General Reevaluation Report and Supplemental Environmental Impact Statement II:

RIO GRANDE FLOODWAY, SAN ACACIA TO BOSQUE DEL APACHE UNIT, SOCORRO COUNTY, NEW MEXICO

October 2013

Prepared by:

U.S. Army Corps of Engineers Albuquerque District

In partnership with:

Middle Rio Grande Conservancy District

State of New Mexico Interstate Stream Commission

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SUPPLEMENTAL ENVIRONMENTAL

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General Reevaluation Report
and
Supplemental Environmental Impact Statement II:

Rio Grande Floodway
San Acacia to Bosque del Apache Unit,
Socorro County, New Mexico

This General Reevaluation Report (GRR) includes an integrated Supplemental Environmental Impact Statement II (SEIS-II) with the sections required for National Environmental Policy Act compliance noted by an asterisk (*) in the Table of Contents.

The responsible lead agency is the U.S. Army Corps of Engineers, Albuquerque District.

Abstract. The GRR/SEIS-II addresses alternative plans to provide higher levels of flood risk management to floodplain communities along the Rio Grande from the San Acacia Diversion Dam downstream to Elephant Butte Lake, New Mexico. This GRR/SEIS-II determines (1) whether the Authorized Project is still implementable; (2) if any changes are necessary for implementation; and (3) if the changes are within the approval authority delegated to the Division Commander, the Corps, or if they require additional Congressional authorization. This GRR/SEIS-II is a complete Alternative Formulation Briefing document with recommendations on future actions to best meet the flood risk management needs within the study area. These future actions are termed the recommended plan.

The recommended plan consists of an earthen levee extending approximately 43 miles along the west bank of the Rio Grande, from the San Acacia Diversion Dam to Tiffany Junction, ending at a point approximately 3 miles north of the Railroad Bridge at San Marcial. The plan consists of replacing the existing non-engineered spoil bank levee to form a structurally sound levee paralleling the U.S. Bureau of Reclamation's Low Flow Conveyance Channel. The plan will provide protection from high and low frequency flood events and long term inundation of the levee. The recommended plan is the National Economic Development plan, which maximizes net economic benefits consistent with protecting the Nation's environment. The local sponsors, the Middle Rio Grande Conservancy District and the State of New Mexico Interstate Stream Commission, support the recommended plan.

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EXECUTIVE SUMMARY

This integrated General Reevaluation Report (GRR) and Supplemental Environmental Impact Statement II (SEIS-II) addresses alternative plans to provide higher levels of flood risk management to floodplain communities within the San Acacia to Bosque del Apache Unit of the Rio Grande Floodway. This reach was included in a comprehensive plan for flood risk management in the Rio Grande basin originally authorized in 1948. This GRR/SEIS-II is the final response to determine (1) whether the authorized project is still implementable; (2) if any changes are necessary for implementation; and (3) if the changes are within the approval authority delegated to the Division Commander, the Chief of Engineers, or if they require additional Congressional authorization. This GRR/SEIS-II presents recommendations on future actions to best meet the flood risk management needs within the study area.

The study area of the current project, San Acacia to Bosque del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The authority provided a comprehensive plan for coordinated development, by the U.S. Army Corps of Engineers (Corps) and Bureau of Reclamation (Reclamation), of water resource and flood risk management on the Rio Grande commencing near Truth or Consequences at about River Mile 123, and extending upstream to the lower end of the Rio Grande Canyon 14 miles above Española, New Mexico, at about River Mile 394. The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs, and levee enlargement and construction. A November 1947 agreement delegated responsibility for channel rectification and maintenance to Reclamation and facilities for local flood protection to the Corps.

As described in the 1948 report, levees had been constructed by local interests through parts of the Española and Middle Valleys of the Rio Grande. These levees were not uniform as to grade, section or standard of construction, and it was proposed to modify and supplement the existing levees. Within the San Acacia to Bosque del Apache Unit, new grades would be established in accordance with the requirements for safely passing a Standard Project Flood of 40,000 cubic feet per second (cfs) at San Acacia diminishing to 30,000 cfs at San Marcial. The proposed levees would be constructed to standard section, with 10-foot crown, 3 on 1 side slopes, and a freeboard of three feet above the maximum water surface. Sixty miles was listed as the length of levees that needed improvement within the Middle Rio Grande Valley. However, the exact location was not described. The alignment of any new or reconstructed levees would depend upon the location of the river channel once channel rectification was complete and at the time the work would be planned in detail.

The present study area extends from the San Acacia Diversion Dam (SADD), located north of the City of Socorro, New Mexico, downstream nearly 58-miles to the upper extent of Elephant Butte Reservoir (Figure 1.1). The river channel and adjacent riparian woodlands, floodplain farmland, and terraced plains of grasses and shrubs characterize the valley, which is bordered by basalt-capped mesas, and mountains. The width of the Rio Grande Valley through the proposed project area varies from eight to twelve miles, with the nearly flat Rio Grande floodplain varying from one to three miles wide. The floodplain and bordering terraces are mostly rural and used for irrigated agriculture, livestock grazing, and wildlife conservation and enhancement. The City of Socorro, with a 2010 population of 9,051, is the major population center in the project area. Smaller communities, such as San Acacia, Polvadera, San Luis, Lemitar, Escondida, San Pedro, and San Antonio, are scattered throughout the project area. Elephant Butte Reservoir, immediately downstream of the project area, is the largest reservoir in New Mexico, storing water for irrigation, hydroelectric power, and recreation. Three major Federally owned facilities within the area of consideration are the Sevilleta National Wildlife Refuge, the Bosque del Apache National Wildlife Refuge (BDANWR) and the Low Flow Conveyance Channel (LFCC) (Figure 1.1): The Sevilleta refuge does not incur damages from flooding within the study area but manages lands in the vicinity of the San Acacia Diversion Dam. The other two facilities incur damages during flood events.

- The Bosque del Apache NWR encompasses 57,191 acres straddling the Rio Grande approximately 10 miles south of Socorro, New Mexico. Wetlands within created impoundments are managed via irrigation and water level manipulation. The Refuge cooperates with local farmers to grow crops for wintering waterfowl and cranes. Farmers plant alfalfa and corn, harvesting the alfalfa and leaving the corn for wildlife (USFWS, 2010).

- The LFCC, completed in 1959, is an artificial, rock lined channel that runs parallel to the Rio Grande between San Acacia and Elephant Butte Reservoir. Reclamation built the LFCC as part of the 1948 Rio Grande Basin authorization for the purpose of reducing consumption of water, providing more effective sediment transport, and improving valley drainage. Operation and maintenance of the LFCC are continuing Reclamation responsibilities.

Historically, flood events in the study area have been associated with two types of events: spring snowmelt runoff from northern New Mexico and southern Colorado, and the runoff from monsoonal storms most often entering the Rio Grande via its two western tributaries, the Rio Puerco and Rio Salado. Both tributaries enter the Rio Grande within 10 miles upstream of the SADD. The largest catastrophic flood events in the study area typically have been associated with monsoonal runoff from these two tributaries. Recorded flood history in the study area goes back to the 1920s. Before that time, newspaper accounts identified major floods in July 1895 and September 1904. Recorded major floods that would exceed the estimated protection afforded by the existing spoil banks occurred twice in 1929 (August 12, with Rio Salado flows of 27,400 cfs, and September 23, with Rio Puerco flows of 37,000 cfs); and again in 1936 (August 4, with Rio Puerco flows of 24,000 cfs); in 1941 (September 23, with Rio Puerco flows of 18,800 cfs); and in 1965 (July 31, with Rio Salado flows of 36,200 cfs). A recurrence of any of these floods would have devastating effects in the study area. In addition, there were smaller but significant flood events in 1976, 1979, 1995, and 2005 that required “flood fights” to prevent spoil bank failure. Without these actions, the existing spoil bank would have failed several times in the past 35 years alone. It has been estimated that a flood associated with the 1 percent exceedance probability event would result in $98.4 million (2012 price level) in damages in the study area (See Figures 5.3-5.9). The start of damages is estimated to occur at a 20- to 14-percent chance flood event[1]. Thus, the study area not only is characterized by large economic losses during flood events, but also a high frequency of damaging events.

Several alternative measures for Flood Risk Management were presented in earlier environmental impact statements. Alternatives previously considered and eliminated from further studies include:

- Flood risk and sediment management dams on the Rio Puerco and Rio Salado.
- Localized levees surrounding the village of San Acacia, the City of Socorro, and the Bosque del Apache NWR.
- Watershed land treatment measures in the Rio Puerco and Rio Salado watersheds.
- Flood proofing.
- Flood zoning.
- Intermittent levee replacement.
- Railroad track realignment.

Preparation of this GRR/SEIS-II became necessary due to several changes that have occurred since the project was authorized in 1948. These include the following:

- Rectification of the Rio Grande channel by Bureau of Reclamation as outlined in the 1948 authorization and construction of the Low Flow Conveyance Channel under the same authority.
- A longer period of record for hydrological data is now available, which permits improved and updated hydrological analysis.
- A levee design modification has been added to address long duration flows: any proposed plan would have to incorporate design features to prevent seepage through the levee due to prolonged flow against the riverward toe.
- The Corps has departed from the use of the freeboard methodology to account for uncertainty and instead uses probabilistic determination of flood risk and levee design.
- Three species have been listed as threatened or endangered since 1994 (the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, and Pecos sunflower — each occurring within the study area, two with critical habitat).

In addition to the alternatives considered in previous reevaluations, this GRR/SEIS-II provides updated evaluations of pertinent alternatives consisting of varying combinations of multiple project features. The array of features and plans are described in detail in Sections 4.5 and 4.6. 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 objectives as well as planning criteria for completeness, effectiveness, acceptability, and efficiency. The recommended plan is the National

[1] The probabilities (0.2%, 1%, 5%, 10%, 14 %, 20%) refer to the probability of a particular flow event is exceeded in any one year. Therefore, the previous nomenclature of the “100-year flood” is more properly defined as the flood having a 1 percent chance of being exceeded in any one year. Similarly, the 5% flood was previously called the “20-year” flood, the 2% flood was previously called the “50-year” flood, and the 0.2% flow was called the “500-year” flood.

Economic Development (NED) plan, which maximizes net economic benefits to the Nation consistent with protecting the Nation's environment.

The recommended plan reflects feasibility level planning and design for an approximately 43 mile long levee along the west bank of the Rio Grande from the SADD to a location approximately 15 miles north of the upper extent of Elephant Butte reservoir near Tiffany Basin. The major feature of the plan is replacement of the existing spoil bank within its current alignment. The recommended plan was chosen from the array of alternatives as well as levee lengths and heights because it maximizes net benefits efficiently. This levee height corresponds to 4 feet above the water surface elevation of the mean 1%-chance exceedance event for the project base year (see Section 4.6.5 for a detailed discussion of levee height and performance).

The GRR/SEIS-II recommended plan only deviates from that authorized by FCA 1948 in ways that were anticipated by the authors of the original document. The 1948 authorization states that the flood risk management measures for the Rio Grande Floodway are "proposed to modify and supplement the existing levees where experience would show the necessity therefore. New grades would be established in the accordance with the requirements for safely passing the Standard Project Floods." Although the authorization states that 40,000 cfs at San Acacia and 30,000 cfs at San Marcial is "prudent," the Corps now employs a risk based approach to assess project performance. The recent hydrologic analysis using approved Corps models and based on a longer period of record identifies the 0.2%-chance exceedance probability as 43,000 cfs at San Acacia.

Changes have been made to the levee alignment in response to changes in river channel location. According to the 1948 authorization, "The alignment of any new or constructed levees would depend upon the location of the river channel at the time the work would be planned in detail." Of the alternative alignments assessed in this reevaluation, the recommended plan consisting of replacement of approximately 43 miles of existing spoil bank was determined to be the alignment that maximizes net benefits based on conditions existing in 2010.

In addition, changes have been made to the levee design to meet superior, modern design standards. The 1948 authorization states that "the levees would be constructed to standard sections, with 10-foot crown, 3 on 1 side slopes and with a freeboard of three feet above maximum water surface." The Corps has departed from the freeboard methodology in favor of a risk based approach to assess project performance. The 2011 recommended plan accounts for uncertainty by describing the probability of successfully passing a particular flood event. In the case of the recommended plan, the probability of passing the 1%-chance event is determined to be 33.6 % for the base year or the year the project is finished..

The recommended plan within the San Acacia to Bosque del Apache Unit of the Rio Grande Floodway has not changed significantly from the plan for the Rio Grande Basin authorized by the Flood Control Acts (FCA) of 1948 (P.L. 80-858, Section 203) and of 1950 (P.L. 81-516) and as set forth in the *Report of the Chief of Engineers* dated April 5, 1948 (HD 243).

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LIST OF ACRONYMS AND TERMS

1992 SEIS	*Final Supplemental Environmental Impact Statement, Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro County, NM*, July 1992.
AEP	annual exceedance probability
AFB	alternative formulation briefing
AMAFCA	Albuquerque Metropolitan Arroyo Flood Control Authority
ASA(CW)	Assistant Secretary of the Army (Civil Works)
AT&SF	Atchison, Topeka and Santa Fe
BDANWR	Bosque del Apache National Wildlife Refuge
BIA	U.S. Bureau of Indian Affairs
BERH	Board of Engineers for Rivers and Harbors
BLM	U.S. Bureau of Land Management
BMP	best management practice
BNSF	Burlington Northern Santa Fe
cfs	cubic feet per second
CNP	conditional non-exceedance probability
CO	carbon monoxide
Compact	Rio Grande Compact
Corps	U.S. Army Corps of Engineers
EAD	expected annual damage
ENSO	El Niño-Southern Oscillation
EQ	environmental quality
ESA	Endangered Species Act
ESI	environmental site investigation
FCA	Flood Control Act
FDM	feature design memorandum
FEMA	Federal Emergency Management Agency
FIA	Flood Insurance Administration
FIRMS	flood insurance rate maps
GDM	general design memorandum
HTRW	hazardous, toxic and radioactive waste
LERRD	land, easements, rights-of-way, relocation, and disposal areas
LFCC	Low Flow Conveyance Channel
LPP	locally preferred plan
GRR	general reevaluation report
MOA	memoranda of agreement
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
NFIP	National Flood Insurance Program
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environmental Department

NMCRIS	New Mexico Cultural Resources Inventory System
NMHPD	New Mexico Historic Preservation Department
NMSHPO	New Mexico State Historic Preservation Officer
NMISC	New Mexico Interstate Stream Commission
NO_x	nitrogen oxides
NPDES	National Pollution Discharge Elimination System
NRCS	U.S. Natural Resources Conservation Service
NWR	National Wildlife Refuge
O_3	ozone
OHWM	ordinary high water mark (relative to Section 404 of the Clean Water Act)
OMRR&R	operation, maintenance, repair, replacement, and rehabilitation
OSE	other social effects
Pb	lead
PDO	Pacific Decadal Oscillation
PSDP	New Mexico Environmental Improvement Division's Prevention of Significant Deterioration Program
PL	public law
PM_{10}	total suspended particulates smaller than 10 microns
PSTB	Petroleum Storage Tank Bureau
P&S	plans and specifications
Reclamation	U.S. Bureau of Reclamation
RED	regional economic development
RBA	risk-based analysis
RGF	Rio Grande Floodway
RGSM	Rio Grande silvery minnow
ROD	record of decision
RM	river mile
SADD	San Acacia Diversion Dam
sq. mi.	square miles
SEIS	Supplemental Environmental Impact Statement
SHPO	State Historic Preservation Officer
SO_2	sulfur dioxide
SPF	standard project flood
SPT	standard penetration test
SWPPP	Storm Water Pollution Prevention Plan
SWWF	Southwestern Willow Flycatcher
TCP	traditional cultural properties
TSP	total suspended particulate matter
USACE	See Corps
USBR	See Reclamation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UST	underground petroleum storage tanks
USWRC	U.S. Water Resources Council
WRDA	Water Resources Development Act

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CHAPTER 1 - INTRODUCTION*

The San Acacia to Bosque del Apache Unit Study is being conducted as a joint effort by the U.S. Army Corps of Engineers (Corps), Albuquerque District, the Middle Rio Grande Conservancy District (MRGCD) and New Mexico Interstate Stream Commission (NMISC). The study is being conducted in coordination with the Bureau of Reclamation (Reclamation), U.S. Fish and Wildlife Service (USFWS), and local non-governmental interests. This document addresses proposed flood risk management measures within the San Acacia to Bosque del Apache Unit of the comprehensive flood risk management plan of the Rio Grande Floodway, New Mexico. This General Reevaluation Report and Supplemental Environmental Impact Statement (GRR/SEIS-II) will support decision making by the Corps, MRGCD, and other responsible agencies to implement the proposed project modifications and ensure compliance with the National Environmental Policy Act (NEPA); current Corps policies, criteria, and guidance; and other pertinent laws and regulations. Potential direct and indirect environmental, social, and economic effects of the proposed action and alternatives will also be addressed in this GRR/SEIS-II.

1.1 REPORT ORGANIZATION

This GRR/SEIS-II has been divided into eight primary chapters, each dealing with a specific subject area relating to the planning process. These include evaluation of the existing condition, projected future without project condition, formulation and comparison of alternatives, and evaluation of effects of the recommended plan. Chapters noted in the report by an asterisk (*) in the Table of Contents are required by the Council of Environmental Quality's *Regulations for Implementing the National Environmental Policy Act*.

Chapter 1 - Introduction provides background information concerning the purpose of and need for the project, project authorization, and project status, as well as the scope of the reevaluation study. This chapter also notes linkages with other related studies and reports.

Chapter 2 – Existing Conditions provides a detailed presentation of the existing environmental conditions within the project area. This chapter also includes a complete discussion of environmental resources that would be affected by implementation of project alternatives.

Chapter 3 – Future Without-Project Conditions defines the conditions expected to exist over the period of analysis in the absence of any action taken by the Federal Government to solve the stated problems.

Chapter 4 – Plan Formulation describes the Corps planning process with respect to the evaluation of alternatives and the ultimate selection of a preferred alternative plan that meets project objectives for flood risk management. In this chapter, planning goals are set, objectives are established, and constraints are identified. This chapter identifies alternatives considered but eliminated from further consideration, as well as evaluation of a preliminary array of alternative plans that adequately address the goals and objectives established. The rationale and criteria for screening of alternative plans is presented, as well as a selection of a final array of alternatives, including the recommended plan that will be evaluated for environmental effects.

Chapter 5 – Description of the Final Array of Alternatives presents a detailed description of the final array of alternatives that meet the objectives of the study, satisfy Corps criteria for selection of a recommended plan, and contribute to national economic development. As part of the final array of alternatives, the recommended plan is described in detail here.

Chapter 6 – Foreseeable Effects of the Proposed Action and Alternatives evaluates the final array of alternatives including the recommended plan for effects to the human environment. Each alternative is described in terms of the positive or negative effect to various components of the environment. The No Action Alternative (the effect of not implementing a Federal project) is evaluated as part of the final array of alternatives.

Chapter 7 – Post Authorization Changes documents that the current proposed plan for the flood risk management within the San Acacia to Bosque del Apache Unit of the Middle Rio Grande Floodway has not changed significantly from the plan authorized by the 1948 and 1950 Flood Control Act (FCA) authorizations. Criteria for construction of flood risk management infrastructure as stated in the 1948 authorizing document is compared to the recommended plan.

Chapter 8 – Conclusion and Recommendations presents the results of alternative evaluation, project cost estimates, project schedule, items of cooperation and a recommendation for further action.

Chapter 9 – Preparation and Coordination lists preparers and reviewers of the GRR/SEIS-II as well as other Federal, state and local agencies and private entities that were coordinated with in preparation of the GRR/SEIS-II.

Chapter10 – References lists references including studies, reports, analyses, and other reference materials used in the preparation of this report.

1.2 PROJECT AUTHORIZATION

The Rio Grande Floodway, San Acacia to Bosque del Apache Unit Project was authorized for construction by the Flood Control Act of 1948 (Public Law 80-858, Section 203), in accordance with the recommendation of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated 5 April 1948, which reads as follows:

> *The comprehensive plan for the Rio Grande Basin as set forth in the report of the Chief of Engineers, dated April 5, 1948, and in the report of the Bureau of Reclamation, dated November 21, 1947, all in substantial accord with the agreement approved by the Secretary of the Army and the Acting Secretary of the Interior on November 21, 1947, is hereby approved except insofar as the recommendations in those reports are inconsistent with the provisions of this Act and subject to the authorizations and limitations set forth herein.*

> *The approval granted above shall be subject to the following conditions and limitations:*
>
> *a) Construction of the spillway gate at Chamita shall be deferred so long as New Mexico shall have accrued debits as defined by the Rio Grande Compact and until New Mexico shall consistently accrue credits pursuant to the Rio Grande Compact;*
>
> *b) Chiflo Dam and Reservoir on the Rio Grande shall be excluded from the Middle Rio Grande Project authorized herein without prejudice to subsequent consideration of Chiflo Dam and Reservoir by the Congress;*
>
> *c) The Bureau of Reclamation, in conjunction with other interested federal agencies, is directed to make studies to determine feasible ways and means of reducing non-beneficial consumption of water by native vegetation in the floodplain of the Rio Grande and its principle tributaries above Caballo Reservoir; and*
>
> *d) At all times when New Mexico shall have accrued debits as defined by the Rio Grande Compact, all reservoirs constructed as a part of the project shall be operated solely for flood control except as otherwise required by the Rio Grande Compact, and at all times all project works shall be operated in conformity with the Rio Grande Compact as it is administered by the Rio Grande Compact Commission.*

The specific responsibilities of the Corps and the Bureau of Reclamation (Reclamation) were described in the comprehensive plan. The major objectives to alleviate inundation are set forth in House Document 243, Appendix E, Project Planning:

a. Provide protection against inundation by flash floods,
b. Provide a stable channel having a lower river bed so that controlled releases of 5,000 cfs could be efficiently carried.
c. Provide a lower river bed so that the channel effectively drains the river valley lands and results in a lower water table.

Items b and c were intended to be performed by the Bureau of Reclamation through channel rectification and dredging. Flood control, now referred to as flood risk management, was to be performed by the Corps of Engineers through construction of dams and levees.

Additional language was provided in WRDA 1992 Section 102 regarding the equitable cost share portioning due to the large amount of Federal properties to be protected by the proposed project:

(s) RIO GRANDE FLOODWAY, NEW MEXICO.--Notwithstanding any other provision of law, the project for flood control, Rio Grande Floodway, San Acacia to Bosque del Apache Unit, New Mexico, authorized by section 203 of the Flood Control Act of 1948 (Public Law 80-858) and amended by section 204 of the Flood Control Act of 1950 (Public Law 81-516), is modified to more equitably reflect the non-Federal benefits from the project in relation to the total benefits of the project by reducing the non-Federal contribution for the project by that percentage of benefits which is attributable to the Federal properties; except that, for purposes of this subsection, Federal property benefits may not exceed 50 percent of the total project benefits.

1.3 PURPOSE AND NEED FOR ACTION*

The purpose of the current project is to reduce the risk of flood damages within the San Acacia to Bosque del Apache Unit. The study area has a long history of flood damage. Recorded flood history in the study area dates back to the 1920s. Before that time, newspaper accounts identify major floods that occurred in July 1895 and September 1904. Recorded major floods (Scurlock 1998), which would have exceeded the estimated protection afforded by the existing levee in the study area, occurred twice in 1929 (August 12, with Rio Salado flows of 27,400 cfs, and September 23, with Rio Puerco flows of 37,000 cfs); as well as in 1936 (August 4, with Rio Puerco flows of 24,000 cfs); in 1941 (September 23¸with Rio Puerco flows of 18,800 cfs); and in 1965 (July 31, with Rio Salado flows of 36,200 cfs). A recurrence of any of these floods would have devastating effects downstream in the study area. In addition, there have been numerous flood events in recent years, more specifically, 1976, 1979, 1995, and 2005, when the MRGCD and Reclamation had to conduct flood fights to prevent levee failure. Without these actions, the existing spoil bank would have failed several times in the past 35 years. It has been estimated that a 1-percent chance flood event occurring today could result in $98.4 million (2012 price level) in damages in the study area. Start of damages is estimated to be between the 20- and 14-percent chance flood events. Thus, the study area would suffer large economic losses during a flood, beginning with a very low flood event. (See Section 1.4.1 for additional information on the flood history of the study area.)

The Corps has received numerous requests from Federal and state agencies, local municipalities and agencies, and individuals to address the flood problems of the Middle Rio Grande Basin. These requests resulted in the U.S. Congress directing the Corps to define the problems of the basin, formulate and evaluate various solutions to these problems, evaluate their applicability under existing Federal programs, and recommend a corrective course of action. The discharge for the 10-percent chance exceedance flow is 15,400 cfs at the SADD which exceeds the minimum discharge of 800 cfs required for study under Corps authorities. Thus, several analyses have been conducted with the objective of addressing the water resource problems of the watershed.

The Flood Control Act of 1948 concluded that the flood problems of the Rio Grande Basin were severe and could be addressed under the Corps' flood risk management program. Due to changes within the basin over the years, including budgetary requirements, real estate constraints, flood risk management features implemented in the upper watershed, and environmental concerns, the features of the project have changed several times. Preparation of this GRR/SEIS-II became necessary due to these changes and specifically those that have occurred since 1993, when the San Acacia to Bosque del Apache Unit Project was last reaffirmed to be implementable, as previously approved, in a Limited Reevaluation and Supplemental EIS (USACE, 1993). This GRR/SEIS-II is the final response to the project authority with respect to the San Acacia to Bosque Del Apache unit. Alternative methods for accomplishing flood risk management in the study area have been evaluated for compliance with Corps planning policy as well as the National Environmental Protection Act (NEPA), both of which were established after 1948.

An EIS was completed in May 1974 (USACE 1974) and filed with the Council on Environmental Quality in 1977. The Water Resources Development Act of 1976 (Public Law 94-587, Section 101a) authorized "the Secretary of the Army, acting through the Chief of Engineers, to undertake the Phase I Design Memorandum stage of Advanced Engineering and Design of the project for flood control and other purposes on the Rio Grande (Rio Puerco and Rio Salado), New Mexico." The proposed alternative included construction of a detention dam on the Rio Puerco and Rio Salado. These advanced studies were subsequently terminated when the State of New Mexico withdrew its support for the project due to cost considerations and the U.S. Fish and Wildlife Service determined that the construction and operation of the two recommended dams was precluded by management restrictions in the deed to their lands. As a consequence of the infeasibility of dam construction, the construction of an engineered, competent levee from and along the alignment of an existing spoilbank emerged as the only other economically feasible alternative. A supplemental EIS was completed in 1992 (USACE 1992; see Appendix D) that evaluated the environmental effects from these alternatives and provided a recommended levee alternative. Nearing completion in 1994, the plans and specifications for the project identified were put on hold due to the new issues stated in bullets above. More detail is provided in Section 1.8 regarding previous environmental impact statements.

1.4 STUDY AREA*

The study area, which corresponds to the San Acacia to Bosque del Apache Unit, comprises a stretch of the Rio Grande extending from the San Acacia Diversion Dam (SADD), near the community of San Acacia, south through the Bosque del Apache National Wildlife Refuge (BDANWR) to the headwaters of Reclamation's Elephant Butte Reservoir, south of the former village of San Marcial. The study area is entirely contained within Socorro County, New Mexico. The City of Socorro, New Mexico, is the largest population center within the county. The San Acacia to Bosque del Apache Unit (Figure 1.1) consists of the Rio Grande floodplain from the SADD near the top of the map (denoted by a yellow triangle) to the upper extent of Elephant Butte Reservoir (denoted by a blue outline) at the bottom center of the map. The areas within the unit that are subject to inundation from the 1%-chance exceedance event are shown in Figures 5.3-5.9.

The Rio Grande stretches approximately 2,000 miles from its headwaters in the San Juan Mountains of southwestern Colorado to its terminus in the Gulf of Mexico near Brownsville, Texas. The Rio Grande is the fifth longest river in North America and the 20th longest in the world. The watershed measures approximately 336,000 square miles, although only about half of the total area, 176,000 square miles, contributes to the river's flow. The Rio Grande passes through three states in the United States (Colorado, New Mexico, and Texas) and four in the Republic of Mexico (Chihuahua, Coahuila, Nueva Leon, and Tamaulipas). The Rio Grande, known as the Rio Bravo in Mexico, forms the international boundary between Texas and Mexico. In 1997, the U.S. Environmental Protection Agency designated the Rio Grande as an American Heritage River.

In the Albuquerque District, the Upper Rio Grande Basin is defined as that part of the river upstream of Fort Quitman, Texas. Within this reach, the river measures approximately 700 miles in length with a drainage area of approximately 30,000 square miles. The Continental Divide forms the western boundary of the Upper Rio Grande Basin while the Sangre de Cristo, Sandia, and Manzano Mountains, and a series of north-south mountain ranges bisecting the state of New Mexico form the eastern boundary.

The major tributaries and respective watershed areas in Colorado and New Mexico are, from north to south, the Conejos River (821 square miles), Rio Chama (3,150 square miles), Galisteo Creek (670 square miles), Jemez River (1,038 square miles), Rio Puerco (6,057 square miles), and Rio Salado (1,394 square miles). The Rio Grande watershed upstream of El Paso, Texas, contains five closed basins: San Luis in Colorado; and the Llano de Albuquerque, North Plains, San Augustine Plains, and Jornado del Muerto in New Mexico.

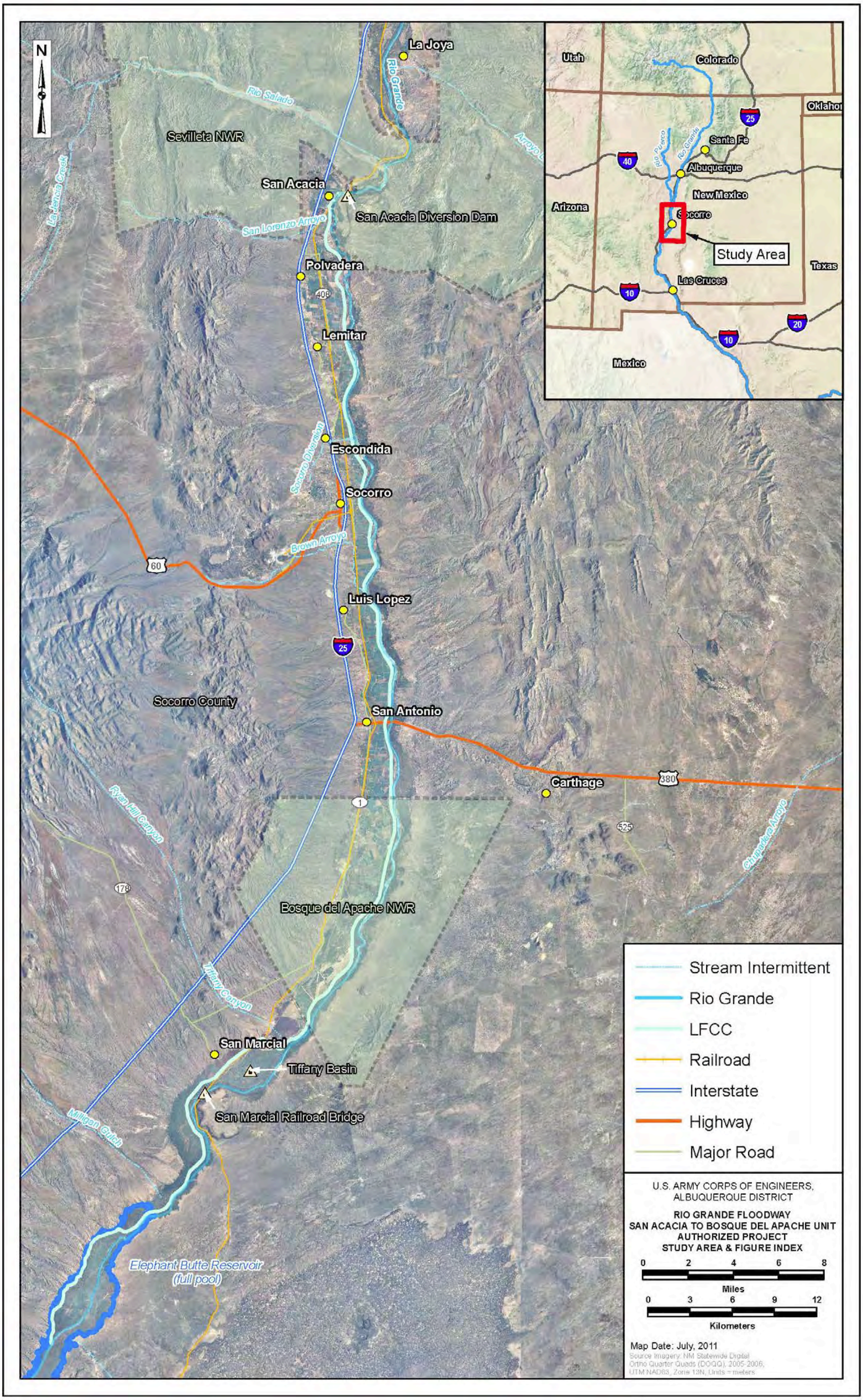

Figure 1.1 Map of the Study Area.

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The Middle Rio Grande refers to the portion of the Upper Rio Grande Basin that passes through central New Mexico and is typically defined as extending from Cochiti Dam downstream approximately 160 miles to San Marcial and the head of Elephant Butte Reservoir (Figure 1.2). The Middle Rio Grande valley extends across four New Mexican counties (from north to south: Sandoval, Bernalillo, Valencia, and Socorro) and six Pueblos (Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta). The Pueblos of Jemez, Santa Ana, and Zia occur on the Jemez River, a tributary to the Rio Grande in this reach. The cities and towns of Bernalillo, Rio Rancho, Corrales, Albuquerque, Los Lunas, Belen, and Socorro are located within the Middle Rio Grande valley.

Figure 1.2 Dams and Diversions along the Rio Grande.
(Map source: Middle Rio Grande Bosque Initiative Website at www.fws.gov/southwest/mrgbi/resources/Dams/index.html).

The San Acacia to Bosque del Apache Unit is the southern-most section of the Middle Rio Grande Valley, comprising the 58 miles between the San Acacia Diversion Dam and the northern end of Elephant Butte Reservoir just below the San Marcial railroad bridge. The principal city in this reach is Socorro with a 2010 population of 9,051. In addition, eight small agricultural villages occur on the floodplain: Polvadera, Lemitar, Escondida, Luis Lopez, San Antonio, San Marcial, Val Verde and La Mesa. The western boundary of this section of the river basin is marked by the Magdalena, Chupadera and Lemitar Mountains and the eastern boundary by a series of lower ranges.

In the San Acacia to Bosque del Apache Unit, the principal land and facility managers in the valley include the Middle Rio Grande Conservancy District, the Bureau of Reclamation, and the US Fish and Wildlife Service. The New Mexico Office of the State Engineer and the New Mexico Interstate Stream Commission administer water rights and address Rio Grande Compact compliance. Elephant Butte Reservoir, immediately downstream of the project area, is the largest reservoir in New Mexico, storing water for irrigation, hydroelectric power, and recreation. Three major Federally owned facilities within the area of consideration are the U.S. Fish and Wildlife Service's Sevilleta National Wildlife Refuge, the Bosque del Apache National Wildlife Refuge (BDANWR) and the Bureau of Reclamation's Low Flow Conveyance Channel (LFCC) (Figure 1.1).

The Sevilleta National Wildlife Refuge (SNWR) is one of the largest refuges in the National Wildlife Refuge System, encompassing 228,700 acres. It runs the full width of the Rio Grande Valley extending from the Sierra Ladrones on the west to Los Pinos Mountains on the east. It is approximately 30 miles in width and 18 miles in length, covering a total of 400 square miles. Elevations on the refuge range from 4,430 feet at the Rio Grande to 8,953 feet at Ladrón Peak. The bulk of the SNWR occurs upstream of the study area. The confluence of both the Rio Salado and Rio Puerco occur on the refuge. The refuge and study area overlap on both sides of the Rio Grande in the vicinity of the San Acacia Diversion Dam. No damages are incurred from flooding to the SNWR within the study area.

Bosque del Apache National Wildlife Refuge (BDANWR) encompasses 57,191 acres straddling the Rio Grande within the project area between the towns of San Antonio and San Marcial. The heart of the refuge is about 12,900 acres of moist bottomlands--3,800 acres of which are active floodplain of the Rio Grande and 9,100 acres are areas where water is diverted to create extensive wetlands, farmlands, and riparian forests. The goal of refuge management is to provide habitat and protection for migratory birds and endangered species, and to provide the public with a high quality wildlife and educational experience (USFWS, 2010). BDANWR cooperates with local farmers to grow crops for wintering waterfowl and cranes. Farmers plant alfalfa and corn, harvesting the alfalfa and leaving the corn for wildlife. The refuge staff grows corn, winter wheat, clover, and native plants as additional food.

In addition to farming, natural and created habitats are managed to provide wildlife habitat. Prescribed burning, exotic plant control, moist soil management, and water level manipulation are used to maintain these habitats. Wetlands within created impoundments are managed via irrigation and water level manipulation. Marsh management is rotated so that varied habitats are always available for resident and migratory wildlife. Wildlife foods grown this way include smartweed, millets, chufa, bulrush, and sedges. Irrigation canals ensure critical water flow. Daily monitoring, mowing, and clearing keeps them functioning. Controlling the water enables refuge staff to manage the habitat (USFWS, 2010).

The LFCC, completed in 1959, is an artificial channel that runs parallel the Rio Grande between San Acacia, New Mexico and Elephant Butte Reservoir. Reclamation built the LFCC as part of the 1948 Rio Grande Basin authorization for the purpose of reducing consumption of water, providing more effective sediment transport, and improving valley drainage. Operation and maintenance of the LFCC are continuing Reclamation responsibilities.

The LFCC was constructed by Reclamation to aid the State of New Mexico in the delivery of water obligated to Texas under the Rio Grande Compact (Compact). Prior to LFCC construction, the channel into Elephant Butte Reservoir was obstructed with sediment and vegetation such that no surface flows entered the reservoir. The LFCC has been credited with assisting New Mexico to significantly decrease its Compact compliance deficit (which was 325,000 acre-ft in 1951).

Elephant Butte Reservoir storage increased in the early to mid-1980s, inundating and burying the last 15 miles of the channel above the reservoir with sediment. As a result, the channel was shortened to 58 miles. Reclamation has proposed moving the LFCC west in the floodplain, away from the floodway, for a distance of approximately 15 miles upstream of the Elephant Butte Reservoir (Reclamation, 2000). Since no structures, irrigation infrastructure or agriculture exist here, the LFCC is the only facility subject to damage from flooding in this reach. The uncertainty of the future location of the LFCC prompts the elimination of this reach from the flood risk management considerations at this time. Thus, the reach under current consideration is 43 miles long, extending from the SADD only as far as San Marcial, and not including the segment from San Marcial to Elephant Butte Reservoir.

The LFCC currently provides valley drainage benefits, water for pumping to benefit the Rio Grande silvery minnow (RGSM), and supplemental irrigation water supplies to the Bosque del Apache National Wildlife Refuge and irrigators of the Middle Rio Grande Conservancy District. Various rehabilitation or relocation strategies would potentially increase water deliveries to Elephant Butte Reservoir, a primary interest of the Compact states.

1.4.1 Flood History

Floods that occur in the Rio Grande Basin are of two general types. The spring floods during the period April through June are the result of snowmelt or snowmelt in combination with precipitation. These floods are characterized by long-duration, high-volume hydrographs that experience a gradual rise to a maximum discharge and a gradual discharge recession. Floods that occur from July through October result from summer rainfall and thunderstorms that generally produce low-volume, short-duration floods that rise sharply to a peak and recede rapidly. Figure 1.3 compares a high-volume, long-duration spring snowmelt flood hydrograph to a low-volume, short-duration rainfall flood hydrograph.

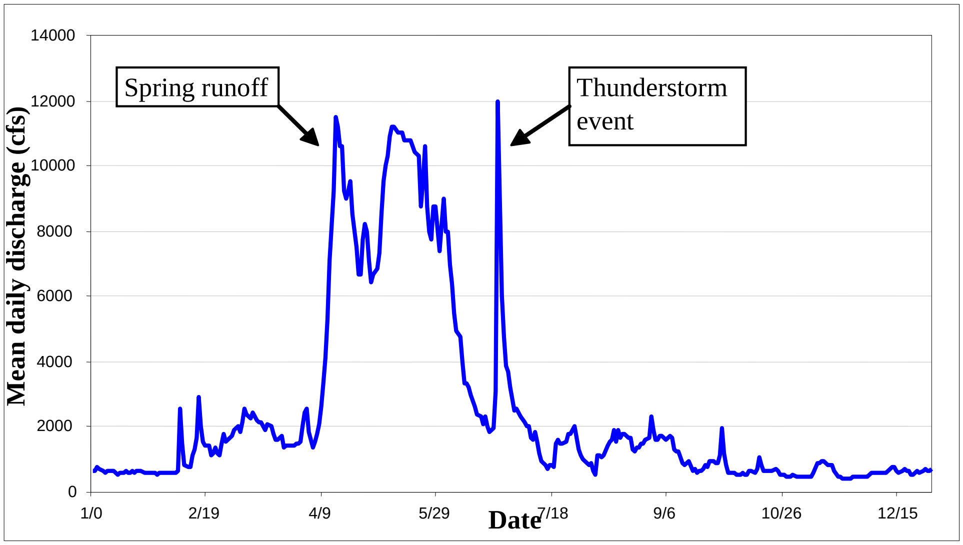


Figure 1.3 Comparison of Spring Snowmelt Hydrograph and Summer Rainfall Hydrograph.

Severe floods have occurred in the Middle Rio Grande Valley on a fairly regular cycle. In the San Acacia to Bosque del Apache Unit from 1850 to 1942, significant flooding occurred approximately every three years, based on historical flood data reported by Scurlock (1998) and reproduced in Table 1.1, below. Flood flows exceeding 100,000 cfs are a regular occurrence, driven both by spring snowmelt and by large summer storms (occasionally in the same year).

Flood frequency and magnitude have been lower in the half-century since 1942. An extended period of drought affected the area from 1942 to 1979. However, in the spring of 1958, a heavy snowpack runoff from the mountainous areas of the Rio Grande Basin produced peaks of 11,000 cfs and 11,800 cfs at Otowi and Bernalillo, respectively. A peak discharge of 9,100 cfs at Albuquerque was produced by the runoff of another heavy snowpack in the mountains of Colorado and northern New Mexico in May 1973. The flood flows stressed sections of the existing levees.

