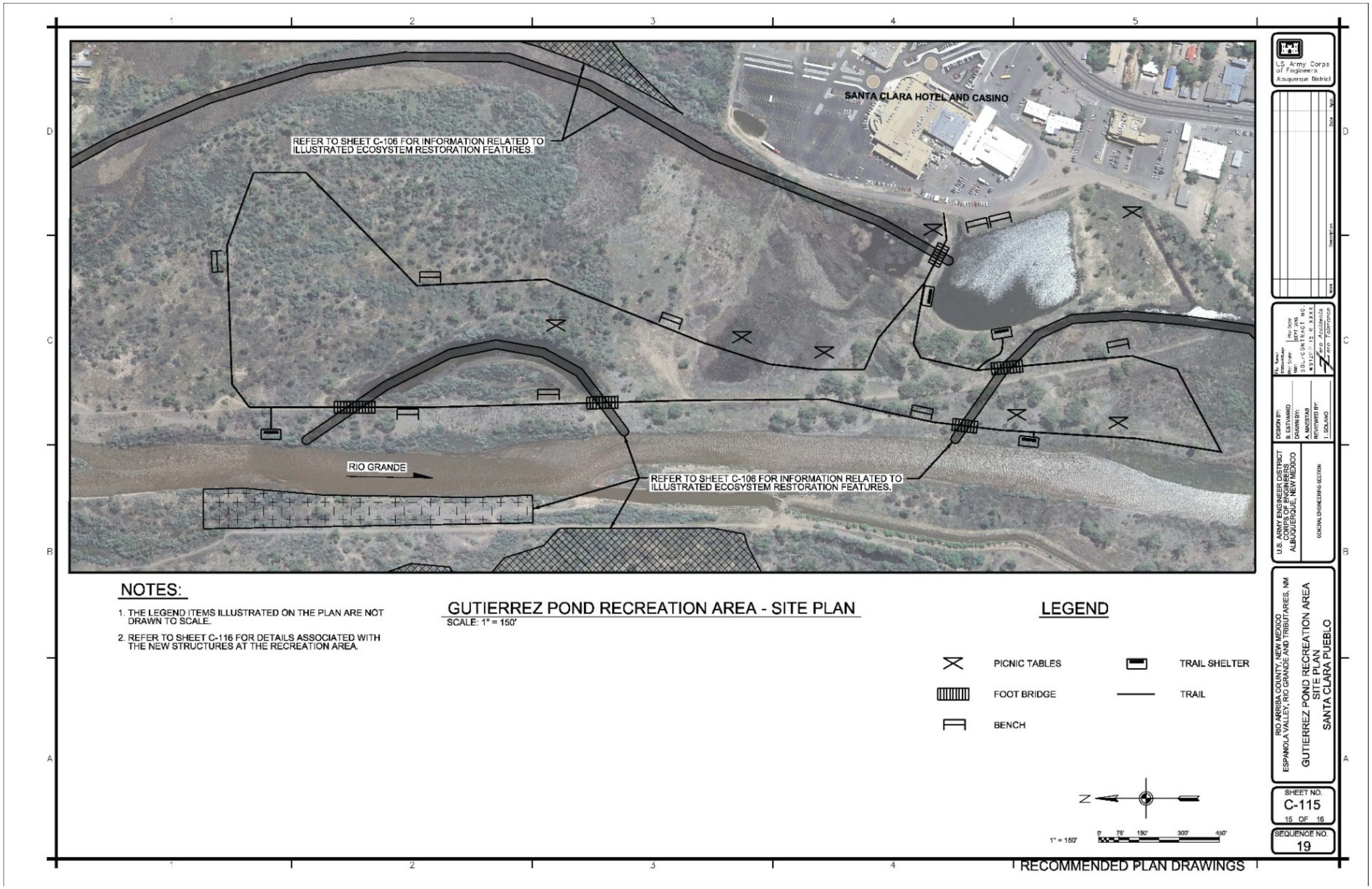
Monitoring of project performance and success would be conducted for at least five consecutive years following construction. Wetland and bosque monitoring would include vegetation survival and mortality, wildlife and vegetation species inventories, floodplain inundation monitoring, and other environmental indicators of project level success for the ecosystem restoration measures. Project monitoring would be coordinated with each sponsor and incorporated with ongoing efforts to reduce duplicate effort. These efforts would continue post-construction to show project benefits and changes in use before and after construction. Wildlife use by ecosystem measures may also be conducted to document parameters inputs for CHAP.

Part of this monitoring may provide information on design that may require changes. Depending on how the project measures function (i.e., as high flows move through the channel, as scouring and/or buildup of sediment could occur), adaptive management would be enlisted to make changes in the field if it is determined to be needed once the recommended plan measures are in use.

3.8.3 **Proposed Recreation Features**

The recreation plan for the Espanola Valley General Investigation study was derived from a 2014 recreation master plan prepared by USACE for Santa Clara Pueblo. Ohkay Owingeh Pueblo wished not to include a recreation plan as a part of their portion of the study. The recreation amenities should complement and not detract from the ecosystem restoration components. Recreational amenities would include formalized gravel trails, informational kiosk and shade structures and park benches. Where possible, gravel trails would follow existing primitive trails or access road alignments. Kiosks and benches would be placed at strategic locations along improved trails. USACE participation is conditioned on provision of reasonable public access rights-of-way, consistent with attendance used in benefit evaluation and in accordance with local recreational use objectives.

Figure 29 Map of proposed recreation plan.



The recreation plan is proposed for one small area in the Santa Clara Pueblo. The plan would allow for interpretive nature trails and amenities at a public access site on the east side of the Rio Grande in the Town of Espanola. Table 21 defines the features, quantities and cost for each feature. The recreation plan is designed to be compatible with the ecosystem restoration purpose of the project and has an estimated cost of $282,000. This is less than 1% of the total restoration project cost on the Santa Clara Pueblos portion of the project. The recreation potential may be satisfied only to the extent that recreation does not significantly diminish the ecosystem outputs that justify the ecosystem restoration project. Figure 30 are examples of a display board and trail shelter.

Table 21 Itemized cost estimate for recreation features.

Feature	Qty	Cost
Gravel Trail	4,100 LF	$ 69,234
Picnic Table	5 ea	$ 54,401
Park Bench	25 ea	$ 77,388
Trail Shelter	4 ea	$ 54,037
3-Panel Display Board	1 ea	$ 10,895
Dog Waste Receptacle	15 ea	$ 10,954
	Total	**$ 282,000**

INFORMATION KIOSK DIAGRAM
N.T.S.

Figure 30 Examples of a display board and trail shelter

3.8.4 Benefits of the Recreation Plan

The recreation should complement and not detract from the ecosystem restoration components. The recreation plan for the Espanola Valley General Investigation study was derived from a 2014 recreation master plan prepared by the USACE for the Santa Clara Pueblo.

The USACE performed additional analysis to identify the benefit-cost ratio for the selected recreation plan. This analysis is presented in Appendix B.

The recreation plan is estimated to cost $282,000. With a period of analysis of 50 years and an interest rate of 2.75% (FY18), the recreation plan has a total annual cost of $10,445. Dividing the benefit of the proposed recreation facilities ($141,358) by the annual cost of the proposed recreation measures ($10,445) the Benefit Cost Ratio (BCR) exceeds 10 to 1.

3.9 Operation and Maintenance

Operation, maintenance, repair replacement and rehabilitation (OMRR&R) becomes the sponsor responsibility after construction of the project. OMRR&R costs are estimated at $120,000 annually (FY 17 price level). These estimates will be refined during final design and development of the Operation and Maintenance (O&M) Manual.