A seven-year “wet cycle” began in 1979 and lasted through 1986 (Welsh, 1997). In 1979, higher than average snow accumulation was augmented by two late storms in May, and lower than normal temperatures through the winter delayed runoff peaks. Average daily flows in the Rio Grande at the Otowi gage exceeded 5,000 cfs from 24 April through 5 July, with a peak discharge of 12,300 cfs recorded on 9 July. Albuquerque experienced a peak flow of 8,650 cfs on 1 June. All USACE reservoirs were storing flood water during this period; flows would have been higher under unregulated conditions.

Table 1.1 Historical Flooding in the San Acacia to Bosque del Apache Unit (Scurlock 1998).

Date	**Location Affected**	**Impact**
1862 August	Albuquerque to Mesilla, New Mexico	Damage of buildings and crops; Mesilla Valley settlers moved to Tularosa Valley; Mesilla was an "almost inaccessible community" due to flood waters.
1866	San Marcial	San Marcial was "wiped out".
1872 Late May, early June	Albuquerque to El Paso, Texas	Most of the floodplain was inundated by runoff from snowmelt in the basin; flow peaked at an estimated 100,000 cfs.
1874 May-June	Confluence of Rio Chama and Rio Grande to El Paso, Texas	Neither river could be crossed safely; widespread damage.
1884 May-June	Del Norte, Colorado, to El Paso, Texas	Residents of Del Norte Valley reported that river flow was the largest they had experienced; runoff from heavy winter snowpack lead to flood damage in virtually every village from Albuquerque to El Paso; several people were killed; extensive damage to buildings and crop fields; river cut through acequia and into old river bed near Peralta; flow estimated at 100,000 cfs; Tomé church destroyed; Valencia totally abandoned; property damage between Alamillo and Lemitar; lower sections of Socorro under [*sic* water, river] observed to be encroaching "upon its western bank" but cutting eastward above Amarillo.
1884 July 2	Santo Domingo to El Paso, Texas	Extensive damage; interruption of work and social activities.
1885	Entire Middle Rio Grande	Extensive damage, almost as severe as June 1884 flood.
1886 September	Valencia to Mesilla	Large number of houses washed away or damaged; hail damage at Belen; railroad and bridges washed out along the Rio Salado and Rio Puerco-of-the-East; homes, fields and bridges damaged, less severe than May flood; San Marcial and Bowling Green destroyed; railroad tracks, cemetery, houses washed out at Chamberina and entire Mesilla Valley; Long Lake formed, remained for a number of years.
1888 Late April-early May	Socorro	Part of the community was inundated.
1889 ca.	Isleta Pueblo to El Paso, Texas	Destroyed most fields below the pueblo and on the west side of the river.
1890	Santo Domingo to Socorro	Pueblo buildings and fields damaged by flooding and residents would not plant in the floodplain due to their concern for more high water; washouts of rail line at two valley locations and some bank cutting at Barelas.
1891 May	Albuquerque to El Paso, Texas	Bridge washed away at Albuquerque; Isleta and Valencia attempted to "boom and dike" the river, but flood wiped out their work; homes destroyed at Valencia, a new 500-yard-wide channel cut with water 5 feet deep flowed through the village; new bridge over the river was destroyed; considerable, widespread damage.
1895 Late July	La Joya to Socorro	At least seven persons killed; property damage; runoff from thunderstorm in Blue Canyon west of Socorro flooded town, causing severe property damage and loss of life; in lower section of town water reached a height of 4 feet.
1896	Near San Marcial	USGS gaging station washed away.
1897 May	Embudo to El Paso, Texas	Widespread damage; flow at Buckman peaked at 15,300 cfs and San Marcial at 21,750 cfs.
1897 October	Near San Marcial	Flow from fall rain peaked at 15,500 cfs.

Date	Location Affected	Impact
1903 June	Otowi Bridge to Socorro	A flood of 19,300 cfs broke through Alameda dike, flooding valley and destroying the settlement; agricultural fields and buildings destroyed.
1904 Sept. 29 to Oct. 8	Buckman to San Marcial	Rain runoff peaked at 17,700 cfs at Buckman and 33,000 cfs at San Marcial; almost all agricultural fields, most of the houses at Corrales, Los Ranchos de Albuquerque, and Corrales bridge destroyed; fields and houses were destroyed or damaged to south; highway near Tomé became an arroyo.
1905 Winter	Entire Upper Rio Grande region	Rains averaged 20 inches.
1906 Early May to mid-June	Lobatos to San Marcial	Intense, widespread rains in northern and central new Mexico caused moderate flooding; peak flow at Lobatos was 8000 cfs and more than 10,000 cfs at San Marcial.
1911 May 8 to June 2	Otowi Bridge to San Marcial	Flow peaked at 10,800 at Buckman and 15,270 cfs at San Marcial; average annual flow at Otowi station exceeded high flows of 1897, 1904 and 1905.
1911 October 4-11	Del Norte, Colorado, to San Marcial	Another flood peaked at 18,000 cfs at Del Norte and at 11,530 cfs at San Marcial.
1911 October	Otowi Bridge to San Marcial	Flow peaked at 15,600 cfs at Otowi Bridge and 11,780 cfs at San Marcial; channel change at Buckman; channel change in river and property damage at San Marcial.
1912 May-June	Otowi Bridge to San Marcial	Flow peaked at 29,000 cfs at Otowi Bridge, 23,800 cfs at Buckman, and 15,145 at San Marcial.
1916 May	Buckman to San Marcial	Flow peaked at 15,900 cfs at Buckman and 25,145 cfs at San Marcial.
1920 May-June	Española to San Marcial	Peak flow of 28,800 cfs at Buckman; community bridge at Española destroyed; partial collapse of Tomé church; parts of Albuquerque and San Marcial damaged; flow at San Marcial 22,500 cfs.
1921 June	Entire Upper Rio Grande region	Flow of 17,400 cfs at Buckman and 19,360 cfs at San Marcial; flood may have peaked at 100,000 cfs downstream.
1924 May	Buckman to San Marcial	Flow peaked at 16,910 cfs at Buckman and 12,400 cfs at San Marcial.
1929 August to September	Buckman to San Marcial	Widespread property damage; Bernalillo town plaza was destroyed; torrential rains on Rio Puerco and Rio Salado watersheds and Rio Grande tributaries around Socorro virtually destroyed San Acacia and also impacted San Antonio, Val Verde and La Mesa; at San Marcial, peak flow reached 47,000 cfs; region’s crops virtually destroyed, as were San Marcial, San Acacia and San Antonio.
1937 Late August-early September	Albuquerque to San Marcial	Levees washed out at a number of locations; agricultural fields and crops damaged.
1941 January to May	Española to Socorro	Twenty-nine inches of precipitation fell during this period; widespread property damage; more than 50,000 acres inundated in valley.
1942 April to June 6	Otowi Bridge to San Marcial	The flow at Albuquerque peaked at 19,600 cfs and at Bernardo at 21,000 cfs.

In 1985, the basin experienced an above average snowpack, and above average precipitation resulted in the snowmelt runoff exceeding 250 percent of normal in many areas of the basin. For the first time, USACE flood control projects in the upper basin (Abiquiu, Cochiti, and Jemez Canyon Dams) were used to provide flood management for the area below Elephant Butte Dam. A 50,000 acre-foot reserve was maintained in Elephant Butte Reservoir to provide space for a 1.0%-chance flood event. In 1986, the observed snowmelt runoff in the Rio Grande Basin was approximately 200 percent of normal. Again, a 50,000 acre-foot reserve was maintained in Elephant Butte Reservoir. Another heavy snowpack and above normal runoff occurred in 1987. The peak discharge at Albuquerque of 7,840 cfs occurred on 24 July. Due to the successive years of full reservoir storage at Elephant Butte Reservoir, a significant amount of sediment deposition created a sediment plug at the headwaters of the reservoir.

In the last few decades, several flood fighting efforts have been required to prevent significant damage to properties in the San Acacia to Bosque del Apache Unit. Accounts of a few of these events are presented in the report of investigation (PGL 26) performed in 1995 on the spoil bank in the project area.

> Discussions with Bureau of Reclamation personnel disclosed that extensive flood fighting has been required to prevent failure of the existing levees along the proposed project. Specific examples provided include two major flood fights that occurred between 1966 and 1969 in the Tiffany Junction area where large quantities of sand and rock were placed to prevent failure. The area was later lined with riprap. In 1973, water against the levee near Brown Arroyo, south of Socorro, eroded 90% of the levee between the hours of 0900 and 1430. Emergency construction was required throughout the night to save the levee. Twice between 1984 and 1989 jetty jacks and riprap had to be placed in the area between San Acacia and Polvadera to keep the saturated levee from failing. At Socorro, a training dike had to be constructed to protect the levee from flood waters. The Bureau continuously hauled granular materials between the years of 1989 and 1991 to maintain the required levee height at the lower reach of the project. During this period and in the same area [Tiffany Basin], there was a levee breach and an almost complete washout of the railroad. Stabilization of the land side low flow conveyance channel, due to seepage, has been a continuing maintenance problem during flows of a frequency as low as two years. Bureau personnel indicated that these are just a few of many examples of flood fighting within the project limits required because of the poor condition of the existing spoil bank levees and without the flood fighting the levees would certainly have failed.
>
> Based on subsurface exploration results, the above observations and past experience during high flows in the river, the Probable Non-failure Point (PNP) is designated as some point within the river channel. Failure could possibly occur due to foundation seepage, piping and sloughing of the land side low flow conveyance channel, before flows break out of the river channel. The Probable Failure Point (PFP) is designated as a point at the toe of the existing levee just above the point where the water first breaks out of the river channel. As previously stated, it is strongly felt that if the levee and the low flow conveyance channel are not stabilized during possible flood fighting activities, failure will occur at some point, when the water reaches the toe of the levee (USACE 1995).

There have not been any low frequency, large magnitude floods in the last several decades. Researchers note that the last significant floods resulting from abnormally high snowpack and precipitation occurred in 1941 and 1942, and floods of equal magnitude have not occurred in the recent past. This trend has been documented throughout this region of the Southwest. It is not yet clear if this represents a permanent climatic shift or a temporary variation in runoff patterns. However, without the ability to definitively determine that this pattern is a permanent climatic change, water resource planners have determined that it is not appropriate to ignore the large historical events. Long periods of time without large events should be expected. Large magnitude, low frequency events by definition have a very low probability of occurring in a given day or year, but have devastating consequences when they do occur. The relatively long hydrologic record in the Rio Grande provides for high confidence in determination of flood frequencies and probabilities reported in this reevaluation.

1.5 DESCRIPTION OF THE AUTHORIZED PROJECT

The study area of the current project, San Acacia to Bosque del Apache Unit, is one unit within the comprehensive plan of development for flood control in the Rio Grande Basin, New Mexico that was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. The Authority provided a comprehensive plan for coordinated development, by the Corps and Reclamation, of water resource and flood risk management along what was known as the Rio Grande Floodway (RGF). The comprehensive plan included channel rectification, improvement of irrigation works, dredging, construction of three reservoirs, and levee enlargement and construction. The RGF project within the comprehensive plan, is the partially confined floodplain of the Rio Grande beginning near Truth or Consequences at about River Mile 123 extending upstream to the lower end of the Rio Grande Canyon 14 miles upstream from Española, New Mexico, at about River Mile 394. A November 1947 agreement delegated responsibility for channel rectification and maintenance to the Bureau of Reclamation and facilities for local flood protection to the Corps of Engineers.

As described in the House Document 243, the Rio Grande Floodway project sought to provide a graded and stabilized channel through the Española and Middle Valleys to Elephant Butte Reservoir, and extending below Elephant Butte Dam to the vicinity of the town of Hot Springs (now known as Truth or Consequences). This channel would be adequate to carry regulated releases from reservoirs. Supplementary levee modification and construction would assure an efficient floodway with adequate capacity to pass safely all uncontrolled flash flood inflows originating below the flood-control reservoirs, and to prevent damage at Hot Springs from spills at the Elephant Butte Dam.

At the time House Document 243 was written, spoil banks had been constructed by local interests through parts of the Española and Middle Valleys but the levees were not uniform as to grade, section or standard of construction, and the Flood Control Act of 1948 sought to modify and supplement the existing levees. New grades would be established in accordance with the requirements for safely passing a Standard Project Flood. House Document 243 recognized that the standard project flood was not consistent in different reaches of the floodway. The discharge for the standard project flood in the San Acacia to Bosque del Apache unit is described as 40,000 cubic feet per second (cfs) at San Acacia diminishing to 30,000 cfs at San Marcial.

The flood risk management improvements for the Middle Valley included in the Flood Control Phase of the 1948 Authorized Plan are as follows (see Figure 1.2):

a. The Chiflo Flood Control Project was proposed in House Document 243; however, it was not authorized for construction. The dam and reservoir would have been located on the Rio Grande located 20 river miles below the Colorado – New Mexico boundary line in Taos County. This was never constructed as described in Section 1.6, below.

b. The Chamita Flood Control Project was a proposed dam and reservoir on the Rio Chama (in Rio Arriba County, approximately 6 miles northwest of Española, NM) at a point located 5 miles above the confluence with the Rio Grande. This was never constructed, but Abiquiu Dam and Lake was constructed upstream on the Rio Chama to provide similar flood control benefits as described in Section 1.6, below.

c. The Jemez Canyon Flood Control Project was a proposed dam and reservoir on the Jemez River located at two miles above its confluence with the Rio Grande, in Sandoval County, approximately five miles northwest of Bernalillo, New Mexico. This project was ultimately constructed.

d. The Rio Grande Floodway (RGF) project was proposed as an integral part of the Flood Risk Management Phase of the Plan. Its major purposes, in conjunction with the operation of the dams, included providing protection against inundation by flash floods; providing a stable channel with a lower river bed so that controlled releases of 5000 cubic feet per second (cfs) could be efficiently carried through the Española and Middle Valleys to Elephant Butte Dam; and providing a lower river bed and levee modifications to assure an efficient floodway so that the channel would effectively lower the valley water table in order to reclaim agricultural land. The RGF project had two components (Table 1.2).

    1. Channel rectification would be accomplished through dredging, by the removal of hard spots, and by making cutoffs or otherwise aligning the channel as required concurrent with the progressive degrading action of clear water releases from the three reservoirs. At the same time that degradation would be progressing, stabilization of the channel would also be accomplished by installing pile dikes, tree retards, sills, revetments, groins or such other controls works as would be required to develop a stabilized channel in the desired location. Removal of sand and detrital plugs, deposited in the floodway by uncontrolled arroyos, would be accomplished as such conditions develop to the extent of causing interference with the proper functioning of the stream channel and floodway. Control of degradation would also be accomplished by making releases of sediment through the outlet works of the three dams. Dredging 20 miles of the river channel above the head of Elephant Butte Reservoir was to be one part of the channel rectification program, and it was recommended that it be accomplished concurrently with the construction of Chamita or Chiflo Dam, whichever was constructed first.

2. Enlargement of existing levees and construction of new levees were seen as necessary to accomplish the flood control objectives. Levees constructed by local interests existed through parts of the Española and Middle Valleys. The levees were not uniform as to grade, section or standard of construction. It was proposed that supplementary levee modification and construction would assure an efficient floodway with adequate capacity to pass safely all uncontrolled flash flood flows originating below the proposed upstream flood-control reservoirs as well as to prevent damage at Hot Springs from spills at the Elephant Butte Dam. New channel grades would be established in accordance with the requirements for safely passing the Standard Project Floods. The proposed levees would be constructed to standard section, with 10-foot crown, 3 on 1 side slopes, and a freeboard of three feet above the maximum water surface. The alignment of any new or reconstructed levees would depend upon the location of the river channel at the time the work would be planned in detail.

It should be noted that levee improvement, as authorized, involved the use of freeboard as a buffer to account for hydrologic, hydraulic, economic, and geotechnical uncertainties. Using the freeboard methodology, hydrologic models would identify the maximum water surface elevation of a certain frequency event, in this case the standard project flood, then design a levee that was three feet higher than that elevation. The added freeboard would account for inherent error in rainfall estimates, topographical survey and hydrologic modeling.

Table 1.2 Pertinent Features of the Rio Grande Floodway Project as Authorized.

1. General	
Uncontrolled drainage area affecting project	13,000 sq. mi.
Percent of total drainage area above Elephant Butte Reservoir	52%
Maximum Uncontrolled Flow with recommend plan (estimated)	
a. Espanola Valley	20,000 cfs
b. Middle Valley above Rio Puerco	42,000 cfs
c. Middle Valley – San Acacia to San Marcial	40,000 cfs
2. Purpose Levee - channel rectification for flood control and drainage	
a. Length of channel affected	198 miles
b. Dredging estimated*	20 miles
c. Dredging estimated*	34,800,000 cy
d. Bank stabilization*	60 miles
e. Existing levees	181 miles
f. Levees requiring improvement	60 miles**

* *To be performed by the Bureau of Reclamation*

** *1948 Authorization identified 60 miles of levee requiring improvement but did not identify the location or limits of levees to be improved.*

The estimated cost of the comprehensive Rio Grande River Floodway Project, as authorized in 1948, was $10.16 million (Table 1.3, 1947 price levels). This figure accounts for channel rectification and levee improvements throughout the Rio Grande Floodway from Española to Truth or Consequences, formerly Hot Springs.

Table 1.3 Estimated First Costs of the Rio Grande Floodway Project as Authorized

	Estimated First Cost (1947 price level)		
Project component	**Federal**	**Non-Federal**	**Total First Cost**
Chiflo Dam and Reservoir (NOT AUTHORIZED)	$ 29,915,700	$ -	$ 29,915,700
Chamita Dam and Reservoir	$ 28,703,060	$ -	$ 28,703,060
Jemez Canyon Dam and Reservoir	$ 6,815,700	$ -	$ 6,815,700
Rio Grande Floodway	$ 10,000,000	$ 160,000	$ 10,160,000
Bluewater Floodway	$ 171,400	$ 75,200	$ 246,600
TOTAL	**$ 75,685,800**	**$ 235,200**	**$ 75,921,000**
TOTAL without Chiflo Dam	**$ 45,770,100**	**$ 235,200**	**$ 46,005,300**

More detailed design demonstrated that this amount was not adequate to accomplish the work required for the entire Rio Grande Basin and the amount was amended by the Flood Control Act of 1950 (PL 81-516), which states:

> *Rio Grande Basin - In addition to previous authorizations, there is hereby authorized the completion of the plan approved in the Flood Control Act of June 30, 1948 for the Rio Grande Basin, at an estimated cost of $39,000,000 for the work to be prosecuted by the Department of the Army and $30,179,000 for the work to be prosecuted by the Department of the Interior as set forth in House Document Numbered 243, Eighty-first Congress.*

1.6 STATUS OF AUTHORIZED PROJECT

The San Acacia to Bosque del Apache Unit portion of the Rio Grande Floodway has not yet been constructed. This GRR/SEIS-II will address results of the reevaluation study and will propose modifications to the Authorized Project to meet current Federal and Corps standards and policies.

Various other portions of the Rio Grande Floodway project have been constructed although in many cases modified from that described in 1948 authorization and as found in House Document 243. Chiflo Dam was not authorized and Chamita Dam was never constructed. However, Abiquiu, Cochiti, and Galisteo Dams were constructed as modifications under the 1948 authority in lieu of Chiflo and Chamita Dams. Galisteo Dam was described in House Document 243 as a separate alternative but was not included as part of the recommended plan. The only dam constructed as stated in the original authorization was the Jemez Canyon Dam.

To simplify management and construction, the flood risk management components of the Rio Grande Floodway were divided into four reaches or units; the Espanola, Cochiti to Rio Puerco, San Acacia to Bosque del Apache and Hot Springs units. Further study and construction of the Rio Grande Floodway components were carried out as described below.

(a) COCHITI DAM - The Flood Control Act of 1960 (P.L. 86-645) authorized the construction of Cochiti Dam for flood risk management and sediment control on the mainstem of the Rio Grande. The much smaller Cochiti Dam provides these services less effectively than the Chiflo Flood Control project described in House Document 243. Cochiti Lake, located approximately 50 river miles above Albuquerque, is about 20 miles long at maximum flood risk management pool. The permanent pool extends about 6.5 miles upstream from the dam and has a surface area of 1,200 acres. Construction on the dam began in 1965 and water storage began in 1973. Cochiti Dam is operated in concert with other Middle Rio Grande multipurpose dams, functioning by: (1) regulating damaging flows; (2) retaining sediment; and (3) developing opportunities for the conservation and development of fish and wildlife resources, and for recreation with water acquired from the Colorado River system. Cochiti Lake flood risk management operations are primarily focused on the Middle Rio Grande Valley, controlling flows between Cochiti Lake and Elephant Butte Reservoir to the maximum channel capacity. Reservoir regulation for flood risk management is coordinated with the regulation of Abiquiu and Jemez Canyon Dams along with the uncontrolled release from Galisteo Dam. Cochiti Dam provides the only flood risk management reservoir for snowmelt runoff regulation on the mainstem of the Rio Grande.

(b) GALISTEO DAM AND RESERVOIR - Galisteo Dam and Reservoir was authorized by the Flood Control Act of 1960 (Public Law 86-645) as part of the Rio Grande Basin. It is located on Galisteo Creek about 12 miles upstream of its confluence with the Rio Grande. The reservoir controls a drainage area of 596 square miles and reduces all floods originating in this watershed from a standard project magnitude to a non-damaging release of 5,000 cfs. Sediment deposition in the reservoir aids in reducing aggradation in the Rio Grande.

The dam is an earthen fill embankment 2,820 feet long with a maximum height of 158 feet. The outlet is an uncontrolled 10-foot diameter conduit 810 feet in length.

(c) JEMEZ CANYON DAM - Jemez Canyon Dam and Reservoir is located on the Jemez River, a tributary of the Rio Grande, 2.8 miles upstream of its confluence with the Rio Grande. The dam was the first project in the basin constructed under the Flood Control Act of 1948 authorization. It was completed and placed in operation in 1953. The dam is situated in Sandoval County, about 5 miles northwest of Bernalillo and about 22 miles north of Albuquerque. The dam is a rolled earthen fill structure. Currently, no pool is maintained behind this dam.

(d) RIO GRANDE FLOODWAY, ALBUQUERQUE UNIT - The Albuquerque Levees were constructed from 1953 to 1956 along the Rio Grande in the vicinity of Albuquerque to provide protection against a flood peak of 42,000 cfs, with 3 feet of freeboard above the design water surface elevation. At that time, prior to construction of Cochiti or Galisteo dams, 42,000 cfs was the “Standard Project Flood” (SPF) used for design, with the probabilistic recurrence interval of 270 years (0.37%-chance). The east-bank levee is 18.8 miles long and west-bank levee is 8.2 miles long.

On the west side of the river, in between the Corrales Levee unit construction in the 1990s and the Albuquerque Levee to the south, no engineered levee was constructed. This "gap" is approximately 5 miles in length. The southernmost 3-mile section of this gap is comprised of high ground, where there is no need for a levee. Along the northernmost 2 miles of the gap, (i.e. from the high ground upstream to the southern terminus of the Corrales Levee) there was not sufficient economic benefit, in the 1950's, to justify continuing the Corrales Levee southward to the high ground. Because this area has since been developed, numerous residential, commercial, and school properties are now at risk.

(e) ALBUQUERQUE NORTH AND SOUTH DIVERSION CHANNELS - The north and south diversion channels were constructed as a modification of the 1948 Authority then named Rio Grande and Tributaries, New Mexico. The construction was authorized by the Flood Control Act of 1954 (PL 83-780). The purpose of the project is to provide flood risk management for the lowlands of the City of Albuquerque and vicinity by intercepting the runoff from the arroyos that drain the slopes of the Sandia and Manzano Mountains to the east of Albuquerque.

The North Diversion Channel extends 10 miles in a generally south to north direction to where it empties into the Rio Grande. The North Diversion Channel is a concrete lined channel throughout its entire length except for a short reach of levied channel where it enters the Rio Grande. The north diversion channel was turned over to the local sponsor, the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) on 14 February 1969.

The South Diversion Channel is approximately 6.5 miles in length and extends in a generally southward direction to merge with the Tijeras Arroyo Channel and then the Rio Grande. The Channel is concrete lined from the outlet up to the junction with Tijeras Arroyo, then lined with riprap upstream to the beginning point. Construction was completed in January 1972 and was accepted by the local sponsor, AMAFCA, in March 1972.

(f) MIDDLE RIO GRANDE FLOOD PROTECTION, BERNALILLO TO BELEN PROJECT - The Middle Rio Grande Flood Protection, Bernalillo to Belen, New Mexico project was authorized for construction by Section 401 of WRDA 1986 (PL 99-662, dated November 17, 1986). The project is located along the Rio Grande and includes seven study units: Bernalillo, Corrales, Mountain View, Isleta east and west, and Belen east and west. The Corrales unit was designated a separable element to assist in orderly construction of the overall Middle Rio Grande Flood Protection project and to meet local sponsor preference and budgetary constraints. The Corrales Levee unit construction was completed in 1997. A General Reevaluation Report is currently underway for the remaining 55.4 miles of existing spoil banks from the southern end of Albuquerque levees to Belen. The reevaluation report covers five units: the Mountain View, Isleta east and west, and Belen east and west.

(g) ALBUQUERQUE WEST LEVEE - The Albuquerque West Levee is 3.1 miles in length and is located along the west side of the Rio Grande from Louise SW (downstream of the South Diversion Channel) to the northern boundary of Isleta Pueblo. The levee was constructed as part of the Central New Mexico Environmental Infrastructure Program authorized by the 1999 Water Resources Development Act, Section 593 authority. Construction was completed in December 2009.

As described, seven major projects have been constructed within the Middle Rio Grande Valley since the 1948 authorization. The San Acacia to Bosque del Apache unit was deferred from further study until a non-Federal sponsor was identified to cost share in the project. A detailed description of past efforts for the floodway in this unit is presented in Section 1.8, below.

1.7 SCOPE AND PURPOSE OF THE GRR/SEIS-II

The purpose of this GRR/SEIS-II is to determine:

- Whether the Authorized Project is still implementable.
- Whether the Authorized Project is still the NED Plan.
- What changes, if any, are necessary for feasible implementation of the plan.
- If these changes are within the approval authority delegated to the Division Commander, or the Corps' Chief of Engineers, or if they would require additional Congressional authorization as outlined in ER 1105-2-100, as amended.

As an integrated document, the GRR/SEIS-II provides for the National Environmental Policy Act (NEPA) and Corps procedures for implementing NEPA (ER 200-2-2). In this report, the Corps addresses the potential impacts and effects of the alternative plans, including the No Action Plan. This GRR/SEIS-II addresses problems and opportunities. It also describes the existing and future with and without-project conditions in the project area; the potential solutions for flood risk management; and the likely array of alternative plans for the modification to the Authorized Project. This document references material and alternatives presented in the previous SEIS for the same study released in 1992 (see Appendix D of this GRR/SEIS-II).

Preparation of this GRR/SEIS-II became necessary due to several changes that have occurred since the project was authorized. These include the following:

- Bureau of Reclamation rectified the Rio Grande channel as outlined in the 1948 authorization and constructed the Low Flow Conveyance Channel under the same authority.
- A longer period of record for hydrological data is now available to allow improved and updated hydrological analysis.

- New levee design criteria that address long duration flows were adopted by the Corps since 1993. Any proposed plan now has to incorporate new design features that prevent seepage through the levee or its foundation due to prolonged flow against the riverward toe.

- The Corps has departed from the freeboard methodology to account for uncertainty and has adopted a probabilistic determination of flood risk and to perform levee design.

- Three species have been listed as threatened or endangered since 1994 (the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, and Pecos sunflower—each occurring within the study area, two with critical habitat).

1.8 PRIOR STUDIES AND REPORTS

1.8.1 Prior Studies and Reports Performed by the Corps

Since the 1948 authorization of the Rio Grande Floodway Project, which encompassed the San Acacia to Bosque del Apache Unit, numerous studies and reports have been completed that document additional analyses, plan formulation, and design changes on the comprehensive plan and its components. These changes are presented in chronological order in Table 1.4. The original EIS (USACE, 1974) was finalized in May 1974 and addresses flood risk management through construction of dams on the Rio Puerco and Rio Salado.

In 1961 the United States Senate directed a further review of the 1948 flood control plan, with particular reference to the Rio Puerco and Rio Salado. The objective of this review was to consider the flood control measures authorized by the 1948 and 1960 Flood Control Acts, determine the extent and magnitude of the flood and sediment related problems caused by the Rio Puerco and Rio Salado in the Reevaluation Report was completed in 1989 for the San Acacia to Bosque del Apache Unit project that showed the NED Plan to be a continuous levee as authorized in 1948. This study resulted in a Phase I General Design Memorandum (GDM) study in 1991. The 1989 Reevaluation Report conducted additional analysis to determine the National Economic Development (NED) Plan. Economic analysis indicated that the NED plan would be the one that utilized available material with minimal waste or borrow, in this case, the plan that reduced flooding risks from the 0.5-percent chance event. This study reaffirmed that the San Acacia to Bosque del Apache Unit project is still a technically viable, economically feasible, and implementable alternative as authorized in 1948.

A supplemental EIS (USACE 1992) was completed in 1992 that evaluated the environmental effects from the four levels of flood risk management identified in the 1989 Decision Document. Nearing completion in 1994, the plans and specifications for the project identified were put on hold due to the new issues that arose. These issues included (1) completion of a longer duration design flood hydrograph for the Rio Grande; (2) three newly listed endangered species identified (i.e., Southwestern Willow Flycatcher [SWWF], the Rio Grande silvery minnow [RGSM] and the Pecos Sunflower); (3) the inundation of the lower 12 miles of levee by the Rio Grande due to several wet years and to high water levels in the Elephant Butte Reservoir; and (4) new Corps guidance for levee design to enable levees to withstand long term inundation. Accordingly, a reevaluation study was recommended to determine the feasibility and implementation of an alternative plan that would address the above information.

In 1999, a reevaluation study and Draft SEIS proposed a project that extended approximately 43 miles of earthen levee from the San Acacia Diversion Dam to San Marcial, New Mexico. It also involved relocation of a 263-foot, 3-span railroad bridge at San Marcial as well as a 2,052-acre sediment management area at Tiffany Basin, New Mexico. During the course of the study, Reclamation also initiated its study on the feasibility of abandoning the LFCC, which could have reduced the flood risk management benefits for the levee project to half. The Corps then recommended postponing the completion of the GRR until Reclamation decided on the LFCC.

Table 1.4 List of Prior Studies and Reports by the Corps.

Studies, Reports and Authorities	**Description of Work Completed**
1941: Public Law 77-228	Initial study authorization. Directs the conduct of a survey for flood risk management on the Rio Grande and tributaries in New Mexico. Survey findings published in the 1948 Chief of Engineers Report.
1948: Report of the Chief of Engineers	Recommends construction of the San Acacia to Bosque del Apache Unit Project. Project Description: Part of the comprehensive Rio Grande Floodway Project (213 miles); San Acacia to Bosque del Apache Unit Project consists of 58 miles of earthen levee from San Acacia Diversion to headwaters of Elephant Butte Reservoir. Non-Federal Sponsor: Middle Rio Grande Conservancy District (MRGCD). Total Project Cost: $10.16 million (comprehensive Rio Grande Floodway Project); $5 million (San Acacia del Apache Unit Project) (1948 price level).
1948: Flood Control Act	Authorized for the Rio Grande Basin as found in House Document 243, proposing an integrated system for flood risk management including the San Acacia to Bosque del Apache Unit Project.
1956: Board of Engineers for River and Harbors Interim Report for Review Survey	Board of Engineers for River and Harbors directed by Senate resolution to review 1948 Chief's Report. Results of the review published in Flood Control Act of 1960: Flood risk management benefits in Middle Valley are reduced with these dams in place. Recommendations: Conduct further review of 1948 Chief's Report to include Rio Puerco and Rio Salado.
1960: Flood Control Act	Authorized construction of Cochiti and Galisteo Dams. 1961 Senate resolution directs further review of 1948 Chief's Report to include evaluation of Rio Puerco and Rio Salado.

Studies, Reports and Authorities	Description of Work Completed
1972: Board of Engineers for River and Harbors Report for Review Survey	Reviews 1948 and 1960 Flood Control Acts. Recommendations: Considered dams on the Rio Puerco and Rio Salado as opposed to levee rehabilitation; dams justified on flood risk and sediment management benefits. Dams justified individually and as a system.
1976: Water Resources Development Act	Recommends dams on Rio Puerco and Rio Salado. Project authorized for Phase 1 Advanced Engineering and Design.
1978: Letter Report from the Secretary of the Army, Senate Doc. No. 95-90 [including the 1974 EIS]	Transmittal from ASA(CW) to Chairman, Committee on Environment and Public Works, recommending dams on Rio Puerco and Rio Salado.
1985: Draft Phase I General Design Memorandum (GDM)	U.S. Fish and Wildlife Service (USFWS) objects to the use of Sevilleta NWR lands for Rio Salado Dam. Alternatives to dams on Rio Puerco and Rio Salado reevaluated. Non-Federal Sponsor: MRGCD (State of New Mexico) withdraws its support. Total Project Cost: $36.6 million (October 1984 price level). Phase 1 GDM never finalized due to loss of support from State. Recommendations: Coordinate with State and sponsor before finalizing GDM.
1989: Reevaluation Report	Reaffirms original Authorized Project (1948) still feasible and implementable. Project Description: Approx. 54 miles of earthen levee from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. Non-Federal Sponsor: MRGCD. Total Project Cost: $33.9 million (October 1988 price level). Project Cost Sharing: 75% Federal – 25% Non-Federal (based on Water Resources Development Act of 1986). Recommendations: Complete a GDM.
1990: Phase I GDM	Project Description: General Design for 54 miles of earthen levee from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. Non-Federal Sponsor: MRGCD. Total Project Cost: $47 million (October 1990 price level). Recommendations: Initiate a Feature Design Memorandum for earthen levee plan.
1991: Feature Design Memorandum	Project Description: Detailed Design for 54 miles of earthen levee from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. Non-Federal Sponsor: MRGCD. Total Project Cost: $49.5 million (October 1991 price level). Recommendations: Initiate plans and specifications for earthen levee plan.

Studies, Reports and Authorities	Description of Work Completed
1992: Water Resources Development Act (WRDA)	Considerations: 50% of levee flood risk management benefits derived from a Federal facility (Reclamation's LFCC). Project Cost Sharing: Non-Federal cost sharing reduced based on percentage of benefits derived from Federal facilities. Maximum reduction limited to 50% resulting in 87.5% Federal and 12.5% non-Federal.
1992: Supplemental EIS 1993: Record of Decision	Project Description: Public review of the project selected in the 1989 LRR; 54 miles of earthen levee from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. ROD signed March 1, 1993. Total Project Cost: $49.5 million (October 1991 price level).
1993: Appendix to Update Project Decision Document	Project Description: Public review of the project selected in the 1989 LRR; 54 miles of earthen levee from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. The 1993 Appendix to Update Project Decision Document (1993 Appendix) was completed that updated the 1989 Reevaluation Report. The 1993 Appendix provided updated economic analysis and the results of environmental considerations and public involvement; a Record of Decision; MCACES that included revised real estate requirements; a Project Management Plan; and incorporated revised cost share requirements that resulted from the Water Resource Development Act of 1992.
1994: Plans and Specifications	Completed for Phase I – plan for the upstream 12 miles of the earthen levee completed. Project Description: 54 miles of earthen levee from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. Non-Federal Sponsor: MRGCD. Total Project Cost: $56 million (October 1994 price level). Nearing completion, the plans and specifications for the Previously Approved Project were put on hold due to the new issues emerging: (1) longer duration design flood hydrograph for Rio Grande; (2) three newly listed endangered species identified (Southwestern Willow Flycatcher, Rio Grande silvery minnow, and Pecos sunflower); (3) Rio Grande inundates lower 12 miles of study area due to several wet years and high water levels in Elephant Butte Reservoir; and (4) new guidance is adopted for the design of levees that will withstand long term inundation.
1999 Draft LRR and Supplemental Environmental Impact Statement	Project Description: Approximately 43 miles of earthen levee from San Acacia Diversion Dam to San Marcial included realignment and reconstruction of the BNSF railroad bridge. Railroad bridge replacement in this project was authorized due to impacts to the bridge caused by increases in water surface elevation as a result of levee construction. This draft document was never finalized.

In 2002, the Corps received a letter from Reclamation indicating their intent to continue to operate the LFCC. The GRR investigation was then reopened in 2003. New data and improved analytical techniques warranted an updated hydrologic analysis. Additional alternatives were developed and evaluated based on their ability to provide increased flood risk management to the study area. The analyses and results are documented in this (2012) integrated GRR/SEIS-II.

In 2007, the Record of Decision (ROD) for the Upper Rio Grande Basin Water Operations Review Final EIS (USBR, 2007c) established that Reclamation will continue operating the LFCC as a passive drain with zero diversion from the Rio Grande. At present, the LFCC passively intercepts and conveys shallow groundwater and irrigation return flows downstream to Elephant Butte Reservoir. Reclamation does not anticipate active diversions to the LFCC in the near future as extensive repairs or channel reconstruction would be needed to resume active diversions.

1.8.2 Studies and Reports Performed by Others

Many studies and reports have been produced by other Federal, state and local agencies and public entities for the Middle Rio Grande including the San Acacia to Bosque Del Apache Unit. Reports with direct relevance to the current study are presented below (Table 1.5).

Table 1.5 List of Prior Studies and Reports by Others.

2005: Final Environmental Assessment (EA), San Acacia Priority Sites, River Miles 114 and 113	Project Description: Reclamation monitors locations where there is danger of river erosion causing damage to levees, road, ditches, and other riverside facilities. These facilities are referred to as "priority sites." Two priority sites, identified as the San Acacia priority sites, are located at RM 114 and RM 113. The project is located approximately 10 miles north of Socorro, NM, and one mile south of San Acacia, NM, on the west side of the Rio Grande between the SADD and Escondida Bridge. Project Purpose: To prevent damage to the levee and LFCC and allow the Rio Grande to migrate naturally toward the west.
2007: Record of Decision (ROD) on Upper Rio Grande Basin Water Operations Review Final EIS	Established that Reclamation will continue operating the LFCC as a passive drain with zero diversion from the Rio Grande. At present, the LFCC functions as a passive drain to intercept and convey shallow groundwater and irrigation return flows downstream to Elephant Butte Reservoir. Reclamation does not anticipate active diversions to the LFCC in the near future as extensive repairs or reconstruction would be needed to resume active diversions.
2008: Finding of No Significant Impact and Draft EA of River Mile 111 Priority Site Project	Project Description: Reclamation proposes to relocate the LFCC and the spoil bank to the west to remove the spoil bank and LFCC from areas being undermined by river meander. RM 111 is located on the west side of the Rio Grande, approximately 5.2 miles downstream of the SADD.
2003-present Save Our Bosque Task Force - Various Documents/reports located at: http://sobtf.org/	Save Our Bosque Task Force (SOBTF) is a grassroots 501(c)(3) organization using Federal, State and local funding to accomplish conservation easements and habitat restoration within the study area. To date, the organization has performed restoration work on five large tracks of land and created or improved many recreation access sites along the reach of the river. Easements acquired through the organization would preclude future development of the floodplain.

1.9 REGULATORY COMPLIANCE

This Environmental Impact Statement was prepared by the U.S. Army Corps of Engineers, Albuquerque District, in compliance with all applicable Federal statutes, regulations, and Executive Orders, as amended, including, but not limited to, the following:

- National Environmental Policy Act (42 U.S.C 4321 *et seq*.)
- CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Part 1500 *et seq*.)
- U.S. Army Corps of Engineers' Procedures for Implementing NEPA (33 CFR Part 230; ER 200-2-2)
- National Historic Preservation Act (16 U.S.C. 470 *et seq*.)
- Archaeological Resources Protection Act (16 U.S.C. 470aa *et seq*.)
- Native American Graves Protection and Repatriation Act (25 U.S.C. 3001 *et seq*.)
- Protection of Historic and Cultural Properties (36 CFR 800 *et seq*.)
- American Indian Religious Freedom Act (42 U.S.C. 1996)
- Clean Water Act (33 U.S.C 1251 *et seq.*)
- Clean Air Act (42 U.S.C. 7401 *et seq.*)
- Endangered Species Act (16 U.S.C. 1531 *et seq*.)
- Fish and Wildlife Coordination Act (48 Stat. 401; 16 USC 661 *et. seq.*)
- Migratory Bird Treaty Act (16 U.S.C. 703 *et seq.*)
- Federal Noxious Weed Act (7 U.S.C. 2814)
- Farmland Protection Policy Act (7 U.S.C. 4201 *et seq.*)
- Executive Order 11593, Protection and Enhancement of the Cultural Environment
- Executive Order 11990, Protection of Wetlands
- Executive Order 11988, Floodplain Management
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations
- Executive Order 13112, Invasive Species
- Energy Independence and Security Act of 2007 (P.L. 110-140, Section 438, 121 Stat. 1492, 1620)

CHAPTER 2 - EXISTING CONDITIONS*

The flood risk management plan authorized for the San Acacia to Bosque del Apache Unit study area was formulated under the consideration of conditions existing at the time of analysis and projected conditions expected to exist in the future, as previously defined in the 1992 SEIS (USACE, 1992; also included as Appendix D of this GRR/SEIS-II). This section updates that information to account for current conditions in the proposed project area.

To define the potential benefits and degree of improvement possible with various alternative solutions to flood risk management problems, a complete understanding of the existing condition of the study area is required. Definition of this existing condition allows the comparison of the value of various alternatives to one another, as well as to the existing degraded condition. Definition of baseline conditions must also be done to determine what the likely future condition is in the absence of measures done to solve observed problems. This condition is called the future “without-project” condition. Future without-project conditions are based on the study of trends and recent behaviors in the study area. To this end, information on existing (presented under Chapter 2) and future without-project conditions (presented under Chapter 3) was collected, analyzed, and quantified. Forecasting these conditions is vitally important to the evaluation and comparison of alternative plans and the identification of impacts (both beneficial and adverse) attributable to proposed Federal actions. A forecast of conditions that will exist for a 50-yer period of analysis without a Federal project was used as the baseline.

2.1 GENERAL ENVIRONMENTAL SETTING*

The proposed project is located in the Middle Rio Grande valley, a 219-mile-long reach of the river in New Mexico extending from Velarde to Elephant Butte Reservoir. The valley is entrenched in an alluvium-filled rift valley that ranges from less than 1 mile to about 12 miles wide. Principal tributaries to the Rio Grande below Cochiti Dam are Galisteo Creek, Rio Jemez, Rio Puerco, and Rio Salado. The latter two tributaries are located approximately 10 and 2 miles upstream of the project area, respectively.

The project area extends from the SADD, located 12 miles north of the City of Socorro, New Mexico, downstream to the railroad bridge over the LFCC at the northern end of Tiffany Junction. Several of the alternatives considered extended south to include the railroad crossing at San Marcial. The project area includes the southern-most section of the Middle Rio Grande valley. River channel, off-channel wetlands, riparian woodlands, floodplain farmland, terraced plains of grasses and shrubs, basalt-capped mesas, and nearby mountains characterize the valley and its surrounding environment. The floodplain and bordering terraces are mostly rural and used for irrigated farmland, livestock grazing, and wildlife conservation. With a 2010 population of 9,051, the City of Socorro is the major population center in the project area. Smaller communities are scattered throughout the project area. Elephant Butte Reservoir, downstream of the project area, is the largest reservoir in New Mexico; it stores water for irrigation and recreation. The project area runs through Bosque del Apache NWR, which provides habitat for wintering waterfowl, cranes, other wading birds, endangered species, and a rich diversity of resident and migrant wildlife (USACE, 1992).

Historically, the segment of the Rio Grande in the proposed project area was a large, braided, and meandering river system with a diversity of channels, oxbows, and marshes, influenced by cycles of frequent floods and periodic channel desiccation (Figure 2.1). Conversion of riparian areas to farmland and diversion of water for irrigation began as early as AD 1350, and peaked about 1880, when an estimated 125,000 acres in the Middle Rio Grande valley were in cultivation (Scurlock, 1998). Tree harvest for fuel wood and building materials, first by the Pueblo people and later by early European settlers, further depleted the larger woody riparian vegetation. The introduction of exotic (non-native) trees and shrubs, including Russian olive, salt cedar, and Siberian elm, which started during the late nineteenth century, created habitat competition for the native species. Large-scale grazing has been important in the valley since the 18th Century. Collectively, these activities narrowed the bosque[2], reduced and altered the species composition of its woodlands, and increased the sediment yield from the watershed (Crawford, *et al*., 1993). There is evidence that drier climatic conditions also affected the watershed's sediment yield by reducing vegetation ground cover (Lagasse, 1980), a phenomena that may increase with climate change.

The ecology of the valley is conditioned by the Great Basin Grassland, Semidesert Grassland, and Chihuahuan Desert Scrub biotic communities through which the river flows (Crawford, *et al*., 1993). The study area has an arid to semi-arid continental climate characterized by light precipitation, abundant sunshine, low relative humidity, and wide diurnal and annual range of temperature (Crawford, *et al*., 1993). Summer daytime temperatures can exceed 100 degrees Fahrenheit (°F). Average maximum temperatures in January range from the upper 30°F range to the upper 40°F range. Temperatures below freezing are common during the winter. Relative humidity is usually low, mitigating considerably the effects of the temperature extremes in both winter and summer. Humidity during the warmer months is below 20 percent much of the time. Wind speeds are usually moderate; however, relatively strong winds often accompany frontal activity in late winter and spring and may exceed 30 miles per hour for several hours. Sources of these moisture-laden air masses are the Pacific Ocean and the Gulf of Mexico. Average annual precipitation is less than 10 inches throughout the study area. Approximately 50 percent of the annual precipitation occurs during the three-month period of July through October, usually as brief, intense thundershowers. Winter precipitation, most of which comes from the Pacific Ocean, falls primarily in connection with frontal activity associated with the general movement of storms from west to east. In winter and spring, moisture transported from the Pacific by westerly winds can be amplified by the El Niño/La Niña phenomenon, which ties regional precipitation to global climate (Crawford, *et al*., 1993).

[2] *Bosque* is Spanish for "woodland" and is frequently applied to the gallery forest found along the floodplains of stream and rivers in the Southwestern United States.

2.2 PHYSICAL ENVIRONMENT*

2.2.1 Climate

The watershed of the Rio Grande in Colorado and New Mexico has a semiarid climate. The region lies in a transitional zone between the more arid desert regions of northern Mexico and the more humid climates to the north. In winter, it receives a majority of its precipitation in the form of snow from large, slow-moving regional storm systems, particularly in the northern and higher elevation portions of the watershed. Melting of this snowpack in the spring is responsible for the increased stream flows between March and June each year.

Winter precipitation is sensitive to global sea surface temperature changes, particularly the El Niño-Southern Oscillation (ENSO) cycle and Pacific Decadal Oscillation (PDO) in the Pacific Ocean. In the 7-10 year ENSO cycle, El Niño years bring warmer and wetter winters to the Southwest (and bigger spring runoffs) while La Niña winters tend to be drier and cooler (bringing lower spring runoffs). El Niño and La Niña winters are separated by ENSO-neutral years where temperature and precipitation tend to be close to the long-term average. The multi-decadal PDO cycle has a “cool” and a “warm” phase: the cool phase brings La Niña-type conditions to the Southwest and the warm phase brings El Niño-like conditions. When the two cycles are in phase (e.g., PDO is cool and it is a La Niña year), the effects are amplified; when they are out of phase, the effects are dampened. These cyclical but irregular climate patterns contribute to the significant variability in precipitation in the region, and therefore to the highly variable stream flows that complicate water management in the basin.

In the late summer and early fall, the region experiences a summer monsoon due to moisture that is drawn into the region from the Gulf of Mexico and Pacific Ocean. During this season, thunderstorms are able to produce intense, but localized and short-lived precipitation events that can cause significant flash flooding in one or a few tributary drainages. Towards the end of the monsoon season, occasional large, wide-area precipitation events can occur when moisture from tropical cyclones is drawn into the region. The monsoon varies from year-to-year in its duration and severity; however, the meteorological controls on this variation are not well understood. The remaining portions of the year tend to be dry. The share of precipitation resulting from winter storms declines from north to south, with monsoon rainfall being the major share of the annual precipitation total in the San Acacia reach. The greatest flood-producing storms have occurred in the transitional seasons, March through May and September through October, when greater temperature differences between air masses moving simultaneously into the region cause increased atmospheric instability.

The climate throughout the San Acacia to Bosque del Apache Unit is similar to that of the City of Socorro, which is located on the floodplain within in the study reach. Socorro receives less than 10 inches of precipitation per year. This precipitation is highly variable, and can deviate from the average by as much as 50%. Precipitation falls mainly as summer and fall storms typified by heavy, short-duration bursts of rain with significant erosion potential. Only 6-7 inches of snow falls in the city. Both summer rain and winter snows increase in intensity with elevation. In Socorro, average January temperatures are 23°F while in July the average is 93°F. Evapotranspiration exceeds precipitation in the summer months (McLemore and Bowie, 1987). Regional vegetation outside the floodway is sparse and xerophytic. The combination of low precipitation and abundant bare ground contributes to the high sediment loads typical of discharge contributed to the Rio Grande from ephemeral washes and permanent streams in the area.

2.2.2 Geology and Soils

The project area lies within the San Marcial Basin in New Mexico, which extends from San Acacia to the upper end of Elephant Butte Reservoir. This basin is bounded to the north and west by the Socorro, Magdalena, and San Mateo mountains. These three ranges are composed primarily of Datil volcanic rocks of Tertiary age overlying sedimentary rocks of Mississippian, Pennsylvanian, and Permian age. The eastern boundary is the San Pasqual Platform, which is a north-south trending block of Mesozoic sedimentary rocks overlain by the Tertiary Santa Fe Formation.

As uplifting occurred during Upper Tertiary time, detritus from the highlands was washed into the basin to comprise what is now a complex sequence of gravel, sand, silt, clay, caliche, and volcanic deposits known as the Santa Fe Formation. Much of the Santa Fe Formation is overlain by unconsolidated Quaternary alluvium and locally thick piedmont detritus. The thickness of the deposits in the deeper parts of the basin is estimated at 15,000 feet. Soils within the study area are generally silty sands and sandy clays.

A subsurface investigation was conducted within the proposed project area at the Low Flow Conveyance Channel (LFCC) and Rio Grande for the 1991 Feature Design Memorandum (FDM). The borings for the FDM were drilled to a maximum depth of 25 feet and indicate that the foundation soils in these areas consist of alluvial materials consisting of predominantly fine silty sand and sand with traces of silt, clay, and gravel. The soils are typically very loose to medium dense with corrected blow counts ranging from a low of 6 to a high of 22.

In 2006, 2008, and 2010, additional subsurface investigations were conducted along the proposed levee alignment in accordance with ETL 1110-2-563 *Engineering and Design: Design Guidance for Levee Underseepage*. Drill log data indicates the foundation materials were predominantly poorly sorted sand and silty sand. Relative densities, determined from correlation to standard penetration tests, varied from soft/loose at shallower depths with generally increasing relative density to hard/very dense to 50 feet. Drill log data indicates the existing spoil bank was constructed of sands, silty sands, and clayey sands, with random layers of clay. Drill log data indicates the majority of the materials are very loose to loose. Materials in the existing spoil bank are layered, potentially indicating that construction was phased. No identifiable zoning or seepage control measures were noted.

Typical alluvial deposits and soils are quite variable and discontinuous. Foundation materials along the proposed levee alignment are generally sands, silty sands, and sandy clays. These foundation soils are generally considered suitable provided adequate preparation is undertaken at locations of identified low-density material. Weak clay layers composed of high-plasticity clay are also present in the foundation. Exploration indicates that the layers are generally randomly located, are relatively thin, and have sand layers above and below that will allow dissipation of excess pore pressures upon construction of the new levee, leading to consolidation and increased strength.

The report of investigation performed in 1995 on the spoil bank in the project area discusses the Probable Non-failure Point (PNP) of the spoil bank. The PNP is the location on the vertical face of the spoil bank that water would reach before the spoil bank failed. In the case of the spoil bank in the San Acacia to Bosque del Apache Unit, a failure occurs in the foundation before water reaches the actual spoil bank. A failure is considered to include: foundation seepage; piping of water through the spoil bank or foundation; sloughing of the riverside bank of drains or in this case, the LFCC; and overtopping or collapse of the spoil bank.

> Based on subsurface exploration results, the above observations [of flood fighting efforts] and past experience during high flows in the river, the Probable Non-failure Point (PNP) is designated as some point within the river channel. Failure could possibly occur due to foundation seepage, piping and sloughing of the land side low flow conveyance channel, before flows break out of the river channel. The Probable Failure Point (PFP) is designated as a point at the toe of the existing levee just above the point where the water first breaks out of the river channel. As previously stated, it is strongly felt that if the levee and the low flow conveyance channel are not stabilized during possible flood fighting activities, failure will occur at some point, when the water reaches the toe of the levee (USACE, 1995; para. 10).

2.2.3 Hydrology and Hydraulics

There are more than 8,500 square miles (sq. mi.) of contributing, uncontrolled drainage upstream of the project area. The two largest ephemeral tributaries are the Rio Puerco (7,350 sq. mi.) and Rio Salado (1,395 sq. mi.). These tributaries meet the Rio Grande approximately 10 miles and 2 miles upstream of the project area, respectively. In combination, these two tributaries can produce flows far greater than the protection provided by the existing spoil banks. Flows from these two tributaries, coinciding with high flows on the mainstem of the Rio Grande, would create the most severe flooding conditions possible through the study reach. Other contributing tributary drainages east of the river provide small flood potentials in comparison to the Rio Puerco and Rio Salado.

2.2.3.1 *River Geomorphology and Sedimentation*

Present water management in the Middle Rio Grande valley implemented as a result of the 1948 authorization for the Rio Grande Floodway includes flood risk and sediment management dams and reservoirs, irrigation storage reservoirs, levees, channel maintenance, irrigation diversions, drainage systems, and runoff conveyance systems. In addition, the river has been laterally stabilized in the floodplain by the installation of jetty jacks in the 1950s and 1960s (Crawford, *et al*., 1993). River sediment and debris settled in the jacks, creating stable banks and a riparian zone of cottonwood, Russian olive, willow, and salt cedar (Crawford, *et al*., 1993). All these activities affect channel morphology through alterations in discharge and sediment load. River discharge influences the size of the channel, whereas the type of material transported influences the character of the channel. The existing spoil bank limits meandering to the areas within the spoil banks and controls the degradation/aggradation process. The increased vegetation hastens aggradation in the overbanks through increased roughness and lowered velocities and energy. The current status of the channel morphology is a result of these earlier and ongoing activities, and water management.

In the San Acacia to Bosque del Apache Unit, stream channel incision has been pronounced from immediately upstream of the San Acacia Diversion Dam extending downstream of the SADD to approximately 4 miles above a point on the river due east of the intersection between US 60 and Interstate 25. Localized geologic uplift is the major contributor to stream channel incision in this reach. Below this point, for a distance of less than 10 miles, the river is neither incising nor aggrading, and below this, the river channel is actively aggrading (Massong *et al.* 2006). Since spoil banks confine the river to a narrow channel, aggradation is occurring within the channel, raising it as much as 10 to 12 feet above the adjacent, sediment-starved floodplain (Figure 2.2).

The Middle Rio Grande is one of the more heavily sediment-laden streams on earth, with annual sediment concentrations as high as about 200,000 mg/L in some years (Baird, 1999). The combination of high sediment loading coupled with confinement of the floodway by spoil banks has resulted in a *perched* channel, whereby the active channel and adjacent overbanks are elevated above the historic floodplain lying outside the leveed floodway. The elevation differences on either side of the spoil bank are becoming worrisome, with disparities on the order of 10 to 15 feet in downstream reaches.

One area of particular concern is Tiffany Basin, located on the west side of the river channel, near the Tiffany Junction railroad siding and immediately upstream of the San Marcial Railroad Bridge. Tiffany Basin has an areal extent of roughly 2,053 acres, is bounded on all sides by either spoil bank or railroad embankment, and is normally isolated from sediment-laden river flows. The absence of frequent deposition has left this basin at a significantly lower elevation than the adjacent river floodway. Separated from spring runoff and flashy peaks by the non-engineered spoil banks, the probability for flooding of this area is greater than its historical frequency would suggest because this flood frequency has been reduced due to flood-fighting efforts by Reclamation.

Sediment is primarily provided by uncontrolled, ephemeral tributary flows from the Rio Puerco and Rio Salado, which contribute large volumes of sediment due to their large drainage areas, arid climate, and sparse vegetation cover throughout most of their drainages. These high sediment loads have contributed to the high aggradation rate in the San Marcial Reach, which historically has been greater than in any other reach in the Middle Rio Grande. For example, from approximately 1880 to 1924, the riverbed aggraded 9 feet at the San Marcial Railroad Bridge. These high sediment loads also contributed to a history of sediment plug formation in the reach often forming approximately 1.5 miles upstream of the San Marcial Railroad Bridge, near RM 70. Three plugs have formed in this area in the last 18 years, in 1991, 1995, and 2005.

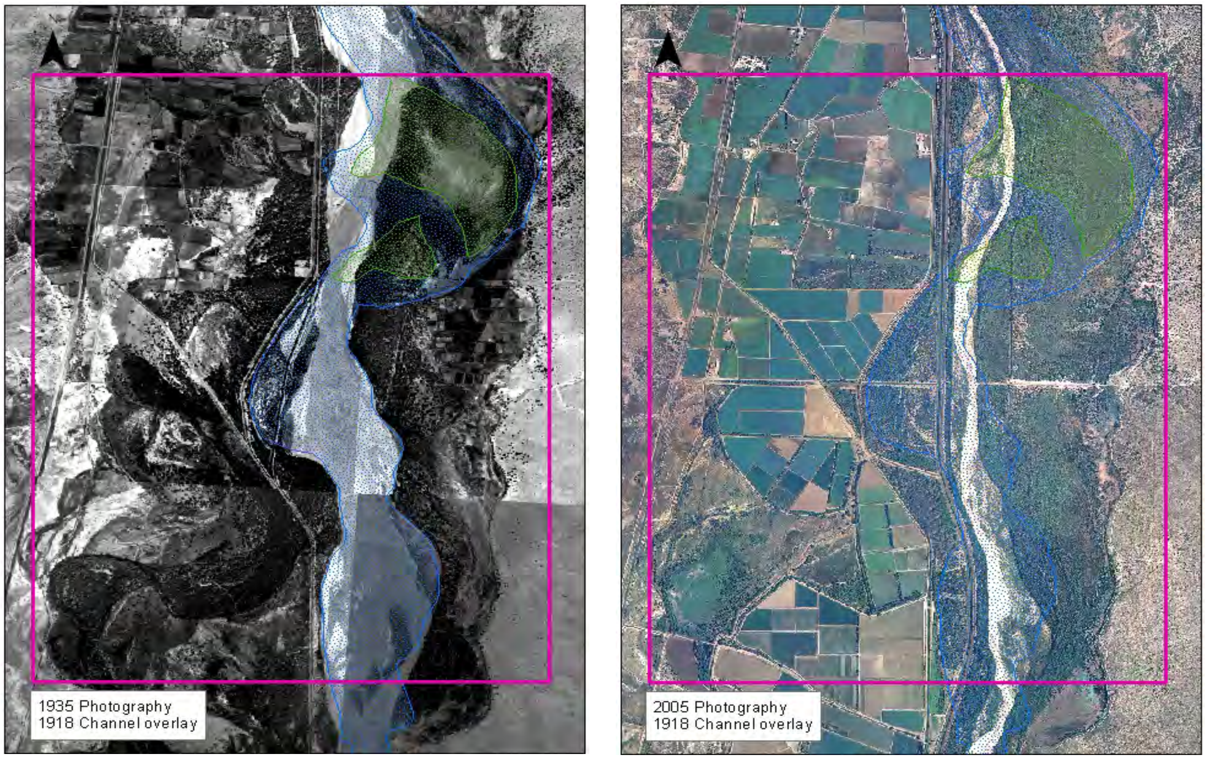


Figure 2.1 Comparison of the 1935 and 2001 Rio Grande Channel.

There are indications of plugs forming in years prior to 1991, but they were apparently removed as part of Reclamation's routine river dredging program of that era. The 1991 plug caused a breach of the spoil bank on the west side of the river. The 1995 plug grew to a length of approximately 5 miles and the 2005 plug to 3 miles. Both of these plugs caused an alarming rise in the water surface against the spoil bank and prompted emergency levee work during periods of high runoff.

During the 2008 spring runoff, a new sediment plug formed in the main channel of the river within Bosque del Apache NWR, immediately downstream of RM 81. The main channel was completely plugged with sediment for a length of 0.5 miles and partially plugged upstream of that for a distance of over a mile. After the spring runoff, a pilot channel, approximately 25 feet in width, was excavated through the plug and excavated spoil material was placed on the west side of the channel to form a spoil berm. The length of the pilot channel was 1.4 miles. The river rapidly widened the pilot channel excavation. Within three months, most of the pilot channel returned to the pre-plug width, with only two short sections of spoil berms remaining, totaling 600 linear feet.

The channel confinement, achieved by channel rectification combined with construction of spoil banks primarily on the west bank, has confined sediment deposition. Since the channel and floodplain inside the spoil banks aggrades, the river channel becomes "perched" above the former floodplain. This perched channel condition exacerbates the consequences from flooding since water entering the former floodplain has no way to drain back into the river. Flood water would remain on the floodplain until it infiltrated or evaporated.

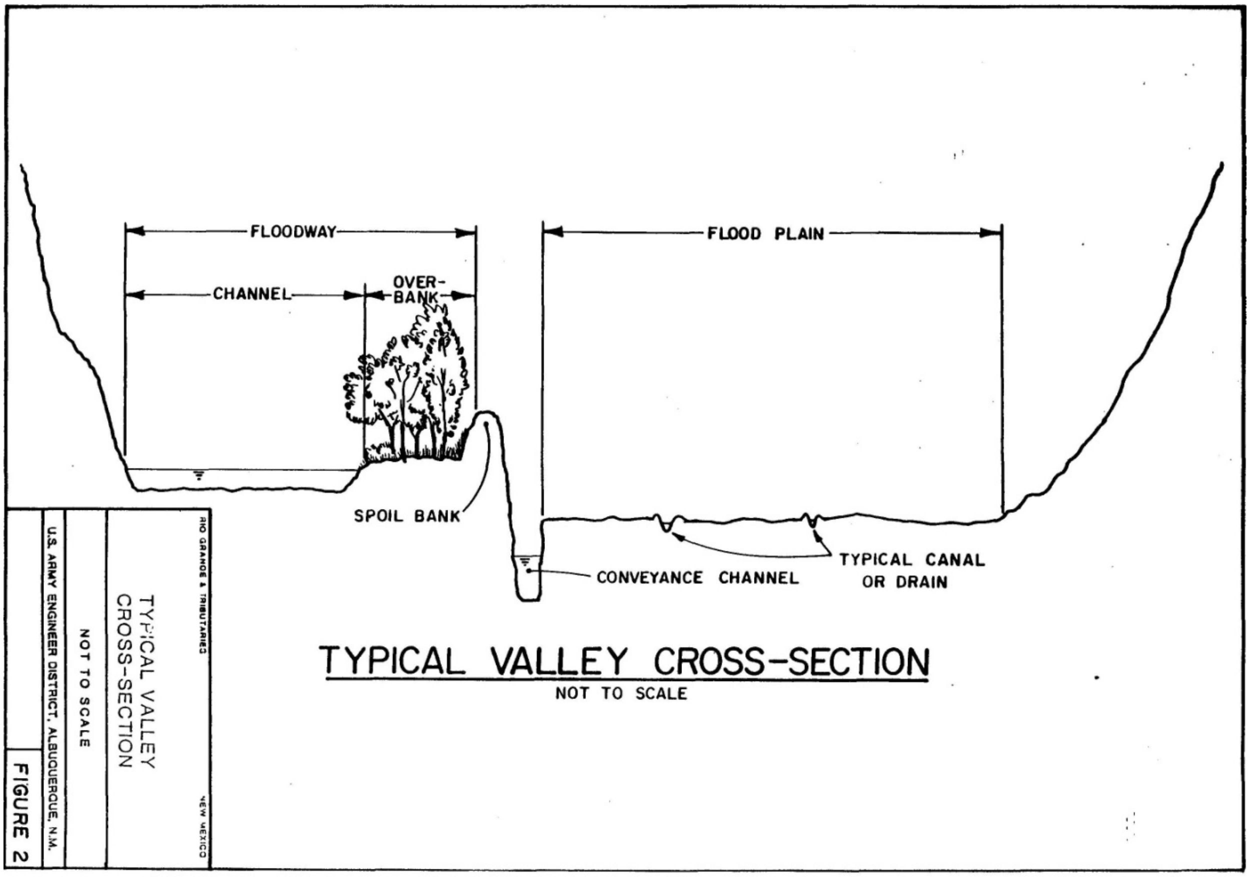


Figure 2.2 Typical Cross Section of Perched Channel

In addition to being affected by the high sediment loads, the geomorphology of the San Marcial Reach and of the lower part of the study area have also been affected by the pool level in Elephant Butte Reservoir since its construction in 1916. During wet periods with a full reservoir, this reach upstream experiences high levels of aggradation. During dry periods and recession of the reservoir, degradation follows. From approximately 1895 to 1935, for example, the riverbed aggraded 13 feet at the San Marcial Railroad Bridge. More recently, U.S. Geologic Survey data at San Marcial showed an average bed elevation increase of 12 feet between 1979 and 1987.

During high reservoir stages, a delta typically forms where the river enters Elephant Butte Reservoir, and sometimes a temporary channel must be cut into this delta to facilitate stream flow. Following the drought-induced drawdown of Elephant Butte Reservoir that began in 2003, a headcut developed near RM 58 within the upper reach of the temporary channel that had been cut through the reservoir delta that had formed during preceding wet years. By September 2009 this headcut had migrated north beyond the south boundary of Bosque del Apache NWR. As this reach has historically been rapidly aggrading, this incision is presumed to be temporary. The aggraded overbanks, which occupy a large proportion of the floodway capacity, are largely unaffected by this localized and transient headcut. From a design perspective, any capacity added through this headcut is ephemeral and could not be relied upon to add meaningful longer-term flood protection within the reach.

2.2.3.2 *Hydrology and Flooding*

The existing west bank spoil bank in the project area provides the current level of flood risk management and corresponding degree of active channel restriction. Studies indicate, with levee maintenance such as described in the previous subsection, the existing spoil bank would potentially fail at a flood magnitude equal to the 20- to 14-percent chance event. Flows of this magnitude have not occurred in the study reach for several decades; however, flows less than 10,000 cfs and as low as 4,300 cfs have caused significant failures of the spoil bank. Surface flows of the Middle Rio Grande are of two general types. One type generally occurs from April through June as a result of snowmelt, which may be augmented by general precipitation (USACE, *et al*., 2007). Spring runoff flows are characterized by gradual rises to moderate discharge rates, large runoff volumes, and approximately two-month-long flow durations, with shorter duration peak flows included. Since it was completed in 1975, flow regulation upstream at Cochiti Dam substantially limits potentials for spring flooding through the study area. The other type of flow is summer monsoonal flash flows that may occur from May through October. Summer monsoon flows are characterized by sharp, high peak flows that recede quickly and generally contain smaller runoff volumes (USACE, *et al*., 2007). However, most of the floods producing the greatest damage within the study area have been flows from summer storms entering the Rio Grande through tributary inflows from the Rio Puerco and Rio Salado. The potential for significant floods within the study area originating through either of these tributary watersheds remains largely unaltered from historical flood potentials. Currently, flows above 7,000 cubic feet per second (cfs) through the Middle Rio Grande valley are considered flood flows. During years of low snowmelt runoff and precipitation, surface flows in the main channel of the river can be eliminated for extended periods because of irrigation or water delivery diversions. The river channel below San Acacia can be dry for several months due to upstream diversions (USACE, *et al*., 2007).

1.4.1, Flood History.

As noted above, the average expected performance of the existing spoil bank is a failure at the 20- to 14-percent chance event having a discharge of about 12,200 cfs at San Acacia (USACE, *et al*., 2007). Discharges for the 2-, 1-, and 0.2-percent chance event frequency levels at the San Acacia Diversion are approximately 25,000, 29,900, and 43,500 cfs, respectively. A discussion on how these discharges are derived is presented in Appendix F2, Hydrology, Hydraulics, and Sedimentation, of this GRR/SEIS-II. Flood flow frequencies are given in Table 2.1.

The area subject to major flood damage from inundation, scour, and sediment deposition by the Rio Grande, prior to placement of the existing spoil bank, was the floodplain on the west side of the river from San Acacia to the upstream end of the Elephant Butte Reservoir pool. The east side of the river is largely undeveloped, with few improvements susceptible to flood damage from the Rio Grande, although there are a couple of rural communities across the river from Socorro (USACE, *et al*., 2007).

Table 2.1 Flood Flow Frequency at San Acacia.[a]

Percent chance exceedance (%)	Return period flood event (year)[b]	Discharge (cfs)
0.2	500	43,500
0.5	200	35,300
1	100	29,900
2	50	25,000
5	20	19,200
10	10	15,400
20	5	11,800
50	2	7,380
80	1.25	4,770

[a] These frequencies are based on the annual instantaneous peak flow series; therefore discharge values are significantly larger than those for similar frequencies based on mean daily discharge values.
[b] The Corps no longer describes discharge frequency in terms of return period; this information is presented only for comparison with older reports.

The existing San Marcial Railroad Bridge, originally constructed in 1929, is a significant restriction that limits the capacity of the channel to pass flood flows downstream. This, in turn, enhances the deposition of sediment and aggradation of the river channel and floodplain, and contributes to an increase in the potential for flood damage to the bridge, leading to interruptions of freight service along this line. The restriction also limits activities to mimic the more natural hydrographs typical of the basin through the reach, which would be necessary to conserve and enhance the environmental attributes of the Middle Rio Grande valley. The bridge alignment is nearly parallel to the river channel with a skew angle of approximately 30 degrees with respect to the river channel. The existing bridge crossing consists of five modified Warren through trusses, each spanning nearly 150 feet. The reinforced concrete bridge piers with timber crib wall abutments supporting these spans are wide, flat-nosed, and inefficient at passing flows. The lower chord of the bridge has been as little as 5 feet above the river bottom in the recent past. The combination of poor bridge alignment and inefficient pier design causes the flow of the Rio Grande to slow drastically through the area, dropping much of its sediment load, which accumulates upstream of the bridge.

Sedimentation impacts in the immediate vicinity of the existing San Marcial Railroad Bridge have been significant, and increasing as time goes on, in terms of reductions in conveyance capacity and increases in maintenance effort. The Corps examined the sedimentation impacts and determined that the sediment would continue to deposit and that the floodway would continue to aggrade at historic rates. For conditions 50 years into the future, the Corps assumed that the BNSF will replace the bridge at some point during the intervening years.

2.2.4 Water Quality

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).

Section 401 of the Clean Water Act requires that a Water Quality Certification Permit be obtained for anticipated discharges associated with construction activities or other disturbance within waterways in the project area. Water quality certification is the responsibility of the New Mexico Environment Department, Surface Water Quality Bureau.

New Mexico's Water Quality Control Commission has designated stream uses and standards in the study area (NMED, 2007). Designated uses for the reach from San Marcial at the USGS gage to the Rio Puerco include irrigation, habitat for marginal warm water aquatic life, wildlife habitat, livestock watering, and secondary contact recreation (fishing, boating). Based on a 2007 water quality review by the New Mexico Environmental Department Surface Water Bureau, designated uses for marginal warm water aquatic life and secondary contact recreation were not fully supported. The survey concluded that aluminum and *Escherichia coli* were the probable cause of the impaired uses, with the probable sources of impairments including avian sources (waterfowl and/or other); impervious surface/parking lot runoff; municipal (urbanized high density area); municipal point source discharges; natural sources; on-site treatment systems (septic systems and similar decentralized systems); and wastes from pets.

Although the Rio Grande has a well-defined channel throughout the study area, flows in portions of the area frequently exceed the bank elevation and inundate the overbank area adjacent to the channel. For the purposes of evaluation, the Ordinary High Water Mark (OHWM) relative to Section 404 was estimated to be the water surface elevation of the 50%-exceedance discharge based on mean-daily-discharge values at the USGS stream flow gage at San Acacia for the period 1974 through 2002. This discharge was determined to be 5,660 cfs by Parametrix (2008).

The Parametrix (2008) study also used two-dimensional hydraulic modeling to map the extent of these flows throughout the study area. The modeled 5,660-cfs discharge intersects with the existing spoil bank and proposed construction areas in three small areas in the northern portion of the project area. Beginning at approximately 1.5 miles upstream from Bosque del Apache NWR, the modeled flows inundate the riverward toe of the spoil bank (and proposed levee construction zone) for the entire downstream portion of the study area.

No wetlands, as defined in Section 404(b)(1) of the Clean Water Act, have been identified within the affected area for the final array of levee construction alternatives.

2.2.5 Air Quality and Noise

As stated in the 1992 SEIS (see Appendix D of this GRR/SEIS-II), the proposed project area is located in USEPA's designated Air Quality Control Region 8, which is an attainment area for criteria pollutants. The USEPA, through the Clean Air Act, regulates and sets standards for pollutant levels in the air. Primary National Ambient Air Quality Standards (NAAQS) are established for the sole purpose of protecting public health. NAAQS have been established for total suspended particulates (PM_{10}) smaller than 10 microns, sulfur dioxides (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3), and lead (Pb). The good air quality in the region is attributed to the low population and correspondingly low number of motor vehicles and no heavy industry discharging particulate matter into the atmosphere. Infrequently, high levels of TSP and CO occur in the proposed project area as a result of wind-blown dust and winter atmospheric inversions, which trap wood smoke and auto emissions in the lower layers of the atmosphere.

Regulations of the New Mexico Environmental Improvement Division's Prevention of Significant Deterioration Program (PSDP) allow air quality to deteriorate in small incremental amounts above existing levels of pollution in attainment areas throughout the state, which includes the majority of New Mexico. The PSDP divides state lands into three classes: Class I areas contain clean air and, therefore, only very small increases in air contaminant levels are permitted; Class II areas contain moderately clean air and, therefore, only moderate increases of air contaminant levels are permitted; and Class III areas are areas of extensive growth with concomitant increases in air contaminant levels. New Mexico does not contain any Class III areas: the majority of areas in New Mexico, and those in the majority of the proposed project area, are designated Class II. The study area contains one Class I area: the Bosque del Apache NWR Wilderness Area within BDANWR. For Class I areas, the annual allowable PSDP increments are: 2 µg/m for $SO_{2;}$ 5 µg/m for TSP; and 2.5 µg/m for NO_x. Significant annual emission rates for CO, NO_x, and SO_2 are 100, 40, and 40 tons per year, respectively.

Noise levels in the proposed project area are low, which is typical in rural, agrarian areas. Major sources of intermittent noise in the area are attributed to automobile traffic, farm operations, railroad operations, and Reclamation's maintenance operations.

2.3 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE ENVIRONMENT*

Echota Technologies Corporation completed a Phase I Environmental Site Assessment of the project corridor. The site assessment was performed on July 20 and August 8, 2005, and consisted of traverses along the perimeter and interior portions of the project. The site assessment also included a visual inspection of adjacent properties in the vicinity of the study area. For the purpose of this assessment, the area evaluated for the project includes the 45 miles of spoil bank starting from the SADD to the BNSF Railroad Bridge that crosses the Rio Grande near the abandoned community of San Marcial. Additional areas included the alternative bridge alignment, the Tiffany Basin area, and the location of the levee associated with the new Low Flow Conveyance Channel realignment completed by Reclamation. In addition to the site reconnaissance, the assessment included a review of aerial photographs, Sanborn Fire Insurance Maps, city directories, government environmental databases, MRGCD maps, and other referenced material.

BNSF operates a rail line through most of the project site. The railroad has been in continuous use for approximately 100 years. Currently, there are no railroad depots or maintenance facilities within the project limits. However, a review of historical information indicates that portions of the property at San Marcial, in the Tiffany area, were developed as a railroad maintenance facility. The facility included a maintenance shop and roundhouse. Developed in the early 1900s, the area was prone to flooding, which eventually led to abandonment of the maintenance facility in 1929. Historical photos show only ruins of the roundhouse existed by 1937. Given the time that has passed since the facility was abandoned, degradation of potential petroleum products, and frequent flushing of the area by flooding, the former railroad maintenance facility is not likely to be considered a hazardous, toxic, and radioactive waste (HTRW) concern. Additionally, the proposed levee alignment is located over 2,000 feet from the former railroad maintenance facility. However, if construction activities are anticipated near the former railroad facility then a Phase II Environmental Site Investigation (ESI) is recommended to verify the degradation of petroleum products.

Reclamation operates two maintenance and storage facilities within the project area. The first maintenance facility is located 0.15 miles west of the SADD near the perimeter of the project limits, and the other is located 0.49 miles north-northwest of the LFCC near San Marcial. These facilities store equipment and vehicles used for construction and maintenance activities for the river spoil banks. The New Mexico Environment Department (NMED) Petroleum Storage Tank Bureau (PSTB) maintains a list of sites where releases of petroleum products from underground petroleum storage tanks (USTs) have occurred. According to NMED PSTB documents, these two Reclamation sites were identified as having leaking USTs. During the course of USACE’s Phase I site assessment, an interview was held with Reclamation, and agency representatives reported that the USTs had been removed from both sites in 1991. NMED PSTB documents indicate that no further action was required. Given the locations of the former leaking USTs in relation to the considered levee work, the two sites are not expected to pose an HTRW risk. However, if construction activities are anticipated near either of the USBR facilities, then a Phase II ESI is recommended to assess potential impacted soils.

Land within the project boundaries is mostly rural and is not developed for uses other than agriculture. There is virtually no development of properties along the east side of the project corridor. However, low-density residential properties do exist to the west near the Interstate 25 corridor and near towns and villages such as Socorro and San Antonio. The site reconnaissance did not identify the presence of spills, drums, storage tanks, solid waste disposal, effluent disposal, discolored or stained soils, or dump sites. It is, however, important to note that the Tiffany area is covered by dense vegetation, and it was not practical to perform a visual of that area during the site visit. It will be necessary to walk the property in search of potential HTRW concerns when this particular area becomes more accessible and if the area is included in any project alternative.

The Tiffany area includes the site of a former railroad maintenance facility (roundhouse) in the former town of San Marcial. Inclusion of the Tiffany area in the project could potentially require that a cursory environmental investigation be performed to address possible remnant soil impact at the roundhouse location as a result of past railroad maintenance activities. Although the site assessment indicates that soil impact is unlikely, the typical scope of a Phase 1 site assessment does not include confirmatory soil sampling.

2.4 BIOLOGICAL ENVIRONMENT*

Historically, the dynamic nature of the Rio Grande supported a patchwork of plant communities, including cottonwood forests. In spite of the occasionally catastrophic effects of large floods, the riparian community benefited from the effects of periodic inundation when the river overflowed its banks during the high spring runoff. Such low-intensity flooding provided water and nutrient-laden sediment to the riparian community; influenced a variety of processes, including the rate at which nutrients cycle through the system; and limited the accumulation of leaf litter and woody debris on the forest floor.

The cottonwood forests that border the Rio Grande in central New Mexico are remnants of a unique and diminishing habitat known locally as the *bosque*, a Spanish word for forest. These riparian forests provide habitat for a wide variety of plants and animals. At least 80 percent of vertebrate wildlife occurring in New Mexico use riparian areas at some stage of their lives and 50 percent are permanent residents (NMDGF 2004). Riparian areas support a greater diversity of breeding birds than all other habitats in the state combined. In addition, the Middle Rio Grande is a critical travel corridor for migrating birds connecting Central and South America to North America along the Rio Grande Flyway. The Middle Rio Grande provides breeding and foraging habitat for two Federally listed endangered species, the Rio Grande silvery minnow (silvery minnow, RGSM) and the Southwestern Willow Flycatcher (flycatcher, SWWF). The scarcity of suitable riparian nesting and nursery habitat has contributed to the decrease in Southwestern Willow Flycatcher and Rio Grande silvery minnow populations. Although once plentiful along the entire Rio Grande, the Rio Grande silvery minnow is now found only within this reach.

The creation of the cottonwood communities depends on stream movement, and sand bars formed by the meandering river provide the conditions necessary for cottonwood establishment (Crawford *et al.*, 1993). Cottonwoods grow well only when roots can reach moisture provided by underground water and where seeds can germinate in bare, moist soil. Therefore, cottonwoods are limited to areas with a permanent water supply. A group of cottonwood seedlings that germinate on a newly-scoured sand bar produces plants that reach maturity at approximately the same time. New seedlings cannot grow in a forest with a closed canopy that prevents adequate sunlight from reaching the forest floor. However, as the river meanders, sections of the mature forest die, thus providing space to establish a new stand of cottonwoods. The result is a variety of patches, or mosaics, ranging from newly established seedlings to old, mature stands of huge trees to open areas with few trees.

Historically, these forest patches were interspersed with wetland areas, transitional zones between terrestrial and aquatic systems where the water table is at or near the surface or where land is covered by water at least part of the year. Wetlands in the Middle Rio Grande Valley included wet meadows, marshes, sloughs, ponds, and small lakes. In combination, these wetland areas constituted a significant component of the floodplain ecosystem, greatly affecting the vegetation and animals present. Wetlands were formed in part by the meandering nature of the river and partly by the high water table in the valley; in some areas, the water table existed at the ground surface, supporting water-loving plants. The resulting mosaic of vegetation types, consisting of patches of cottonwood forest of different ages mixed with various wetland communities and open areas of low terrestrial vegetation, supported a large diversity of organisms. As a consequence, the Middle Rio Grande valley had an extremely rich assortment of plant and animal life.

The Rio Grande was listed as one of the World Wildlife Fund's top ten most endangered rivers in the world (Wong, *et al.*, 2007) because of water over-extraction. Regulation of water in the Rio Grande has changed the mosaic of vegetation types once present in the valley. The wetlands have been greatly reduced, and the cottonwood trees are dying out. From 1935 to 1989, surface area covered by wet meadows, marshes, and ponds declined by 73% along the Middle Rio Grande floodplain. Although once widespread throughout floodplains in New Mexico, many cottonwood forests have been cleared for farming, flood risk management projects, and urban development. Non-native plants and animals have spread throughout the valley, often displacing the population of native species. The only remaining extensive tracts of Rio Grande cottonwoods are found along the Rio Grande in central New Mexico, from approximately Española south to the Belen area.

Changes to channel geometry have reduced overbank flooding and floodplain connectivity, limiting regeneration of riparian habitat. The long-term impacts of channel incision on wetland and riparian habitat are two-fold: a gradual reduction in the number of wetland and riparian plant species results in shrinking areas of these habitat types while at the same time, the lower ground water and surface water elevations relative to floodplain terraces reduce the probability of regeneration of these habitats.

2.4.1 Riparian Plant and Animal Community

Despite the various disturbance factors listed above, the Middle Rio Grande valley supports one of the highest value riparian ecosystems remaining in the Southwest (Crawford, *et al.*, 1993). The major plant communities in the active floodplain of the Middle Rio Grande valley include woodlands, shrublands, grasslands, and emergent wetlands (Tetra Tech, 2004). Vegetation mapping produced by Parametrix (2008) has been used to quantitatively characterize the vegetation composition and is the most complete digitized coverage available to date. Plant communities currently occupy approximately 12,700 acres bordering the Rio Grande (see Figure 2.1).

Riparian woodlands have a canopy of Rio Grande cottonwood and, less extensively, Goodding willow (Parametrix, 2008). These bosque habitats comprise about 3,885 acres (31 percent) of the riparian vegetation in the study area. An understory of native shrub species (primarily coyote willow and seep-willow) occurs in only a small percentage of woodland stands. The majority (approximately 3,290 acres) of bosque has an understory dominated by salt cedar - an exotic shrub that has extensively colonized the Rio Grande floodway since its introduction in region in the early 1900s - and, secondarily, by Russian olive, another exotic shrub.

Table 2.2 Vegetation and Open Water Types within the Floodway of the Study Area.

Plant Community or Open Water Type	Acres	Percent of Vegetated Area
Riparian woodland		
Native understory	599	4.7
Mixed understory	1,656	13.1
Exotic understory	1,630	12.9
Woodland Subtotal	*3,885*	*30.7*
Riparian shrubland		
Native	1,581	12.5
Mixed native and exotic	236	1.9
Exotic	5,887	46.5
Shrubland Subtotal	*7,704*	*60.8*
Emergent wetland	459	3.6
Dry grassland and open areas	625	4.9
Subtotal - All Vegetation	**12,672**	**100.0**
Pond and small channel	138	
Rio Grande channel	1,343	
TOTAL	**14,153**	

Source: Parametrix, 2008

Riparian shrublands are the most abundant plant community in this reach, occupying over 7,700 acres (61 percent of all vegetated area). Again, exotic shrub species, primarily salt cedar, dominate this plant community type (Parametrix, 2008). The structure of shrub stands can vary widely depending on age and species composition. Young stands or those in relatively dry areas may be short (less than 5 feet in height) and sparsely distributed. The majority of shrub stands in the study area consist of moderately dense to very dense stands of 5- to 15-foot-tall salt cedar. Native shrub species (coyote willow, seep-willow, and screwbean mesquite) occupy only about 1,600 acres (13 percent of all vegetation types).