Future O&M activities would include the following: Replacement of displaced rip rap in GRF's, treatment or removal of non-native invasive plant species in project areas and clearing obstructions or accumulated sediment in high flow channels. Rip Rap replacement and sediment removal are only expected to be required after large flow events. Experience with these types of features in the Albuquerque reach demonstrate that clearing can be accomplished by hand in most cases. Maintenance requirements will be informed by annual monitoring as described in detail in Appendix C Environmental Resources.

3.10 Cost Apportionment and Average Annual Costs

The costs of water resources studies and projects developed by USACE are shared between Federal and non-Federal sponsors as defined in laws and administrative provisions. WRDA of 1986 established new cost sharing rules for all studies and projects conducted by USACE. Post-study project costs, Planning Engineering Design (PED) and construction, are cost shared between USACE and the local sponsor(s) 65% and 35% respectively. Costs for recreation included in ecosystem restoration projects is generally cost shared 50% and 50%.

For the Espanola Valley restoration project each sponsor is responsible for the cost of developed to date, the total project is divided among the two sponsors with 50.5 % under the responsibility for Santa Clara and 49.5% under Okay Owingeh pueblo. Santa Clara Pueblo proposed recreation measures, in addition to ecosystem restoration measures, to be constructed within the tribal boundaries (Table 24).

The Average Annual Cost for the Espanola GI Ecosystem Restoration Project is $2,300,241. This figure includes Total First Cost, OMRR&R and Monitoring and Adaptive Management.

The Average Annual Cost for Ohkay Owingeh Pueblo is $1,152,824. This figure includes Total First Cost, OMRR&R and Monitoring and Adaptive Management.

The Average Annual Cost for Santa Clara Pueblo is $1,147,342. This figure includes Total First Cost, OMRR&R and Monitoring and Adaptive Management.

Table 22 Recommended Plan Cost Breakdown and Apportionment

Oct. 2017 Price Level, ($1,000's)	**TOTAL FEDERAL**	**TOTAL NON-FEDERAL**	**Total**
Construction (Ecosystem Restoration)	$33,361	$13,332	$46,693
Construction Recreation (50/50 Cost Share)	$141	$141	$282
LERRDs	$61	$3,072	$3,133
PED	$4,410	$1,470	$5,880
Construction Management	$2,549	$1,373	$3,922
Monitoring &Adaptive Management	$1,346	$725	$2,070
Total First Cost (Ecosystem Restoration and Recreation)	**$41,868**	**$20,112**	**$61,980**

Table 23 Pueblo of Ohkay Owingeh Cost Apportionment

Ohkay Owingeh Pueblo	**Oct. 2017 Price Level, ($1,000's)**	
	TOTAL FEDERAL	**TOTAL NON-FEDERAL**
Construction (Ecosystem Restoration)	$16,755	$6,825
LERRDs	$30	$1,458
PED	$2,227	$742
Construction Management	$1,287	$693
Monitoring &Adaptive Management	$679	$366
Total First Cost (Ecosystem Restoration)	**$20,979**	**$10,084**

Table 24 Pueblo of Santa Clara Cost Apportionment

Santa Clara Pueblo	**Oct. 2017 Price Level, ($1,000's)**	
	TOTAL FEDERAL	**TOTAL NON-FEDERAL**
Construction Ecosystem Restoration	$16,605	$6,508
Construction Recreation (50/50 Cost Share)	$141	$141
LERRDs	$31	$1,613
PED	$2,183	$728
Construction Management	$1,262	$679
Monitoring &Adaptive Management	$666	$359
Total First Cost (Ecosystem Restoration and Recreation)	**$20,888**	**$10,027**

(NOTE: This page left intentionally blank.)

4 - Expected Future With-Project Effects*

The expected future with-project condition is the most likely condition expected to exist in the future with the implementation of a particular water resources development project. Comparison of expected future with-project to conditions to expected future without-project condition will be performed to identify the beneficial and any adverse effects of the proposed alternatives. These with- and without-project comparisons provide the framework for the evaluation of alternative plans to the human environment.

4.1 Hydrology, Hydraulics and Sediment Transport*

4.1.1 **Hydrology**

4.1.1.1 Expected Future With-Project Conditions

The recommended plan will provide for the movement of water from the Rio Chama, Santa Cruz River and Rio Grande into the currently disconnected floodplain. This change in the distribution of water into the water-starved riparian zone ensures the success of the implemented restoration measures. The less frequent large floods already spread across the floodplains so the recommended plan will not affect the occurrence of large flood inundation. Some of the proposed measure will actually improve the final draining of these large floods from the floodplains. The more frequent small floods will be slightly delayed as the flood wave moves down the valley through additional parallel channels and a wider main channel.

The recommended plan will have negligible impact of hydrology (Appendix A).

4.1.2 **Geomorphology**

4.1.2.1 Expected Future With-Project Conditions

Construction of the GRFs will quickly begin changing the shape of the Rio Chama and Rio Grande channel-forms immediately upstream. In time, the upstream channels should become shallower for a significant distance. If so, the Rio Chama and Rio Grande could again become braided in these areas.

Implementation of those ecosystem restoration measures, which include excavation outside of the river channels, will immediately improve flow conditions in the floodplain by increasing flow conveyance capacity (Appendix A).

4.1.3 **Hydraulics**

4.1.3.1 Expected Future With-Project Conditions

The recommended plan includes the implementation of following hydraulic structures (Appendix A):

- GRFs will raise upstream water surface profiles on the Rio Chama and Rio Grande for the more frequent flow events which will then be diverted into the high-flow channels. Eventually, the GRFs will also stabilize the upstream river banks and channel bottoms.

- High-flow channels will redirect water from the Rio Chama, Santa Cruz River and Rio Grande by diverting flows into and through newly excavated waterways and then returning the water back to its source. Diverting flows into these side channels will help stabilize the main channel between the diversion and the return.
- Terraces will be excavated to provide additional riverbank slope. The terrace excavation increases flow conveyance capacity. As a result of increased water conveyance, the river channel, for the length of the terrace, will have increased stability.
- Swales will connect existing and constructed low areas. Hydraulic effects are negligible.
- Wetlands will collect surface water and provide interaction with ground water. Hydraulic effects are negligible.
- Vegetation management will change water resistance in the floodplain. In some areas, this will mean a slowing of water flows for the duration of the overbank flow event. In other areas, this will mean an increase in water velocity for the duration of the overbank flow event.

4.1.4 **Sediment transport**

4.1.4.1 Future With-Project Conditions

The GRFs are sizable structures that will immediately trap the coarser sediments upstream, such as sand and gravel. Over time, the entrapment area will spread upstream until sediment transport equilibrium is achieved. After channel bed equilibrium has been achieved, the banks of the Rio Chama and Rio Grande may stabilize from sediment deposition and revegetation. In addition, the GRFs on the Rio Grande will arrest the upstream migration of existing headcuts.

In the high-flow channels, on the terraces and in the areas of vegetation management, water velocities will decrease. When this occurs, fine sediment particles, such as clays and silts, will settle out of the water column. These fine sediments will eventually become new topsoil, where excavation occurs, or will add to already existing topsoil.

Locations of the swales and wetlands are end points for surface water runoff. These measures will most likely collect clays, silts and debris acting as sediment traps preventing these materials from entering the main channel.

4.2 Water Depletions*

The Proposed Action consists of approximately 38 acres of water features (e.g. high flow channels and wetlands), the majority of which lie within the designated 600-foot Rio Grande Floodway. All features would be evaluated to determine whether they require depletions offsets. Work on those features 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.

4.3 Economics*

The recommended plan has NED benefits as a result of proposed recreation component in the with project condition see Section 3.8.4.

4.4 Environmental Resources*

The recommended 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. The recommended plan also improves the resource needs as described in Section 1.5 and throughout the document. The recommended plan would improve the scarce native riparian habitat to a more pristine state, including a mosaic of habitat types. The recommended 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 recommended plan meets the goals of increasing habitat units.