Salt cedar is a prominent colonizer of exposed, bare soil sites in the riparian zone (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, 1993). 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 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. Salt cedar also becomes established in the understory of mature cottonwood stands in the project area where there is sufficient light (Crawford, *et al.*, 1996).

Small areas of emergent wetlands are scattered throughout the floodway. These consist of marshes dominated by broad-leaved cattail and hardstem bulrush along the riverbank or in poorly drained depressions within the overbank area. Wet meadows consisting primarily of saltgrass also occur. Together, these comprise only 459 acres in the floodway of the study area (3.6% of all vegetation types). No wetlands, as defined in Section 404(b)(1) of the Clean Water Act, have been identified within the affected area for the final array of levee construction alternatives.

Studies by Hink and Ohmart (1984) and Thompson *et al.* (1994) have characterized wildlife use of the various plant associations that make up the riparian plant community in the proposed project area. These characterizations conclude that the riparian community, as a whole, supports a rich assemblage of vertebrate species, particularly birds. The highest numbers of vertebrate wildlife were found in marshes; cottonwood stands with a dense understory of Russian olive or coyote willow; and Russian olive shrub stands. Open areas, early growth stands, salt cedar, and river bars support lower densities and numbers of vertebrate species.

Of about 20 reptile and amphibian species found in bosque habitat, only a few are widespread and common. These species include eastern fence lizard, New Mexico whiptail, and Woodhouse’s toad. 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 in the bosque are representative of drier upland habitats. A distinct assemblage of species associated with denser vegetation cover in wetter habitats includes tiger salamander, western chorus frog, bullfrog, northern leopard frog, Great Plains skink, New Mexico garter snake, western painted turtle, and spiny softshell turtle. Western rattlesnakes have also been noted in the riparian zone.

The most common breeding bird species in Rio Grande riparian areas include the Mourning Dove, Black-chinned Hummingbird, Gambel’s Quail, Northern Flicker, Ash-throated Flycatcher, European Starling, Bewick’s Wren, American Robin, Northern Oriole, Black-headed Grosbeak, Lesser Goldfinch, Spotted Towhee, Blue Grosbeak, Yellow-billed Cuckoo, Greater Roadrunner, Lazuli Bunting, Indigo Bunting, Summer Tanager, Yellow-breasted Chat, Brown-headed Cowbird and Wild Turkey. Common breeding raptors include Cooper’s Hawk, Swainson’s Hawk, Western Screech-Owl, and Great-horned Owl (Crawford *et al*., 1996).

Generally, the abundance of breeding birds increases with the complexity and density of vegetation structure, which is thought to be related to the increased food, cover, or nest substrate it provides (Crawford, *et al*., 1996). Along the Rio Grande, the highest breeding densities typically have been found in marshes, cottonwood stands with a well developed shrub understory, and in tall shrub stands (Hink and Ohmart; 1984; Hoffman 1990; Thompson *et al.*, 1994; Stahlecker and Cox, 1997). Within this woodland type, avian abundance is approximately four times greater along the riverward and landward edges of the bosque than in the interior of the stand (Hink and Ohmart, 1984). Bosque stands with a sparse understory generally support fewer breeding birds. Stands of intermediate age or structure vary widely in breeding bird use among the studies conducted (Farley, *et al.*, 1994), but in light of the general lack of natural cottonwood and willow regeneration along the Rio Grande, are important for their potential to develop into mature stands.

Salt cedar stands (with or without a cottonwood canopy) have relatively low breeding bird use. Species commonly breeding in salt cedar include Mockingbird, Lark Sparrow, Western

Meadowlark, Black Throated Sparrow, Blue-Grey Gnatcatcher, and Crissal Thrasher. Some birds, such as the House Wren, Virginia's Warbler, MacGillivray's Warbler, and Lincoln's Sparrow, are associated with salt cedar during migration and winter months (Crawford, *et al*., 1996).

The Rio Grande is a major migratory corridor for songbirds (Yong and Finch, 2002), waterfowl, and shorebirds. At various times of the year, riparian areas support the highest bird densities and species numbers in the Middle Rio Grande. Both the river channel and the drains adjacent to the bosque provide habitat for species such as Mallards, Wood Ducks, Great Blue Herons, Snowy Egrets, Green Herons, Belted Kingfishers, and Black Phoebes. Agricultural fields and grassy areas with little woody vegetation are important food sources for sparrows and other songbirds during migration and winter. Bosque del Apache NWR in the southern portion of the study area attracts tens of thousands waterfowl, Snow Geese, and Sandhill Cranes in the fall and winter (Crawford, *et al*., 1996).

Common small mammals in the study area are white-footed mouse, western harvest mouse, house mouse, tawny-bellied cotton rat, and rock squirrel. Small mammals were found to be more abundant in more moist and densely vegetated habitats and those with dense coyote willow than at drier sites. Hink and Ohmart (1984) described assemblages of small mammals associated with different habitat types. Crawford's desert shrew and white-footed mouse were associated with moist forest and woodland habitats. Well-vegetated, grassy habitats and emergent wetlands were occupied by western harvest mouse, plains harvest mouse, house mouse, and tawny-bellied cotton rat. Also occurring on the study area is the New Mexican jumping mouse, which is a state endangered and Federal candidate species. As a Federal candidate species, it receives no legal protection under the Endangered Species Act. The deer mouse is associated mainly with dry cottonwood forest habitat. Open salt cedar habitat had four small mammal species typically found in dry upland habitats: silky pocket mouse, Ord's kangaroo rat, Merriam's kangaroo rat, and northern grasshopper mouse. Large mammals likely to occur in the project area include beaver, raccoon, and muskrat in aquatic and wetland habitats; and long-tailed weasel, striped skunk, rock squirrel, Botta's pocket gopher, coyote, and common gray fox in riparian woodlands. Mountain lion are known to occasionally frequent the river corridor near San Marcial and mule deer and elk range through the study area.

2.4.2 Aquatic Plant and Animal Communities

The native ichthyofauna of the Rio Grande in New Mexico has historically consisted of at least 19 and perhaps as many as 27 native fish species (Sublette, *et al.*, 1990; Platania 1993a). Through several studies and examination of catalogue collections, there has been documentation of extirpation of at least six species of native fishes from the basin. Regulated water storage and delivery, changes in channel morphology, and introduction of non-native fish have greatly influenced the existing aquatic community in the proposed project area.

Fish sampling by Platania (1993b; Dudley and Platania, 2008) from 1987 to 2007 in the Rio Grande, from San Acacia Diversion Dam downstream to Elephant Butte Reservoir, confirmed the following 14 species: gizzard shad, common carp, red shiner, Rio Grande silvery minnow, fathead minnow, flathead chub, longnose dace, river carpsucker, white sucker, smallmouth buffalo, black bullhead, channel catfish, western mosquitofish, and white crappie. Red shiners and the Rio Grande silvery minnows were the most abundant fish captured. Other fish that were common included flathead chub, river carpsucker, channel catfish, and western mosquitofish.

An inventory of fish species performed in the LFCC in October 1992 (Lang and Altenbach, 1994) found the following 18 species: gizzard shad, red shiner, common carp, Rio Grande chub, fathead minnow, flathead chub, longnose dace, river carpsucker, white sucker, black bullhead, yellow bullhead, channel catfish, rainbow trout, western mosquitofish, green sunfish, bluegill, largemouth bass, and yellow perch. Longeared sunfish and white bass were found in the LFCC during earlier separate surveys (Bestgen and Platania, 1989).

The reach of the Rio Grande along the proposed project area is designated as a warm water ecosystem. There are extended periods of low flow, with extremes in habitat characteristics, such as depth, velocity, and cross-sectional area, and water quality parameters, such as temperature, dissolved oxygen, and suspended sediment, which require existing communities to have wide environmental tolerances (Crawford, *et al.*, 1993). The river channel is used by a variety of wildlife, primarily birds, when streamflow is present. Wintering waterfowl use the river as loafing habitat, while herons and egrets forage in shallow pools. Winter Sandhill Crane flocks typically use sand bars for night roosting. Sand bars, river, and dry channel are characteristically low in species diversity and density (Hink and Ohmart, 1984); however, animals such as raccoons, coyotes, lizards, Killdeer, Water Pipits, Spotted Sandpipers, Juncos, and Mountain Bluebirds are common users. As with aquatic life, wildlife use of the channel is limited by the altered flow regime caused by diversion of water from the river channel (Crawford, *et al.*, 1993).

2.4.3 Invasive Plant Species and Noxious Weeds

The Federal Noxious Weed Act of 1974 (P.L. 93-269; 7 USC 2801) provides for the control and eradication of noxious weeds and their regulation in interstate and foreign commerce. Executive Order 13112 directs Federal agencies to prevent the introduction of invasive (exotic) species and to control and minimize the economic, ecological, and human health effects that invasive species cause. In addition, the State of New Mexico, under administration of the U.S. 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 effect 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.

The principal noxious weeds known to be found commonly in the project area include perennial pepperweed (Class A), as well as salt cedar and Russian olive (Class C). Other invasive species that are prevalent in recently disturbed areas include kochia, tumbleweed, and yellow sweet clover.

2.4.4 Special Status Species

Three agencies have primary responsibility for the protection of animal and plant species in New Mexico. The U.S. Fish and Wildlife Service (USFWS), under the authority of the Endangered Species Act of 1973, maintains a list of animal and plant species which have been listed or are proposed for listing as Endangered or Threatened based on present status and potential threat to future survival. Additionally, the USFWS has classified Species of Concern (formerly "Category 2" candidate species). The New Mexico Department of Game and Fish (NMDGF), under the authority of the Wildlife Conservation Act of 1974, maintains a list of animal species whose prospects of survival or recruitment in New Mexico are in jeopardy. The New Mexico Energy, Minerals and Natural Resources Department, maintains a list of State-endangered plant species protected under the New Mexico Endangered Plant Species Act (9-10-10 NMSA) and regulation NMFRCD Rule No. 91-1. Following are descriptions of special status species which have the likelihood to occur within the proposed project area.

Both the Bald Eagle and the Peregrine Falcon were listed as endangered under the Federal Endangered Species Act when analyses began on the spoil banks within this study area. Also during these analyses the Mountain Plover was under consideration for listing. Additionally, when the project began, an effort was underway to establish a self-sustaining migratory flock of wild Whooping Cranes in the Rocky Mountain flyway, including New Mexico. All four bird species have been included in discussions of special status species in previous documents reporting the results of these levee analyses. Presently, both the Bald Eagle and Peregrine Falcon have been delisted as recovered in New Mexico and elsewhere (USFWS, 1999b; 1999c). The Mountain Plover was never listed, after additional information indicated that the threats to the species included in the proposed listing were not as significant as earlier believed (USFWS, 2003c). The effort to re-establish the Whooping Crane ended in 1989 (USFWS, 2004), and no Whooping Cranes survive from this population (International Crane Foundation, 2009). As such, these four bird species are no longer discussed in this GRR/SEIS-II as species of special concern.

Currently, the special status species in the study area are the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, the Pecos sunflower, and the Interior Least Tern. These four species are described below. Additional information on listed species can be found in Appendix C of this GRR/SEIS-II.

2.4.4.1 *Rio Grande Silvery Minnow (Hybognathus amarus)*

Formerly, the Rio Grande silvery minnow was one of the most widespread and abundant species in the Rio Grande basin of New Mexico, Texas, and Mexico (Bestgen and Platania, 1991). At the time of its listing as Federally endangered under the Endangered Species Act in July 1994, the silvery minnow was restricted to 5 percent of its historic range in a portion of the Middle Rio Grande in New Mexico between Cochiti Dam and the headwaters of Elephant Butte Reservoir (Platania, 1991; USFWS 1994). In 2008, an experimental population of silvery minnow was reintroduced to the Big Bend area of the Rio Grande in Texas. The species is also listed by the State of New Mexico as an endangered species, Group II. The USFWS documented that dewatering of portions of the Rio Grande below Cochiti Dam through water regulation activities, the construction of main stem dams, the introduction of non-native competitor/predator species, and the degradation of water quality are all possible causes for declines in Rio Grande silvery minnow abundance (USFWS, 1993a).

Critical habitat for this species was originally designated in July 1999 (USFWS, 1999a) but was declared invalid by the U.S. District Court for the District of New Mexico in November 2000. Following additional environmental and economic analyses, the USFWS re-designated critical habitat in February 2003 (USFWS, 2003b) to include the Rio Grande channel from Cochiti Dam downstream to the utility line crossing at RM 62 (approximately 6.6 miles downstream from the San Marcial Railroad Bridge) except for certain Pueblo lands. As defined, critical habitat also extends laterally from the river bank to the levee, if present, or up to 300 feet from the bank if a levee is absent. Therefore, much of the entire project area is within the designated critical habitat area. Constituent elements of critical habitat required to sustain the Rio Grande silvery minnow include (USFWS, 2003b):

- A hydrologic regime that supplies sufficient flowing water capable of forming and maintaining a diversity of aquatic habitats necessary to provide food and cover needs for all life stages of the species.

- A hydrologic regime that supplies sufficient flowing water to prevent the formation of isolated pools that restrict fish movement, foster increased predation by birds and aquatic predators, and congregate disease-causing pathogens.

- Water of sufficient quality to maintain natural, daily, and seasonally variable water temperatures in the approximate range of greater than 1°C (35°F) and less than 30°C (85°F), as well as adequate dissolved oxygen and pH.

- Seasonally variable water temperatures and dissolved oxygen concentrations.

The Rio Grande silvery minnow is a moderately sized, stout minnow, potentially exceeding 4-inches total length. Its major spawn occurs in the late spring coinciding with high spring snowmelt flows (Sublette, *et al.*, 1990) and additional spawns can occur during summer discharge pulses generated by thunderstorm activity or marked increases in reservoir discharges. This species produces neutrally buoyant, free-floating eggs that can drift considerable distances downstream with the current (Sublette *et al.*, 1990; Bestgen and Platania, 1991; USFWS, 1994; Platania, 1995), particularly wherever the channel no longer is well connected to the floodplain. Development and hatch of larval silvery minnows may occur within 1 to 2 days, with another 3 to 5 days required for the larvae to develop swimming ability, depending on temperature (Platania, 1995). Larvae then seek quiet waters off-channel. Maturity for this species is reached toward the end of the first year. Field collections since 1995 indicate that most individuals of this species live slightly more than one year, with significant mortality following their first spawn. A small percentage reach their second spawn at age two, with most of those individuals lost from the population shortly after. Historical collections from the Middle Rio Grande and laboratory culture stocks both indicate that silvery minnows have the potential to live for at least 5 years (Cowley *et al.*, 2006).

The downstream displacement of young, developing silvery minnows partially explains the greater abundance of the species in the San Acacia reach found during the 1980s to the early 2000s (Bestgen and Platania, 1991; Platania, 1993a; Smith and Jackson, 2000). For example, in 1999, over 95 percent of the Rio Grande silvery minnows captured occurred downstream of San Acacia Diversion Dam (Platania and Dudley, 1999; Smith and Jackson, 2000). The young that drifted downstream as they developed to maturity could not return upstream past the irrigation diversion dams at Isleta and San Acacia, thus restricting the species' redistribution. Those Rio Grande silvery minnows that drifted downstream from San Marcial, due to high velocities in the narrow and deep channel, are believed to be ultimately transported into Elephant Butte Reservoir, where none survive (USFWS, 2003a).

Silvery minnow fall population numbers — indicative of annual recruitment — are positively correlated to the number of days in May and June that flows are equal or greater than 2,000 cfs and negatively correlated to the number of days that flows are equal or less than 200 cfs (Dudley, *et al.*, 2005). Population numbers also appear to positively correspond to the area of available nursery habitat (Porter and Massong, 2004). From 2000 through 2005, Rio Grande flows were significantly reduced downstream from Isleta Diversion Dam during late July through September due to widespread drought and low flow regimes. However, these flows were consistent with requirements allowed under the then currently applicable Biological Opinions (USFWS, 2001; 2003a), as issued by the USFWS for water operations in the Middle Rio Grande valley. During this period, the majority of the silvery minnow population resided in the Albuquerque reach due to sustained flows, translocated silvery minnows salvaged from the drying downstream reaches, and the release of cultured minnows (Dudley and Platania, 2008). Snowmelt runoff in the Middle Rio Grande in 2005 was the largest and longest sustained discharge since 1979. Silvery minnow responded to these large flows with significantly increased spawning. Autumnal population monitoring efforts in 2007 demonstrated that Rio Grande silvery minnow abundance was significantly lower than that recorded in 2005 but that it was significantly higher than in 1996 or 2000-2004 (Dudley and Platania, 2008). Population levels in 2006 only approached the lows observed following extensive river drying in 1996. However, mean densities in 2007 were the second highest recorded since 1997. Increases were particularly notable in the Isleta Reach, and to a lesser extent in the Angostura Reach, from October 2006 to October 2007.

Aquatic habitat for the Rio Grande silvery minnow includes stream margins, side channels, and off-channel pools, where water velocities are lower than in the main channel. Areas with detritus and algal-covered substrates are preferred. The lee sides of islands and debris piles often serve as good habitat. Stream reaches dominated by straight, narrow, incised channels with rapid flows would not typically be occupied by the Rio Grande silvery minnow (Sublette, *et al.*, 1990; Bestgen and Platania, 1991).

In the proposed project area, past river maintenance and water operation activities have reduced the total habitat from historic conditions and altered habitat conditions for the Rio Grande silvery minnow. Narrowing and deepening of the channel, lack of side channels and off-channel pools, and changes in natural flow regimes have all adversely affected the Rio Grande silvery minnow and its habitat. These environmental changes have degraded spawning, nursery, feeding, resting, and refugia areas required for species survival and recovery (USFWS, 1994). In addition, San Acacia Diversion Dam at the upstream end of the project area blocks upstream movement and restricts species redistribution.

2.4.4.2 *Southwestern Willow Flycatcher (Empidonax traillii extimus)*

The USFWS listed the Southwestern Willow Flycatcher (flycatcher) as endangered in February 1995 (USFWS, 1995a). The flycatcher also is classified as endangered (Group I) by the State of New Mexico (NMDGF, 1987). The current range of the flycatcher includes Arizona, New Mexico, southern California, extreme western Texas, southwestern Colorado, and southern portions of Nevada and Utah (USFWS, 2002). In New Mexico, flycatchers are known to breed along the Rio Grande, Zuni, San Francisco, and Gila River drainages. A recovery plan for the flycatcher has been completed (USFWS, 2002).

Critical habitat for the flycatcher was designated in July 1997 (USFWS, 1997a); however, pursuant to an order from the U.S. District Court of Appeals Tenth Circuit, the USFWS conducted an economic analysis and re-designated critical habitat in October 2005 (USFWS, 2005a). Most of the defined critical habitat includes areas outside of the Middle Rio Grande and outside of New Mexico. Critical habitat along the Middle Rio Grande includes, in part, the Rio Grande floodway from the southern boundary of the Pueblo of Isleta downstream to the headwaters of Elephant Butte Lake at RM 62 (approximately 104 river miles), except for lands within Sevilleta and Bosque del Apache NWR. Within the study area, designated critical habitat for the flycatcher encompasses the entire floodway from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir, except for that on NWRs.

On August 15, 2011, the USFWS again proposed to revise critical habitat for the flycatcher (Federal Register 76:50542-50629), and a final designation was published on January 3, 2013 (USFWS 2013a). This re-designation substantially increased the area of critical habitat within the project area, all of which is within the Sevilleta and Bosque del Apache NWRs (see Figures 2.3-2.4).

Loss and modification of nesting habitat is the primary threat to this species (USFWS, 1994; 2002). Loss of habitat used during migration also threatens the flycatcher's survival. Large scale losses of southwestern wetland and cottonwood-willow riparian habitats used by the flycatcher have occurred (Phillips, *et al.*, 1964; Carothers, 1977; Johnson and Haight, 1984; Howe and Knopf, 1991).

The flycatcher is an obligate riparian species and nests in thickets associated with rivers, streams and wetlands where dense growth of willow, buttonbush, boxelder, Russian olive, salt cedar, or other plants are present (Finch and Stoleson, 2000). Nests are frequently associated with an overstory of scattered cottonwood. Throughout the flycatcher's range, these riparian habitats are now reduced, widely separated, and occur in small and/or linear patches. Flycatchers nest in thickets of trees and shrubs approximately 6 to 23 feet in height or taller, with a densely vegetated understory that can reach 12 feet or more in height. Surface water or saturated soil is usually present beneath or adjacent to occupied thickets (Phillips, *et al.*, 1964; Muiznieks, *et al.*, 1994). At some nest sites, surface water may be present early in the breeding season with only damp soil present by late June or early July (Muiznieks, *et al.*, 1994; Sferra, *et al.*, 1995; Finch and Stoleson, 2000). Habitats not selected for nesting include narrow (less than 30 feet wide) riparian strips, small willow patches, and stands with low stem density (USFWS, 2002). Suitable habitat adjacent to high gradient streams does not appear to be used for nesting. Areas not utilized for nesting may still be used during migration (Yong and Finch, 1997).

Flycatchers begin arriving in New Mexico in early May and spring migration of the Southwestern and more northerly subspecies continues into early June (Yong and Finch, 1997). Breeding activity in New Mexico begins immediately and young may fledge as soon as late June. Late nests and re-nesting attempts may not fledge young until late summer (Sogge and Tibbitts, 1992; Sogge, *et al.*, 1993; USBR, 2005a). Fall migration in New Mexico occurs from early August through mid-September (Yong and Finch, 1997).

Formal surveys for breeding flycatchers in the study area were begun by the New Mexico Natural Heritage Program in 1994 (Mehlhop and Tonne, 1994) and 1995 (Henry, *et al.*, 1996) in the San Marcial area, and have been conducted annually by Reclamation throughout the study area. Table 2.3summarizes the locations of known territories (that is, occupied by a male or pair of flycatchers) within the floodway of the study area during 2004 through 2012.

Table 2.3 Known Southwestern Willow Flycatcher Territories[a] in the Study Area, 2004-2012.

Reach	**Reach length (river-miles)**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012[b]**
San Acacia Diversion Dam to US Hwy. 380	29	0	0	1 (0) [c]	0	3 (2)	1 (0)	1 (0)	3 (0)	7 (1)
US Hwy. 380 to south boundary of BDANWR	13	1 (1)	0	4 (2)	7 (5)	5 (2)	20 (11)	37 (27)	54 (40)	60 (40)
South boundary of BDANWR to River-Mile 68	6	16 (4)	3 (0)	9 (3)	4 (1)	8 (4)	6 (3)	5 (2)	4 (0)	1 (1)
Total	**48**	**17 (5)**	**3 (0)**	**14 (5)**	**11 (6)**	**16 (8)**	**27 (14)**	**43 (29)**	**61 (40)**	**68 (42)**

[a] The term “territories” includes pairs or single males detected throughout the breeding season.
[b] Preliminary data from 2012.
[c] Values in parentheses indicate the number of territories on the west bank of the Rio Grande.

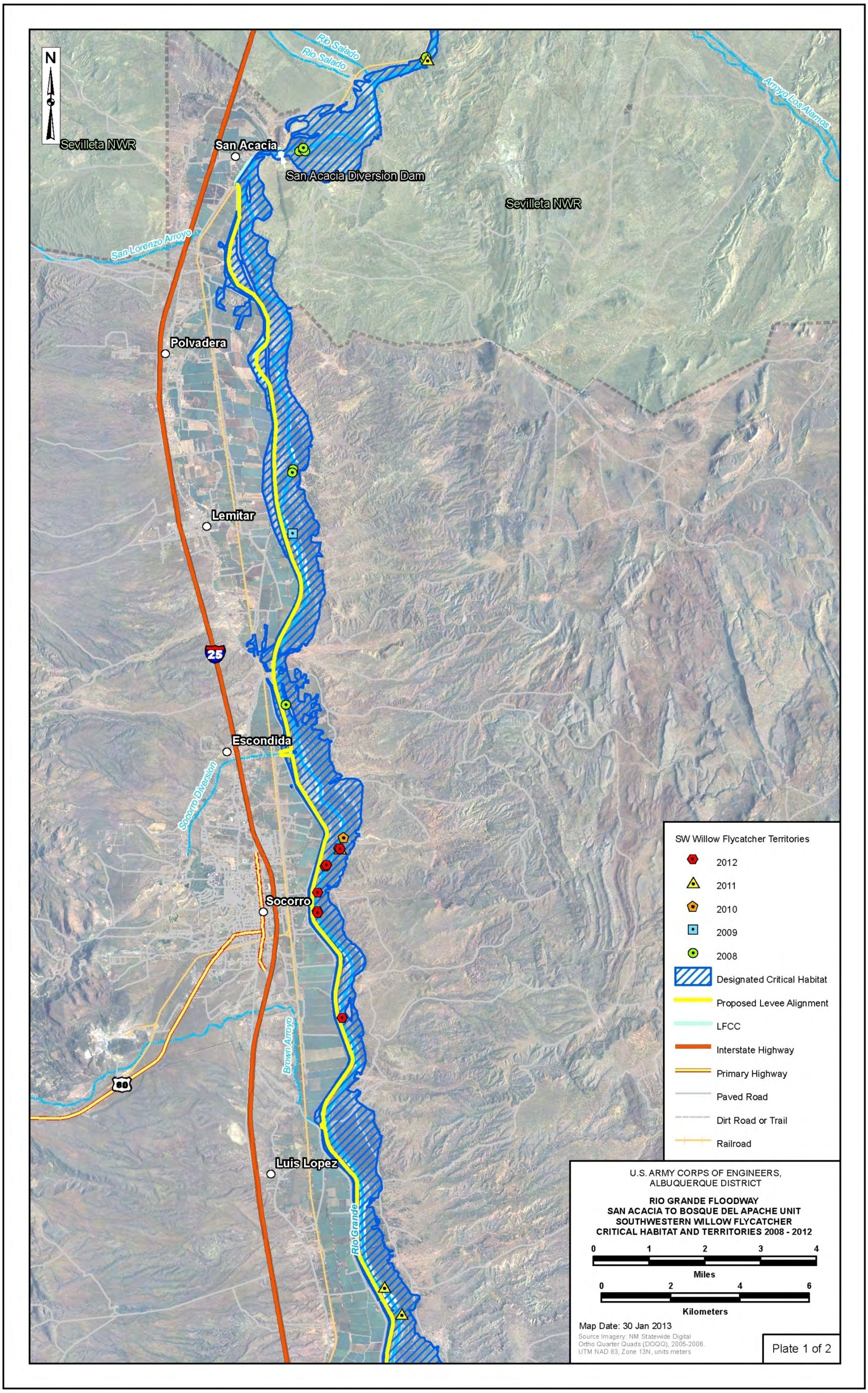


Figure 2.3 Southwestern Willow Flycatcher occupied territories (2008-2012) and designated critical habitats in the northern portion of the study area.

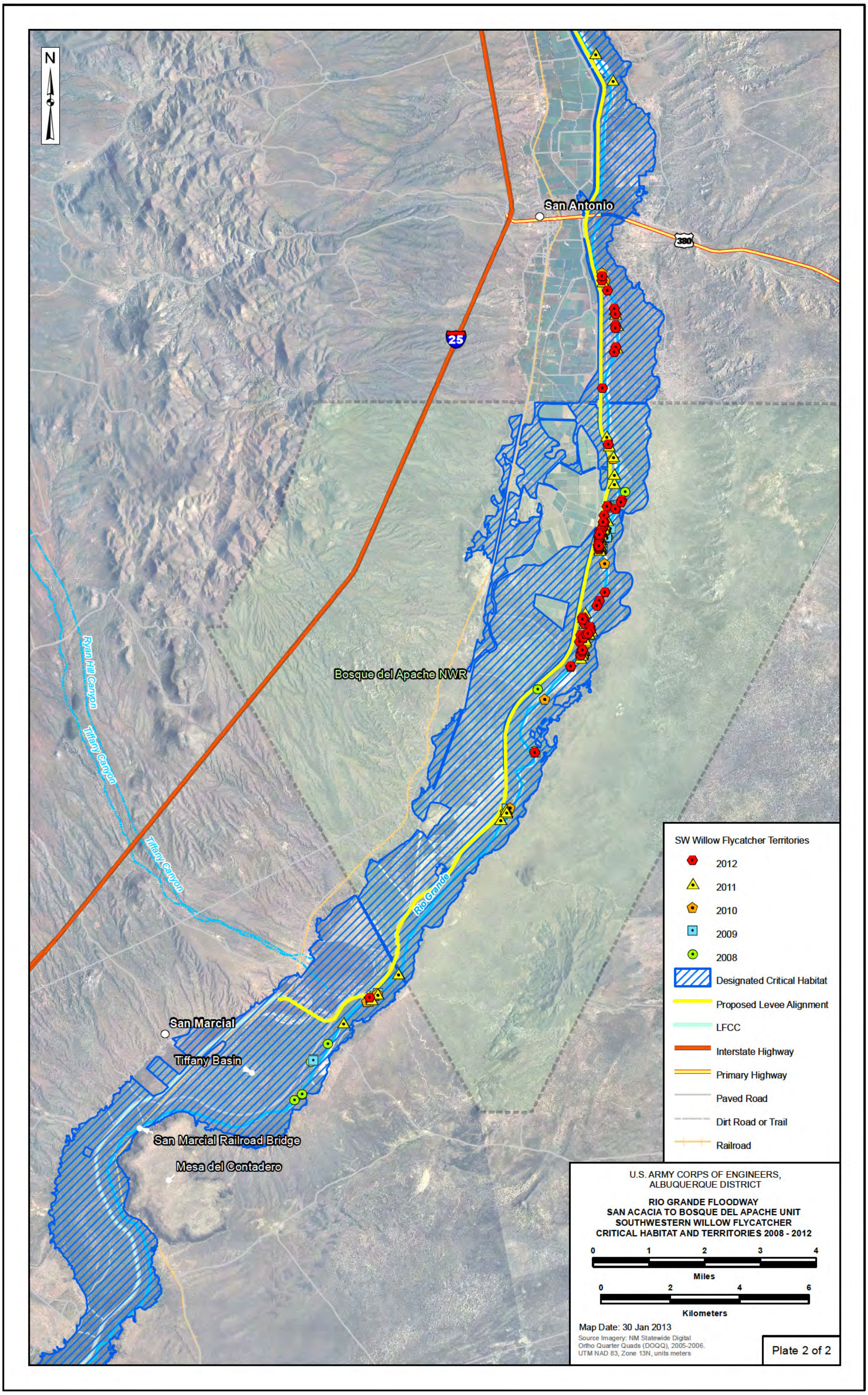


Figure 2.4 Southwestern Willow Flycatcher occupied territories (2008-2012) and designated critical habitats in the southern portion of the study area.

Spring migrant flycatchers have been regularly observed in a variety of riparian vegetation types throughout the Rio Grande floodway in the study area. Occupied breeding habitat in the study area is composed of dense riparian shrubs, chiefly Goodding willow, coyote willow, and salt cedar. At least a partial canopy of Rio Grande cottonwood or Goodding willow may be present. The majority of flycatcher nests have been found to be situated within 150 feet of the river bank or other water bodies (USBR, 2005a).

From 2004 through 2011, relatively few flycatchers (0 to 3 territories) have occurred in the reach from the San Acacia Diversion Dam to U.S. Highway 380 near San Antonio. Also, the locations of territorial birds have changed from year to year throughout this 29-mile-long reach. In 2012, preliminary survey results indicate that 7 territories were established in the floodway near Socorro (Vicky Ryan, Biologist, Reclamation, *pers. comm.*, July 17, 2012).

In the 13 river mile reach from Highway 380 to the south boundary of BDANWR, flycatcher occupation has increased dramatically from 1 territory in 2004 to 60 in 2012. In 2008, a sediment plug in the Rio Grande channel near the middle of BDANWR caused the majority of the flow to inundate riparian vegetation in the floodway adjacent to the channel. Flycatchers were attracted to this area, presumably, by the resultant increased willow growth and wetter substrate. In 2012, 40 of the 60 flycatcher territories in this reach were located on the west bank of the river, ranging from 50 to 1,300 feet of the alignment of the current spoil bank and proposed engineered levee.

Flycatchers have nested less numerously, but more consistently, in the 6-mile-long reach south of BDANWR to River Mile 68 (Table 2.3).

The largest breeding population of flycatchers along the Rio Grande in New Mexico occurs in the upper reaches of Elephant Butte Reservoir, approximately 5 miles downstream from the San Marcial Railroad Bridge. Receding lake levels allowed the establishment of riparian shrub species that were quickly colonized by the flycatcher. The number of territories has grown from 12 in 1999 to 298 in 2010 (USBR, 2011). This colony very likely serves as a source for birds which nest in the San Marcial and upstream areas of the study area.

2.4.4.3 *Interior Least Tern (Sterna antillarum athalassos)*

The Interior Least Tern is a colonial-nesting waterbird that rarely swims, spending much of its time on the wing. These birds forage during flight, snatching fish, crustaceans, and insects from the surface of the water. The Least Tern nests on the ground, typically on sites that are sandy and relatively free of vegetation such as sandbars in rivers. In New Mexico, alkali flats are selected as nesting areas (NMDGF, 1988). The interior population of the Least Tern was listed as Federally endangered on May 28, 1985. This subspecies is also listed as endangered by the State of New Mexico.

The major inland population resides in the Mississippi River Basin. New Mexico is on the western periphery of its range. In New Mexico, this species breeds in the vicinity of Roswell, most regularly at Bitter Lake NWR, a key habitat area of the state. This species is occasionally seen at Bosque del Apache NWR, as well as Española, Sumner Lake, Glenwood, Las Cruces, and Alamogordo (NMDGF, 1988). Bosque del Apache NWR may be the only potential nesting area within the proposed project area; however, fluctuating water levels in the river corridor are not conducive to nesting (USBR, 1993). The Least Tern's decline and range reduction can be traced primarily to the elimination and degradation of nesting habitat.

2.4.4.4 *Pecos Sunflower (Helianthus paradoxus)*

The Pecos sunflower was listed as a threatened species under the authority of the Endangered Species Act on November 19, 1999. Its final Recovery Plan was published in 2005 (USFWS, 2005b). The Pecos sunflower is a member of the sunflower family (Asteraceae) growing from 4.25 to 6.5 feet tall and is branched near the top. The sunflower is an annual that depends upon re-establishment by seed. Seeds may remain dormant in the soil until germination conditions are suitable. Optimal conditions for seed germination occur when high water tables or precipitation reduce soil surface salinity (USFWS, 2008). The Pecos sunflower flowers from September to October (USFWS, 2008).

This species is dependent on saturated, saline soils of desert wetlands associated with rivers and spring systems. Adult plants grow well in standing water (USFWS, 2008). They are found from about 3,300 to 6,600 feet elevation. The species is typically distributed along a moisture gradient where it is closely associated with saltgrass and infrequently associated with sites drier and wetter than those occupied by saltgrass (USFWS, 2008). Threats to this species include drying of wetlands from groundwater depletion, alteration of wetlands (e.g., wetland fills, draining, impoundment construction), competition from non-native plant species, excessive livestock grazing, mowing, and highway maintenance.

The USFWS designated critical habitat for the Pecos sunflower in March 2008 (USFWS, 2008). In total, approximately 1,305 acres in Chaves, Cibola, and Guadalupe counties, New Mexico, and in Pecos County, Texas, fall within the boundaries of the final critical habitat designation. The La Joya Wildlife Management Area in Socorro County, New Mexico, which is about 10 miles north of the study area, was considered but excluded from the designated critical habitat. The NMDGF prepared a Habitat Management Plan for the Pecos sunflower on the La Joya Wildlife Management Area to support the conservation of the species. It was found that the provisions of this Habitat Management Plan covered and included proactive conservation measures beyond what is required in a Section 7 consultation of the Endangered Species Act. Therefore, it was found that excluding the area from critical habitat designation may provide more benefits to the conservation of the Pecos sunflower (USFWS, 2008).

In 2008, seeds from the La Joya population were used to establish a reintroduced population on private property within the floodway of the Rio Grande north of San Antonio. This reintroduced population was established as a cooperative effort between the landowner, the U.S. Fish and Wildlife Service, and the New Mexico Energy, Minerals and Natural Resources Department, Forestry Division. The State of New Mexico and the USFWS consider this to be a reintroduction within the historic range of Pecos sunflower. After identifying suitable habitat on the property, biologists obtained seeds from the La Joya population and planted them in several small patches. Although a current population estimate is unavailable, some of the original seeded patches have expanded in numbers and area. The population is protected from grazing by an exclosure, and the landowner is conducting habitat management work in cooperation with the USFWS (Robert Sivinski, *pers. comm.*, Oct. 1, 2010). Due to its recent establishment, the population's long-term viability has not been assessed. This habitat and sunflower population belong to the landowner and neither have ESA protection from the actions of the landowner, unless an action is proposed that would have a Federal nexus (Robert Sivinski, *pers. comm.*, Oct. 1, 2010). This population was not considered for critical habitat designation because it became established after the rulemaking process was complete.

The privately-owned sunflower population is located on the east bank of the Rio Grande, on the opposite side of the river from Luis Lopez. The stand is approximately 0.5 mile from the current active river channel and is separated from the river by higher ground. It would not be flooded by the 50%-chance event (7.380 cfs at San Acacia), but would be inundated by the 10%-chance (15,400 cfs) and larger events.

2.5 CULTURAL RESOURCES*

Very few changes are required to update the information contained in the 1992 SEIS regarding cultural resources background or concerns. Several factors are responsible for the changes and additions that will be required. These factors include the acquisition of more precise information regarding the project scope, the refinement of the project footprints, and the increased emphasis on consultation with Native American tribes. The 1992 SEIS mentions 130 known historic properties in the general area of the project; identifying two of these properties as listed on the National Register of Historic Places. A review of the 1992 SEIS and historic properties documentation in 2012, found that these two historic properties include the NM Laboratory of Anthropology (LA) archaeological sites LA282, the Teypama Piro Site, near Socorro and LA287, the Cerro Indian Pueblo, near San Acacia. LA282 was listed on the NM State Register of Cultural Properties, No. 884, on August 12, 1982, and on the National Register of Historic Places, No. 83004179, on October 21, 1983. However, LA287 has not been included on either the NM Register or the National Register, although it remains eligible for nomination to both registers. Both of these sites occur outside of the project area. Examples of other important archaeological sites adjacent to the project area include historic properties such as the BNSF railroad bridge (noted below), the remains of the historic town site of San Marcial (LA86992), and prehistoric pueblo ruins such as San Pascual (LA487) and Qualacu (LA757), all of which are eligible for nomination to the state and National Registers.

At the time of the publication of the 1999 GRR, the number of known sites near the project increased to 198 sites. This increase reflects expanding development in the area that resulted in the need for more archaeological surveys that recorded archaeological sites; however, this increase is substantially less than the overall state-wide increase of about 15 percent per year. By 2005, approximately 210 archeological sites had been documented in the general vicinity of the project area. In 2012, a search of the New Mexico Historic Preservation Division (NMHPD), Archaeological Records Management Section’s (ARMS) New Mexico Cultural Resource Information System (NMCRIS) database (data as of January 31, 2012) was conducted to review and verify archaeological site data. Of the 210 archaeological sites in the general vicinity of the project area, a total of 85 sites occur within or immediately adjacent the Area of Potential (flooding) Effect (APE) as depicted in Figures 5.3 – 5.9. Of these, approximately 35 are located on the west side and 50 are located on the east side of the existing MRGCD spoil bank levee. Determinations of eligibility for potential nomination to the National Register of Historic Places have not been made for the majority of the archaeological sites in the area, therefore, they are considered eligible until an official determination is made. These 85 sites, including the prehistoric pueblo ruins such as San Pascual (LA487) and Qualacu (LA757), have potentially been affected by historic flooding. The Corps has previously conducted Section 106 consultation with the New Mexico State Historic Preservation Officer (SHPO) regarding potential flood related effects to San Pascual and made recommendations to BDANWR (HPD Consultation No's 055280 and 074310, USACE, 2005, 1998; Appendix F-8).

In previous planning and environmental studies for this project, the removal and relocation of the historic BNSF railway bridge located near San Marcial was considered as a project alternative. Therefore, it is discussed in several locations in this GRR/SEIS-II and other supporting cultural resources documentation for the project. Subsequently, the Corps determined that they had no authority to remove or relocate the BNSF bridge; therefore, removal and relocation of the bridge, although discussed in the following cultural text, is no longer included as a project alternative.

The project under evaluation in this document is one of several Corps undertakings along this segment of the Rio Grande. Previous consultation between the Corps and the SHPO were conducted under the provisions of a programmatic memoranda of agreement negotiated under the Substitution Agreement. At that time the Corps, in consultation with the SHPO, identified the existing spoil bank levee along the Middle Rio Grande as a significant element of the large array of flood risk management, drainage, and irrigation facilities constructed in the 1930s by the MRGCD (NMHPD Consultation No's 054093 and 088135; Appendix F-8). The extensive MRGCD irrigation (canals, laterals and drainage ditches) and spoil bank levee system was reconstructed in the 1950s and 1960s by the Corps and Reclamation. The MRGCD system has been widely recognized by the Federal, state, and local cultural resources and historic preservation community as being eligible for nomination to the National Register of Historic Places under criteria a, b, and d of 36 CFR § 60.4. These facilities have had far-reaching impacts on water usage and politics from the time of their construction to the present day. As a means of mitigating the adverse effect of loss of the original spoil bank levee through rehabilitation, the Corps prepared a package of documentation including a historic narrative, engineer drawings, and photographs for the New Mexico Archives and public dissemination; this public report is entitled *Historical Documentation of Middle Rio Grande Flood Protection Projects: Corrales to San Marcial* (Berry and Lewis, 1997). In 2003, Reclamation consulted with the SHPO and their LFCC has been determined "…eligible for listing on the National Register under criterion a, at the local level of significance" (USBR, 2003). The historic town site of San Marcial, estimated to be buried under about 30-feet of flood deposited sediment (Van Citters, 2000:13-22, 33), is considered eligible for nomination to the National Register under criterion d of 36 CFR § 60.4 (NMHPD, 2012).

Due to a revision in the regulations of Section 106 of the National Historic Preservation Act that omitted (but reserved) any discussion of Substitution Agreements between individual SHPO and the Advisory Council on Historic Preservation, all prior memoranda of agreement negotiated under this provision are null and void. Therefore, all future consultation with the New Mexico SHPO will occur through the normal Section 106 process. Depending on final decisions concerning project features, a new MOA may be required.