4.4.1 **Floodplains and wetlands**

The recommended plan would increase floodplain connectivity using GRFs, high-flow channels, swales / wetlands, and terrace lowering. The 46.3 acres for GRF construction would increase floodplain connectivity for 107 acres. High-flow channels would increase connectivity for 22.2 acres, and terrace lowering would add about 45 acres. The swales / wetlands would increase floodplain connectivity with groundwater to support native riparian vegetation.

The excavation for the proposed high-flow channels and terrace lowering would impact the existing floodplain. These features would be designed, however, so that there is no negative impact to existing flood control levees. Therefore, these measures may affect the floodplain, but these impacts are anticipated to be positive.

The excavation for the proposed swale / wetlands / ponds (64.5 acres) would impact the existing floodplain. These features would be designed, however, so that there is no negative impact to existing flood control levees. Wetlands within the Recommended Plan Area would be avoided during implementation. One wetland / swale measure is proposed to restore a previous wetland. The measure would improve groundwater connectivity for the wetland, and may create habitat that would potentially benefit the mouse. The existing wetland may be temporarily affected during excavation and re-vegetation. The recommended plan would not have long-term impacts to existing wetland habitat. Therefore, these measures may affect the floodplain, but these impacts are anticipated to be positive.

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 water or wetlands of the United States. A 404 (b) (1) Evaluation has been completed (Appendix C). All conditions under Nationwide Permits 33 (Temporary Construction, Access, and Dewatering) and 27 (Aquatic Habitat Restoration, Establishment, and Enhancement Activities) would be adhered to during construction. A water quality certification permit under Section 401 of the CWA would also be required. USACE would coordinate activities and schedule with the Ohkay Owingeh and Santa Clara Pueblos to allow water quality monitoring during project implementation. Therefore, the project would have no effect on existing wetlands during construction and would have a positive effect by creating wetland habitat.

The cumulative effects of the GRFs, high-low channels, terrace lowering, swale / wetlands / ponds would increase floodplain connectivity to surface and ground water. The recommended plan would improve the resilience of riparian and wetland habitat under the projected trends of climate change.

4.4.2 **Noxious weeds and invasive species**

The recommended plan includes 104 acres of vegetation management to remove salt cedar, Russian olive, and other invasive species, followed by planting of native riparian vegetation in addition to the excavation measures.

4.4.3 **Vegetation communities**

As discussed in Section 3.8 Descriptions of the Recommended Plan, the proposed project would improve or restore high value habitat and critical functions to support those habitats into the future. The recommended plan consists of 314 acres of ecosystem restoration measures to restore and protect 958 acres of the bosque within the study area. This figure is a conservative estimate used for the analysis of plans. The restoration will have far reaching benefits throughout the Espanola Valley and for those migratory species using the Rio Grande Flyway. Restored critical functions such as improving hydrologic connectivity between the river and riparian zone and restoring habitat diversity will provide for a self-sustaining restoration well beyond the50 year period of analysis.

The GRFs to be constructed on Ohkay Owingeh Pueblo would improve floodplain connectivity for about 80 acres, and prevent the loss of approximately 644 acres by arresting the channel incision that would occur under the future without project. Terrace lowering would provide over 57 acres of connectivity with the river by excavating the banks. The proposed high-flow channels (21 acres) would transport much-needed water across the terraces to bosque vegetation and improve floodplain connectivity on both Pueblos. Willow swales (48 acres) provide microenvironments in which native plants can thrive due to the reduced depth to the water table and moist soils. The proposed swale/wetland measures (17 acres) focus on development of open water or marsh wetlands with fluctuating water levels and various vegetative species. These wetlands provide open water habitat for migrating and local waterfowl, and provide aquatic habitat for numerous species.

Grubbing prior to excavation of the recommended measures would remove invasive tree and plant species. All of these measures include planting with native plant species following excavation. The increased floodplain connectivity would provide soil conditions favorable to native riparian vegetation. Vegetation management over 104 to replace invasive plants with native riparian vegetation creates additional habitat.

The cumulative effects of vegetation management in combination with the floodplain connectivity measures would increase native riparian and wetland vegetation. The increased riparian vegetation would increase habitat unit values over the life of the project (Figure 31 and Figure 32).

4.4.4 **Fish and wildlife**

The vegetation management strategy for each measure may be varied to support development of the riparian mosaic based on water demands. Replacing dead material and non-native vegetation with a mosaic of native vegetation should lead to a system of less water use, 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 effects during construction, which would be caused by the proposed action.

In order to minimize potential effects on nesting birds in the study area, clearing of live vegetation would only occur between August 15 and April 15. Per the 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 in compliance with the requirements of the MBTA.

Recent studies done by Bateman et. al (2008) found that eastern fence lizards (*Sceloporus undulatus*) 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 perhaps, removing non-native plants in the understory allows more opportunities for heliothermic lizards to bask in areas where light does penetrate the cottonwood canopy.

Other wildlife such as arthropods, mammals, amphibians and reptiles would also be displaced during implementation of the proposed action. The Middle Rio Grande Ecosystem Restoration Project (USACE 2011) identified herbicide toxicity as a risk to amphibians that could be avoided by eliminating the use of herbicide use during the month of September. Therefore, herbicide use within the study area would only take place between October and April.

Since the ultimate goal is to re-vegetate 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. Therefore, the Recommended Plan would have short-term negative effects on wildlife with long-term positive benefits. The variability of habitat types would also provide different niches for different groups of wildlife (birds, herpetofauna, fish, small mammals and arthropods).