An archaeological survey for cultural and historic resources was conducted in 1997 along the study area's 43-mile long existing spoil bank levee and adjacent land (Doleman, 1997). With the exception of the MRGCD spoil bank levee and USBR's LFCC, no other sites or features were identified within the proposed levee construction area. For this portion of the project, the Corps determine that the reconstruction spoil bank levee would have an adverse effect on historic properties; however, the Corps provided historic documentation to mitigate for the adverse effect. If the Tiffany Basin feature is included in the final preferred alternative, additional survey will be needed to establish whether the remains of the town site of San Marcial are within the overbank flooding portion of the Basin. The rights-of-way for the considered, relocated BNSF railway bridge and the LFCC will also have to be surveyed for cultural resources if the recommended plan includes this option.

The existing BNSF railroad bridge (No. 1006.A) was constructed in 1930 by the Atchison, Topeka and Santa Fe (AT&SF) Railway and the American Bridge Company. A "Warren Through Truss" design, the bridge is composed of five 149-foot long steel trusses on timber and concrete piers. The total length of the structure is 853 feet. the Corps evaluated the structure using the system developed by the New Mexico State Highway and Transportation Department in consultation with the SHPO (NMHPD Consultation No 054201; Appendix F-8). It scored 72 points out of a possible 108, placing it in the top one-third of the rating. This value is consistent with the ratings of similar highway structures. Therefore, it is considered to be potentially eligible for listing on the National Register of Historic Places under criteria a, c, and d. Level II Historic American Building Survey documentation has been completed as well as a public report (Van Citters, 2000).

Additional consultation with the SHPO may be required if the existing BNSF railway bridge is to be removed and if the remains of the San Marcial town site are to be flooded as part of the use of Tiffany Basin. Any new access roads, borrow or waste sites and staging areas will be surveyed and reported upon. In most cases it should be possible to relocate the road or other impact areas in order to avoid any sites that may be discovered. If avoidance is not possible, the Corps, in consultation with the SHPO and Native American tribes that have cultural resources concerns in the area, shall develop and implement a data recovery plan prior to initiation of any ground disturbing activities.

Consistent with the Department of Defense's American Indian and Alaska Native Policy, signed by Secretary of Defense William S. Cohen on October 20, 1998, and based on the State of New Mexico Indian Affairs Department and Historic Preservation Division's 2011 and 2012 Native American Consultations List, government to government tribal scoping letters describing the facets of the project and inviting consultation were sent to the ten Native American Tribes/Pueblos on record as having concerns in Socorro County. The tribes include the Pueblos of Acoma, Isleta, and Ysleta del Sur, and the Comanche, Fort Sill Apache, Hopi, Kiowa, Mescalero Apache, Navajo, and White Mountain Apache (Appendix F-8). To date, the Corps has received no tribal concerns regarding the proposed project (Appendix F-8). No traditional cultural properties are known to occur within or adjacent to the project area.

2.6 INDIAN TRUST ASSETS*

Indian Trust Assets (ITAs) are a legal interest in assets held in trust by the United States Government for Indian tribes or individuals. The United States has an Indian Trust Responsibility to protect and maintain rights reserved by or granted to Indian tribes or individuals by treaties, statues, executive orders, and rights further interpreted by the courts. The Secretary of the Department of the Interior (DOI), acting as the trustee, holds many assets in trust. Some examples of ITAs are lands, minerals, water rights, hunting and fishing rights, titles and money. ITAs cannot be sold, leased, or alienated without the express approval of the United States Government. The Indian Trust Responsibility requires that all Federal agencies take all actions reasonably necessary to protect such trust assets. The Department of Defense's American Indian and Alaska Native Policy (DoD Policy) and DOI's Secretarial Order 3175 and the Reclamation's ITA Policy require that the Corps, as the project's Lead Federal Agency, and Reclamation, as the Federal Land Managing Agency, consult with tribes and assess the impacts of its projects on ITAs. If any ITAs are identified and are to be impacted, further consultation on measures to avoid or minimize potential adverse effects will take place. If the project results in adverse impacts, consultation regarding mitigation and/or compensation will take place.

Consistent with the DoD Policy, and based on the State of New Mexico Indian Affairs Department and Historic Preservation Division's 2011 and 2012 Native American Consultations List, government to government tribal scoping letters describing the facets of the project and inviting consultation were sent to ten Native American Tribes/Pueblos that have indicated they have concerns within Socorro County (see the tribal consultation list as noted in Section 2.5 above; Appendix F-8). To date, the Corps has received no tribal concerns regarding the proposed project (Appendix F-8). No concerns regarding ITAs have been brought to the attention of the Corps.

2.7 SOCIOECONOMIC ENVIRONMENT*

2.7.1 Demography

The City of Socorro is the largest population center in the study area and other communities in the study area are within commuting distance of Socorro. Of the 17,866 people that live within Socorro County, 9,051 live in the City of Socorro according to the 2010 U. S. Census. The two main industries in the study area are education and research, public administration and accommodation and food service followed by agriculture, forestry and mining. The two largest employers within Socorro County are the New Mexico Institute of Mining and Technology, and the National Radio Astronomy Observatory. Household income and racial statistics are provided in Section 2.7.5 Environmental Justice, below.

Table 2.4 Employment by industry for the study area relative to the county, state and country.

INDUSTRY	United States	New Mexico	Socorro County	Tract 9783.03
Civilian employed population 16 years and over	141,833,331	888,761	6546	1,480
Agriculture, forestry, fishing and hunting, and mining	1.9%	4.1%	4.3	8.6%
Construction	7.1%	8.5%	5.9	5.2%
Manufacturing	11.0%	5.3%	3.5	1.3%
Wholesale trade	3.1%	2.2%	0.8	0.0%
Retail trade	11.5%	11.6%	7.8	4.4%
Transportation and warehousing, and utilities	5.1%	4.6%	5.4	2.9%
Information	2.4%	1.9%	1.1	2.1%
Finance and insurance, and real estate and rental and leasing	7.0%	5.1%	3.5	3.2%
Professional, scientific, and management, and administrative and waste management services	10.4%	10.8%	9.9	7.2%
Educational services, and health care and social assistance	22.1%	23.4%	37.2	39.9%
Arts, entertainment, and recreation, and accommodation and food services	8.9%	10.3%	10.7	11.1%
Other services, except public administration	4.9%	4.7%	3.3	2.9%
Public administration	4.8%	7.5%	6.7	11.2%

2.7.2 Flood Hazards

Recorded flood history in the study area goes back to the 1920s (see Table 1.1). Before that time, newspaper accounts identified major floods in July 1895 and September 1904. Recorded major floods, which would exceed the existing estimated protection (20- to 14-percent chance events) afforded by Reclamation's existing spoil banks, occurred twice in 1929, once in 1936 and 1941, and the last time in 1965. A recurrence of any of these floods would have devastating effects. In addition, there have been numerous smaller flood events in recent years, more specifically in 1976, 1978, and 1995, when the Sponsor has had to conduct flood fights to prevent spoil bank failure. These actions have included around-the-clock levee patrols to identify weak locations in the spoil banks, placement of rock in areas eroding into the channel, sandbagging around sinkholes adjacent to the spoil bank, and clearing bridges of debris. Without these actions, the existing spoil bank would have failed several times in the past two decades.

2.7.2.1 *Historical Flooding*

The following are descriptions of the larger floods that have occurred within the study area.

(a) Floods of August and September 1929

The Middle Rio Grande valley between San Acacia and San Marcial suffered from two floods in 1929, one on August 12 and the other on September 23. The descriptions of these floods follow the descriptions of Scurlock (1998). The flood of August 12 was caused by a general storm that occurred between August 8 and 11 in southern Colorado and northern and western New Mexico. During this period, much of the area received over two inches of precipitation. The heaviest rainfall centered over the Rio Chama, Rio Puerco, and Rio Salado watersheds and the side arroyo drainage near Socorro. Floodwaters and accompanying sediment damaged crops and homes in San Acacia, San Antonito, Val Verde, La Mesa, and San Marcial. Studies conducted by the New Mexico State Engineer's Office determined that peak discharges on the Rio Puerco and Rio Salado on August 12 were about 30,600 cfs and 27,400 cfs, respectively. The estimated flow on the Rio Grande at Bernardo, about five miles upstream from the Rio Puerco confluence, was 7,000 cfs. Combined flows peaked at an estimated 24,000 cfs about midnight on August 13 at San Marcial, about 60 miles downstream from Bernardo.

The storm that caused the flood of September 23 was similar to the August storm. From September 21 to 23, one to four inches of rain fell in the Rio Grande basin. Peak flows on the Rio Puerco and Rio Salado on September 23 were estimated by the State Engineer to be 35,000 cfs and 20,000 cfs, respectively. These flows nearly synchronized and joined with a flow of about 9,000 cfs on the Rio Grande to peak at an estimated 60,000 cfs at San Acacia. The resulting flood destroyed crops on 90 percent of the farmed acreage in the valley, washed out portions of the roadbed of the Atchison Topeka and Santa Fe Railway Co., damaged dikes and ditches, and destroyed the villages of San Acacia, San Antonito, and San Marcial.

(b) Flood of July-August 1965

Heavy thunderstorm activity over the Rio Salado and Rio Puerco watersheds produced peak flows of 36,200 cfs on Rio Salado near San Acacia at 11:10 p.m. on July 31, and 3,210 cfs on the Rio Puerco near Bernardo at 6:45 p.m. on August 3. The Rio Grande at San Acacia peaked at 17,200 cfs on August 1. This peak on the Rio Grande was the result of the flow from the Rio Salado and illustrates the effect on the mainstem of large-peak, small-volume flows from the Rio Salado.

(c) Existing Flood Problems

Based on a detailed hydrologic analysis conducted for this report, damages likely to be sustained within the study area for various flood events have been estimated. Table 2.5 summarizes these single occurrence damages associated with the 10-, 2-, 1-, and 0.2-percent chance flows for the San Acacia to Bosque del Apache reach of the Rio Grande.

The 2010 Census indicates the average household size in Socorro County is 2.46 persons. Multiplying this figure by the number residential and apartment structures in the 1%-chance and

0.2%-chance floodplains suggest that the study area has a population at risk (PAR) of 1,317 persons from the 1%-chance flood and 1,597 persons from the 0.2%-chance flood.

Upon review of the single occurrence damages for the study area, it can be concluded the potential for a significant economic impact is great. It should be reiterated that the start of damages is estimated to be between a 20- and 14-percent chance events, which equates to a 20- to 14-percent chance, respectively, of flood damages in any given year. Thus, the study area not only is characterized by large economic losses during major flood events, but also a very low event during which damages would begin.

2.7.2.2 *Damageable Property*

The largest development within the Rio Grande floodplain is Reclamation's LFCC. Approximately 36.5 miles of the LFCC are susceptible to flooding. Damages to the LFCC begin with failure of the spoil bank, which can occur with a 20- to 14-percent chance event. Frequent failures result in sediment deposition within the channel and erosion damage to the channel and its facilities. Reclamation personnel estimate that $150,000-$700,000 is spent annually to maintain the existing spoil bank and the LFCC in the study area. In the event that the LFCC is rendered inoperable, water that could have been transported down the narrow, deep LFCC is instead subject to evaporative losses in the wider, shallower Rio Grande. According to Reclamation personnel, destruction of the LFCC in any year can cause unavoidable water losses for the subsequent five years. This reach of the LFCC had a likely economic value of $125 million in 2012 price level. Damages caused by a 1-percent chance event to the LFCC are estimated at $20.7 million (August, 2010 price level). It is important to note that these numbers are based on the assumption that the future configuration and operation of the LFCC remain as they are today.

The Bosque del Apache NWR would suffer severe damages in the event of a large magnitude flood that breaches the spoil bank. A majority of the fields, impoundments, and extensive water distribution facilities that provide habitat for a myriad of wildlife species would be flooded, potentially scoured, and covered with sediment. Recreational and educational opportunities at the refuge could be severely impaired would be interrupted until flooding ceased and infrastructure was repaired or replaced.

As is the case with the rest of the study area, the existing protection to the refuge is equivalent to that for a 20- to 14-percent chance of flood damages in any given year. Facilities on the refuge especially vulnerable include their investment in the creation and maintenance of riparian wetland areas, food crops and the refuge's irrigation system west of the existing spoil bank, which serves and supports these wetland areas and their irreplaceable habitat. Losses to these facilities would be potentially devastating to refuge developments and to populations of waterfowl, cranes, and other species utilizing the refuge. There is also the interruption of this source of recreation which is considered a unique experience during winter months when migratory waterfowl are present.

In addition to the LFCC, there are many residential, commercial, and public properties within the Rio Grande floodplain, with 90% of these being within the City of Socorro. The average structure ranges from 30 to 50 years old. As shown in Table 2.5, there is an estimated 1,225 residential, 166 commercial, 11 public and 1 apartment structures within the 1-percent chance floodplain. Table 2.6 shows the single occurrence damages of property by category within the various flood event floodplains. In total, the study area has about $98 million (August 2010 price level) worth of damaged incurred by the 1-percent chance event. Damages caused by a 0.2-percent chance event to the study area are estimated at $129 million (August 2010 price level).

Table 2.5 Number of Structures within the Floodplain – Existing Conditions.

Land Use Category	**Event**							
	10%		**2%**		**1%**		**0.2%**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Residential	856	10.97	1,131	3.39	1,225	20.41	1,517	16.87
Commercial	105	1.78	145	2.57	166	1.93	207	1.36
Public	4	0.13	5	0.55	11	0.69	15	0.13
Apartment	0	0.00	0	0.00	1	0.34	3	0.26
TOTAL	**965**	**11.11**	**1,281**	**4.30**	**1,403**	**20.42**	**1,742**	**16.95**

Table 2.6 Single Occurrence Damages – Without-Project Conditions.

LAND USE CATEGORY	**Single Occurrence Damages per Exceedance Event (x $1,000; August, 2010 Price Level)**			
	10%	**2%**	**1%**	**0.2%**
Residential	$4,584	$7,025	$7,874	$9,956
Resident Contents	$1,457	$2,235	$2,539	$3,193
Commercial	$1,962	$3,924	$4,685	$6,005
Commercial Contents	$15,792	$21,256	$23,998	$29,017
Public	$152	$203	$240	$281
Public Contents	$133	$183	$248	$356
Apartment	$1	$1	$3	$16
Apartment Contents	$0	$1	$1	$5
Outbuildings	$108	$174	$199	$259
Outbuilding Contents	$73	$108	$124	$162
Streets, Roads	$10,466	$21,720	$25,021	$36,715
Utilities	$232	$762	$898	$1,317
Railroad	$1,693	$1,839	$1,928	$2,830
Vehicles	$2,703	$3,430	$4,086	$5,075
Agriculture	$704	$1,100	$1,209	$1,493
Irr. Drains	$210	$396	$440	$798
LFCC	$14386	$18,961	$20,747	$27,275
Recreation	$2,837	$2,837	$2,837	$2,837
East Bank	$286	$373	$401	$482
Flood Emergency Costs	$600	$958	$1,094	$1,448
TOTAL	**$58,379**	**$87,486**	**$98,570**	**$129,520**

2.7.3 Land Ownership

Federally-owned land within Socorro County accounts for a majority of the land ownership. Federal administration of lands particular to the proposed project area includes Reclamation, the USFWS, and isolated parcels managed by the U.S. Bureau of Land Management (BLM). Private land comprises 29.6 percent of the total acreage, with much of this land being devoted to agriculture. State land equals 14.4 percent, and Indian lands total 1.3 percent.

Reclamation holds interest in nearly all the land associated with the west bank spoil bank from San Acacia to Bosque del Apache, and related appurtenant structures. The spoil bank and its adjacent 20-foot-wide maintenance road are currently estimated at 600 acres. All these lands are currently under Federal control. The sedimentation storage basin feature at Tiffany would consist of approximately 2,053 acres. These lands are currently under private ownership.

2.7.4 Land Use and Classification

Agriculture dominates existing land use in the Middle Rio Grande valley within the proposed project area. Within the Rio Grande floodplain, there is irrigated farming and livestock pasturage, with livestock grazing on the bordering terraces and mountains. Valley lands west of the LFCC are almost entirely developed for irrigated agriculture. Livestock grazing also occurs within the riparian zone, some of which is unauthorized. Irrigated agriculture is an important component of the economy and way of life for people living along the Rio Grande. The MRGCD operates and maintains irrigation facilities for floodplain farms, and Reclamation operates and maintains the LFCC and its related features.

2.7.4.1 *Water Management Facilities*

(a) Irrigation

The MRGCD was formed in 1925, primarily because of concerns over a decrease in irrigated areas in the Middle Rio Grande valley resulting from water shortages, poor drainage, inadequate irrigation facilities, and periodic flooding. From 1925 to 1935 the MRGCD constructed El Vado Dam (a storage reservoir on the Rio Chama), four major irrigation diversion dams on the Rio Grande (one of which is San Acacia), two canal headings, and 345 miles of main irrigation canals. It also rehabilitated old irrigation ditches. The San Acacia Diversion Dam diverts water from the Rio Grande to provide irrigation water to fields in the Socorro area. MRGCD operates and maintains irrigation and flood risk management facilities in the Middle Rio Grande valley.

Elephant Butte Dam was completed by Reclamation in 1916, to provide reservoir storage for the irrigation of farmlands along the Rio Grande between Truth or Consequences, New Mexico, and Fort Quitman, Texas. The reservoir also provides storage for supplying the Republic of Mexico with 60,000 acre-feet of water annually under the Treaty of 1906. The reservoir’s original capacity was 2,137,200 acre-feet, while the reservoir’s current capacity is 2,065,000 acre-feet (1988). A hydropower facility at the dam generates electricity. The upstream limit of the reservoir is just above San Marcial.

In addition to the network of irrigation facilities in the floodplain below San Acacia, Bosque del Apache NWR operates an extensive water distribution system to irrigate crops, develop and maintain ponds and marshes, and to manage vegetation. Sources of water are the LFCC and irrigation and drainage canals. The LFCC is an especially valuable source of water for wetland management at Bosque del Apache NWR, which maintains by far the most extensive wetland along the Middle Rio Grande (Crawford, *et al.*, 1996).

(b) Flood Risk Management

The dominant structure in the study area that provides some flood risk management protection to floodplain development is the spoil bank identified for replacement in the Recommended Plan. This spoil bank, located east of the LFCC and west of the main Rio Grande channel, was built using material that was excavated to create the LFCC and material excavated during subsequent maintenance and rehabilitation activities. It extends the entire length of the LFCC and varies in size. Additional structures in the immediate study area are local diversion channels at Socorro, including a discharge channel to the Rio Grande constructed by the Corps in 1964, and Reclamation's Brown Arroyo Project south of Socorro, which also discharges into the Rio Grande.

As described in Sections 1.4.1 Flood History and 2.2.2 Geology and Soils, the existing spoil bank and foundation exhibit failure by way of seepage, piping and sloughing of the spoil bank or LFCC once the river channel exceeds bank full. The average expected performance of the existing spoil bank is a failure at the 20- to 14-percent chance event having a discharge of about 12,200 cfs at San Acacia (USACE, *et al.*, 2007).

The USFWS, BLM, U.S. Bureau of Indian Affairs (BIA), U.S. Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service), and the MRGCD have also constructed or presently operate flood risk management structures in the Middle Rio Grande Valley. The USFWS constructed and operates water control structures as well as flood management dikes at Bosque del Apache NWR. The BLM has made improvements in both the Rio Puerco and Rio Salado, including dikes, diversions, small reservoirs, and detention dams. The BIA has constructed several dams for flood and sediment management on Indian Reservations located within the Rio Puerco and Rio Salado watersheds. The NRCS constructed two floodwater retarding structures in 1961, one on Big Draw and one on Prop Canyon, both tributaries of Bluewater Creek. Land treatment was also instituted on these tributary watersheds by the NRCS.

(c) Water Conservation and Delivery

As part of the authority granted to Reclamation under the provisions of the Flood Control Acts of 1948 (Public Law 80-858, dated June 30, 1948) and 1950 (Public Law 81-516, dated May 17, 1950), Reclamation constructed the LFCC on the west side of the Rio Grande floodway between 1951 and 1959. The headgates at San Acacia were put into operation in May 1959. Thus, the Rio Grande downstream from San Acacia consists of the river channel proper, the LFCC, and a spoil bank separating the two channels. This LFCC, as originally built, extends approximately 75 miles from the San Acacia Diversion Dam to the "narrows" in Elephant Butte Reservoir and has a capacity of approximately 2,000 cfs. The purpose of the LFCC is to transmit river flows through a critical water-loss area, thus preventing the flows from spreading across the wide floodplain and subsequently dissipating by high evaporation, high seepage, and phreatophytic-vegetation transpiration. The diversion of river flows (up to 2,000 cfs) into the LFCC assists in conserving water and making water deliveries required by the Rio Grande Compact and the 1906 Treaty with Mexico, which requires annual delivery of 60,000 acre-feet. The conveyance of sediment in the LFCC is intended to lessen deposition and aggradation in the Rio Grande channel. The primary use of water in the Middle Valley is for domestic, municipal, and irrigation purposes. Recreation and fish and wildlife benefits are incidental to these primary objectives. The LFCC delivers water to the Socorro Division of the MRGCD and to the Bosque del Apache NWR.

A period of record analysis shows an average savings of about 32,000 to 47,000 acre-feet of water annually, depending on prevailing climate conditions during the assessment period, as a result of the LFCC-induced reductions in evaporation, transpiration, and ground water recharge (Figure 13 in Tetra Tech, 2004). As stated, material excavated during construction of the LFCC was used to form an embankment that would provide some protection from high flows in the Rio Grande. Reclamation is currently rehabilitating the LFCC by removing accumulated sediment and revetting its side slopes to prevent sloughing and to increase efficiency. Maintenance roads, bridges, and various water-control structures have also been added. The LFCC is much lower than the Rio Grande channel through the study area as a result of sediment deposition and channel aggradation in the Rio Grande.

The record number of high spring runoffs and high reservoir conditions during the 1979 to 1987 period heavily impacted the LFCC, causing it to breach several times during this period. These conditions diminished the capability to operate the conveyance channel to the point that no water could be diverted into the channel without damaging it. A significant reduction in the capacity of the channel and complete sedimentation of the lower 15 miles of the LFCC occurred as a result of recent high water storage at Elephant Butte Reservoir and resultant sediment deposition and backwater effects. Reclamation extensively rehabilitated the Rio Grande floodway and LFCC below Bosque del Apache NWR in response to this extensive sedimentation. Although current storage within Elephant Butte Reservoir is no longer considered high due to several recent dry years, previous damage sustained by the LFCC and the sediment accumulation within it have prevented usage of the lower 15 miles of the LFCC.

Because of the above concerns, in 1996 the Albuquerque Area Office of Reclamation initiated a planning study of the LFCC between San Acacia and Elephant Butte Reservoir. The objective of the study was to develop a plan for possible changes to the Rio Grande channel and the LFCC, which would affect the system's configuration, its operation, or both. The need for an evaluation of this system was created by recent trends in river morphology, changing hydrologic conditions, increased public attention to the environment, and legal considerations. During the initial scoping activities for this study, it was determined that the general alignment of the LFCC from San Acacia to San Marcial would not be changed. However, the LFCC from San Marcial to Elephant Butte Reservoir likely could undergo some alignment changes. A list of alternatives to relocate and/or realign the LFCC was formulated, and a draft EIS was produced in September 2000. This EIS was cancelled by Reclamation in 2007 (USBR, 2007b).

The 2007 ROD for the Upper Rio Grande Basin Water Operations Review 8 (USBR, 2007c) established that Reclamation will continue operating the LFCC as a passive drain with zero diversion from the Rio Grande. The ROD noted that controversial issues associated with operation of Reclamation facilities included projected ecosystem impacts resulting from possible future active diversion to the LFCC in the San Acacia reach of the river. This reach includes critical habitat for both the Rio Grande silvery minnow and Southwestern Willow Flycatcher and is of particular concern to the USFWS. At present, Reclamation does not divert water from the Rio Grande to the LFCC. Instead, the LFCC functions as a passive drain to intercept and convey shallow groundwater and irrigation return flows downstream to Elephant Butte Reservoir. Reclamation does not anticipate active diversions to the LFCC in the near future as extensive repairs or reconstruction would be needed to resume active diversion.

Whereas infiltration of surface water is considered a loss in terms of delivery of surface waters to downstream users, there is an unquantified benefit to the local groundwater recharge. The groundwater aquifer in this area is used for municipal and agricultural water supply. Recharge is necessary to sustain this valuable resource.

(d) Operation and Maintenance of the Rio Grande Floodway

Reclamation is responsible for operation and maintenance activities within the Rio Grande floodway throughout the proposed project area. This includes maintaining and operating the LFCC and its adjacent spoil bank. Any large sediment plugs which occur within the floodway or LFCC are removed as part of their program to maintain flow. Likewise, any breach of the spoil bank would be promptly repaired. It is also likely that additional sediment would be piled on top of or adjacent to the existing spoil bank as materials from the floodway are removed.

2.7.5 Transportation Facilities

The primary transportation facilities affected by the Rio Grande within the project area are the Burlington Northern Santa Fe Railway Company (BNSF) facilities. BNSF's north-south main line parallels the Rio Grande between San Acacia and San Marcial. The single track main line crosses the Rio Grande at San Marcial, the downstream end of the project area, and just upstream of the upper limits of the Elephant Butte pool area.

The existing bridge crossing consists of five modified Warren Through Trusses, each spanning 149 feet 6 inches. Bridge piers are reinforced concrete and abutments are timber crib walls. The type of foundation used for the piers and abutments is unknown. The bridge alignment and design, with respect to river hydraulics is poor, posing a severe restriction to river flows. The bridge's alignment is nearly parallel to the river channel, with a skew angle of approximately 30 degrees with respect to the river channel. Piers supporting these spans are wide, flat-nosed, and inefficient at passing flows. The lower chord of the bridge has been as little as 5 feet above the present river bottom in the recent past. The combination of poor bridge alignment and inefficient pier design causes the Rio Grande to slow down drastically through the area, dropping much of its sediment load, which backs-up upstream of the bridge.

From the limited available files and conversations with knowledgeable persons, an outline of the bridge's history can be sketched. The river bed elevation has aggraded a vertical distance of approximately 37 feet since 1895, although there is some confusion on the exact amount of the increase. The deck of the bridge has been raised and the piers extended vertically at least two times since it was built in an attempt to keep up with this aggradation and to increase capacity under the bridge. Still, sediment has continued to accumulate under the structure.

The BNSF is aware of two major incidents of flooding requiring major work on the bridge with long delays and detours in rail service. The first was in the late 1920's, most likely 1929. District records indicate there were two flood peaks in that year, one in August and the second in September. Flows were estimated to have peaked at 24,000 cfs and 60,000 cfs, respectively, at San Marcial (Scurlock 1998). It was during the September 1929 peak that the villages of San Acacia, San Antonio, and San Marcial were destroyed. As a result of a major flood event, the entire bridge and approach tracks were completely buried under sediment. There were also several buildings, including a roundhouse, which were all buried under sediment. The railroad bridge was unearthed, new piers were designed and constructed, and the bridge was set on these raised piers.

The second event remembered by railroad employees occurred in the early 1940's, probably 1941. In that year, 29 inches of rain fell from January through May, flooding 50,000 acres of the valley floor from Española to Socorro (Scurlock 1998). Once again, this was a major event that resulted in loss of rail service for a significant amount of time. The piers were extended and the bridge was raised on the rehabilitated piers. Railroad personnel believe this was the last time that the bridge was raised. There may well have been other events in addition to these two, but BNSF employees are unaware of any others.

BNSF representatives also stated they are aware of the large amounts of sediment that has accumulated under the bridge in recent years. They stated that they had visited the site in the mid-1980s and there was approximately 8 to 10 feet of clearance under the bridge deck. They again visited the site in about 1989 and there was only 2 feet of clearance under the bridge. They also described a close call around 1990 when water was just touching the low steel of the bridge. Although traffic was not stopped, the railroad was very concerned and monitored the bridge closely. Also, the spring and summer of 2005 were very wet. High flows were approximately six inches above low steel for over a month. Once again, BNSF monitored the bridge closely, but no closures were deemed necessary. Other than these recent incidents, most quantitative data on past water problems has been lost, but enough qualitative information exists to suggest the existing condition flood threat to the bridge is severe.

The railroad is of the opinion that the San Marcial Railroad Bridge could last another 50 years with proper maintenance and no significant flood events, or it could fail next year should a large event occur. Therefore, it can be concluded that the existing bridge has a life of over 50 years, unless a large event occurs. As sediment continues to accumulate under and upstream of the bridge, the railroad will continue to work with Reclamation on their maintenance program to attempt to extend the bridge's life. Should minor damage occur as the result of a flood, BNSF will attempt to repair it immediately. However, the threat of failure during a moderate to large flood event is very real. Should the bridge fail, BNSF will attempt to replace it as soon as possible with a larger-capacity structure. This track is a major north-south route and it cannot be abandoned.

In addition to the railroad, there are also highway facilities that traverse the study area. U.S. Highway 380 is an important transportation artery that crosses the Rio Grande about 10 miles South of Socorro at San Antonio, New Mexico. This highway carries heavy traffic to southeastern New Mexico as well as local traffic to military installations. Also, County Road 85-82 crosses the Rio Grande north of the City of Socorro, between the villages of Escondida and Pueblito. Vehicular traffic on this road is very light and local.

2.7.5.1 *Specialized Land Use:*

(a) Sevilleta National Wildlife Refuge

The Sevilleta NWR is located between Bernardo and the City of Socorro on both sides of the Rio Grande. This 220,200-acre refuge was founded in 1973, and is managed by the USFWS in its natural state. This refuge is managed primarily as a research area and is closed to most recreational uses. However, limited waterfowl and dove hunting, and special tours including environmental education programs for students are supported by the facility. A part of the refuge boundary, located just north of the SADD and east of the centerline of the Rio Grande, from the Diversion to the southern boundary of the refuge, interfaces with a three-mile section of the proposed levee alignment.

(b) Bosque del Apache National Wildlife Refuge

The Bosque del Apache NWR is located 18 miles south of the City of Socorro and 8 miles south of the Village of San Antonio, and is bisected by the Rio Grande and its floodplain. The refuge, founded in 1939, includes 57,191 acres. It is located at the northern edge of the Chihuahuan desert and straddles the Rio Grande approximately 20 miles south of Socorro, New Mexico. The heart of this refuge is approximately 12,900 acres of moist bottomlands — 3,800 acres are active floodplain of the Rio Grande and 9,100 acres are areas where water is diverted to create extensive wetlands, farmlands, and riparian forests. The rest of the BDANWR is made up of arid foothills and mesas, which rise to the Chupadera Mountains on the west and the San Pascual Mountains on the east. Most of these desert lands are preserved as wilderness areas. This refuge provides valuable habitat for a large number of resident birds and wildlife. In addition to providing wildlife habitat, the refuge hosts various scientific studies, environmental education activities, and public recreational uses, such as sightseeing, photography, bird watching, and hunting and fishing opportunities for snow geese, deer, quail, doves, rabbit, and a diversity of warm water fish. The LFCC and spoil bank interface with the refuge for a distance of approximately 12 miles.

2.7.6 Environmental Justice

On February 11, 1994, then President Clinton issued Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. This Executive Order requires Federal agencies to identify and address disproportionately high or adverse human health and environmental effects of Federal programs, policies, and activities on minority and low-income populations. An accompanying memorandum and guidance from the White House Council on Environmental Quality emphasized that Federal agencies would analyze the environmental effects, including human health, economic and social effects, of

Federal actions, including effects on minority communities and low-income communities as part of the NEPA analysis and provide opportunities for community input.

In April of 1995, the EPA released a guidance document entitled Environmental Justice Strategy: Executive Order 12898. In short, this document defines the approaches by which the EPA would 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.

Consideration of environmental justice concerns includes compilation of race and ethnicity data and the poverty status of populations. These data are presented from census data published by the U. S. Census Bureau. The project area corresponds to two census tracts within Socorro County. One of these tracts best characterizes the population affected by flooding in the project area since the large majority of residential structures included in damage estimations occur in this tract. Census tract 9783.03 encompasses the Rio Grande floodplain west of the Rio Grande and east of Interstate Hwy 25 from just north of the SADD south to Hwy 380. Census tract (9781) encompassing roughly the eastern half of Socorro County includes the remaining project area east of the Rio Grande and south of Hwy 380. Although the remaining study area within tract 9781 includes rural residences the BDANWR and several ranches or tracts lacking damageable structures make up a large part of the land area. According to the 2006-2010 American Community Survey 5-Year Estimates the median household income in tract 9783.03 was $36,286 as compared to 33,284 for Socorro County and 43,820 for New Mexico. A higher percentage of the residents in tract 9783.03 (21 percent) were classified as having household income below poverty than in New Mexico (14 percent) or in the US (10 percent). This figure is slightly less than that for Socorro County. (U.S. Census Bureau, 2010).

Table 2.7 Household income in project area compared to the county, state and country.

	United States	**New Mexico**	**Socorro County**	**Study Area (Tract 9783.03)**	**Tract 9781**
Population 16 years and over	238,733,844	1,561,181	14,144	2,997	3,602
Median household income (dollars)	$ 51,914	$ 43,820	$ 33,284	$ 36,286	$ 36,875
Total Households	76,254,318	497,372	17,521	806	1,158
households with Income in the past 12 months below poverty level	7,685,345	69,175	4703	168	289
% of households with Income in the past 12 months below poverty level	10%	14%	27%	21%	25%

Minority populations, as defined by the U.S. Census Bureau, are also present in the county. The study area has a higher percentage of Hispanics (50.5 percent) when compared to Socorro County, New Mexico and the United States. American Indians in the study area make up a smaller proportion of residents (5.8 percent) than in Socorro County or New Mexico and higher than that of the United States. (U.S. Census Bureau, 2010).

Given the high probability of flooding in the study area, residents are at risk of incurring flood damages to homes and contents. Depending on the location of homes in the floodplain and depth of flooding for a given flood event people residing here risk the losing some portion of the contents of the home, and would be faced with the costs of clean-up, repair or, in extreme cases, total loss of the structure. These losses, or the annual cost of insurance to offset the losses, present a significant financial burden especially to the low income households. For those residents living in poverty, the loss would be catastrophic.

Table 2.8 Ethnicity in project area compared to the county, state and country.

ETHNICITY	United States	New Mexico	Socorro County	Study Area (Tract 9783.03)
White alone or in combination	74.8	71.5	77.7	84.5
Hispanic or Latino	9.5	29.8	39.1	50.5
Black or African American alone or in combination	13.6	2.8	1.4	1.2
Hispanic or Latino	0.6	0.6	0.4	0.4
American Indian and Alaska Native alone or in combination	1.7	10.7	12.8	5.8
Asian alone or in combination	5.6	2	1.7	0.6
Native Hawaiian and Other Pacific Islander alone or in combination	0.4	0.2	0.1	0
Some Other Race alone or in combination	7	16.8	9.3	10.7

2.8 AESTHETICS*

As discussed in the 1992 SEIS, the general visual setting of the proposed project area is thought to be of high aesthetic quality, with the exception of sporadic litter and domestic garbage. The Middle Rio Grande valley, with its irrigated fields, riparian forest and woodland, and river channel, forms a verdant corridor in an arid and sparsely vegetated land. The riparian forest and woodland is thought to possess moderate to high visual qualities, while the existing spoil bank has lower aesthetic appeal because of the scarcity of vegetation on the spoil bank and disturbed soils. While the spoil bank presents a visual obstruction it also provides an elevated vantage point to view both the floodway and former floodplain viewsheds.

CHAPTER 3 - FUTURE WITHOUT-PROJECT CONDITIONS*

This chapter evaluates the *future without-project conditions*, commonly also known in the NEPA process as conditions resulting from the No Action Alternative. Evaluation of these conditions is part of the study process that considers what would happen in the future if no Federal project is implemented. Because these projections become more unpredictable the farther into the future they are made, the *future without-project conditions* were defined to a point 50 years into the future and are also called the Project Year 50 conditions.

3.1 PHYSICAL ENVIRONMENT*

3.1.1 Climate and Climate Change

The council on Environmental Quality (CEQ) has proposed that agencies determine whether climate change considerations are warranted in the determination of effects in NEPA documents (Sutley, 2010). They postulate that sensitivity, location, and timeframe of a proposed action will determine the degree to which consideration of these predictions or projections is warranted. The agency may then assess the extent that the effects of the proposed agency action or its alternatives will add to, modify, or mitigate those effects.

It is difficult to predict or quantify the effects of various possible climate change conditions. USGS Circular 1331, *Climate Change and Water Resources Management: A Federal Perspective* (USGS, 2009), points out that the best available scientific evidence based on observations from long-term monitoring networks indicates that climate change is occurring, although the effects differ regionally. Additional research and monitoring are needed to fill knowledge gaps and advance our planning capabilities. Although neither will eliminate uncertainties, research and monitoring will provide significant improvements to our understanding of the effects of climate change on water resources, including quantity and quality, and in evaluating associated uncertainties and risks required for more informed decision making. USACE policy guidelines (USACE 2011a) require the integration of climate change adaptation planning into all USACE programs, and projects.

Warming temperatures have already produced observable changes in the hydrologic cycle of the West: (1) average annual temperatures in the mountain West have increased at least 1.4°F compared to the 20th Century average (MacDonald, 2010; USACE, 2011b); (2) temperature increases have been greatest in mountainous regions in the winter and spring, with temperatures increases of 2.8 to 4°F above the long term average in the period January through March (Bonfils *et al.*, 2008; Saunders and Maxwell, 2005); and (3) snowpack declines have been observed (McCabe and Wolock, 2009; Pederson *et al.*, 2011; Gutlzer *et al.*, 2006) due to declines in snow water equivalence, more winter precipitation falling as rain, and earlier spring melt (Hidalgo *et al.*, 2009; Stewert *et al.*, 2005), all of which contribute to reduced spring runoff in many Western streams. Total precipitation is largely unchanged (Mote *et al.*, 2005; Enquist and Gori, 2008), but higher growing season temperatures translate into greater losses through evapotranspiration. These changes to the hydrological cycle, if they were to continue, indicate a significantly increased potential for severe droughts (Seager *et al.*, 2007) and increasing flood risks in the future.

Additional trends have been observed in the West that may impact regional hydrology in unexpected ways that have yet to be quantified. Wildfires have increased in size, intensity, and frequency (Westerling *et al.*, 2006), driven in part by warmer temperatures and greater evaporative losses, but also by changing land use and forest management practices (Baker 2009). Warmer winter temperatures and drought stress have enabled pests — such as the mountain bark beetle — to produce stand die-offs among several species of pine, including both pinyon and ponderosa pine (Breshears *et al.*, 2005), and other trees. Both fire and tree stand die-off leave hillslopes bare, allowing for greater erosion by wind, rainfall, and runoff. Thus, if these trends continue, it is possible that flashy runoff from summer thunderstorms will produce greater runoff than historically, while at the same time reducing soil moisture recharge in upland areas. Bare hillslopes may also be less able to retain winter snows due to greater solar gain and greater loss to sublimation, contributing to higher winter base flows and lower spring runoff flows.

Bias-corrected, spatially downscaled ensemble climate models for the Rio Grande project that the observed warming trend will continue, with mean annual temperatures by 2100 potentially rising to 4°F (trimmed range of model results, 2-7°F) over the baseline period of 1950-1999 (Reclamation, 2011b). Precipitation is likely to remain about the same, or decline slightly by the end of the century. In models, the April 1 snow water equivalence for mountain snow packs shows a strongly declining trend in many areas. Combined, these trends produce reductions in total spring runoff volume and significant advances in the timing of spring runoff (earlier in the year) compared to the historic record (Reclamation, 2011b; see also Cayan *et al.*, 2010; Christensen and Lettenmaier, 2007)).

Higher temperatures have been projected by the U.S. Global Change Research Program (USGCRP) for the Southwest as a whole. USGCRP modeling suggests that by 2080, the mean annual temperature in the Southwest may increase approximately 4 to 6°F (2 to 3.5°C) under moderate emissions scenarios and as much as 7 to 10°F (4 to 6°C) in higher emissions scenarios (USGCRP, 2009). Recent analysis suggesting the higher warming scenario may be more likely, with temperature increases of 4 to 7°F (2 to 4°C) by 2050 (Barnett and Pierce, 2009).

Although observed trends and model projections provide guidance on future climate change, great uncertainty surrounds both magnitude and rate of change estimates. These uncertainties prevent the quantitative treatment of climate change projections in model efforts at this time.

3.1.2 Geology and Soils

Without a project, future geology and soil conditions in the study area are anticipated to remain relatively unchanged. Soils in the floodway would remain largely composed of sands, silty sands, and clayey sands, as upstream tributaries continue to provide a source for these materials. The spoil banks are composed of these source materials and construction techniques resulted in numerous sand layers that allow excess pore pressures to dissipate and lead to consolidation and strengthening of these structures. However, avulsions inside the current spoil banks are likely to continue to erode and threaten portions of the levee system. Repairs of spoil bank erosion would likely utilize the nearby available spoil material from the floodway. Thus, the composition of the spoil bank is projected to ultimately remain as it is today and the geology and soil characteristics of the study area would remain in their current state in the future without-project condition. As stated in Sections1.4.1 Flood History and 2.2.2 Geology and Soils, the existing spoil bank has the potential to fail during a 20- to 14-percent chance event in any given year.

3.1.3 Hydrology and Hydraulics

The hydrology and hydraulics of the Middle Rio Grande valley are a highly modified, controlled system, governed by water management activities and facilities (USACE, *et al*., 2007). As noted in the discussions contained in Chapter 2, present water management includes flood risk and sediment management dams and reservoirs, irrigation storage reservoirs, levees, channel maintenance, irrigation diversions, drainage systems, and runoff conveyance systems. No major changes to these are anticipated in the future (USACE, *et al*., 2007). The following paragraphs summarize the reasons for this conclusion.

3.1.3.1 *River Geomorphology and Sedimentation*

The extensive system of water management and channel maintenance tends to limit any potential shift or change in the river geomorphology for the main Rio Grande channel through the study area (Massong, *et al*., 2007). Current sinuosity is considered to be low, and this would not change in the future. Natural avulsions would continue to occur within the constraints of the floodway. Reclamation is expected to continue to maintain the channel and spoil banks, as it has done in the past.