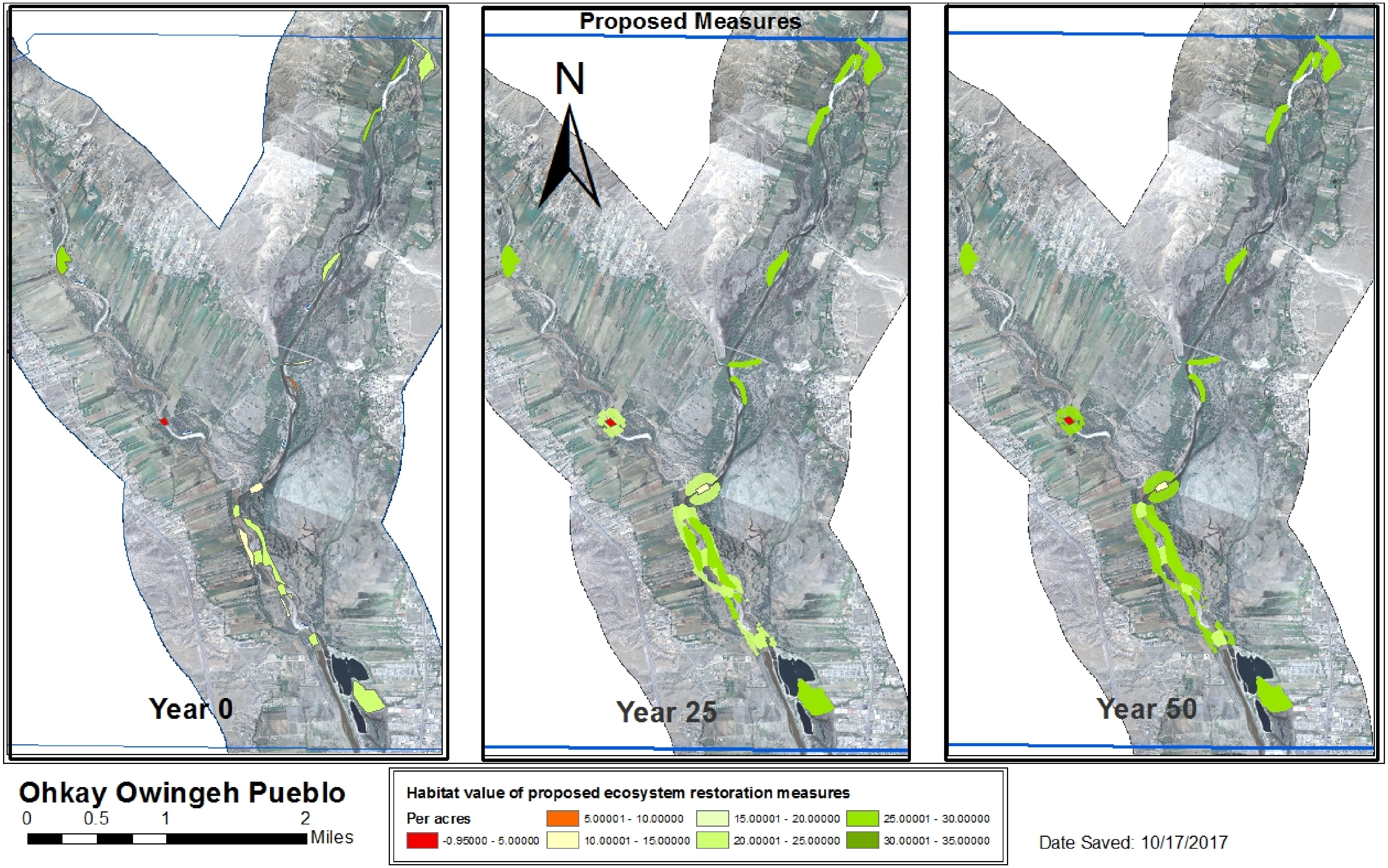


Figure 31 Increase in habitat units with recommended measures on Ohkay Owingeh Pueblo.

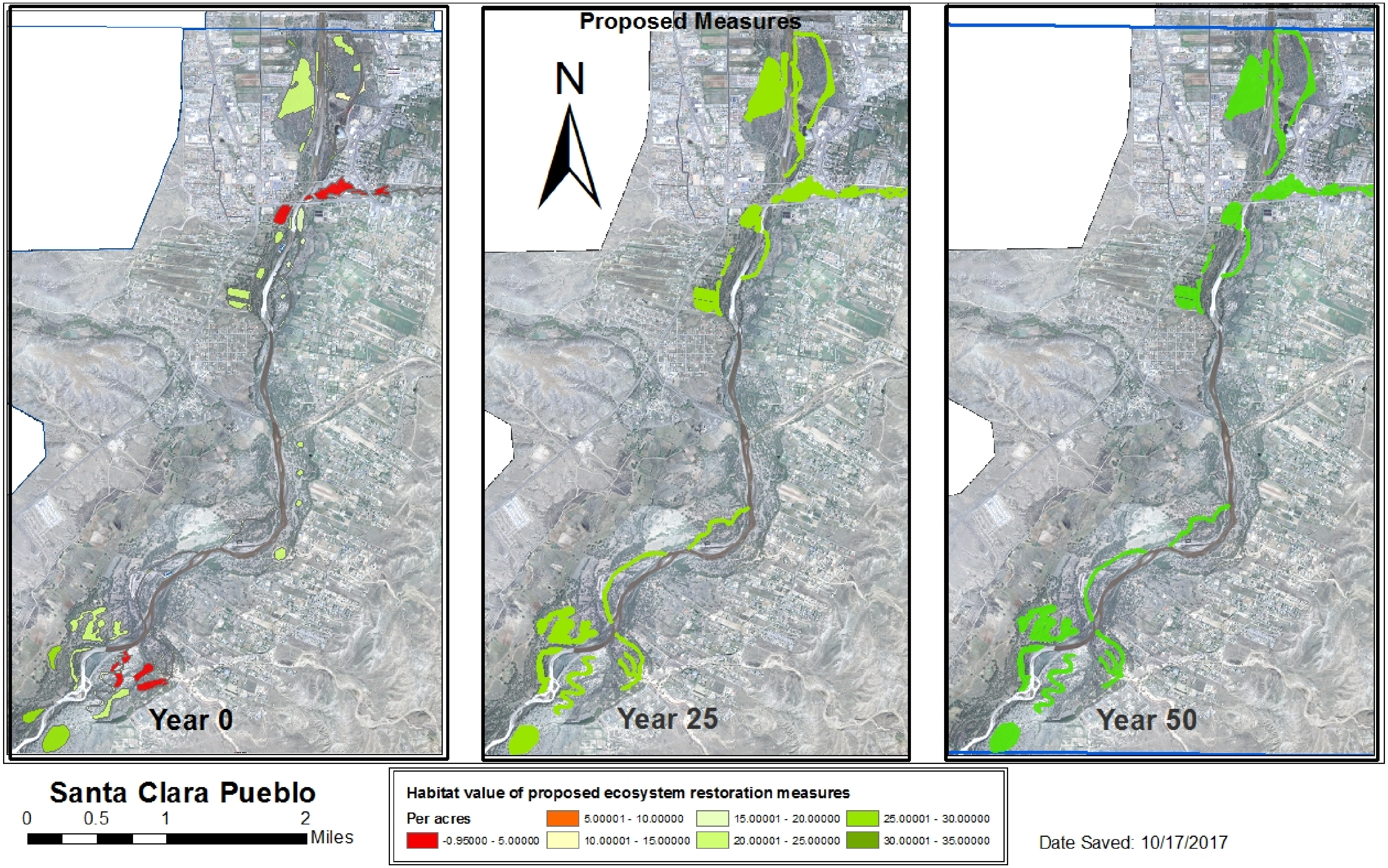


Figure 32 Increase in habitat units with recommended measures on Santa Clara Pueblo.

In accordance with the Fish and Wildlife Coordination Act, USACE has been and will continue to coordinate with the USFWS and seek their advice and recommendations on fish and wildlife resources during all phases of the project. USACE will coordinate with the USFWS (and other agencies as appropriate) on the more 'long-term' recommendations. The recommended plan would improve the resilience of riparian and wetland habitat for wildlife under the projected trends of climate change.

4.4.5 **Special status species**

The effects of the recommended plan were evaluated for the Southwestern Willow Flycatcher, the Western Yellow-billed Cuckoo, and the New Mexico meadow jumping mouse in a Biological Assessment submitted to the USFWS (March 13, 2015). The recommended plan would improve riparian habitat value for these special status species.

4.4.5.1 Southwestern Willow Flycatcher

The Recommended Plan would create habitat that would potentially benefit the flycatcher. Creation of willow swales in the Recommended Plan would provide potential habitat for the flycatcher. Terrace lowering and high-flow channels should create natural willow and cottonwood stands. Over time, these cottonwood and willow stands would develop the preferred density and stature for flycatcher nesting.

Based on the surveys conducted by the sponsors within the Recommended Plan Area, flycatchers are likely to be present in the study area during the ten year construction period (2017 through 2027 or beyond). Surveys would be scheduled during each year of construction to verify presence or absence during the period of project implementation. It is very possible that migrants would be present in the study area in summer and fall. If nesting flycatchers are detected then consultation with USFWS would be reinitiated. Any nesting territories discovered would be avoided.

Therefore, USACE has determined that the Recommended Plan may affect, but are not likely to adversely affect, the flycatcher. The proposed ecosystem restoration measures may affect, but not likely to adversely modify designated or proposed critical habitat for the flycatcher. Construction of the measures described in the proposed action may provide beneficial habitat for the flycatcher.

4.4.5.2 Yellow-Billed Cuckoo

Disturbance of vegetation for the construction of measures would be outside the breeding season, avoiding effects to the cuckoo. Measures in the Recommended Plan would create habitat that would potentially benefit the cuckoo. Edge habitat adjacent to terrace lowering and high-flow channels should create ecotones that favor cuckoos. It is likely that migrants would be present in the study area in summer and fall. Surveys at the locations where migrants have been detected would continue each year as they have in the past. If nesting cuckoos are detected then consultation with USFWS would be reinitiated. Any nesting territories discovered would be avoided. If any occupied habitats are detected, these areas would also be avoided.

Therefore, USACE has determined that the proposed work may affect, but are not likely to adversely affect, the Western Yellow-billed Cuckoo. The proposed ecosystem restoration measures may affect, but not likely to adversely modify designated or proposed critical habitat for the Yellow-billed Cuckoo. Construction of the measures described in the proposed action may provide beneficial habitat for the cuckoo.

4.4.5.3 New Mexico Meadow Jumping Mouse

The New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*; mouse) was listed as endangered on the June 10, 2014 (USFWS 2014). Proposed critical habitat for the mouse includes two marshes on Ohkay Owingeh Pueblo (USFWS 2013). Trapping surveys for the mouse in the Recommended Plan Area would confirm whether the action area remains unoccupied during the ten year construction period (2017 through 2027 or beyond). The pueblo and the Service should discuss monitoring strategies prior to construction in possible mouse habitat.

Therefore, USACE has determined that the proposed work may affect, but not likely to adversely affect, the New Mexico Meadow Jumping Mouse. The proposed ecosystem restoration measures may affect, but not likely to adversely modify designated or proposed critical habitat critical habitat for the New Mexico Meadow Jumping Mouse. Construction of the measures described in the proposed action may provide beneficial habitat for the mouse.

4.4.6 **Water quality**

Soil disturbance would result from vegetation clearing, 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 contractor's 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 and affect surface water quality if they reached the Rio Chama and Rio Grande. Spills of such materials could similarly contaminate surface water in the river or irrigation infrastructure. All equipment would be inspected daily to ensure that oil, fuel, hydraulic fluid, or other potential contaminants are not leaking. All petroleum products would be stored outside of the 1% ACE event 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 proposes 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 Nationwide 27 (Stream and Wetland Restoration Activities) for work that would take place to restore wetland habitat function. 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 has been obtained by both Pueblos. USACE would coordinate with the Pueblos of Ohkay Owingeh and Santa Clara regarding activities and schedules to allow the opportunity for monitoring water quality conditions during project implementation.

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. Some ground disturbance may take place. A Storm Water Pollution Prevention Plan (SWPPP) for the project is required for construction. This would be developed by the contractor who would be required to adhere to this plan and required to file a Notice of Intent (NOI) with the Environmental Protection Agency. Through this NOI the contractor performs all work in accordance with the Nationwide NPDES permit prior to commencement of construction activities. The SWPPP would also include a Spill Control Plan. Compliance with these requirements would ensure that the Recommended Alternative would have no significant effect on the water quality of the Rio Grande. Water quality would be monitored throughout the project. Silt fences (without lead weights) would be installed prior to construction in all areas and other standard BMPs would be implemented. All construction activities would be in compliance to all applicable Federal, state and local regulations.

There may be a short-term adverse effect on water quality during construction along the banks of the river but that portion of construction would take place during low flows of the river. Also, once the water features have been constructed, many of them would provide a benefit to water quality. Those water features where wetland plants are installed would provide improved water quality as the wetland plants take up materials in the water passing through the feature (such as storm water passing through wetlands constructed near these features, or sediment laden water passing through the high-flow channels). Therefore, there would be a minor short-term adverse effect on water quality during construction only and a positive long-term benefit to water quality by the Proposed Action.

4.4.7 **Air quality**

Air quality in the study area is generally good to excellent due to the lack of urban industrial development. Although high winds are common in and around the study 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. All vehicles involved in construction at the project site would be required to have passed a current New Mexico emissions test and have required emission control equipment (if required).

Since there would be ground disturbance during construction of all features in the Proposed Action, BMPs to minimize air quality disturbance would be employed. These include covering trucks to avoid fugitive dust violations and wetting down work areas. Speed limits on access roads would be limited to 15 mph, which would also minimize dust.

All work areas would be continually wet down to minimize dust. Therefore, short-term adverse 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 by the recommended plan.

4.4.8 Noise

The Pueblos generally are quiet with limited background noise. The OSHA noise standard (29 CFR 1910.95) limits noise levels to 90 decibels (environmental sound intensity measured as dBA) averaged over an eight-hour day, 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 will reduce the exposure below 115 dBA.

Equipment to be used during construction would include pieces generating a fair amount of noise. This noise would be somewhat abated by the distance from construction sites to nearby housing. Travel on the access roads to and from work locations would also 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 (as described above) would be adhered to. Therefore, there would be minor, short-term noise impacts by the recommended plan during construction, which would occur only during normal working hours. There would be no long-term adverse effects to noise by the recommended plan.

4.4.9 Aesthetics

The aesthetics of the bosque may temporarily be affected during construction by the presence of construction equipment and excavation. Following construction and revegetation the disturbed area of the bosque would resume functioning as a healthy ecosystem. The ecosystem restoration measures in the recommended plan would benefit the aesthetic value of the bosque.

4.4.10 Land use and classification

There would be no long-term adverse effects to land use outside the bosque by the recommended. The ecosystem measures would support traditional cultural uses of the bosque. The cumulative effects of the recommended plan would be beneficial.

4.5 Cultural Resources*

The Area of Potential Effects (APE) for the project is defined in section 2.4.1.3. Identified cultural resources within the APE include: the bosque itself, San Gabriel de Yunque-Ouinge (Juan de Oñate's first capital in New Mexico), the Rio Grande Bridge at San Juan Pueblo, and a recent diversion for the Acequia de los Vigiles. As discussed above, the USACE determined that the proposed project would have *no historic properties affected* for the portion within Santa Clara lands, and *no adverse effect to historic properties* within Ohkay Owingeh lands. The Santa Clara THPO and New Mexico SHPO concurred with these determinations on August 4, 2016 and February 2, 2017, respectively. As such, effects to any of these properties from the proposed projects would not be adverse. Further, the bosque itself is a vital cultural resource. In protecting and restoring the bosque, future conditions are expected to include an overall benefit, serving to support, preserve, and enhance its continued vitality as a cultural resource.

4.6 Hazardous, Toxic, and Radioactive Waste (HTRW)*

A preliminary assessment of the study area was performed in 2009. The assessment identified multiple gasoline stations and dry cleaning located outside of the study area in the city of

Espaňola. One record identified the North Railroad Avenue Plume Superfund site that is known to have a current, direct impact to the groundwater underlying a portion of the northern part of the Santa Clara. The records note that approximately 58 acres of land are underlain by the groundwater contamination associated with this Superfund site, and a portion of the 58-acre contaminant plume extends southward beneath the northern portion of the Santa Clara Pueblo lands. The target contaminant is associated with dry cleaning solvents. Information provided by the assessment did not change formulation or locations of any proposed restoration measures. The results of the assessment do not anticipate any impact of the project on known HTRW concerns nor do the known sites impact selection or implementation of the proposed project..

USACE will conduct a Phase I ESA prior to award of a construction contract. If there are any additional HTRW issues identified they will be avoided to the extent possible per Engineering Regulation, HTRW Guidance for Civil Works Projects (ER 1165-2-132).

USACE has determined that existing conditions have not undergone major changes since the 2009 assessment. This will be verified during the Phase I ESA. The future with-project condition will not likely impact the existing HTRW conditions within the study area. If any HTRW issues are discovered, they will be avoided or the proposed measures may be altered or removed to avoid significant impacts from HTRW..

4.7 Geotechnical Engineering*

It is expected that the soils present within the proposed areas for construction of the grade restoration features (GRFs) will be highly permeable and consist of boulders, cobbles, gravels, sands, silts, and clays. Depth to groundwater table is expected to be shallow within the proposed areas for construction of GRFs. Depth to bedrock is unknown but not expected to be within the proposed limits of the GRF foundations. There are no expected issues related to geotechnical engineering aspects of this project; therefore, the necessary information requiring collection and analysis can be performed once the project moves into design.