The Rio Grande channel in the lower two-thirds of the study area currently exhibits an overall aggradational trend, especially through Bosque del Apache NWR where a sediment plug formed in 2008. Similar plugs also have formed downstream of Bosque del Apache NWR in previous years (Massong, *et al*., 2007). Due to the low water levels in the reservoir during recent years, this aggradational trend has slowed, and channel down-cutting has predominated from near the San Marcial Railroad Bridge south into the dewatered portion of the upper Elephant Butte Reservoir basin (Massong, *et al*., 2007). When the reservoir returns to previous historical pool depths, the trend of floodplain and channel aggradation is expected to return along the lower reaches of the study area.

The vertical movement of the channel bed likely would be markedly affected by a breach of the spoil bank, wherever the present channel is "perched" above the floodplain. There are numerous areas along the proposed project area where the main channel bed now sits 10 to 15 feet above the historical floodplain. A large flow escaping the spoil bank would cause the flow energy within the floodway channel to markedly increase and would conceivably produce a deep headcut within the main channel. The length of any such resulting headcut would depend upon where a breach occurred, and could extend for considerable distance upstream since no geologic grade-controlling formations are known to exist within the project area. The persistence of such a headcut would most likely be limited because the existing spoil bank would be repaired and the cut would likely naturally refill relatively rapidly with sediment. The short-term effects from such an occurrence, however, would be expected to include increased sediment transport capacity, increased bank instability, lower local groundwater levels, and increased risk of subsequent spoil bank failure. The riverbed material mobilized as a consequence of the breach would be transported downstream and deposited within both the downstream floodplain and Elephant Butte Reservoir. This increased deposition could add to the damages in the form of additional channel maintenance and sediment removal costs, lost reservoir storage, physical property damage, and agricultural losses. Deposition of this additional material in the LFCC or as a plug within the Rio Grande Floodway channel would further aggravate the water salvage and conveyance issues, placing New Mexico's compliance with the Rio Grande Compact at risk. In the future, without the implementation of a Federal project, the floodplain would continue to aggrade and the channel would continue to avulse within the existing floodway, as constrained by the existing spoil bank.

3.1.3.2 *Hydrology and Flooding*

Although climate change may eventually affect flood magnitude and frequency, these cannot at present be reliably quantified. Therefore, discharge-frequency data for the study area were computed based on 61 years of historical information. Although additional data gathered in future years would serve to refine this analysis, there is no reason to believe any significant change in the estimated flood hydrographs would occur. Had the record only equaled 20 or 30 years, there would be potential for changes in the discharge projections. However, with the available information, there is little anticipated change in the numbers used for this report.

Also, no significant increase in development or construction is expected to occur in the watershed; therefore, the peak discharges are not expected to increase due to developed conditions in the watershed, and the hydraulics are not expected to change due to construction of other projects. As such, the risk of the levee overtopping during a flood would remain essentially unchanged from current conditions, while the risk of piping through the levee, leading to potential failure of the levee, would increase as levee heights increase.

As noted in Chapter 2, the existing spoil bank only provides protection from flow events of a magnitude of less than the 20-percent chance. Any spoil bank breach and any damages from sediment erosion or deposition would be quickly repaired by Reclamation. The existing spoil bank is projected to be maintained by Reclamation into the future, as it has done for decades, with spoil bank height increasing in response to the aggradation of the floodplain.

Overall, there is very little opportunity for any lateral movement of the floodway in the future, and flooding potentials in the study area would be expected to remain very similar to the current conditions. There would remain a high, unchanged potential for significant flooding to occur along the west bank of the study area. In addition, potential damage from a levee breach would increase due to aggradation of the channel and floodplain, increased levee height, and the accompanying increase in potential energy in the water accompanying the flood flows. The City of Socorro and the unincorporated villages in the floodplain would continue to be threatened by periodic flooding. Socorro would continue to participate in the National Flood Insurance Program to obtain relief after damaging events. Needs for flood insurance would continue, unchanged. Likewise, the LFCC would continue suffer from periodic flood damage as it currently does. The San Marcial Railroad Bridge would remain a major constraint to unregulated river flows through the Middle Rio Grande Valley. Aggradation of the river channel upstream from the bridge is projected to continue. Reclamation would continue to maintain the maximum channel capacity at the railroad bridge. Should the railroad bridge be damaged during a flood, the

BNSF would likely repair the structure as soon as possible. Likewise, if the bridge were to be destroyed, the BNSF would likely replace it with a larger-capacity structure along its current alignment as soon as possible. Because this is a major route for rail service in New Mexico, it is unlikely that this line or the bridge would be abandoned. Therefore, the hydrology and flooding characteristics of the study area are not anticipated to vary from their existing conditions in the future without-project scenario.

3.1.3.3 *Sedimentation*

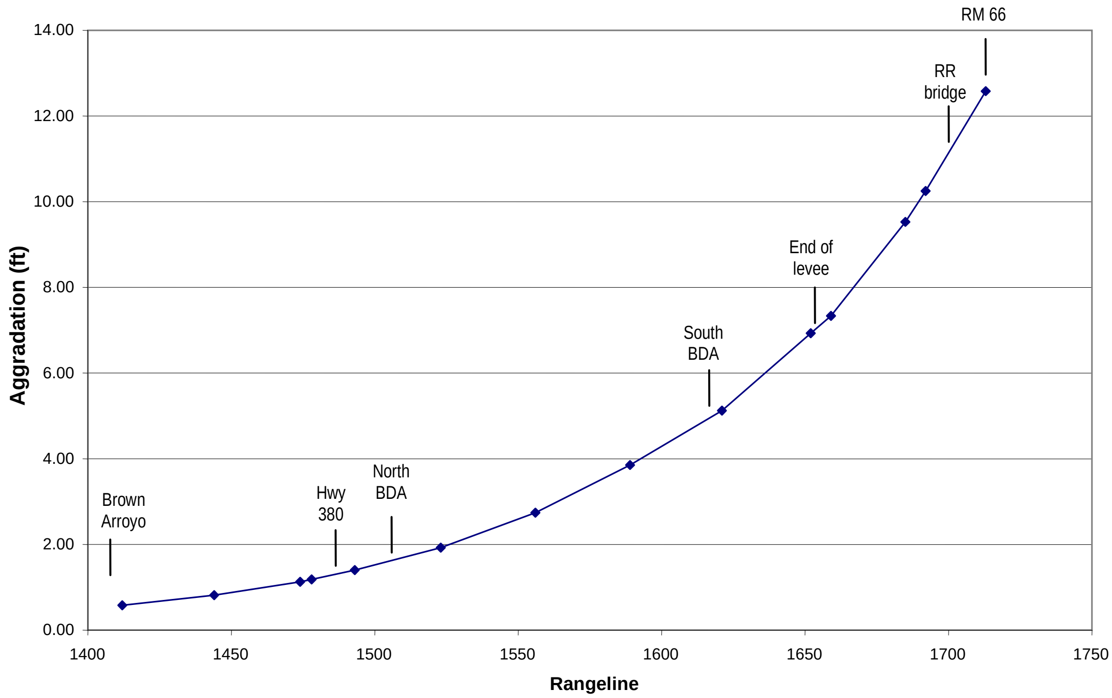
Data from range line surveys produced by Reclamation in 1972, 1992, and 2002 were used to analyze the long-term aggradation and degradation trends for this reach. Station and elevation data from these surveys were used to calculate the area between a datum (5,500 feet) and the cross section elevations for each range line for each year. Differences between these cross sectional areas for each year were then compared for 1972 to 1992, 1972 to 2002, and 1992 to 2002 to analyze aggradational and degradational trends. In each case, the area from the later year was subtracted from the area from the earlier year. A positive value indicated an aggradational trend for that range line and a negative value indicated a degradational trend. These values were plotted against the range line numbers to determine where the reach displayed general aggradational or degradational trends.

The reach showed a general degradational trend upstream from Brown Arroyo (approximately 10 river-miles south of the Escondida Bridge) and an aggradational trend downstream from there. The reach from Brown Arroyo downstream to a point about 7 river miles south of the San Marcial Railroad Bridge was then analyzed to quantify the aggradational trend. A regression analysis was performed on each data set (1972 to 1992, 1972 to 2002, and 1992 to 2002). The 1972 to 2002 data set was ultimately used because it provides the longest period of record.

An equation relating the rate of aggradation to the position in the reach was developed. This equation was used to predict the rate of aggradation for any point within the aggradational reach.

Figure 3.1 and Table 3.1 present the predicted 50-year aggradation at range lines along the aggradational reach. The predicted 50-year aggradation was modeled to project future without-project conditions. For both the HEC-RAS model and the FLO-2D model, the elevation of the entire floodway was raised by an amount corresponding to its position in the aggradational reach. Channel degradation was ignored in the HEC-RAS model. The HEC-RAS model is the design model and ignoring degradation was considered to be more conservative analysis approach for levee design height determination. For floodplain inundation calculations, the FLO-2D model was used. Degradation was incorporated into the FLO-2D model. The degradation was applied to the channel only in the degradational reach of the future conditions FLO-2D model.

Figure 3.1 Predicted 50-Year Aggradation for Selected Range Lines along the Study Reach.



The identified aggradational trend starts at approximately the city of Socorro and increases in the downstream direction. It was assumed that the rate of aggradation observed from the relatively short timeframe of the 1972 through 2002 data set would continue into the future. The calculated rate of aggradation was found to be consistent when compared to historic rates observed by Leopold, *et al*. (1992) in the San Marcial vicinity. Circumstantial evidence, including measured floodplain elevations within and outside of the existing spoil banks and historic documentation of channel elevation changes relative to the San Marcial Railroad Bridge, provide weight-of-evidence support for the calculated rate of aggradation as well. The Corps included the aggradational trend in the future conditions hydraulic modeling for plan formulation and design.

Table 3.1 Predicted 50-Year Aggradation for Selected Range Lines along the Study Reach.

Reach #	Description	Reference Range Lines			Annual Deposition* (ft)	Over 50 Years* (ft)
		U/S	D/S	Typical		
1	Upstream of San Acacia Div. Dam	CO 1174	SA 1210	RP 1190	-	-
2	Downstream of San Acacia Div. Dam	SA 1210	SA 1232	SA 1218	-0.092	-4.6
3	-	SA 1232	SA 1259	SA 1256	-0.068	-3.4
4	-	SA 1259	SO 1298	SA 1268	-0.056	-2.8
5	-	SO 1298	SO 1304	SO 1299	-0.036	-1.8
6	Escondida Bridge	SO 1304	SO 1324	SO 1320	-0.028	-1.4
7	Socorro N. Div. Channel	SO 1324	SO 1337	SO 1327	-0.024	-1.2
8	-	SO 1337	SO 1340	SO 1339	-0.02	-1
9	-	SO 1340	SO 1349	SO 1346	-0.02	-1
10	Socorro area	SO 1349	SO 1368	SO 1360	-0.016	-0.8
11	-	SO 1368	SO 1400	SO 1394	-0.01	-0.5
12	-	SO 1400	SO 1409	SO 1401	-0.01	-0.5
13	-	SO 1409	SO 1419	SO 1414	0.012	0.6
14	-	SO 1419	SO 1472	SO 1450	0.018	0.9
15	Hwy. 380 Bridge	SO 1472	SO 1484	SO 1482.6	0.024	1.2
16	-	SO 1484	SO 1498	SO 1491	0.028	1.4
17	BDANWR	SO 1498	SO 1531	SO 1517.2	0.036	1.8
18	BDANWR	SO 1531	SO 1595	SO 1550	0.052	2.6
19	BDANWR Downstream of RM 78	SO 1595	SO 1616	SO 1603.7	0.086	4.3
20	BDANWR South Boundary	SO 1616	SO 1652	SO 1641	0.124	6.2
21	-	SO 1652	SO 1682	SO 1662	0.15	7.5
22	San Marcial Bridge	SO 1682	EB 14	SO 1701.3	0.222	11.1

** Negative values indicate degradation. Values listed are mean cross sectional elevation changes. Thalweg elevation changes may differ significantly. Areas identified as degradational were considered to be stable for future conditions numerical modeling.*

The analysis also included the assumption that any long-term aggradation would distribute evenly across the entire floodway, including overbank areas, for a given cross section. This may under-predict channel aggradation in the short term. Most sediment deposition occurs within the channel, and immediately adjacent to the channel in the overbank areas. This has the effect of “raising” the channel more than the floodplain, creating the perched channel that exists in much of the project area. However, in the long term, the channel is likely to avulse to lower areas of the floodway at some time in the future and begin depositing its material in these lower overbank areas. Therefore, in the long term, distributing the aggradation evenly across the cross section within the floodway is a reasonable projection.

As discussed in Section 3.1.1 above, predicted increases in Rio Grande valley temperatures may have the effect of reducing the amount of upland vegetation and, therefore, increasing erosion into stream channels. However, concurrently projected decreasing streamflow volumes may lower the potential for sediment transport within the river channel. The potential effect of long-term climate change on sediment transport is not quantifiable at this time, and, therefore does not warrant alteration of the predicted 50-year aggradation curve.

3.1.4 Water Quality

In general water quality within the study area would remain the same or possibly decline slightly. Population growth in the upper and Middle Rio Grande valley is expected to continue a moderate growth in the areas of Albuquerque and Santa Fe. Population growth and changes in land use within the study are not expected to change dramatically in the future (see Section 3.5). Demand on limited water resources within the Rio Grande Basin would increase and potentially impact water quality through slight increases in salinity and other pollutants from use and reuse of water for municipal supply and irrigation.

A major function of the floodway in the study area is to convey water per the Rio Grande compact and international treaty to downstream users. Since this water is stored in reservoirs upstream of the study area it passes through the Middle Rio Grande without being diverted to municipal and agricultural users and is therefore not subject to the addition or concentration of salts and other pollutants.

The impacts to water quality from increasing demand are partially offset by diversions of water from other river basins. Water from the San Juan and Chama rivers is currently diverted into the Rio Grande in northern New Mexico. Other diversions are likely to occur in the future. These diversions largely benefit municipal users in the Rio Grande valley; however, the additional water contributes to riverine resources as it is delivered through the system.

Water and sediment quality are likely to be negatively impacted without construction of a superior flood risk management project in the study area. The spoil banks are considered to have a high probability of failing during high frequency flood events. The consequences of a spoil bank failure are exacerbated by the perched channel condition in the lower study reach. A spoil bank breach would result in all or a large portion of floodwaters flowing from the river channel into the lower elevations of the former floodplain. Due to the perched channel condition, floodwaters would not flow back into the river channel but rather drain through irrigation channels and the LFCC. The limited capacity of these channels would ensure a prolonged inundation of the floodplain landward of the spoil bank.

In inhabited areas flood waters could become contaminated with microbes, both bacterial and viral (Wade, et al, 2004). Microbial exposure is a concern because wastewater treatment plants, residential septic systems, municipal sanitary sewer systems and agricultural operations can be affected by flood waters and can contaminate flooded areas. The LFCC and irrigation channels would convey the microbial contaminated floodwater to the floodplain and eventually to the municipal irrigation storage of Elephant Butte reservoir. The concentration of microbes in floodwater depends on how many and what kind of sources contributed to the contamination, the volume of contaminants released, the degree of their dispersion in the environment and the level of treatment of the affected wastewater-treatment facilities before the flooding (Salvato, Nemerow, and Agardy, 2003; Hurst, et al., 2007). Contaminated floodwater unable to drain in to irrigation infrastructure would remain in the former floodplain until it infiltrates or evaporates. The remaining concentrated microbial contamination on floodplain surface soils may require treatment to reduce microbial hazards (EPA, 2011; NLA, 2011)

Waters of the United States and wetlands, as defined in Section of the Clean Water Act, would continue to be potentially impacted by the activities of Federal, State, local and private entities. The actual activities and extent of impact are not predictable.

3.1.5 Air Quality and Noise

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

3.2 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE ENVIRONMENT*

Current waste concerns within the study area are limited to domestic trash and litter. Due to increased awareness and protection of the Middle Rio Grande corridor, it is anticipated that HTRW contamination in the future would be limited to illegally dumped materials and litter. It is likely that access to the floodway area would continue to be limited in some reaches, as an attempt to reduce trash and litter. The approaches to the bridge frequently sustain river flows adjacent to the embankments that potentially leach HTRW contaminated materials, if present into the water. By their nature, railroad facilities contain fuel and oil products dripped from trains, creosote used to preserve the ties, and chemicals sprayed on the embankments to control weeds. This condition will continue into the future. Therefore, the HTRW environment of the study area is not anticipated to change in the future without the implementation of a Federal project.

3.3 BIOLOGICAL ENVIRONMENT*

3.3.1 Riparian Plant and Animal Community

During the last two centuries, human induced hydrological, geomorphological, and ecological changes have heavily influenced the composition and extent of floodplain riparian vegetation along the Middle Rio Grande (Bullard and Wells,1992; Dick-Peddie, 1993). In the future without-project scenario, the current status of the riparian ecosystem would continue to degrade due factors unrelated to the proposed project and discussed in Section 2.4, including aggradation and degradation patterns, flow regulation, irrigation withdrawals, channel dredging, exotic shrub invasion, fire, and drought and climate change.

By 2080, the mean annual temperature in the Southwest is projected to increase approximately 4 to 6°F under conservative climate scenarios and as much as 7 to 10°F in higher emissions scenarios (USGCRP, 2009). Recent analysis suggesting the higher warming scenario is more likely, with temperature increases of 4 to 7°F by 2050 (Barnett and Pierce, 2009). While effects have not been quantified at his time, the condition of riparian vegetation within the study area may degrade due to lower streamflow volumes and increased evaporation rates associated with warmer temperatures.

Additionally, the presence of tamarisk leaf beetle (*Diorhabda* sp.) has recently been recognized to be advancing in the direction of the study area from the north (Albuquerque) and south (El Paso) (Tamarisk Coalition, 2012). There is a highly likely chance of extensive defoliation of saltcedar (tamarisk) throughout the San Acacia reach. Although it is an exotic species, saltcedar is a significant floristic component of the riparian community. The defoliation and, perhaps, loss, of large stands would be detrimental to the relatively few wildlife species that preferentially inhabit saltcedar. In the event of widespread loss of this shrub species, it is not known at the present time whether native woody vegetation would recolonize former saltcedar areas due to high soil salinity.

3.3.2 Aquatic Plant and Animal Community

In the future without-project scenario, the current status of the aquatic ecosystem would continue to degrade, including continued fragmentation of remaining habitat, aggradation of the floodplain coupled with increasing depths to groundwater, and narrowing of the river channel from the effects of water regulation and the restriction of historical river avulsion patterns due to constrains on the channel, resulting in the loss of warmwater aquatic habitat and wetlands.

3.3.3 Invasive Plant Species and Noxious Weeds

Invasive species and noxious weeds will continue to thrive and spread within the floodway and on adjacent lands, especially in areas of substrate disturbance. Reclamation, in coordination with MRGCD, would continue its maintenance program along the alignment of the spoil bank and LFCC, including regular mowing. Bosque del Apache NWR would continue its long-standing program to remove invasive species (principally saltcedar and other shrubs) and replace them with native riparian species.

3.3.4 Special Status Species

3.3.4.1 *Rio Grande Silvery Minnow (Hybognathus amarus)*

As discussed in Chapter 2, the decline in the abundance and distribution of the silvery minnow appears attributable to extensive and widespread changes in the physical conditions of its required natural habitats, such as modification of stream discharge patterns by impoundments; longitudinal river segmentation by irrigation diversions; channel desiccation; stream channelization; disconnection of much of the floodplain from it channel; water quality degradation related to agricultural, industrial, and urban sources; and the introduction of numerous non-native fish that potentially compete with or prey on silvery minnows (USFWS, 2003a).

Although future without-project conditions for the silvery minnow in the proposed project area are projected as continuing to be affected by the above-mentioned influences, several actions have occurred recently along the Middle Rio Grande Valley that may help alleviate some of these influences. These actions are:

- Obtaining and managing water to minimize dewatering of the Isleta and San Acacia reaches from 1997 through 2009, and managing to ensure spring flow pulses in most of these years to stimulate minnow spawning (USFWS, 2003a). Reclamation contracted with the City of Albuquerque to use a portion of their San Juan-Chama water in minimizing dewatering of the San Acacia reach from 1997 through 2009. However, the City began to integrate its allocation of the San Juan-Chama water into it drinking water supply in late 2008; consequently, the availability of this water supply to support silvery minnow population during periods of channel drying will decline and likely be eliminated in future years (USBR, 2005c).

- In 1996, Reclamation opened a connection from the LFCC to the Rio Grande about 9.5 miles downstream of the SADD facilitating wetting the river in the lower part of this reach, and minimizing the loss of silvery minnows during low-flow periods (USBR, 2000). MRGCD also periodically discharges water through some of its irrigation returns and wasteways with the intent to help limit some of the impacts of channel desiccation on silvery minnows.

- Starting in 1996, and continuing through 2008, Reclamation has removed a series of sediment plugs between Tiffany Basin and Bosque del Apache NWR (Massong, *et al*., 2007). Their removal helps to facilitate higher releases through Cochiti Dam and thereby improve the ability to develop and maintain desirable silvery minnow habitat in this reach.

- In addition, a series of habitat restoration projects have been implemented along the Middle Rio Grande, particularly in the Albuquerque and Isleta reaches (USBR, 2007c; 2008). Similar habitat projects are being assessed for implementation in the San Acacia Reach, including within the proposed project area (Parametrix, 2008).

Hydrologic analysis determined that during a 20- to 14-percent chance event, an extensive breach of the spoil bank could potentially increase the wetted surface area of the floodplain by 42,000 acres. This is based on a given stage for flood flows and the resulting water surface elevation after the failure of the existing spoil bank. Since the channel of the Rio Grande Floodway throughout the study area has aggraded to elevations of up to 15 feet above the historical floodplain outside of the existing spoil bank, any breech of the spoil bank during flood flows, under future without-project conditions, would discharge silvery minnows and other fish from the elevated channel down on to the floodplain. Except for individuals that might find their way into the LFCC or into the irrigation system, most such fish would likely eventually desiccate on the drying floodplain; little potential exists for the discharged fish to return to the channel. However, given the very high reproductive potentials for silvery minnow (i.e., about 2,000 eggs per female at age 1 and increasing markedly in older fish, with some living 5 years and rarely longer), the relatively low proportion of population likely affected, and the relatively low probability of the above described event, the importance to population numbers for the species in the Middle Rio Grande is likely minimal.

3.3.4.2 *Southwestern Willow Flycatcher (Empidonax traillii extimus)*

The flycatcher is endangered due to extensive loss and modification of habitat; brood parasitism by the Brown-headed Cowbird; extensive loss of breeding habitat across its range, particularly the cottonwood/willow riparian habitats of southwestern wetlands; water diversion and impoundment; channelization; livestock grazing; off-road vehicle and other recreational uses; and hydrological changes resulting from these and other land uses (USFWS, 2003a). The loss of this habitat has reduced their reproduction and recruitment potentials for the flycatcher, as well as population numbers for this species; however, its effective range is unchanged (USFWS, 2002). Within the project area, survey work by Reclamation indicates that habitat is not likely limiting flycatcher numbers, except in the subreach between San Acacia and Escondida (Moore and Ahlers, 2006). Their annual assessments also indicate that the USFWS recovery goal of 100 sustained flycatcher territories along the Middle Rio Grande reach has been exceeded since 2003 (Moore and Ahlers, 2006).

Future without-project habitat conditions for the flycatcher in the proposed project area are likely to degrade over time as the trees used for nest placement continue to mature. However, habitat restoration efforts and related activities ongoing or projected to be initiated by several Federal agencies are projected to help mitigate some of this deterioration of habitat along the study area.

The Bosque del Apache NWR would continue their extensive efforts to eradicate saltcedar and restore native vegetation that would improve habitat conditions for the flycatcher in this reach.

3.3.4.3 *Interior Least Tern (Sterna antillarum athalassos)*

Future without-project conditions for the Interior Least Tern at the Bosque del Apache NWR would be a continuation of existing conditions discussed in Chapter 2. The probability of flooding would continue to threaten habitat and foraging opportunities provided by refuge managed wetlands.

3.3.4.4 *Pecos Sunflower (Helianthus paradoxus)*

Future without-project conditions for the privately-owned Pecos sunflower stand within the floodway would be a continuation of existing conditions discussed in Chapter 2. Its continuation would depend on following the specific management practices agreed to at its establishment.

3.4 CULTURAL RESOURCES*

Evaluation of the study area under future without-project conditions indicates that approximately 35 archaeological sites on the west side and 50 sites along the east side of the existing MRGCD spoil bank levee have been subjected to or have the potential to have been affected to some unknown extent by historic flooding in the past, such as the two major flood events that occurred in 1929 and another in 1937. These archaeological sites, located within or immediately adjacent to the floodplain, include pueblo ruins such as San Pascual (LA487) and Qualacu (LA757) as well as the remains of the town site of San Marcial. All of these archaeological sites may potentially be affected by impacts that result from flooding, such as erosion of sites from flow over or against the side of a site, or inundation that results in water saturation of buried cultural deposits at archaeological sites. The extensive MRGCD irrigation and spoil bank levee system, the USBR LFCC, as well as the historic BNSF Railway bridge are eligible for nomination to the National Register of Historic Places. Determinations of eligibility for potential nomination to the National Register of Historic Places have not been made for the majority of the archaeological sites in the area, therefore, they are considered eligible until an official determination is made. In the future without-project conditions, e.g., if the spoil bank levee is not reconstructed, the MRGCD levee, the BNSF bridge, and USBR's LFCC are susceptible to failure and flood damages during flood flow events. The MRGCD, USBR, and BNSF are continually conducting operations and maintenance activities to maintain the structural integrity of their structures.

Under the future without-project conditions there is no change in the potential for effects from future flooding to these archaeological sites, to historic properties, or to sites located downstream of the project area. For example, in both the 1% exceedence probability with- and without project scenarios (Figures 5.3 - 5.9), all of these archaeological sites and historic properties remain vulnerable to flood related effects. USACE and Reclamation continue to manage river flows within their control to avoid effects to archaeological sites including coordination with the BDANWR for sites such as San Pascual and Qualacu (USACE, 2005, 1998).

3.5 SOCIOECONOMIC ENVIRONMENT*

3.5.1 Demography

Increases in population for the City of Socorro over the recent decades have primarily been due to expanded college and governmental research programs and reactivation of the area's mining industry. The population growth in Socorro County is flat over the decade leading up to the 2010 census (down insignificantly from 18,078 reported in the 2000 Census to 17,866 in the 2010 Census). It is also anticipated that communities in the unincorporated areas of the valley will lose population to incorporated communities such as Socorro. These projections are considered accurate for the future, even without the implementation of a Federal project.

3.5.2 Flood Hazards

Since the main river channel within the lower two-thirds of the study area is aggrading and is predicted to continue to do so in the future, the positive effects of the spoil bank would be reduced, and flood depths in the overbanks would increase due to less storage capacity in the floodway. Thus, the hazards due to flooding in the watershed would likely increase in the future if no remedial actions are taken to address the existing water resource problems. This would indicate that the existing capacity of the spoil bank will decrease in the future, without the implementation of a Federal project.

It is expected that Reclamation would continue to maintain the existing spoil bank to its current standards. It is currently assumed that it would continue providing protection to the west bank floodplain from flood events of a magnitude of less than the 20-percent chance. However, due to the aggradational state of the lower two-thirds of the project, the flood hazard is expected to increase in the future, even with continued maintenance or raising of the spoil banks. The additional hazard comes from the increase in the hydraulic gradient of seepage through the spoil bank, as well as an increase in the energy of flood flows that would leave the floodway during a breach.

3.5.2.1 *Flooding Problems*

Table 3.2 summarizes the estimated single occurrence damages associated with various flood events for the San Acacia to Bosque del Apache reach of the Rio Grande. A decrease in total single occurrence damages is shown for the 1- and 0.2-percent chance events compared to current flood risk damage estimates shown in Table 3.2. This results from the decreases in the number of damageable properties within the floodplain, as discussed in the following section.

Table 3.2 Single Occurrence Damages – Future Without-Project Conditions.

LAND USE CATEGORY	**Single Occurrence Damages per Exceedance Event (x1,000; August, 2010 Price Level)**			
	10%	**2%**	**1%**	**0.2%**
Residential	$4,572	$7,014	$7,863	$9,945
Residential Contents	$1,451	$2,229	$2,533	$3,187
Commercial	$1,962	$3,924	$4,685	$6,005
Commercial Contents	$15,792	$21,256	$23,998	$29,017
Public	$152	$203	$240	$281
Public Contents	$133	$183	$248	$356
Apartment	$1	$1	$3	$16
Apartment Contents	$0	$1	$1	$5
Outbuildings	$105	$170	$195	$256
Outbuilding Contents	$71	$106	$122	$160
Streets, Roads	$10,466	$21,720	$25,021	$36,715
Utilities	$232	$762	$898	$1,317
Railroad	$1,693	$1,839	$1,928	$2,830
Vehicles	$2,703	$3,430	$4,086	$5,075
Agriculture	$704	$1,100	$1,209	$1,493
Irrigation Drains	$210	$396	$440	$798
LFCC	$14386	$18,961	$20,747	$27,275
Recreation	$2,837	$2,837	$2,837	$2,837
East Bank	$286	$373	$401	$482
Flood Emergency Costs	$600	$958	$1,094	$1,448
TOTAL	**$58,379**	**$87,486**	**$98,570**	**$129,520**

3.5.2.2 *Damageable Property*

Local realtors in Socorro have noted that most of the recent development in the study area has occurred outside the floodplain. They also predict development will continue to occur, primarily outside of the floodplain, in the future. Future flood damages resulting from basin development or growth in the floodplains are not expected to be significant. Table 3.3 shows the number of structures within the footprints of various probability events. However, future without-project flood damages to existing properties are expected to increase in parts of the study area due to sediment aggradation within the Rio Grande. Generally, areas north of Socorro are expected to degrade, while areas south are expected to aggrade. As shown on Table 3.2, above, the total value of damages caused by a 1-percent chance event to the study area are estimated at $98.57 million (August, 2010 price level). The LFCC holds the potential of resulting in the greatest costs related to possible damages due to uncontrolled damages in the study area. However, repairs would be expected to occur almost immediately after a flood to ensure its continued operation. Future without-project condition damages caused by a 1-percent chance event to the LFCC are estimated at $20.7 million (August, 2010 price level). It is important to note that these numbers are based on the assumption that the future configuration and operation of the LFCC remain as they are today. In addition, without implementation of a Federal project, agricultural lands within the project area would likely be subjected to increased flood damages due to higher runoff in the watershed and continued aggradation of the main river channel.

Table 3.3 Mean Number of Structures within the Floodplain, Future Without-Project Conditions.

Land Use Category	**Percent Chance Exceedance Event**			
	10%	**2%**	**1%**	**0.2%**
Residential	385	549	583	758
Commercial	110	179	190	214
Public	6	14	14	15
Apartment	2	3	3	6
Outbuilding	274	434	450	492
Total Structures	**777**	**1179**	**1240**	**1485**

3.5.3 Land Ownership

Since Reclamation would continue to operate and maintain the LFCC and the USFWS would continue to operate and maintain Bosque del Apache NWR, Federal interest in the lands under and adjacent to the spoil bank would remain as they are today. Lands located within the floodway, including the considered Tiffany Basin Management area, would likely remain in their current status since they would continue to be subject to periodic flooding due to their locations in the floodplains. Therefore, without the implementation a Federal project, it is anticipated there would be no changes in land ownership within the study area in the future.

3.5.4 Land Use and Classification

No substantial changes in land use are expected in the future without-project conditions.

3.5.4.1 *Water Management Facilities*

(a) Irrigation

The MRGCD network of diversion dams, storage reservoirs, canal headings, irrigation canals, rehabilitated old irrigation ditches, and Reclamation's LFCC all serve to provide irrigation water to the study area. The MRGCD has provided this service for over 70 years and it is not anticipated that any changes would occur to affect this service in the future. Similarly, Reclamation's Elephant Butte Reservoir, downstream of the study area, has provided irrigation and water supply storage for southern New Mexico, Texas, and Mexico for over 80 years and would continue to do so into the foreseeable future. Although the LFCC is susceptible to damage from flooding, repair would be expected to occur almost immediately after a flood to ensure its continued operation. Therefore, it can be concluded that without the implementation of a Federal project, future changes in irrigation facilities or activities would be limited to potential changes in the LFCC operation.

(b) Flood Risk Management

It is expected that Reclamation would continue to maintain the existing spoil bank to its current standards. It is currently assumed that it would continue providing protection to the west bank floodplain from flood events of a magnitude of less than the 20-percent chance. However, due to the aggradational state of the lower two-thirds of the project, the flood hazard is expected to increase in the future, even with continued maintenance or raising of the spoil banks. The additional hazard comes from the increase in the hydraulic gradient of seepage through the spoil bank, as well as an increase in the energy of flood flows that would leave the floodway during a breach. As presented in Section 1.4.1 Flood History, although flood events have not exceeded the 20-percent chance event, the existing spoil bank has experienced failures within the past several decades in the form of seepage, sand boils, and sloughing of the bank of the spoil bank or LFCC.

It is also expected that all additional flood risk management improvements operated by the City of Socorro, the USFWS, and BLM would be maintained in the future to their current operating condition. No other flood risk management projects are known to be in the planning stages within the San Acacia study area.

(c) Water Conservation and Delivery

The dominant water conservation and delivery structure within the study area is Reclamation's LFCC. Reclamation initiated a planning study of the LFCC in 1996, with the objective of identifying potential changes to its configuration, operation, or both, because there was a possibility of changing this facility and its water conservation and delivery attributes (USBR, 2000). Since that time, these studies have been halted and the draft EIS for the proposed action canceled (USBR, 2007b). As established by the 2007 ROD (USBR, 2007c), Reclamation will continue operating the LFCC as a passive drain for subsurface flows with zero diversion from the Rio Grande.

(d) Operation and Maintenance of Rio Grande Floodway

Reclamation has operation and maintenance responsibilities within the Rio Grande floodway through the study area. They would continue to provide sediment removal, and erosion and flood risk management in the future, similar to their past operations. It is not expected that these responsibilities or actions would change. Therefore, future without-project conditions would result in Reclamation continuing to spend an estimated $2 million annually maintaining the spoil bank and the LFCC, as well as additional time and funds to maintain the main river channel through the study area.

3.5.4.2 *Transportation Facilities*

The primary transportation facility within the area is the BNSF railroad. The BNSF bridge at San Marcial is currently in the floodplain of the Rio Grande and is at risk of being damaged or destroyed from moderate or large flood events. Although BNSF is aware of the flood risk, the railroad currently considers it acceptable, and therefore, has no plans to replace this structure in the near future. It is Reclamation’s intention to maintain the channel such that the current capacity of the bridge is not further reduced. Their maintenance program will continue into the future until the structural integrity of the bridge deteriorates to the point it must be replaced. However, this is not expected to occur within the next 50 years, and is therefore beyond the period of analysis covered by this report. It can be concluded that without a Federal project, the railroad bridge would continue to function as it does under current conditions or until a large event destroys the bridge and it is replaced with a bridge elevated above the floodplain.

Similarly, U.S. Highway 380 and County Road 85-82 would continue to operate with no expected changes to occur in the future.

3.5.4.3 *Specialized Land Use*

(a) Sevilleta National Wildlife Refuge

Future without-project conditions of this refuge are expected to remain similar to those conditions that exist today on the refuge.

(b) Bosque del Apache National Wildlife Refuge

The Bosque del Apache NWR would suffer severe damages in the event of a large magnitude flood that breaches the spoil bank. A majority of the fields, impoundments, and extensive water distribution facilities that provide habitat for a myriad of wildlife species would be flooded, potentially scoured, and covered with sediment. Recreational and educational opportunities at the refuge could be severely impaired.

The future without-project conditions for the refuge indicate inadequate flood risk management under the existing spoil bank system. As is the case with the rest of the study area, the existing protection to the refuge is equivalent to that for a 20- to 14-percent chance of flood damages in any given year. Since Reclamation will continue to maintain the spoil bank, this protection is anticipated to remain constant in the future. Facilities on the refuge especially vulnerable include their investment in the creation and maintenance of riparian wetland areas and the refuge's irrigation system west of the existing spoil bank, which serves and supports these wetland areas and their irreplaceable habitat. Losses to these facilities would be potentially devastating to refuge developments and to populations of waterfowl, cranes, and other species utilizing the refuge. Finally, future conditions without the implementation of a Federal project would not provide containment of flood flows to meet native flora regenerative and maintenance needs, which is currently not possible under existing conditions.

3.5.5 Environmental Justice

In the future without project condition, high probability of flooding remains in the study area. As stated in previous sections, future development if any would not likely change the demographics in Socorro County and the study area. Losses of property, agricultural production, or annual cost of insurance to offset the losses present a significant financial burden especially to the low income households. For those residents living in poverty, the loss would continue to be catastrophic.

3.6 AESTHETICS*

Without the project, the future aesthetic value of the proposed project area would remain largely as it is today, which is thought to be of moderate to high visual quality. There are no data to indicate that the existing aesthetic characteristics of the study area, including the irrigated fields, riparian forest, woodlands, and river channel, will change significantly either with or without the implementation of the proposed project.

CHAPTER 4 - PLAN FORMULATION

The process for the development and evaluation of alternatives to the Authorized Project was conducted in accord with standard Federal procedures for planning water resources projects, regulations, and laws, and the requirements of NEPA. During the scoping process, an array of alternative plans were developed and evaluated to meet the specific planning objectives in consideration of the concerns of the resource agencies and other interested persons. Public involvement and public review of previous NEPA documents made up a large source of information and public scoping included in the current study. The 1972 Environmental Impact Statement (EIS) and 1992 Supplemental EIS (as well as a 1999 Draft Supplemental EIS) were previously prepared for the San Acacia to Bosque Del Apache Unit flood risk management study. Alternatives that were considered in previous EISs but were screened from detailed consideration are described briefly and included by reference in this GRR/SEIS-II. An array of alternatives not previously considered or including updated modifications is described in the current reevaluation.

Alternatives are evaluated according to their ability to meet project objectives, environmental compliance, and acceptability while avoiding, minimizing and, if necessary, mitigating adverse effects to the environment. This chapter describes the plan formulation and evaluation criteria, screening of the alternatives, and criteria for the identification of the recommended plan.

4.1 PLAN FORMULATION PROCESS

The plan formulation process 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 recommended plan. It describes the Corps' 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. 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. 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. 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. 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 the Corps' *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. 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 flood risk management 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 recommended plan.

6. A plan is selected for recommendation, and related responsibilities and cost allocations are identified for project approval and implementation.

4.2 PROBLEMS AND OPPORTUNITIES*

The analysis of a wide range of technical issues, numerous meetings, previous public involvement and site visits identified a number of problem areas in the San Acacia to Bosque Del Apache Unit resulting from a variety of natural and human-induced changes. These problems are summarized below.

- There is a risk of flood hazard to health and human safety within the study area. Water depths in the occupied floodplain of over 10 feet can occur during flood events or as a result of failure of the spoil bank. Loss of life is the major concern; however, health could be affected by sewage contamination carried by floodwaters and latent effects such as mold in water damaged buildings.

- There is a risk of flood damage to existing properties and infrastructure within the floodplains of the study area. A substantial amount of damage to buildings, infrastructure, utilities, conveyance infrastructure and agriculture has occurred and will occur in the future during flood events.

- There is a risk of ecological damage from flooding within the floodplains of the study area. Flooding within a natural river system is beneficial and necessary to the ecology. Within the study area, however, contamination of floodwaters and loss of infrastructure within the wildlife refuge are detrimental effects that offset the benefits. Further, floods overtopping or breaching the spoil bank create a situation that traps endangered Rio Grande silvery minnow outside the river channel ultimately resulting in their death.

- Bank erosion and channel stability problems in the Rio Grande threaten flood risk management infrastructure. The meandering river channel often comes in contact with and erodes the toe of the spoil bank.

- Continued aggradation of the Rio Grande in the study area is decreasing floodway capacity while creating a perched channel. Aggradation of the channel has raised the riverbed as much as 15 feet above the former floodplain outside the spoil bank. Not only has this reduced channel capacity, but it has created a situation in which spoil bank overtopping or breaching would have devastating consequences.

- Continued aggradation in the area of San Marcial has reduced the capacity of the floodway and the channel under the railroad bridge in the past. The limited capacity under the bridge after periods of aggradation as well as inferiority of spoil banks in various locations limits operational flows from Cochiti Reservoir.

- Degradation of riparian and aquatic ecosystems is ongoing. This includes the continued fragmentation of remaining habitat, lack of overbank flooding (within the floodway), and the spread of non-native vegetation.

- During the reevaluation, the potential for spoil bank failure due to long-term inundation was identified as a common concern. During past flood fighting efforts, inundation of the toe and foundation of the spoil banks for periods greater than a few days resulted in sloughing, piping and sand boils at some locations.

Opportunities were identified from information obtained in the without-project assessment and Corps' understanding the of public's concerns. These are summarized below:

- Provide publicly acceptable and economically justified flood risk management measures and plans.

- Incorporate environmental protection features as part of the design of flood risk management features.

- Provide superior flood risk management infrastructure to allow a wider range of operational releases from upstream dams. Flexibility in reservoir operation would benefit water delivery and allow for modification of water delivery releases that benefit riparian habitat and endangered species.

The following planning objectives were considered in the reevaluation of the Authorized Project for the San Acacia to Bosque del Apache Unit. The objectives, which are derived from the problem and opportunity statements above, guide the plan formulation process. All of these objectives would be met to some degree during construction of a recommended project between construction start in 2012 to its finish in 2026 given the current schedule for this project:

- Reduce the risk of flood hazard to health and human safety within the study area. Reduce the risk of loss of life and risk to health from flood related hazards.
- Reduce the risk of flood damage to existing properties and infrastructure within the floodplains of the study area by 90 percent.
- Reduce the risk of ecological damage from flooding within the floodplains of the study area.
- Increase the capacity of the floodway throughout the study area to carry floodwaters.
- Prevent damage of flood risk management infrastructure within the study area from erosion.

This completes step one of the planning process, identification of problems, opportunities and objectives. Step two, identification of existing and future without project conditions was accomplished and presented in Chapters 2 and 3. The next step is to formulate an array of alternative solutions that solve the problems and meet the objectives of the study. Alternatives were brought forward from previous documents and an initial set of new alternatives was developed. Next, all alternatives developed in the past or as part of the current reevaluation are evaluated for their ability to achieve study objectives. Alternatives are also evaluated based on additional criteria presented in the next section.