4.7.1 **Future With-Project Geology and Soils**

No changes are anticipated in site geology and soils over the project lifetime.

4.8 Climate*

There is anticipated to be no difference in the future without-project and future with-project climate conditions. The project will have no effect on climate change in the region. Project climate change impacts to the recommended plan can be found in Appendix G.

Climate change is very likely to result in smaller, earlier spring runoff flows in rivers, and reduced late summer base flows in the Rio Grande, the Rio Chama, and perennial tributaries. Drought is projected to occur more often, last longer, and be more intense. Higher temperatures are anticipated to increase soil moisture stress for plants. Climate change may result in stronger monsoons and/or summer thunderstorms, and with stronger storms interspersed with longer dry periods between, but the consensus on this is low. Larger summer floods are a potential result.

The recommended plan would improve the resilience of riparian and wetland habitat by improving floodplain connectivity and removing invasive plant species. This value of this habitat for wildlife may increase as downstream riparian habitat area shrinks under projected trends of climate change.

4.9 Socioeconomics*

The population of the State of New Mexico is projected to increase by approximately 37% between the last official U.S. Census in 2010 and the year 2040 (Table 25). The population of Rio Arriba County is expected to remain fairly constant while the population of Santa Fe County may increase by approximately 28%. The Census Bureau does not have projected population numbers for the census designated populations of Ohkay Owingeh, Santa Clara or San Ildefonso Pueblo

Table 25. Española Valley Population Projection Statistics for 2010 through 2040.

Española Valley	**Total Population (individuals)**	**Projections**			
		2020	**2030**	**2035**	**2040**
New Mexico	2,059,179	2,351,724	2,613,332	2,727,118	2,827,692
Rio Arriba County	40,246	41,026	40,872	40,509	40,008
Santa Fe County	144,170	164,006	178,124	182,410	184,832

* Respondents may have multiple answers to census survey resulting in numbers greater than the total population.

The recommended plan is not expected to have any influence on future demographics.

4.9.1 Environmental justice*

The proposed ecosystem restoration measures will support the Pueblos of Ohkay Owingeh and Santa Clara in addressing environmental issues and concerns. Restoration of floodplain connectivity and revegetation is consistent with the cultural uses and values for the bosque. The proposed ecosystem restoration and FRM measures seek to address disproportionate effects of previous actions on the bosque ecosystem and the Pueblo communities.

4.10 Effects Analysis*

The effects of the proposed action were evaluated based on comparison of the existing (baseline) and future without project (No Action) conditions for the floodplain and riparian zone. The No-Action and proposed action alternatives would not adversely affect geology and soils, sponsor agricultural lands and practices, water quality, cultural and socioeconomic resources, environmental justice, Indian Trust Assets, or recreation. The proposed action would increase floodplain connectivity, benefitting the riparian habitat and associated wildlife.

4.10.1 **National Ecosystem Restoration Analysis**

The Feasibility Study for the Española Valley Ecosystem Restoration Project followed the USACE six-step planning process specified in Engineering Regulation (ER) 1105-2-100. This 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 provides a framework for problem solving and sound decision making. A number of alternatives were considered and rejected, including: 1) the No Action Alternative; and 2) alternatives with recreational and interpretive features.

4.10.2 **Description and Evaluation of Alternatives**

4.10.2.1 No Action Alternative Summary

Without-project future conditions were projected using CHAP for comparison of restoration benefits. The Rio Grande Valley, the river, floodplain, and the associated fish and wildlife populations would be expected to continue to experience adverse effects from channel incision, invasive plant species, and Federal, State, and private water resource development projects. The local sponsors would continue removal of non-native vegetation as they are able, but the proposed measures for increasing floodplain connectivity would not be constructed.

4.10.2.2 Tentatively Selected Plan Summary

The Tentatively Selected Plan is based on Best Buy Plan #37 (Appendix B of the main report) generated by the Incremental Cost Analysis (CE/ICA). The Tentatively Selected Plan represents the most cost-effective aggregation of restoration features that best meet the objectives of the restoration project. Implementation of the Tentatively Selected Plan would restore approximately 272 acres of the project area by improving hydrologic connectivity with the floodplain and supporting native vegetation. In addition, recreational use of the bosque would be improved by creating designated trails with benches, signs and other interpretive features.

4.10.2.3 Selected Alternative

The selected alternative consists of ecosystem restoration measures to restore 272 acres of the bosque within the Study Area. The measures are designed to (1) improve hydrologic connectivity with the floodplain by constructing grade restoration facilities (GRFs), high-flow channels, terrace lowering, willow swales and wetlands, and (2) restore native vegetation and habitat by reduction of exotic species, and riparian forest revegetation with native plant species. The restoration measures proposed by the habitat team were refined by the sponsors prior to incremental cost analysis. The proposed ecosystem measures would result in a net increase of 6,271 habitat units at year 25, and 8,258 habitat units at year 50. Work would be phased over seven to ten years with an initial construction phase potentially in the fall of 2018.

4.10.2.4 Access and Staging

All proposed measures are in proximity to the river channel. Access through the riparian forest to the river edge is available. A temporary access road from the nearest existing road would be constructed to access proposed construction areas. These temporary access roads would be removed and reseeded once construction is complete unless requested by the sponsor. Any additional disturbance caused by equipment accessing the site would be reseeded with native vegetation and mulched once complete.

Access to all work areas would occur along existing roads, and staging would occur in adjacent open areas made available by the sponsor. Equipment would access proposed construction areas from the nearest road. Staging could also take place within the bosque if other areas are not available. Additional access and subsidiary staging areas required to facilitate construction activities would be coordinated with the sponsors.

The recommended plan will have negligible impact of hydrology, while having a beneficial effect on floodplain connectivity. The GRFs will have a temporary effect on sand and gravel transport through the project. Over time, sediment will accumulate in and upstream of the GRFs until sediment transport achieves equilibrium.

The recommended plan would have no effect on water depletions.

The recommended plan would increase floodplain connectivity to surface and ground water, increase native riparian and wetland vegetation, and increase wildlife habitat value. The recommended plan would improve the scarce native riparian habitat to a more pristine state, including a mosaic of habitat types that provide habitat for the numerous migratory birds and other wildlife species.

The recommended plan would have short-term negative effects on wildlife with long-term positive benefits.

The recommended plan would have no long-term adverse effects to water quality, air quality, or noise.

The ecosystem restoration measures in the recommended plan would benefit the aesthetic value of the bosque.

4.11 Cumulative Effects*

The project would provide valuable riparian habitat within the Rio Grande valley. Improving habitat quality in the project area would strengthen the wildlife corridor between several Wild and Scenic Rivers, national wildlife refuges, state parks and wildlife management areas. The project would complement the nearby Los Luceros Historic Area (152 bird species) and the Rio Grande Flyway.

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5 - Real Estate

5.1 Alternative Facilities

There are no geographically suited alternative project facilities. There are no known sales of Pueblo lands and no sales anticipated.

5.2 Real Estate Requirements

At this time, all construction activities will be on tribal lands within the Pueblos of Ohkay Owingeh and Santa Clara.

5.3 Ownership of LERRD Required for the Project

The Sponsors already own land in fee. Staging areas, rights of ingress and egress, construction and remediation activities must be approved in advance in writing by each individual Pueblo's council. Public roads will be utilized for ingress and egress purposes to access Pueblo lands.

5.4 Non-Standard Estates

The use of non-standard estates is not required for this project.

5.5 Existing Federal Projects that Lie Within LER Required for the Project

There are no existing Federal projects within the LER required for this project.

5.6 Existing Federally-Owned Land within the LER Required

There is no Federally-owned land within the LER required for the project.

5.7 Navigation Servitude

Exercise of navigational servitude is not required for this project.

5.8 Potential Flooding Induced by Construction, Operation, or Maintenance of Project

No induced flooding is anticipated.

5.9 Application or Enactment of Zoning Ordinances

Application or enactment of zoning ordinances is not proposed in connection with this project.

5.10 Facility/Utility Relocations

No relocations of facilities or utilities within the project footprint are proposed in connection with this project.

5.11 Opposition to the Project

There is no known opposition to this project by any landowners in the vicinity.

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6 - Coordination and Public Views*

6.1 *Compliance with Environmental Requirements

6.1.1 USFWS Coordination Act

USACE has coordinated with the U.S. Fish and Wildlife Service to fulfill requirement of the Fish and Wildlife Coordination Act throughout the planning process. The Final FWCA report (13 July 2015) included in Appendix C was reviewed by the New Mexico Department of Game and Fish, and the Forestry Division of the New Mexico Energy, Minerals, and Natural Resources Department. The USFWS made several recommendations for project planning, construction, vegetation management, and monitoring.

USACE shall incorporate the following recommendations from the FWCA report. Use the Combined Habitat Assessment Protocols (CHAP) for habitat analysis. Construction activities should occur outside the migratory bird nesting season of March through September. Vegetated areas should be clear outside the nesting season. Avoid disturbing nesting areas until young have fledged.

Protect mature cottonwood trees from damage during clearing of nonnative species or other construction activities using fencing, or other appropriate materials. Use local genetic stock wherever possible in the native plant species establishment throughout the riparian area. Scarify compacted soils or replace topsoil and revegetate all disturbed sites with suitable mixture of native grasses, forbs, and woody shrubs. Any use of backfill should be uncontaminated soils suitable for revegetation with native plant species.

The following FWCA recommendations are beyond the normal scope of an ecosystem restoration this project. These recommendations are suitable for consideration by action agencies and stakeholders as future projects.

Preparation of a GIS based restoration overview of all restoration efforts in the Project area from Rio Grande Canyon to White Rock Canyon. Previous experience with the Middle Rio Grande Endangered Species Collaborative Program indicates this is a complex activity beyond the scope of this project.

Conduct a detailed geomorphic analysis to identify impacts to groundwater levels in the riparian zone would be useful. This study is the scope of this project.

Removal of additional jetty jacks is future project requiring substantial analysis and funding.

There are opportunities to work with the City of Española as an interested stakeholder on re-evaluation of flood easements and ecosystem restoration projects.

6.1.2 ESA consultation and compliance

USACE submitted a draft Biological Assessment to the U.S. Fish and Wildlife Service on March 13, 2015. The draft Biological Assessment is included in Appendix C. USACE has been communicating with the Service throughout the consultation. Pending communications with the tribal sponsors, the Service anticipates there will be no adverse effects to the species or modification to their critical habitat. Consultation will be concluded prior to the Civil Works Review Board.

6.2 Public Involvement

Local experience with similar restoration projects and public concerns are considered during all phases of plan formulation (Appendix I). The initial public meetings were held in the fall of 2007 at each of the Pueblos. Areas of concern included technical considerations based upon the specifics of the study, loss of riparian areas traditionally known as bosque, flood risk management, and opportunities for incidental recreation.

The planning effort included extensive involvement by the Pueblos of Ohkay Owingeh, Santa Clara, and San Ildefonso (Appendix I). Numerous plan formulation workshops and meetings are planned for the remainder of the feasibility phase. These workshops and meetings introduce the project to the public, give individuals and agencies an opportunity to identify issues for consideration in the feasibility report, and solicit input on the project. The study's PDT and tribal attorneys created a Communications Plan, which includes all legal requirements for the inclusion of public views and comments.

6.3 Habitat Team

An interdisciplinary habitat team was convened to provide guidance for the Española Valley, Rio Grande and Tributaries, New Mexico Study. The habitat team (Table 26) was composed of staff from the sponsors and USACE, along with other federal and state agencies.

Table 26 Habitat team members.

Name	Title	Organization
Charlie Lujan	Environmental Department	Ohkay Owingeh Pueblo
Naomi Archuleta	Environmental Department	Ohkay Owingeh Pueblo
Bruce Bauer	Environmental Department	Santa Clara Pueblo
Dino Chavarria	Environmental Department	Santa Clara Pueblo
Jeffrey Lyons	Environmental Department	Santa Clara Pueblo
Neil Weber	Chief Environmental Dept.	San Ildefonso Pueblo
Jerome Martinez	Natural Resources Department	San Ildefonso Pueblo
Ray Flores	Parks & Recreation Department	San Ildefonso Pueblo
Stephen Martinez	Project Manager	San Ildefonso Pueblo
Jill Wick	Biologist	NM Dept of Game and Fish
Norman Jojolla	Biologist	US Bureau of Indian Affairs
Hector Garcia	Ecologist	US Bureau of Reclamation
Vicky Ryan	Biologist	US Bureau of Reclamation
Cyndie Abeyta	Biologist	US Fish and Wildlife Service
Dave Morgan	Biologist	La Calandria
Robyn Tierney	Biologist	La Calandria
Tom O'Neill	Biologist	Northwest Habitat Institute
Cory Langhoff	Biologist	Northwest Habitat Institute
Steve Cary	Biologist	Audubon Society

The FDEA was circulated for a 30 day public review from 30 November 2015 to 31 December 2015. Table 26, is the mailing list for the public review. The document was available on the Albuquerque District's Website and electronic copies were available upon request.

Public review comments were received from the New Mexico Department of Game and Fish, and the New Mexico Interstate Stream Commission. These comments did not result in significant changes to the report such as reformulation or additional analysis. Comments from the Interstate Stream Commission included a request for analysis of water depletions from restoration measures to comply with the Rio Grande Compact. The USACE and sponsors has coordinated with NMISC and initially determined that no depletions will occur due to implementation of the project. This evaluation will be finalized once detailed design of the project has been completed.

Table 27. Distribution list for NEPA Public Review.

Name	Agency	Location
Mr. Joseph Jojola	Bureau of Indian Affairs	Albuquerque, NM
Mr. Aden Seidlitz	Bureau of Land Management	Santa Fe, NM
Ms. Jennifer Faler	Bureau of Reclamation-AAO	Albuquerque , NM
Ms. Liz Beth Walker	NRCS Service Center	Hernandez, NM
Mr. Wally Murphy	U.S. Fish and Wildlife Service	Albuquerque, NM
Ms. Maria Garcia	US Forest Service	Española, NM
Mr. Arturo Blanco	USEPA, Region 6	Dallas, TX
Mr. Kelly Duran	City of Española	Española, NM
Chairperson of the Board	East Rio Arriba Soil and Water Conservation District	Española, NM
Mr. Tony Delfin	EMNRD-Forestry Division	Santa Fe, NM
Dr. Matthew Wunder	New Mexico Department of Game & Fish	Santa Fe, NM
Mr. Michael Vonderheide	New Mexico Environment Department	Santa Fe, NM
Mr. Anthony Lujan	NM Department of Transportation	Santa Fe, NM
Mr. Rolf Schmidt-Petersen	NM Interstate Stream Commission	Albuquerque, NM
Mr. Tomas Campos III	Rio Arriba County	Española, NM
Mr. John Blevins	USEPA, Region 6	Dallas, TX
Mr. Gifford Velarde	Jicarilla Apache Nation	Dulce, NM
Dr. Jeffrey Blythe	Jicarilla Apache Nation	Dulce, NM
Ms. Amie Tah-bone	Kiowa Tribe of Oklahoma	Carnegie, NM
Mr. Timothy Begay	Navajo Nation	Window Rock, NM
Ms. Tamara Billie	Navajo Nation	Window Rock, NM
Ms. Ora	Navajo Nation	Window Rock, NM
Mr. Anthony Moquino	Ohkay Owingeh	Albuquerque, NM
Mr. Christy Van Buren	Pueblo of Picuris	Penasco, NM
Dr. Bruce Bernstein	Pueblo of Pojoaque	Santa Fe, NM
Mr. Brian Montoya	Pueblo of San Ildefonso	Santa Fe, NM
Mr. Ben Chavarria	Pueblo of Santa Clara	Espanola, NM
Mr. Donovan Gomez	Pueblo of Taos	Taos, NM