4.3 PLANNING CRITERIA

4.3.1 Planning Criteria

4.3.1.1 *Federal Planning Criteria*

The primary Federal goal in water and related land resources project planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, while following all National environmental statutes, applicable Executive orders, and other Federal planning requirements. Water and related land resource project plans are formulated to alleviate problems and take advantage of opportunities to contribute to this objective. NED contributions include increases in the net value of the National output of goods and services, and can be measured in terms of monetary outputs such as reductions in flood damage and emergency response costs.

Ecosystem restoration is also one of the primary missions of the Corps Civil Works Program. The Corps' objective is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. NER measurements are based upon changes in ecological resource quality as a function of improvement in habitat quality or quantity, and are expressed quantitatively in physical units or indexes (not monetary units). The Corps has reaffirmed its commitment to the environment by formalizing a set of

Environmental Operating Principles applicable to all its decision-making and programs. These principles, as presented below, foster unity of purpose on environmental issues, reflect a new tone and direction for dialogue on environmental matters, and ensure that conservation, environmental preservation, and restoration are considered in all Corps activities.

1. Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.

2. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.

3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.

5. Seek ways and means to assess and mitigate cumulative impacts to the environment while bringing systems approaches to the full life cycle of our processes and work.

6. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and of impacts of our work.

7. Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.

Federal, State, and local environmental quality goals and policies are considered in evaluating the long-term effect that the alternatives may have on significant environmental resources. Significant environmental resources are defined by the Water Resources Council as those components of the ecological, cultural, and aesthetic environments which, if affected by the alternatives, could have a material bearing on the decision-making process. Avoidance of adverse impacts, followed by minimization and then mitigation of unavoidable, significant adverse impacts, is the formulation direction that is called for within NEPA.

A method of displaying the positive and negative effects of the various alternative plans is to use the system of accounts as suggested by the U.S. Water Resources Council (USWRC). The accounts are categories of long-term impacts, defined in such a manner that each proposed plan can easily be compared to one another. The accounts used include NED, environmental quality (EQ), which includes the National ecosystem restoration (NER) analysis, regional economic development (RED), and other social effects (OSE). More detailed information on these accounts and associated analyses are presented in Section 4.7.5 of this GRR/SEIS-II.

As suggested by the USWRC, the alternative plans are also compared using the following criteria: completeness, effectiveness, efficiency, and acceptability. Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure realization of the planned objectives. Effectiveness is the extent to which an alternative resolves the identified problems and achieves the specified objectives. Efficiency is the extent to which an alternative is the most cost-effective means of addressing the identified problems while realizing the specified objectives consistent with protecting the Nation's environment. Acceptability is the workability and viability of an alternative to other Federal agencies, affected State, tribal, and local agencies; and public entities, given existing laws, regulations, and public policies. Additional detail for these criteria is provided in Section 4.7.6

Corps guidance on collaborative planning (EC 1105-2-409, dated 31 May 2005) provides that any alternative plan may be selected and recommended for implementation if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse, in the four accounts described above. Current policies on cost-sharing would apply, so that the Federal cost-share would be based on the NED Plan, or another plan approved by the Assistant Secretary of the Army (Civil Works) (ASA(CW)).

WRDA 2007 §2031 provides for the establishment of revised principles and guidelines for water and related land resources implementation studies, but specifies that certain projects are not subject to the revised guidelines. The revised principles and guidelines apply explicitly only to projects specifically where a feasibility study or a reevaluation has not yet commenced. Due to the fact that both the feasibility study and reevaluation for the San Acacia Project have commenced in advance of issuance of revised principles and guidelines, these specific requirements of WRDA 2007 do not apply. In spite of this, the spirit and intent of these requirements were followed for both avoidance of impact to, and protection of, existing natural resources.

4.4 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in this study include:

- Flood risk management features should not induce or compound negative effects to flooding or environmental resources outside the study area.
- Total benefits must equal or exceed total costs for any plan to be implementable by the Federal government or the Corps.
- Any flood risk management solution should maintain water delivery capabilities through the study area.
- Any recommended project must be within the non-Federal sponsor's ability to undertake the responsibilities of supporting the project through construction, and operating and maintaining it through its useful life.
- Project features cannot significantly impact the endangered Rio Grande silvery minnow, Interior Least Tern, or Southwestern Willow Flycatcher.

4.5 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION*

Since there have been previous flood risk management studies and decision documents produced for the San Acacia to Bosque del Apache Unit, an array of alternatives has been developed and evaluated with input and comment from the public and other agencies. This section presents alternative plans considered in previous documents and eliminated from further consideration because they did not meet study objectives, were economically infeasible, or were otherwise not implementable. It begins with an overview of the alternatives previously considered, and a discussion of the recommended plan. This is followed by sections providing additional information on each alternative. Additional detail for these alternatives can be found in the previous 1972 EIS and 1992 SEIS. Some alternatives presented in previous documents are reevaluated with additional detail or updated information. Additional detail for updated evaluations can be found in Appendix F-10, Economics.

The alternatives eliminated from further consideration have in common the fact that individually and collectively they are impracticable since they do not meet planning objectives and therefore, do not fulfill the purpose and need of the project. Many of the alternatives are eliminated because they are incomplete, ineffective or unacceptable per those planning criteria presented in Section 4.3. Alternatives put forth in previous EIS or SEIS analyses were found to not be effective or acceptable. Many alternatives although they received due consideration, were found to be ineffective since they do not reduce flood damage to agricultural land, the BDANWR and the LFCC. A breach of the spoil bank could damage or destroy these features. Only the alternatives carried forward for additional analysis described in Chapter 5 provide protection to these features throughout the study area.

4.5.1 Overview of Measures and Alternatives Eliminated from Further Consideration

The following table summarizes the measures and alternatives evaluated in the current and previous studies to accomplish flood risk management for the San Acacia to Bosque del Apache Unit. Detailed information on newly evaluated alternatives is provided in Chapters 4, 5, and 6 and Technical Appendix F of the GRR/SEIS-II Report.

Table 4.1 Summary of Alternatives Previously Considered

Management Measure	Alternatives Considered in Previous Studies	Assessment	Qualifies for Further Consideration
1. Flood Risk and Sediment Management Dams	• Rio Puerco and Rio Salado damsites alternative	Conflicts over land use, environmental impacts, and availability of real estate at damsites made this alternative infeasible.	No
2. Watershed Land Treatment	• Various land management measures implemented within the Rio Puerco and Rio Salado watersheds	These alternatives do not effectively reduce flood flows from the watershed.	No
3. Non-Structural	• Floodplain management regulations	Regulations and zoning are already in place.	No
	• Flood warning systems	Would reduce risk to life and safety but have a minor reduction in property damage.	No
	• Retrofitting or dry proofing • Elevation of structures • Floodwalls	Flood proofing methods were found to be of very limited applicability and an incomplete solution.	No
	• Buyout / acquisition	Buyouts or acquisitions would provide an incomplete solution.	No
	• Replace the San Marcial Railroad Bridge so that it is above the floodplain	The Corps does not have the authority to replace the bridge.	No
4. Engineered Levee	• Local levees (Village of San Acacia, City of Socorro, Bosque del Apache NWR)	This alternative had lower net benefits; was unable to protect the LFCC or agricultural lands and communities; partitioned the land; and had internal drainage problems.	No
	• Intermittent levee replacement	This alternative was found to be impractical due to the extent of levees requiring replacement and the inability of the entire levee system to withstand long term inundation.	No
	• Standard project flood levee (Authorized Project)[4]	No longer meets Corps criteria for design and	No

[4] In 1946 the Corps established the application of the Standard Project Flood (SPF) criteria to levee design. The SPF represents the flooding discharge expected from the most severe combination of critical meteorological and

Management Measure	Alternatives Considered in Previous Studies	Assessment	Qualifies for Further Consideration
		selection of the NED plan and does not withstand long term inundation.	
	• Engineered levee along the current spoil bank alignment from the SADD and extending along the west side of Tiffany Basin (only implemented in conjunction with the Tiffany Basin sediment management feature)	This alignment provides the same benefit as a similar levee that extends along the east side of Tiffany Basin but at a higher cost.	No
	• Engineered levee from SADD to Tiffany Basin that includes Seepage controls. (alternative length and heights evaluated in detail)	Meets Corps criteria for design and selection of the NED plan and withstands long term inundation.	Yes
5. Tiffany Sediment Basin (Passive alternative)	• Allow sediment laden river flows to transport and deposit sediment into Tiffany Basin	Results in unacceptable negative impacts to wildlife, including endangered species, and in unacceptable water losses.	No
Tiffany Sediment Basin (Active alternative)	• Mechanically transport sediment into Tiffany Basin and actively spread the sediment.	Active method is not economically feasible and results in unacceptable water losses.	No

Based on the previous planning study assessments, many flood risk management alternatives are removed from further consideration. Alternatives with updated information or evaluated for the first time in this GRR/SEIS-II include: all non-structural alternatives, Tiffany Sediment Management Basin, an approximately 43 mile levee from the SADD to Tiffany Basin (Alternative A) and an approximately 47 mile levee along the same alignment but extending downstream along the west side of Tiffany Basin (Alternative K). Detailed information regarding these alternatives can be found in Appendix F-10, Economics. The engineered levee alternative is retained and advances to the next planning activity to formulate alternative scales of length and height for consideration. Since one purpose of the reevaluation is to demonstrate the changes from the authorized plan, the SPF levee is presented in Chapter 7, Post-Authorization Changes.

hydrological conditions reasonably possible in a given geographical region, excluding extremely rare combinations. The SPF is no longer a valid design target, having been superseded by more current guidance. Instead, a full range of floods, including those that would exceed the SPF, is to be used in formulation and evaluation of alternatives.

4.5.1.1 *Levee Size and Scales*

This reevaluation process also provides an opportunity to reformulate alternatives; based on new information. The engineered levee alternative was evaluated for two levee lengths and five heights. The combination of length and height that maximizes net benefits was chosen as the recommended plan.

Table 4.2 Levee Measures

Retained Measures	Description of Management Measure and Components
Alternative A	43- mile engineered levee from San Acacia Diversion to northern end of Tiffany Basin
Alternative K	Alternative A with the addition of a 4-mile engineered levee along the East side of Tiffany Basin

4.5.2 Flood Risk and Sediment Management Dams

As stated, the result of the 1961 Congressional directive to review the levee construction plan authorized in 1948 was a recommendation that flood and sediment control dams be constructed on the Rio Puerco and Rio Salado in lieu of levee improvements of the Authorized Project. This recommendation was then followed by advanced engineering and design studies and a subsequent reevaluation report and SEIS (1992) addressing these dams. Of several damsites evaluated, one was selected on the Rio Puerco and one on the Rio Salado. These dams would have temporarily detained floodwater and released it at a flow rate which the existing Rio Grande channel could safely convey. Additionally, they would have retained a significant part of the large sediment load currently being deposited in the Rio Grande, associated irrigation and water conveyance systems, and downstream water storage facilities. Briefly, these damsites are as follows:

(1) Rio Puerco - The Hidden Mountain Site. This damsite would have been located about 17 river miles from the mouth of the Rio Puerco. This alternative would have required about 18,500 acres of land and cost about $63,000,000 (1988 price levels).

(2) Rio Salado - The La Jencia IJinsa Site. The damsite would have been located about 15 miles upstream of the confluence of the Rio Salado with the Rio Grande. This alternative would have required about 5,400 acres of land and cost about $52,000,000 (1988 price levels).

Alternatives involving these dams were not pursued because of the cost of the two dams, conflicts over land use, and constraints on the USFWS that prohibited inundation of about 300 acres of land on the Sevilleta National Wildlife Refuge.

4.5.3 Watershed Land Treatment

This measure was the subject of a substantial cooperative study effort among the Corps of Engineers, agencies of the United States Departments of Agriculture and Interior, State and local government agencies, and private interests. A variety of land treatment practices were considered, resulting in the development of three alternative plans. These three alternatives would have cost $26,000,000, $72,000,000, and $94,000,000 (1988 prices). While these alternatives would have contributed to reduced soil erosion, improved water quality, enhanced wildlife use, and improved cover, among other benefits, they would not have effectively served the primary objective of flood risk management in the San Acacia to Bosque del Apache Unit. Substantial land treatments have been implemented since the 1948 authorization within the watersheds to achieve localized land management goals.

4.5.4 Non-Structural Measures

Non-structural measures to reduce or prevent flood damage were considered but were found to be of very limited applicability as well as practicability. Agricultural and wildlife refuge lands and the LFCC are not suited to floodproofing, and existing urban development is, in general, not economically feasible to flood proof. Floodproofing and zoning are only applicable to areas where urban development was ongoing but not yet in place (USACE, 1992). This comprised only a very small proportion of the floodplain under study.

4.5.5 Floodproofing and Zoning

A variety of non-structural flood damage reduction measures were presented in past documents; however, more recent information on these methods is currently available. Non-structural measures were reevaluated to determine if they would meet the planning objectives. The evaluation of these measures is discussed below.

4.5.5.1 *Floodplain Management Regulations*

As of 2011, Socorro County participates in the National Flood Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) that identify Special Flood Hazard Areas for the Rio Grande and tributaries.[5] For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced. While new regulations may limit or prevent flood damage to new development within the floodplain it would do little to alleviate flood damage occurring to existing structures, infrastructure and agriculture. This measure was not carried forward for alternative evaluation.

4.5.5.2 *Flood Warning Systems*

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages outside of sandbagging efforts requiring days to construct. The primary benefits of such a system are credited for providing early evacuation of residents and

[5] Preliminary flood hazard maps for portions of Socorro County were last updated on 16 September 2011 and can be found at http://maps.riskmap6.com/NM/Socorro/, accessed 30 MAR 2012.

reduction in damages to vehicles and structure contents. However, since most flooding in the study areas results from localized summer thunderstorms proximate to the San Acacia reach, and not due to snowmelt, flood warning lead times are short. Flood warning in Socorro, NM (the major damage center in the study area) is currently less than a few hours since the only river gage downstream of the Rio Puerco and Rio Salado is located at the SADD. Addition of early warning gages on these tributaries or rain gages in the upper watersheds of could improve warning times by several hours; however, they would not allow for effective reduction of structural damages.

The evaluation presented in the Economics Appendix assumes that 1.0 of the 1.74 vehicles per capita in Socorro County residences have been evacuated, and that all operable commercial and public vehicles have already been evacuated prior to any flooding. A flood warning system would present benefits by reducing the amount of residential contents subject to flooding. Residential contents are half the Residential EAD. It is assumed that an effective and understood flood warning system would allow residents to protect structure contents. Removing damageable items from the dwelling or raising them above flood stage would decrease EAD by at most 7.8%. The high residual damages, and the flood threat to Federal properties (the Low Flow Conveyance Channel and Bosque del Apache NWR) and to other infrastructure (roads, agriculture, utilities, public and commercial properties) suggests that a flood warning system is ineffective and incomplete on its own.

4.5.5.3 *Flood Proofing*

Flood proofing offers the opportunity to provide flood protection to individual structures on a structure-by-structure basis, or to a group of structures. Flood proofing techniques typically include buyouts, relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s). Flood proofing techniques considered for alternative development are:

1) Relocation of Existing Structures: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance, and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the identified flood hazard area. This also requires purchase of the flood prone property; selecting and purchasing a new site; and lifting/moving the structure to the new site.

   Corps experience has indicated that relocations and buyouts only work when the land left behind is repurposed to some other public good, such as a public park or reuniting the acquired land with the floodway. The Federal Emergency Management Agency estimates relocation costs at between $99 and $116 per square foot (1999 dollars), which exceeds the depreciated replacement costs of just about every structure in the floodplain (FEMA, 2009:3-28, Table 3-9). The study area floodplain extends for over 43 river miles, and represents a wide and flat area next to the perched Rio Grande main channel. Reuniting the floodplain outside the floodway with the channel, which sits higher than the floodplain, would create ponding over much of the valley that would have significant negative environmental impacts as well as unacceptable water losses to evaporation and infiltration. Relocations also do nothing for the flood risk to agricultural lands, public and Federal properties (the Low Flow Conveyance Channel and Bosque del Apache National Wildlife Refuge), and is therefore an incomplete solution to the flood problem.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure; demolition of the structure; relocation assistance; and applicable compensation as required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-Federal sponsor.

   As stated previously with relocations, acquiring properties in a floodplain next to a perched channel has limited utility. The acquired land cannot be returned to the floodway without exacerbating the flood problem. Further, the study area’s floodplain extends over 43 river miles, and is over 1 mile wide in parts. Evacuating the floodplain does nothing to remove agriculture or Federal properties from the floodplain and therefore would represent an incomplete solution to the flood problem.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Application of a waterproof coating to exterior walls and installation of temporary closures or flood shields are commonly used flood proofing techniques. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, dry flood proofing can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, due to the type of construction and typical lack of anchoring to a foundation.

   Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Tables F-2A and F-2B in the Economics Appendix (E-10) display the water surface elevations associated with various events. In many locations, flood stages are expected to exceed 3 feet, rendering the flood proofing measures ineffective for many buildings in the floodplain. Once again, floodproofing does nothing to remove agriculture or Federal properties from the floodplain and therefore would represent an incomplete solution to the flood problem. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or

concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator. The disadvantages of levees or berms are: 1) can impede or divert the flow of water in a floodplain; 2) can block natural drainage; 3) are susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable property space. The disadvantages of floodwalls are: 1) high cost; 2) closures for openings required; and 3) give a false sense of security. While this solution may be practical for buildings with adequate space and lower floodwater depths, the floodwater depth associated with many structures make berms impossible due to the land area required and impractical for floodwalls due to the cost floodwalls of that height. Ring levees or floodwalls do nothing to remove agriculture or Federal properties from the floodplain and therefore would represent an incomplete solution to the flood problem. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures can be raised on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

   FEMA has estimated that elevation in place for slab-on-grade homes (the most common foundation type in the study area) can cost $80-88 per square foot (2009 dollars) for a frame structure, and $88-96 per square foot for a masonry structure (FEMA, 2009). That value exceeds the per square foot depreciated replacement cost of most of the structures in the floodplain, which makes this alternative infeasible. Elevation of buildings does nothing to remove agriculture or Federal properties from the floodplain and therefore represents an incomplete solution to the flood problem.

6) Elevation of the San Marcial Railroad Bridge

   The railroad bridge at San Marcial crosses the Rio Grande approximately 15 miles upstream of the Elephant Butte Reservoir pool. This structure was analyzed to determine the probability of flooding on the bridge under without- and with-project conditions. BNSF provided elevations on the railroad bridge that would cause service interruption, damage to the bridge, and bridge destruction, if the water surface reaches them. These elevations were defined as follows:

   - Closure Elevation: This elevation is at the bottom chord, or low steel of the bridge. When the water surface reaches this elevation, the bridge would hypothetically be closed to traffic. Hydraulic analyses show that the water surface will reach closure elevation during a flow of approximately 2,500 cfs. According to BNSF, the bridge will be closed for 36 hours, incurring the expense of diverting 30,000 daily estimated tonnages through a detour of 105 miles. On a per event basis, the “closure event” would cost $118,125.

- Damage Elevation: This elevation was given as the elevation at which structural damage to the bridge would occur if the water surface were to reach it. This elevation is achieved when the water surface reaches one foot above the low chord of the bridge. The water surface will reach the damaging elevation during a flow of approximately 4,600 cfs. In this event ("damage event"), the bridge was assumed to be damaged and would take 30 days for repairs, which amounted to transportation detour losses of $5.36 million.

- Destruction Elevation: This elevation was given as the elevation at which the bridge would be destroyed. This occurs when the water surface reaches one foot above the bridge deck, or top of rail. The water surface will reach the destruction elevation during a flow of approximately 19,000 cfs. The "destruction event" assumed that the destruction of the bridge would be total, and would incur an estimated replacement cost of $73.4 million. This event would also result in transportation detour losses of $46 million.

As shown in Table 4.3, the replacement of San Marcial Railroad Bridge is expected to pass somewhat higher flows than the 0.2-percent chance event without destruction. In the table, the low chord is reached, at the 50-year aggradation state, with a 0.5-percent chance event, but destruction of the new bridge is not anticipated until an event with a lower probability than a 0.2-percent flood occurs.

Table 4.3 Affect of Annual Chance Exceedance Flow Event on the Existing San Marcial Railroad Bridge and its Replacement

Event	**Existing Bridge (Without-Project)**	**Existing Bridge (Future Without-Project)**	**Existing Bridge (With-Project Year 1)[1]**	**Existing Bridge (Future With-Project Year 50)[1]**	**Replacement Bridge (With-Project Year 1)**	**Replacement Bridge (Future With-Project Year 50)**
Closure Event	>50%	99%	>50%	99%	<0.2%	0.5%
Damage Event	>50%	99%	>50%	99%	<0.2%	<0.2%
Destruction Event	<0.2%	99%	<0.5%	99%	<0.2%	<0.2%

[1] *Reclamation will continue sediment removal efforts as long as the existing railroad bridge remains.*

Over the 50-year period of analysis there is a cumulative probability that one or more of these damaging events will occur. There is a small probability that a closure or damage event could occur each year over the period of analysis for the project, but the bridge failure event could only occur once this period. After the failure event, it is assumed that BNSF would replace the structure with a new bridge.

The replacement of the San Marcial Railroad Bridge would derive much of its benefits from reduction in required traffic reroutes, tonnage, and distance of the reroutes, and likelihood of repairs or replacement of the existing bridge after a damaging event. Additional benefits could also include improvements in water conveyance in the Rio Grande and cost savings associated with a change in Rio Grande operations, however, the measure does not reduce flood damages to any other part of the floodplain.

Although replacement of the bridge would be a wise investment, it is not within the authority of the USACE to replace the bridge absent induced damages from a Federal project. Table 4.3 shows that there is no difference between with and without project closure and damage events and a slight increase in frequency of destruction events, however this difference does not constitute a significant increase of induction of damages by a levee project. This alternative measure is not advanced for further consideration since it is not within the authority of the USACE to replace the bridge.

4.5.6 Local Levees

Under this alternative, local levees would be constructed adjacent to the village of San Acacia, the City of Socorro, and Bosque del Apache NWR. Under this alternative, portions of the existing earthen embankments adjacent to the village of San Acacia, the City of Socorro, and Bosque del Apache NWR would be removed and would be replaced and extended to tie into high ground north and south of these developments. The combined length of these levees would be 18 miles and would cost about $15,000,000 (1988 price levels) for 1%-chance flood protection. The LFCC would be protected for short intermittent lengths. This alternative was not recommended because of its lower net economic benefits due to inability to protect structures, agricultural land, and infrastructure outside of urbanized locations as well as the LFCC. This alternative also requires extensive land acquisition, extensive partitioning of land, and causes internal drainage problems.

4.5.7 Intermittent Levee Replacement

This alternative consists of not replacing or rebuilding those embankment sections that were determined to be structurally sound. This alternative was found to be impractical in previous reevaluations that did not account for long term inundation. No part of the existing spoil bank would meet current criteria for levee performance; therefore, this alternative is not considered further.

4.5.8 Engineered Levee along the West side of Tiffany Basin (Tiffany West Levee)

This approximately 3-mile levee would run along the west perimeter of Tiffany Basin between the basin, and the LFCC and railroad tracks. This levee would act as an extension of a 43-mile constructed levee from the SADD to the north end of Tiffany Basin. This segment has little benefit as a stand-alone levee segment and would only be implemented in conjunction with the Tiffany Basin sediment management feature and the larger upstream levee feature. The levee would be built from spoil from construction of the 43-mile levee. The utility of this levee segment would be to reduce the risk of flooding of approximately 1 mile of LFCC and railroad if the Tiffany Basin sediment management feature described in 4.5.9 was implemented. However, it would not reduce the risk of flooding in Tiffany Basin and the potential for damaging erosion to upstream infrastructure in the event of a breach in the spoil bank in this reach.

This alternative has little utility without implementation of the Tiffany Basin sediment management feature. Further, this levee extension would be constructed where no spoil bank exists currently so that borrow material would be needed for levee construction. This alternative provides the same benefits as a levee extension along the east side of Tiffany Basin (see Section 4.6.2) at a higher cost and so is not considered for further evaluation.

4.5.9 Tiffany Basin Sediment Management (Passive Method)

As stated in Chapter 2 Existing Conditions, the combination of high sediment loading coupled with confinement of the floodway by spoil banks has resulted in a *perched* channel, whereby the active channel and adjacent overbanks are elevated above the historic floodplain lying outside the leveed floodway. One area of particular concern is Tiffany Basin, located on the west side of the river channel, near the Tiffany Junction railroad siding and immediately upstream of the San Marcial Railroad Bridge. Tiffany Basin has an aerial extent of roughly 2,053 acres, is bounded on all sides by either spoil banks or railroad embankment, and is normally isolated from sediment-laden river flows by the existing spoil bank.

Following an examination of the 1992 aggradation/degradation rangelines, it was clear that the well-documented long-term aggradational trend was continuing in the vicinity of Tiffany Basin and the San Marcial Railroad Bridge. It was also clear that this long-term trend would reach magnitudes that threaten the capacity of the floodway to carry flood events without spilling over the spoil bank. The channel capacity under the railroad bridge immediately downstream of Tiffany Basin was also in question.

The potential for a breach of the spoil bank sending a flood wave into the area caused the design team to consider the impacts that could be associated with such an event. There is a concern that given a spoil bank failure, the high-energy associated with the flows around the initial failure could cause a *head cut* initiating near the breach and progressing up the river channel. With 10 to 15 feet of elevation differential, plus the hydrostatic head just prior to a breach, there is considerable shear stress available to scour subsurface materials until hydrostatic pressures reach equilibrium. The possibility of a head cut and associated risk to flood risk management structures upstream is worth considering in project design.

Allowing the Rio Grande to flow through the spoil bank into Tiffany Basin is primarily a means to control sediment aggradation within the Rio Grande. A modification to the existing spoil bank would facilitate controlled routing of a portion of sediment-laden river flows through Tiffany Basin. In this case, gaps or inlets would be constructed in the spoil bank that would allow the river to flow into the basin but would be armored to prevent a head cut from forming. This could not only reduce hydrostatic pressure differences on the spoil bank, but also promote deposition to lessen the elevation differences. Sediment removed from the floodway could maintain capacity of the floodway, reduce downstream channel maintenance, and reduce storage loss in the reservoir. This sediment management feature would have some design issues to overcome, such as achievement of adequate hydraulic head to allow passive drainage of the basin. Water losses to evaporation and infiltration, and potential entrapment of fish are also a concern for this alternative feature, as it is for the existing basin.

While the primary purpose of the Tiffany Basin feature is to maintain floodway capacity by decreasing channel aggradation in this reach and alleviate the potential for a head cut, ancillary benefits from the feature include: reduction of Bureau of Reclamation annual efforts to remove sediment from the Rio Grande channel downstream (estimated at roughly 37 years); and sequestering sediment outside of the Elephant Butte Reservoir pool. The end-state of this feature (no perched channel and hydrologically connected floodplain) would be beneficial to the environment by restoring approximately 2,000 acres of Rio Grande floodplain. However, detrimental environmental effects would persist during the intervening 30-50 years during which the basin fills with sediment.

A feasible solution could not be developed to some of the potential effects of including the Tiffany Basin within the active floodway. These factors included: the extended duration (30 or more years) to fill the basin with sediment; the entrapment and removal of endangered silvery minnow from the river habitat while simultaneously diverting sediment from the channel; the inability to promptly salvage diverted minnows from Tiffany Basin; and the high water depletion associated with evaporation and infiltration of river flows trapped in the basin.

4.5.10 Tiffany Basin Alternative Sediment Management (Active Method)

The potential to alleviate the perched channel condition in the lower reach of the study area is a highly desirable accomplishment for purposes of flood risk management, water delivery, and ecosystem restoration. The team investigated a method of transporting sediment from the Rio Grande into Tiffany Basin without diverting river flows, entrapping Rio Grande Silvery Minnows and incurring water depletions. Installation of a sediment collector in the river channel removes sediment from the Rio Grande and deposits the sediment landward of the levee. Accumulated sediment is then spread using heavy equipment. The sediment collector is essentially a concrete flume set into the river bottom perpendicular to the channel. A grate over the flume allows sediment particles as large as sand grains to enter the flume and excludes larger sediment, fish, and larger invertebrates. A mechanical conveyor transports the trapped sediment through the bank and levee via a pipe. Water is not transported through the system and the only water loss is from the saturated sediment. Sediment accumulated landward of the levee is then mechanically spread with heavy equipment to a depth even with the bottom of the river channel.

This method of sediment management has low installation cost (about $780,000, August, 2010 prices) but extraordinarily high operations and maintenance costs (over $16 million). Those costs are attributed to dispersing the equivalent of four dump trucks worth of sediment daily for over 30 years. Employing the sediment collection device has the same performance characteristics, and the same benefits identified for alternatives that include Tiffany Basin but incur a much larger cost. Since O&M is the responsibility of the local sponsor this alternative would place an unacceptable long-term burden on the MRGCD. This aspect of the Tiffany Basin feature is therefore not considered further.

4.6 DESCRIPTION OF PRELIMINARY ALTERNATIVES*

After removing the alternatives previously considered but found economically infeasible, impracticable, ineffective or not implementable, the Corps conducted a detailed evaluation of levee alternatives for flood risk management. Two levee lengths were evaluated for their ability to meet the study objectives and criteria. Similarly, five levee heights were evaluated for each alternative to determine the optimal benefit cost ratio as well as performance relative to study objectives. Levee alignments that deviated from the alignment of the existing spoil bank were evaluated. Changes to the alignment for significant reaches would incur substantial additional cost to acquire real estate, borrow and perform relocations of the LFCC or irrigation infrastructure and would have greater impacts on natural resources for little gain in flood risk benefits, and therefore would not be the NED plan. Deviations in the alignment in two small reaches (2.5-4 miles) were evaluated in combination with the recommended plan. These are present in Section 4.8 and further in Chapter 6. All the alternatives are compared against the No-Action Alternative and the 1948 Authorized Project.

4.6.1 Engineered Levee from San Acacia Diversion to Tiffany Junction at the Northern End of Tiffany Basin (Alternative A)

This approximately 43 mile levee reconstructed from the existing spoil bank materials is located along the same alignment as the spoil bank and parallels the LFCC (Figure 4.1). The new levee would remain trapezoidal in cross-section with a 15-foot-wide crest. Side slopes would vary between 1 vertical to 2.5 horizontal and 1 vertical to 3 horizontal, depending on the height of the levee. The existing spoil bank contains adequate material to construct the entire length of the new levee without the need for additional borrow. Perforated pipe toe drains, discharge pipes into the LFCC, and risers would be required for levee heights greater than 5 feet. An 8-foot-wide by 4-foot-high inspection trench, with 1V:1H side slopes, would also be required for levee heights greater than 5 feet. In addition, a 2-foot-wide bentonite slurry trench extending downward from the design water surface elevation to the bottom of the inspection trench would be required for levee heights greater than 5 feet. The slurry trench would extend from 2 feet below the levee embankment crest to 5 feet into the foundation material. Rip-rap would be necessary along portions of the levee to protect for scour during high flows.

The approximately 43 mile levee would include appurtenant structures that accommodate complete tie-in at the northern and southern ends as well as tributary crossings along its length. Specialized design considerations are included the approximately 43 mile levee within approximately one mile of the SADD due to high flow velocities and a narrow right of way for levee construction. Specific details for these appurtenances are described in Section 5.1.5.

This levee length and alignment was evaluated at five levee heights to determine the optimal balance between cost and flood damage prevented or benefits. This evaluation is presented Section 4.6.5, below.

4.6.2 Levee from SADD to Tiffany Junction Coupled to an Engineered Levee along the East Side of Tiffany Basin (Tiffany East Levee) (Alternative K)

Alternative K is the levee from SADD to Tiffany Junction (Alternative A) with a 4-mile levee extension along the eastern side of Tiffany Basin (the Tiffany East Levee). The Tiffany East Levee is a 4-mile levee from Tiffany Junction downstream to the San Marcial Railroad Bridge that includes the same seepage and drainage appurtenances as the longer levee. The Tiffany East Levee connects to the main levee at the head of Tiffany Basin and extends along the basin's eastern perimeter (Figure 4.2). The levee would also consist of replacement of the existing spoil bank along the existing alignment. The levee would run along the perimeter of Tiffany Basin between the river channel and the basin. The utility of this feature would be to reduce flooding of Tiffany Basin as well as of approximately one mile of the LFCC and railroad track west of the basin. The feature would indirectly prevent a potential headcutting condition, water losses, and negative impacts to endangered species that would occur if the spoil bank at Tiffany Basin failed.

This levee length and alignment was also evaluated at five levee heights to determine the optimal balance between cost and flood damage prevented or benefits. This evaluation is presented Section 4.6.5 below.

Figure 4.1 Alternative A.

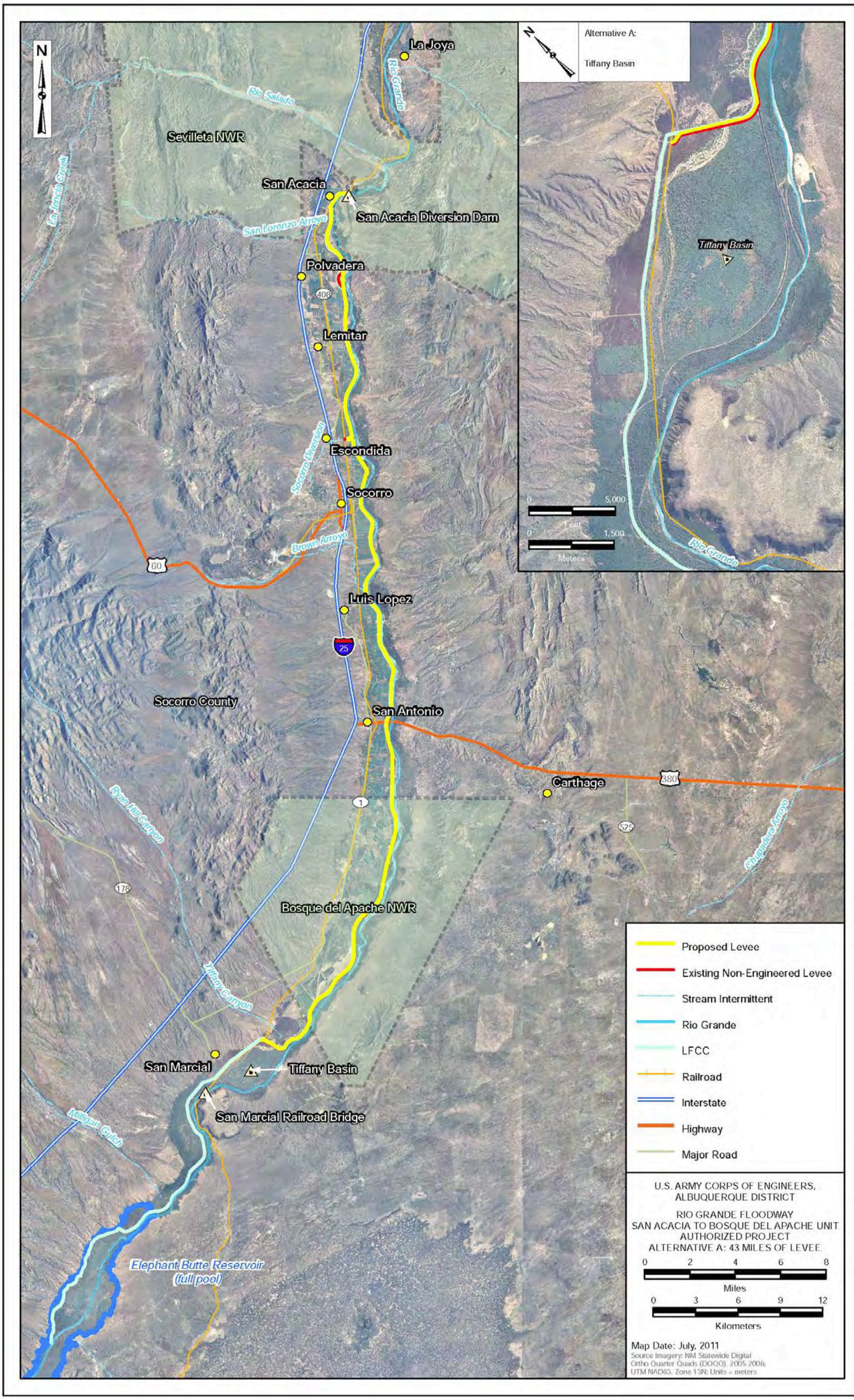


Figure 4.2 Alternative K.

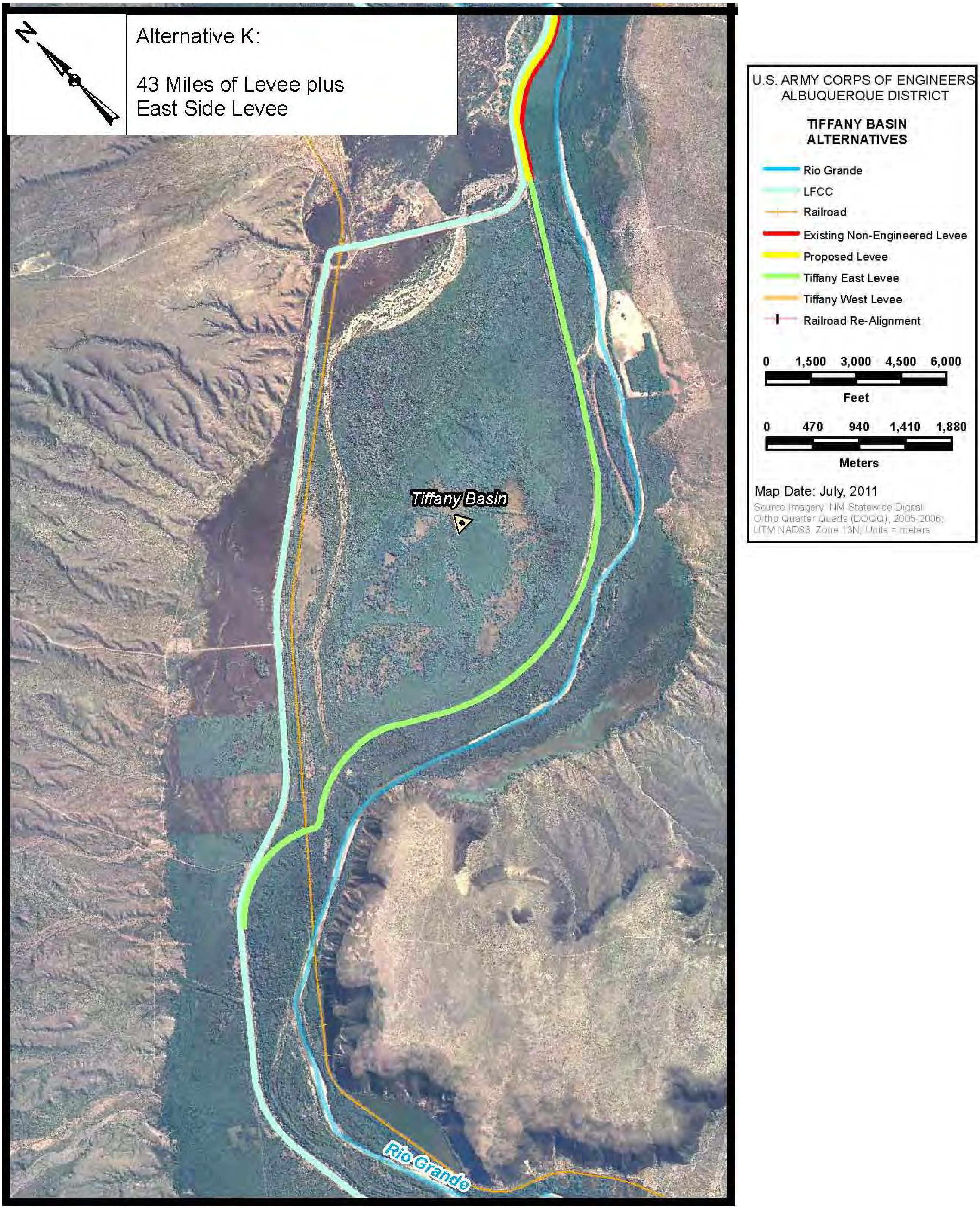


Table 4.4 Array of Alternative Levee Measures.

Alternative	Engineered Levee From SADD to Tiffany Junction	Extended Levee South Along East Edge of Tiffany Basin (Tiffany East Levee)
No Action		
A	X	
K	X	X

4.6.3 No-Action Alternative (Without-Project Condition)

A "No-Action Alternative" is required pursuant to NEPA. Herein called the No-Action Alternative, and synonymous with the "without-project condition" described in Chapter 3, this alternative considers the likely future conditions in the project area in the absence of a Federally cost-shared and locally supported project. The No-Action Alternative does nothing to alleviate risks to public health and safety. Under this alternative, no changes to the existing environment in and around the existing levee are expected unless catastrophic levee failure occurs. No additional flood risk management would be provided under the No-Action Alternative. Without modification to the existing system, the study area would continue to be at risk during a flood, beginning with a very low flood event, and the affected community would be faced with continued economic development concerns.. Under this alternative, Reclamation would continue to maintain the existing levee to its current standards. The existing levee is expected to continue providing protection to the west bank floodplain from flood events of a magnitude of less than the 20-percent chance. However, due to the aggradational state of the lower two-thirds of the project, the flood hazard is expected to increase in the future, even with continued maintenance or raising of the spoil banks.

4.6.4 Authorized Project (1948)

The current project was authorized by the Flood Control Acts of 1948 (P.L. 80-858, Section 203) and 1950 (P.L. 81-516), in accordance with the recommendations of the Chief of Engineers, as found in House Document No. 243, 81st Congress, 1st Session, dated April 5, 1948. As described in the 1948 report, supplementary levee modification and construction would assure an efficient floodway with adequate capacity to pass safely all uncontrolled flash flood inflows originating below the flood-control reservoirs. Levees constructed by local interests were not uniform as to grade, section or standard of construction and it was proposed to modify and supplement the existing spoil banks. New grades would be established within the study area in accordance with the requirements for safely passing a Standard Project Flood of 40,000 cubic feet per second (cfs) at San Acacia diminishing to 30,000 cfs at San Marcial. The proposed levees would be constructed to standard section, with 10-foot crown, 3 on 1 side slopes, and a freeboard of three feet above maximum water surface. Sixty miles was listed as the length of levees that needed improvement but the exact location within the Middle Rio Grande valley was not described. The alignment of any new or reconstructed levees would depend upon the location of the river channel once channel rectification was complete and at the time the work would be planned in detail.