Name	Agency	Location
Mr. Robert Espinosa	Pueblo of Taos	Taos, NM
Mr. Charles Dorame	Pueblo of Tesuque	Santa Fe, NM
Mr. Peter Pino	Pueblo of Zia	Zia Pueblo, NM
Mr. Jimmy Arterberry	Comanche Nation of Oklahoma	Lawton, NM
Mr. Danny Naranjo	Pueblo of Santa Clara	Espanola, NM

6.4 Non-Federal Views and Preferences

In general, the non-Federal views and preferences regarding ecosystem restoration measures, and the problems they addressed, were obtained through coordination with the local sponsors and with other various local and regional public agencies, community groups, resource conservation groups and the public. The New Mexico Department of Game and Fish and Audubon New Mexico provided input to the Habitat Team during evaluation of proposed measures. These coordination efforts consisted of public meetings held during the reconnaissance and feasibility phases. Announcement of public meetings was made in local media providing the date, time, place, and subject matter.

6.5 Summary of Project Management, Coordination, Public Views and Comments

The responsibilities for this task are shared between the USACE and the three local sponsors. The sponsors have provided in-kind services to assist in completing this task (Appendix I). This effort has included developing a public involvement plan; developing a mailing list of all public and private interests (including federal, state, local and non-governmental agencies), who will be kept informed of study progress and results; and conducting multiple public workshops (as defined by the tribal sponsors) which have also served as NEPA scoping meetings to gather ideas and concerns regarding ecosystem restoration, possible flood risk management, and incidental recreational water issues in the study area. Public meetings were held to discuss evaluation of alternative plans and the selection of the recommended alternative. The stakeholders include Ohkay Owingeh Pueblo, Santa Clara Pueblo, San Ildefonso Pueblo, the City of Española, the U.S. Fish and Wildlife Service, and other parties that express an interest in the study.

7 - Preparers

Name	Title	Organization
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Kathy Skalbeck	Study Planner	USACE
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John Schelberg	Archeologist	USACE
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Ron Kneebone	Tribal Liaison	USACE

7.1 Pueblo Reviewers

Name	Title	Organization
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Lawrence Cata	Environmental Department	Ohkay Owingeh Pueblo
Various	Tribal Council	Ohkay Owingeh Pueblo
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J. Yepa	Environmental Department	Santa Clara Pueblo
Dino Chavarria	Environmental Department	Santa Clara Pueblo
Jeffrey Lyon	Environmental Department	Santa Clara Pueblo
Joseph Gutierrez	Environmental Department	Santa Clara Pueblo
Bruce Bauer	Geospatial Specialist	Santa Clara Pueblo
Various	Tribal Council	Santa Clara Pueblo
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Matthew Tafoya	Rights Protections	Santa Clara Pueblo
Ben Chavarria	Rights Protection	Santa Clara Pueblo
Michael Chavarria	OEA	Santa Clara Pueblo
Ray Florez	Environmental Department	San Ildefonso Pueblo
Neil Weber	Chief Environmental Dept.	San Ildefonso Pueblo
A. Garcia	Environmental Department	San Ildefonso Pueblo
Chris Moquin	Environmental Department	San Ildefonso Pueblo
Myron Gonzales	Environmental Department	San Ildefonso Pueblo
Nathan Gonzales	Environmental Department	San Ildefonso Pueblo
Various	Tribal Council	San Ildefonso Pueblo

7.2 District Quality Control Reviewers

Name	Title	Organization
Mark Doles	Chief, Plan Formulation	USACE
Stephen Scissons	Chief, Hydrology and Hydraulics	USACE
Julie Alcon	Chief, Environmental Resources	USACE
Shelley Ramos	Chief, Geotechnical Engineering	USACE
Cecilia Horner	Chief, Environmental Engineering	USACE
Michael Prudhomme	Chief, Cost Engineering	USACE
Ondrea Hummel	Ecologist	USACE
Corina V. Chavez	Civil Engineer	USACE
Patty Phillips	Project Manager	USACE

8 - District Engineer's Recommendation

Consideration has been given to all significant aspects in the overall public interest, including engineering feasibility, economic, social and environmental effects. The recommended plan for the Española Valley, Rio Grande and Tributaries, New Mexico meets all requirements for implementation under Federal and USACE regulations. The recommended plan includes:

The recommended plan is the NER plan.

The recommended plan is described in greater detail in Chapter 4, Section 4.6 Description of the Recommended Plan.

I recommend that the ecosystem restoration improvements in the Española Valley, Rio Grande and Tributaries, New Mexico be constructed generally in accordance with the recommended plan herein and with such modifications thereof as at the discretion of the Chief of Engineers may be advisable at an estimated first cost of $61,981,000 (October FY 2017 dollars). Federal implementation of the recommended project would be subject to provision that the non-Federal sponsors and the Secretary of the Army shall enter into a binding Project Partnership Agreement (PPA) defining the terms and conditions of cooperation for implementing the Española Valley, Rio Grande and Tributaries, New Mexico project, and the non-Federal sponsors comply with applicable Federal laws and policies, including but not limited to:

1. Provide 35 percent of total ecosystem restoration costs as further specified below:
    a. Provide 35 percent of design costs allocated by the Government to ecosystem restoration, in accordance with the terms of a design agreement entered into prior to commencement of design work for the ecosystem restoration features;
    b. 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 all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration features;
    c. Provide, during construction, any additional funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of total ecosystem restoration costs;
2. Provide 50 percent of total recreation costs as further specified below:
    a. Provide 35 percent of design costs allocated by the Government to recreation in accordance with the terms of a design agreement entered into prior to commencement of design work for the recreation features;
    b. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to recreation;

   c. 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 all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the recreation features;

   d. Provide, during construction, any additional funds necessary to make its total contribution for recreation equal to 50 percent of total recreation costs;

3. Provide, during construction, 100 percent of excess recreation costs in the event that the Federal share of total recreation costs exceeds 10 percent of the Federal share of total ecosystem restoration costs;

4. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, 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 purpose is authorized;

5. 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 features, hinder operation and maintenance of the project, or interfere with the project's proper function;

6. 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;

7. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;

8. 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. 4601-4655), and the Uniform Regulations contained in 49 C.F.R. 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;

9. 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 features, at no cost to the 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 Government;

10. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsors own or control for access to the project for

the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

11. 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;

12. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after the final accounting, to the extent and in such detail as will properly reflect total project costs.

13. Comply with all requirements of applicable Federal laws and implementing regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, as amended (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and Army Regulation 600-7 issued pursuant thereto; and 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (labor standards originally enacted as the Davis-Bacon Act, the Contract Work Hours and Safety Standards Act, and the Copeland Anti-Kickback Act);

14. 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 Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigations unless the Government provides the non-Federal sponsors with prior specific written direction, in which case the non-Federal sponsors shall perform such investigations in accordance with such written direction;

15. Assume, as between the Government and the non-Federal sponsors, 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 Government determines to be required for construction, operation, and maintenance of the project;

16. Agree, as between the Government and the non-Federal sponsors, that the non-Federal sponsors 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

17. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 1030) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 22130)), 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.

I certify that the planning activities have been implemented in accordance with USACE planning policy, design and construction standards and applicable Federal and State laws. The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a National Civil Works construction program nor the perspective of higher review levels within the Executive Branch.

Recommendations may be modified. However prior to transmittal to Congress, each of the non-Federal sponsors, the State of New Mexico, and stakeholders will be advised of any modifications and will be afforded an opportunity to comment further.

Date	James L. Booth Lieutenant Colonel, U.S. Army District Commander

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