For purposes of comparison, levee construction criteria presented in the 1948 are presented as the "Authorized Project". It should be noted that the 1948 authorization does not contain full levee design; therefore, many aspects of the comparison will be incomplete. The levee project described in the 1948 authorization is not a reasonable alternative for detailed comparison due to the reasons presented in 1.7 Scope and Purpose of the GRR/SEIS-II which are:

- Rectification of the Rio Grande channel by Bureau of Reclamation as outlined in the 1948 authorization and construction of the Low Flow Conveyance Channel under the same authority.
- A longer period of record for hydrological data is now available, which permits improved and updated hydrological analysis.
- A levee design modification has been added to address long duration flows: any proposed plan would have to incorporate design features to prevent seepage through the levee due to prolonged flow against the riverward toe.
- The Corps has departed from the use of the freeboard methodology to account for uncertainty and instead uses probabilistic determination of flood risk and levee design.
- Three species have been listed as threatened or endangered since 1994 (the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, and Pecos sunflower — each occurring within the study area, two with critical habitat).

In particular, the design flood event for the authorized project is not accurate and a lack of seepage control would bring the integrity of the levee into question by today's standards. A longer period of record provides for a more accurate estimation of the flood event probabilities and demonstrates that the probable maximum flood described in HD 243 was underestimated. The authorized project did not specify any seepage control to prevent failure from long duration flows. Without the proper seepage control, levee failure could result from prolonged flow against the riverward toe.

As part of the requirement for Corps reevaluation studies a comparison of the recommended plan must be made to the project originally authorized by Congress. This discussion is presented in Chapter 7, Post Authorization Changes. No further discussion or comparison of this alternative is presented for the purposes of NEPA since this is not a reasonable alternative to carry forward.

4.6.5 Levee Sizes

For all levee features, five alternative levee heights were evaluated in a framework incorporating elements of risk and uncertainty in hydrology, hydraulics, and economics. Levee sizes corresponded to the 1-percent chance event water surface elevation (increased in 1-foot increments) to 4 feet above the 1-percent chance event stage. It should be noted that any increase in levee height has a corresponding increase in levee width. The alternative levee heights shown in Table 4.5 describe a height that corresponds to a mean event stage.

Table 4.5 Alternative Levee Heights

Levee	Description
Base Levee	The top of the levee corresponds to the water surface elevation for the mean 1-percent chance exceedance event
Base Levee + 1 ft	Base levee plus 1 foot of levee height
Base Levee + 2 ft	Base levee plus 2 feet of levee height
Base Levee + 3 ft	Base levee plus 3 feet of levee height
Base Levee + 4 ft	Base levee plus 4 feet of levee height

The NED plan, the plan that maximizes net benefits, will produce the most benefits at the lowest cost. Therefore the added cost of larger levees may be offset by providing more benefits due to the increased assurance of preventing higher flood stages (e.g., less frequent flood event). The evaluation of levee sizes demonstrated that the Base Levee + 4 ft height most efficiently produced the maximum net benefits for the levee features. A larger levee project would incur substantial borrow costs for material, real estate costs to accommodate the wider footprint, and potentially mitigation costs.

4.6.5.1 *Levee Performance and Associated Risks*

(a) Risk-Based Analysis

Corps policy has long acknowledged risk and uncertainty in predicting floods and their impacts, and accounts for these factors through risk-based analysis. Historically, planning relied on analysis of the expected long-term performance of flood risk management measures, on application of safety factors and freeboard, on designing for worst-case scenarios, and on other indirect solutions to compensate for uncertainty. These indirect approaches were necessary because of the lack of technical knowledge of the complex interaction of uncertainties in estimating hydrologic, hydraulic, and economic factors due to the complexities of the mathematics. However, with advances in statistical hydrology and the availability of analysis tools, it is now possible to describe the uncertainty in the hydrologic, hydraulic, and economic functions, to describe the uncertainty in the parameters of the functions, and to explicitly describe the uncertainties in results when the functions are used. Through this risk-based analysis (RBA), and with careful communication of the results, the public can be better informed about what to expect from flood risk management projects and thus can make better informed decisions. The RBA is integral to the Corps plan formulation process, which systematically reviews the characteristics of the problem to identify and evaluate promising candidate flood risk management measures or combinations of measures. The policies, methods and procedures for the RBA conducted in this effort are as detailed in ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, and in EM 1110-2-1619, *Risk-Based Analysis for Flood Damage Reduction Studies*.

(b) Overview of RBA in Flood Risk Management Studies

The determination of equivalent annual damages (EAD) in a flood risk management study must take into account complex hydrologic, hydraulic, and economic information. Specifically, EAD is determined by combining the discharge-frequency, stage-discharge, and stage-damage functions, and then integrating the resulting damage-frequency function. Uncertainties are present for each of these functions and are carried forth into the EAD computation. Once levees have failed and water enters the floodplain, then stages in the floodplain become more critical to the EAD computation than stages in the river channel. Additionally, economic efficiency of a plan or alternative is not the sole criterion for plan selection. Performance indices that assist in making informed decisions could include expected annual exceedance, long-term risk, and conditional probability of non-exceedance. These engineering performance indices allow for plan-to-plan comparison of risk of failure based on either the full range of floods or a specific flood. These indices are described below.

Consistent with the requirements set forth in EC 1105-2-412, *Assuring Quality of Planning Models*, HEC-FDA version 1.2.4 was used to compute average annual and equivalent annual damages (EAD). Corps guidance stipulates that the plan which reasonably maximizes net national economic development benefits, consistent with the Federal objective, be identified. Project benefits for flood risk management measures are identified through successive iterations of existing and future without-project scenarios, changing key hydrologic and/or hydraulic variables as the measures warrant. HEC-FDA is the only model certified for formulation and evaluation of flood risk management plans using risk analysis methods, and was used in this study.

The annual exceedance probability (AEP) measures the probability of a project or alternative being exceeded in any one year. As larger alternatives are analyzed, the AEP drops (e.g., a without-project of 10-percent drops to a 0-percent chance with the Base Levee + 4 ft alternative representing a decrease in flood risk). The long-term risk numbers measure the chance of having one or more damaging floods over a given period of time. The conditional non-exceedance probability (CNP) is an index of the likelihood that an alternative will not be exceeded, given the occurrence of a specific hydrometeorological event. As with other measures, project conditions reduce the risk and larger projects have a greater reduction in risk than small projects. Table 4.8 presents the CNP and reduction of risk for the No Action Alternative and five levee heights.

(c) Sources of Uncertainty

This study, as with other flood risk management studies, has critical uncertainties associated with the hydrologic, hydraulic, and economic data used to compute estimates of EAD and project performance statistics. The major sources of uncertainties considered in this study include:

- Hydrology: Uncertainties inherent in discharge-frequency determination at locations without a long-term record of stream gage data.
- Hydraulics: Modeling risk parameters (i.e., channel n-value, overbank n-value, infiltration, and sediment).
- Economics: Structure value, content value, foundation height, depth-damage percentage, responses to flood forecasts and warnings, flood fighting efforts, cleanup costs, business losses, estimate of stage associated with a given discharge, estimate of damage for a given flood stage, and estimate of future land use.

(d) Project Performance

Project performance describes the effectiveness of the project at containing various flows over the 50-year project period of analysis. As described in the future without-project condition, the Rio Grande channel is incising in the upper reach of the study area and aggrading in the lower two thirds. The capacity of the channel and floodway in turn, is changing over time. A levee of a specific height can be described as capable of passing a flood event with a certain probability. However, this is only true for that point in time. The probability of passing the same event is higher or lower at a different point in time or different location along the levee system. These measures of project effectiveness describe the variability of project performance over time and along the project length.

Table 4.8 compares project performance for plan A among increments of levee height to the without project condition in the base plus 50 years. For each levee height the probability of the levee being exceeded by any flow through the period of analysis is calculated. The Conditional Non-exceedance Probability (CNP) presented in Table 4.8 is also the probability of passing a certain event through the entire levee system in the future year, or year the Rio Grande has accumulated sediment at the end of the period of analysis.

Table 4.6 Project Performance and Residual Flood Risk.

Alternative	**AEP**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Years	**30 Years**	**50 Years**	**10%**	**2%**	**1%**	**0.2%**
No Action	99.9%	~100%	~100%	~100%	~0%	~0%	~0%	~0%
Base Levee	43.0%	99.6%	~100%	~100%	8.8%	5.3%	1.4%	0.1%
Base Levee + 1 ft	17.8%	85.8%	99.7%	~100%	18.2%	12.3%	4.3%	0.5%
Base Levee + 2 ft	17.0%	84.6%	99.6%	~100%	33.0%	23.4%	10.1%	2.1%
Base Levee + 3 ft	9.8%	64.3%	95.5%	99.4%	50.8%	38.8%	19.7%	5.5%
Base Levee + 4 ft	0.5%	4.8%	13.7%	21.8%	67.8%	56.3%	33.6%	12.6%

Logically, long term risk decreases and CNP increases with levee height. Long term risk decreases appreciably for the Base Levee + 4 ft, however, there is always a residual risk of flooding. Table 4.8 presents a 0.1 % probability of containing the 0.2%-chance exceedance event for the Base Levee. A four foot taller levee (Base Levee + 4 ft) has a 12.6% probability of passing the same event without being exceeded or overtopped.

The figures presented in table 4.8 demonstrate CNP for the entire project as a whole and for the entire 50 year period of analysis. For the floodway within the San Acacia to Bosque del Apache unit the performance for the upper third of the project would increase over time while the lower two thirds decreases. The changes are attributed to the changes in channel depth and capacity of the floodway. Since the channel does not aggrade in the northern portions of the project, the probability of passing flood events through the period of analysis is higher than in the southern third of the project area. The same analysis was completed for Alternative K with similar results. Detailed analysis can be found in appendix F-10 Economics.

4.6.5.2 *Benefits*

Table 4.7 presents the net equivalent annual benefits for the No Action Alternative and Plan A at the five levee height variations. Only Plan A at the various heights is presented for the purposes of demonstrating levee height optimization. Details of Plan K at the various levee heights can be found in Appendix F-10, Economics. Annual benefits represent the difference between the without- and with-project equivalent annual damages. Project performance will change over time and location along the project length, and the calculation of benefits accounts for this variability. As shown in this table, the analysis indicates that the levee that maximizes benefits is the Base Levee + 4 ft plan.

It is unlikely that a larger levee would generate more net benefits for the following reasons. The amount of soil present in the existing spoil bank far exceeds the amount needed for the Base Levee. Since any proposed engineered levee will follow the same alignment as the existing spoil bank, any excess soil will have to be removed from the footprint. Likewise any engineered levee that requires more soil than is present on site will require soil from some borrow area. Since transporting soil is a costly process, any levee plan that minimizes spoil of borrow is efficient.

Table 4.7 Net Equivalent Annual Benefits for Five Levee Height Variations.

Levee Height	**Equivalent Avg. Annual Benefit and Avg. Annual Cost (x $1,000, Aug 2010 Price Level)**		
	Benefits	**Cost**	**Net Benefits**
No Action	0	0	0
Base Levee	12,160	10,073	2,086
Base Levee + 1 ft	15,023	10,385	4,638
Base Levee + 2 ft	16,500	10,712	5,788
Base Levee + 3 ft	17,370	10,860	6,510
Base Levee + 4 ft	17,995	10,973	7,022

Cost efficiency is apparent in the levee plans that minimize spoil or borrow and remain in the existing spoil bank footprint. Above the Base Levee + 4 ft plan, the project incurs escalating construction, real estate and mitigation costs. Remaining benefits are from the severe and rare events, which are only captured through levee height increases. However, the remaining benefits are not enough to offset increases in cost.

Residual damages are the damages from flooding that would occur if the levee was overtopped. Various levee heights have a probability of passing a certain flow event and likewise there remains a probability of a larger flow exceeding the height of the levee. Residual flood risk is expressed in terms of the damages that would be caused by a flow event that exceeds the levee height. Table 4.9 presents the residual equivalent annual damages for the various levee heights analyzed. There is a small probability that flood damages will occur even with the maximum levee height, which would be due to overtopping by very severe, although rare, events.

Table 4.8 Average Annual Damages for Benefit Categories by Levee Height for Plan A

LAND USE CATEGORY	Average Annual Damages (x $1,000 August, 2010 price level)					
		Residual Equivalent Annual Damages				
	EAD	Base	Base + 1'	Base + 2'	Base + 3'	Base + 4'
Residential	$ 2,199	$ 1,059	$ 444	$ 176	$ 65	$ 23
Commercial	$ 5,594	$ 2,234	$ 933	$ 367	$ 133	$ 47
Public	$ 120	$ 79	$ 49	$ 34	$ 22	$ 13
Apartments	$ 1	$ 1.9	$ 0.7	$ 0.3	$ 0.1	$ 0.04
Outbuildings	$ 77	$ 36	$ 15	$ 6	$ 2	$ 0.1
Streets, Roads	$ 1,894	$ 600	$ 414	$ 260	$ 154	$ 127
Utilities	$ 61	$ 20	$ 14	$ 8	$ 5	$ 4
Railroad	$ 193	$ 56	$ 41	$ 27	$ 16	$ 13
Vehicles	$ 343	$ 101	$ 69	$ 55	$ 33	$ 28
Agriculture	$ 101	$ 14	$ 9	$ 11	$ 7	$ 6
Irr. Drains	$ 36	$ 12	$ 8	$ 5	$ 3	$ 2
LFCC	$ 6,366	$ 1,937	$ 1,297	$ 877	$ 519	$ 72
Recreation	$ 822	$ 30	$ 17	$ 10	$ 10	$ 10
East Bank	$ 272	$ 275	$ 274	$ 275	$ 275	$ 275
Emergency Costs	$ 158	$ 14	$ 9	$ 6	$ 4	$ 3
TOTAL	**$ 18,237**	**$ 6,469**	**$3,594**	**$ 2,117**	**$ 1,248**	**$ 623**

Benefits attributable to Reclamation's LFCC as well as benefits attributable to the Refuge serve as benefits to other Federal properties. Recreation in this table accounts for potential flood damages the unique recreation service provided by the BDANWR. Damages occur to the recreation service both in interruption and damages to the facilities at the refuge. These benefits are approximately 40.7 percent of the total benefits of the project. As the size of the project increases and its performance against flood events improves, the benefits to Federal properties decrease. This decrease simply means that non-Federal properties within the floodplain located further away from the LFCC, BDANWR, and the Rio Grande also receive benefits from the flood risk management project. Sensitivity studies indicate that excluding benefits to Federal properties does not affect plan selection or the size of the plan that maximizes net benefits. More detailed information is presented in Appendix F-10, Economics.

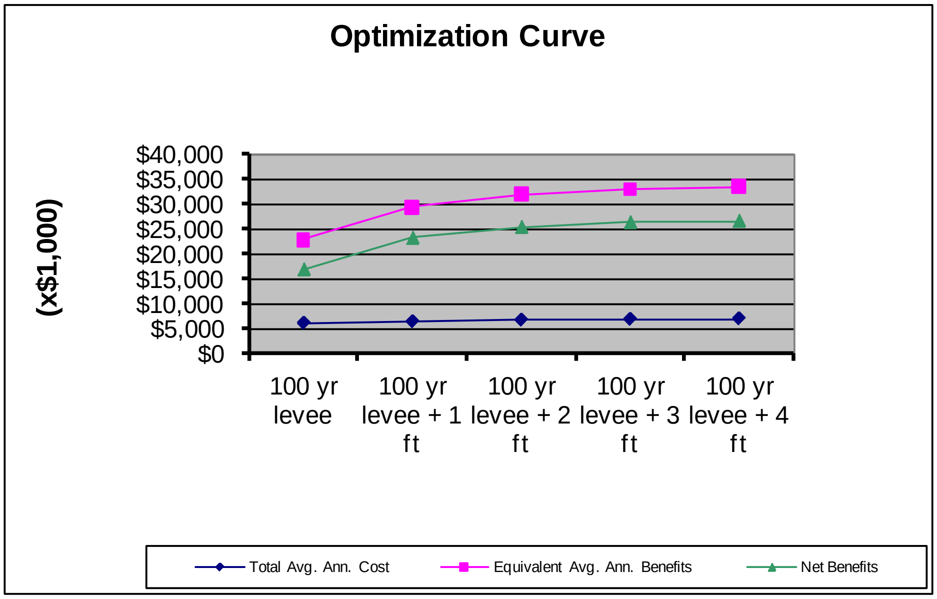


Figure 4.3 Optimization Curve

4.7 SCREENING OF ALTERNATIVE PLANS

Preliminary alternatives including non-structural measures and levees were screened based on completeness, effectiveness and efficiency earlier in this Chapter. Two levee alternatives (A and K) are then advanced in evaluation. Section 4.6 focused on optimization of levee height to identify the levee size that provides for study objectives most efficiently. The optimal levee height is then applied to screening of remaining alternative levee lengths. Those alternatives are then compared based on several criteria as summarized in Table 4.14.

The following features are common to all alternatives:

- 610-ft long concrete floodwall from SADD upstream to high ground.
- 1.08 miles of soil cement embankment on the west bank of the Rio Grande, downstream of SADD.
- Excavation of 12.4 acres on the east bank terrace, immediately downstream from SADD.
- Slide-gate closure structure at Brown Arroyo.
- 5.68 miles of riprap bank protection.
- 275- to 478-acre spoil deposition area at Tiffany Basin.

The NED plan is the plan that maximizes net economic benefits while protecting the Nations environment. The discussion in Section 4.6 demonstrates that the levee height that maximizes net benefits in both levee Alternative A and K is the height corresponding to Base Levee + 4 ft. The following comparison of levee alternatives will be restricted to this levee height. For detailed economic analysis of each levee alternative at each levee height please see Appendix F-10 Economics. Since environmental considerations were made during design of alternatives, the final array of alternatives had similar impact on ecological and cultural resources. Economic evaluation to include costs for environmental mitigation was the primary screening tool at this stage of plan selection. A detailed environmental impacts assessment of the final array of alternatives is presented in Chapter 6.

4.7.1 Ecological Resources

This section summarizes the preliminary effects determinations that were made for the initial array of alternatives and the without-project condition; see Appendix F-9 for detailed information. Relationships to four specific ecological resource categories were assessed during the screening of alternatives: aquatic habitat, Rio Grande silvery minnow, riparian habitat, and Southwestern Willow Flycatcher. Since no assessment approach is common to these four assessment categories, effects on ecological resources for the 3 alternatives were evaluated based on a relative scale ranging from +3 for *significantly beneficial* to -3 for *significantly adverse*. The most favorable alternative based on effects to ecological resources is Alternative A, the 43-mile levee from SADD to Tiffany Basin.

Differences in effects among the various levee heights evaluated are a matter of degree, with increasing protection of the floodplain. Although inundation, scouring, and sediment accretion are natural processes of sand-bed rivers such as the Rio Grande, the recovery of plant and animal communities from the 1-percent chance flood event would be slow.

The alternative plans were formulated to avoid and minimize adverse effects to riparian and aquatic habitat from the levee footprint. Permanent disturbance to soil and associated vegetation would occur in some areas within the southern third of the project area due to physical constraints, resulting in the new levee toe extending beyond the existing riverward levee toe. Furthermore, permanent removal of vegetation would be required to accommodate a 15-foot-wide vegetation-free zone along the riverward toe, in compliance with ETL 1110-2-571, which requires that no vegetation (except grasses) be allowed to grow within 15 feet of the riverward toe of new levees. Any adverse effects would be mitigated by revegetation in the floodplain and riparian zone of available area reclaimed into the active floodplain.

4.7.2 Cultural Resources

Determinations of eligibility for potential nomination to the National Register of Historic Places have not been made for the majority of the archaeological sites in the area, therefore, they are considered eligible until an official determination is made.

Regarding construction, with the exception of the MRGCD spoil bank levee and Reclamation's LFCC, both eligible for nomination to the National Register of Historic Places, no archaeological sites, historic properties, or features were identified within the proposed levee construction area including access routes. For this portion of the project, USACE is of the opinion that the reconstruction would have an adverse affect to historic properties, including the MRGCD spoil bank levee and USBR's LFCC; however, USACE has provided historic documentation to mitigate for the adverse effect. In most cases, it should be possible to relocate a construction road or other impact area in order to avoid any archaeological sites that may be discovered under any of the alternatives. If avoidance is not possible, USACE, in consultation with the SHPO and

Native American tribes that have cultural resources concerns in the area, shall develop a data recovery plan prior to initiation of any ground disturbing activities.

Regarding flooding, approximately 35 archaeological sites on the west side and 50 sites along the east side of the existing MRGCD spoil bank levee as well as portions of the MRGCD irrigation and spoil bank levee system and the USBR LFCC are located within or immediately adjacent to the floodplain and have been subjected to or have the potential to have been affected to some unknown extent by historic flooding in the past. In both the 1% exceedence probability With- and Without Project scenarios (Figures 5.3 - 5.9), all of these sites have the potential to be affected to some unknown extent by flooding in the future. These archaeological sites include pueblo ruins such as San Pascual (LA487) and Qualacu (LA757), both located within the BDANWR as well as the remains of the buried town site of San Marcial located within the Tiffany Basin. USACE and Reclamation continue to manage river flows within their control to avoid effects to archaeological sites within or immediately adjacent to the floodplain; however, these sites remain vulnerable to flooding (USACE 2005, 1998).

4.7.3 Economic Evaluation

Economic analyses compared the current economic impact due to flooding to predicted reduction in impacts (benefits) under the range of levee plans and heights to identify the plan that maximizes net benefits. The evaluation required a risk-based analysis of the flood problem under the existing condition. The future without-project condition is then determined, and finally a risk-based evaluation in terms of benefits and costs of the various alternatives under the with-project condition was completed.

Consistent with the requirements set forth in EC 1105-2-412, *Assuring Quality of Planning Models*, HEC-FDA version 1.2.4 was used to compute average annual and equivalent annual damages (EAD). Corps guidance stipulates that the plan that reasonably maximizes net National Economic Development benefits, consistent with the Federal objective, be identified. Project benefits for flood risk management measures are identified through successive iterations of existing and future without-project scenarios, changing key hydrologic and/or hydraulic variables as the measures warrant. HEC-FDA is the only model certified for formulation and evaluation of flood risk management plans using risk analysis methods, and was used in this study.

4.7.3.1 *Base Year and Economic Period of Analysis*

Base year conditions are defined as those conditions which are expected to exist within the study area in the earliest year that a project could begin to produce benefits. For the San Acacia to Bosque del Apache Unit Project, base year conditions begin immediately after construction, when operation begins.

A thorough assessment and evaluation was conducted for existing conditions in the project area, and this was brought forward in time based on expected future changes in the project area and its resources over a 50-year period of analysis. A base year of 2026 was chosen on the assumption that construction would begin in October 2012 and be completed in 2026. The period of analysis would end in 2074. These periods provide the basis for comparison and evaluation of alternatives. For the purposes of this analysis, a common base year was assumed for all plans to allow for an accurate comparison of costs and potential impacts.

4.7.3.2 *Floodplains from FLO-2D Output*

For floodplain mapping, the two-dimensional model FLO-2D was used. FLO-2D models the terrain as a grid outside of the channel. For this project, a 500-foot grid cell size was used. FLO-2D output includes a maximum water surface elevation for each cell. This output was used to create the water surface for each model run. The water surface was then analyzed with the digital terrain model in ArcGIS to create floodplain mapping for different frequencies and conditions. Floodplains for the 1-percent chance with- and without-project conditions are presented in Figure 5.3 through 5.9. In these figures, the with-project floodplains are shown for the 43-mile engineered levee from the SADD to Tiffany Junction (Alternative A). FLO-2D analysis was also conducted for Alternatives B-K (not shown).

The following assumptions were made in modeling the different conditions in FLO-2D.

- For the Without-Project conditions, it was assumed that all existing spoil banks are not able to contain flood flows. Therefore spoil banks were completely removed from the without-project model. . (This should not be confused with “start of damages” condition used for Economics models. See Appendix F-10, Para F-04 “HEC-FDA Use.”)

- For the 10-percent exceedance event (15,400 cfs at the SADD), the inflow hydrograph from precipitation events attenuates below 10,000 cfs within the project area. Downstream of this location, the 10-percent exceedance snowmelt hydrograph (steady 10,000 cfs) dominates. Therefore, floodplains are mapped for the precipitation events upstream, and floodplains for the snowmelt event are mapped downstream.

- For With-Project levee design, the Corps assumed that the existing spoil bank downstream of the project area would remain for some period of time before breaching and create a higher tailwater condition. However, for the with-project conditions analyzed for floodplain determination, it is assumed that the existing spoil banks beyond the lower end of the project would not contain flood flows. This would potentially create a backwater effect outside of the lower end of the constructed levee. In order to get better resolution in this area a separate FLO-2D model (100-foot grid) was created to model the backwater effect of the spoil bank failure beyond the lower end of the project. This backwater floodplain created by the 100 foot grid FLO-2D model was used for the backwater extent of flooding in the floodplain maps.

- The proposed overbank excavation along the east bank downstream of San Acacia Diversion Dam was not modeled using FLO-2D. Therefore the automated method used to plot floodplains did not reflect the associated flooding in this area. For the With-Project condition floodplains, this area was manually added to the floodplain.

- The active floodway is expected to change geomorphically in the future. A future conditions model was created in which individual cross sections were uniformly raised or lowered to account for predicted aggradation and degradation 50 years in the future. The channel is expected to degrade over the next 50 years in the upper reach just downstream of the SADD. The channel then becomes fairly stable for the remaining upper third of the project area. Downstream of Brown Arroyo near Socorro the channel and floodplain within the floodway becomes aggradational.

4.7.4 Benefit-Cost Analyses for the Alternative Plans

4.7.4.1 *Annual Benefits*

Annual benefits and residual damages for each of the five levee heights were developed for Alternatives A and K. As previously mentioned, these benefits are derived from comparison of With- and Without-Project forecasts. The analyses indicate that the levee height plan that maximizes net benefits for all the alternatives is the largest levee analyzed, the Base Levee + 4 ft. The comparison of each levee height variation for each alternative plan is presented in more detail in Section F-16 of Appendix F-10, Economics.

4.7.4.2 *Costs*

Project costs were developed for the alternative plans. For the purposes of comparing costs to benefits, the latter of which are typically presented on an average annual basis, the costs have been amortized over the projected 50-year period of analysis using the Federal discount rate of 4.375 percent to yield an annual cost. Interest during construction was based on a 240-month construction schedule assuming uniform expenditures over the period. Similar to the benefits presented in Table 4.11, the cost estimates in Table 4.12 represent those of the Base Levee + 4 ft levee height.

4.7.4.3 *Net Benefits*

Economic efficiency is based on the alternative with the greatest return on investment, as measured by annual net benefits. Annual net benefits are determined as the difference between the annual benefits (derived from comparison of With- and Without-Project forecasts) and the annual costs of an alternative. The alternative that offers the greatest net benefits is known as the NED Plan. Table 4.11 shows net benefits and the benefit-to-cost ratio for each alternative. The benefits presented in the table are specific to the Base Levee + 4 ft levee heights.

Table 4.9 Annual Benefits.

	Alternative Plans	
	A	**K**
Levee	17,615	17,615
Tiffany Basin (RR and Reroutes)	379	375
Equivalent Average Annual Benefits	17,995	17,990

Values in $1,000’s, August 2010 price level, 4.375% Interest Rate, 50-Year Period of Analysis.

Plan A provides higher average annual and net benefits. The calculation of benefits incorporates the changes in project performance over the period of analysis. That is, as the channel in the lower portion of the project aggrades the capacity of the floodway is diminished and the probability of the levee being exceeded by more frequent events. The upper portions of the project remain the same or increase in performance during the period of analysis. While Alternative A would capture over 90% of the benefits by preventing all of the frequent events and many of the less frequent larger events there is a residual risk for levee overtopping from very large vents.

As stated earlier a flood warning system would present benefits by reducing the amount of residential contents subject to flooding. Residential contents are half the Residential EAD. It is assumed that an effective and understood flood warning system would allow residents to protect structure contents. Removing damageable items from the dwelling or raising them above flood stage would decrease EAD by at most 7.8%. Removal of vehicles from the floodplain also reduce potential damages. Most importantly, life safety risk is reduced by timely evacuation of the floodplain. A flood warning system will be required as part of any structural plan. The flood warning system will be incorporated into the local or county emergency response in the unlikely case of levee overtopping or failure.

Table 4.10 Project Costs for Alternative Plans at the Base Levee + 4 ft Height.

	Alternative Plans[1]	
	A	**K**
Total Construction Costs		
Levee	123,389	125,054
Overbank Lowering	4,990	4,975
LERRDS (Easements, Relocations, etc)	4,854	4,854
Planning, Engineering and Design	8,047	8,048
Construction Management	20,298	20,298
First Costs	163,106	163,228
Interest During Construction[2]	60,318	60,363
Total Investment Costs	223,424	223,592
Average Annual Costs	11,077	11,085

[1] *Errors due to rounding.*
[2] *240-month construction; 4.375%.*
Values in $1,000's, August 2010 price level, 4.375% Interest Rate, 50-Year Period of Analysis.

Table 4.11 Net Benefits for Alternative Plans

	Alternative Plans[1]	
	A	**K**
Equivalent Avg. Annual Benefits	17,994	17,990
Annual Costs	11,077	11,085
Net Benefits	**6,918**	**6,905**
Benefit-to-Cost Ratio	*1.62*	*1.62*

[1] *Errors due to rounding.*
Values in $1,000's, August 2010 price level, 4.375% Interest Rate, 50-Year Period of Analysis.

The figures in Tables 4.11 through 4.13 are based on preliminary cost estimates that were used to compare alternative plans. The detailed costs provided for the recommended plan will be different due to refinement of construction quantities and changes to a 20-year construction schedule.

4.7.5 System of Accounts

As stated in Section 4.3.1.1 of this GRR/SEIS-II, the four accounts used to compare proposed water resource development plans are the National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and other social effects (OSE) accounts. These accounts are discussed below. The development of comparative tables (Table 4.12 and Table 4.13) was undertaken to establish and discuss the potential impacts and benefits of each alternative.

4.7.5.1 *National Economic Development (NED)*

For all project purposes except ecosystem restoration, the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment will be selected. The Assistant Secretary of the Army for Civil Works may grant an exception when there are overriding reasons for selecting another plan based on other Federal, State, local, and international concerns. Because the purpose of this study is to reduce risk of flooding, the plan formulation and selection process for this reevaluation study is primarily driven by NED plan selection criteria. As shown, the alternative plan that maximizes net benefits is Alternative A.

4.7.5.2 *Environmental Quality (EQ)*

The EQ account is another means of evaluating the alternatives to assist in making a plan recommendation. The EQ account is intended to display the long-term effects that the alternative plans may have on significant environmental resources. Significant environmental resources are defined by the U.S. Water Resources Council (USWRC) as those components of the ecological, cultural, and aesthetic environments, which, if affected by the alternative plans, could have a material bearing on the decision-making process. Table 4.14 provides a summary comparison of project impacts for some resources. Chapter 6 provides a detailed discussion of impacts to environmental resources.

4.7.5.3 *Regional Economic Development (RED)*

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

Any proposed Federal project would benefit the local and regional economy though employment and purchase of materials such as riprap, bentonite and fuel for construction equipment during the 20 year period of construction. The increased construction-related employment would have a corresponding beneficial effect on the local economy. Increases would tend to be focused in lower specialization sector. The regional benefit would be proportional to the size or cost of the alternative project.

4.7.5.4 *Other Social Effects (OSE)*

The OSE account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic, and man-made and natural resources.

The Bosque Del Apache National Wildlife Refuge represents a significant recreation opportunity in the study area that is important to both the region and the Nation. Providing flood protection to the Refuge (in the form of levees) preserves this recreation opportunity for continued enjoyment by visitors. Alternatives that excluded the levees provided no means to preserve this recreation opportunity.

The floodplain is roughly 1.5 to 2 miles wide, and sits below the perched Rio Grande. In the event of a flood, warning times may prevent evacuation, but flood velocities are not expected to be sufficient to dislodge vehicles using local roads; however, the field inventory did not identify any high water marks as the floodplain is generally flat, and does not include low water crossings, although there may be unexpected areas with more flood depth due to local topography. Most flood fatalities occur in vehicles moving through the floodplain (http://www.nws.noaa.gov/oh/hic/flood_stats/recent_individual_deaths.shtml, accessed 4/5/12).

The flood hydrograph described in the hydrology and hydraulics appendix outlines two flood scenarios. Floods generated by local thunderstorms have short warning, rapid onset, relatively short duration (3-4 days) with the flood peak passing within hours. Floods generated by snowmelt in uncontrolled drainages downstream of Cochiti dam have considerably more warning time, but the volume and duration suggests a 90-100 day inundation duration. Only a small portion of the urbanized areas of the City of Socorro will be impacted, as most of the city sits above the floodplain. Public services are not expected to be disrupted outside of the floodplain. The flood impacts will fall mostly upon the rural areas outside of the city. Evacuations will be necessary, and reoccupation and cleanup time and costs from New Orleans and Mississippi River floods (longer duration, though much deeper than projected for this study) suggest that the emergency costs used in this report (from Carlsbad, NM) are fairly conservative.

Table 4.12 System of Accounts: No Action, Authorized Project, and Alternatives A and K

Criteria	No Action	Authorized Project	Alternative A	Alternative K
National Economic Development				
Annual NED Benefits (x$1,000)	-	Unknown	17,995	17,990
Annual Costs (x$1,000)	-	Unknown	11,077	11,085
Net Benefits (x$1,000s)	**-**	Unknown	**6,918**	**6,905**
B/C Ratio	-	Unknown	*1.62*	*1.62*
Environmental Quality				
Air Quality	Existing sources of air pollution would be expected to remain the same.	No significant short- or long-term deterioration of air quality would be expected from levee construction.	Same as Authorized Project.	Same as Authorized Project.
Noise	Noise sources and sensitive receptors expected to remain the same.	Temporary and intermittent increase in noise levels in the immediate vicinity of construction activities due to operation of heavy machinery.	Same as Authorized Project.	Same as Authorized Project.
Vegetation	Continued fragmentation of remaining habitats on either side of levee.	The unvegetated levee would be narrower in the northern third of the project and wider in the southern two-thirds for the project footprint compared to the no action alternative.	Similar footprint to the Authorized project due to smaller levee but with the addition of a 15 foot vegetation free zone on the riverside toe.	Same as Plan A but extending 4 miles farther to the south.
Special Status Species	Habitat conditions for the Rio Grande silvery minnow and flycatcher are likely to degrade.	Unknown	Minor adverse impacts would occur due to placement of some riprap in the river channel and removal of riparian trees in the southern two thirds of the project. These impacts would be mitigated.	The longer levee alternative would result in slightly more disturbance of flycatcher habitat. Additional mitigation will be required for this alternative. No additional impacts to silvery minnow would occur.

Criteria	No Action	Authorized Project	Alternative A	Alternative K
Cultural Resources	Expected to remain the same.	Unknown	No cultural resources are significantly impacted by this alternative.	Same as Alternative A.
Aesthetics	Aesthetics and visual resources expected to remain the same.	Unknown	A lower levee profile in the northern third of the project would provide views of the riparian corridor in the floodway.	Same as Alternative A.
Regional Economic Development				
Employment	No impacts on employment.	Temporary increase in construction-related employment. The increased construction-related employment would have a corresponding short-term beneficial effect on the local economy. Increase would tend to be focused in lower specialization sector.	Same as Authorized Project.	Same as Authorized Project.
Housing Supply and Business	No effect on housing supply or businesses.	Implementation of Authorized Project would not require removal of residences or displacement of businesses.	Same as Authorized Project.	Same as Authorized Project.
Local Government Finance	No direct impacts on local government finance.	Unknown	Non-Federal sponsor's initial investment of $15.1 million for construction plus annual maintenance.	Non-Federal sponsor's initial investment of $11.10 million for construction plus annual maintenance.
Growth Inducing Impacts	Growth within the study area will not be "induced" by a lack of project implementation.	Any potential growth in this area would be limited by market factors that are unrelated to elements of the proposed action.	Same as Authorized Project.	Same as Authorized Project.

Criteria	No Action	Authorized Project	Alternative A	Alternative K
Public Health and Safety	Safety threats associated with flood hazards would continue to exist for properties within the floodplain; due to the aggradational state of the lower two-thirds of the project, flood hazard is expected to increase in the future, even with continued maintenance or raising of the existing levee.	Designed to reduce risk of flooding along the Rio Grande from the probable maximum flood.	Designed to reduce flood damages along the Rio Grande efficiently.	Same as Alternative A.
Recreation	Recreational facilities and access expected to remain the same and would not receive reduced risk of flooding.	Temporary restriction of access to the riparian zone and LFCC during construction would affect recreational pursuits (e.g., seasonal hunting, nature observation, fishing, and picnicking).	Same as Authorized Project.	Same as Authorized Project.
Transportation	Traffic is expected to remain the same.	Temporary increase in traffic on local roadways due to haul trucks and worker vehicles.	Same as Authorized Project.	Same as Authorized Project

4.7.6 Associated Evaluation Criteria

The selection of a recommended plan from the alternative plans requires the incorporation of additional decision-making criteria. As suggested by the USWRC, the alternative plans are compared using the following criteria: completeness, effectiveness, efficiency, and acceptability. The evaluation of the alternative plans by established criteria are described below and are presented in Table 4.12 and Table 4.13. The authorized plan as presented in House Document 243 does not include a levee design or alignment but rather, criteria that a levee would have to meet. Since a specific design was not presented in the authorizing documents some comparisons cannot be made. These aspects are labeled “unknown” in the comparison tables.

4.7.6.1 *Completeness*

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure realization of the planned objectives. A complete alternative (1) meets the objectives, (2) needs no further actions for complete fulfillment of the project, (3) is consistent and reliable, (4) is capable of being physically implemented, and (5) mitigates unavoidable adverse environmental effects, as appropriate. In general, all of the preliminary alternatives, with the exception of the No-Action Alternative, are fully formulated and complete. No further measures are needed to allow for the functioning of the alternatives. The No-Action Alternative does not address the established objectives for the study area.

4.7.6.2 *Effectiveness*

Effectiveness is the extent to which an alternative resolves the identified problems and achieves the specified objectives. The No-Action Alternative is ineffective at meeting any of the criteria for flood risk management in the study area. All of the plans formulated provide some contribution to the specified planning objectives. All of the plans reduce the risk of flooding within the study area from a 1-percent chance flood event or less.

4.7.6.3 *Efficiency*

Efficiency is the extent to which an alternative is the most cost-effective means of addressing the identified problems while realizing the specified objectives consistent with protecting the Nation’s environment. The criteria for judgment are those of average annual costs compared to average annual benefits (primarily flood risk management benefits), from which benefit-cost ratios and values for net annual benefits are derived. As presented in this document, Alternative A provides the highest net benefits.

4.7.6.4 *Acceptability*

Acceptability is the workability and viability of an alternative to other Federal agencies, affected State, tribal, and local agencies; and public entities, given existing laws, regulations, and public policies. Acceptability is defined as acceptance of the plan by the local sponsor and the concerned public. The relative acceptability of the alternatives is judged on the basis of feedback and tentative support indicated by the non-Federal sponsors. While any of the plans could become the Recommended Plan in the Final GRR/SEIS-II, this decision may depend in part on public acceptance as expressed through the public review process.

Table 4.13 Associated Evaluation Criteria for the Alternatives.

Criteria	No Action	Authorized Project	Alternative A	Alternative K
Completeness	Does not meet objective.	Technically feasible; reduces the flood risk to inhabited reaches in the study area by a large degree.	Same as Authorized Project.	Same as Authorized Project.
Effectiveness	Does not meet objective.	Reduces the flood risk to inhabited reaches in the study area by a large degree.	Designed to reduce risk of flooding along the Rio Grande from a 1-percent chance flood event.	Same as Alternative A.
Efficiency	Does not meet objective.	Unknown	Net benefits estimated at $6.918 million; B/C ratio of 1.62.	Net benefits estimated at $6.905 million; B/C ratio of 1.62.
Acceptability	Does not meet objective.	Unknown	Consistent with stakeholder input.	Consistent with stakeholder input.

4.7.7 Fulfillment of Objectives

Early in the planning stages, objectives were identified to monitor the development of various social and environmental elements of alternatives. Implementation of the recommended plan is expected to achieve the following benefits, which are consistent with the study objectives. Table 4.14 presents a comparison of the likely future attainment of project objectives among the alternatives considered in detail.

4.7.7.1 *Flood Risk Management*

Flooding along the Rio Grande in the study area poses a serious risk to life and health, and has the potential for causing millions of dollars in flood damage to homes, businesses, public facilities, infrastructure, and agriculture. Flooding of the populated areas of Socorro and San Acacia would also result in pollution of floodwaters from sewage and chemicals located in these areas. Flooding within the San Acacia to the Bosque del Apache Unit and vicinity has occurred often during the past decades and has only been prevented in recent years by flood fighting efforts that prevented catastrophic damages due to spoil bank failure. The alternative plans were formulated to reduce the risk of periodic flooding and associated damages within the floodplains of the study area.

Table 4.9 shows that either alternative levee significantly decreases the risk of flooding over the future without project condition. Alternative Plan A which includes the levee from San Acacia to

Tiffany Junction provides for significant reduction in flood damages. Similarly, Alternative Plan K reduces risk of flooding of the LFCC and railroad to a greater extent downstream of Tiffany Junction by means of the longer levee system. Similarly, damage to agriculture and infrastructure at the Bosque del Apache National Wildlife Refuge would be reduced in plans that include a levee in the area of the refuge. Wetlands managed and crops planted in and around the refuge for the benefit of wildlife would continue to be available during critical migration and reproduction periods.

Table 4.14 Fulfillment of Objectives.

Objectives	**No Action**	**Auth. Proj.**	**Alt. A**	**Alt. K**
Reduce the risk of flood hazard to health and human safety within the study area. Reduce the risk of loss of life and risk to health from flood related hazards.	0	3	3	3
Reduce the risk of flood damage to existing properties and infrastructure within the floodplains of the study area by 90 percent.	0	3	3	3
Reduce the risk of ecological damage from flooding within the floodplains of the study area.	0	3	3	3
Increase the capacity of the floodway throughout the study area to carry floodwaters.	0	3	3	3
Prevent erosion that threatens flood risk management infrastructure within the study area.	0	2	3	3

Legend: 3= meets the objective to greatest degree; 2= meets the objective; 1= somewhat meets the objective, 0=does not meet objective.

4.7.7.2 *Erosion Threatening Flood Risk Management Infrastructure*

Hydraulic analysis of the proposed alternatives identified areas of high velocity at or near the levees as well as the potential for channel aggradation or degradation. All of the alternative levees consist of engineered slopes that include slope and toe protection at critical locations, which would prevent erosion of levees. One area that poses a highly erosional condition is the area immediately below the SADD. High velocities in the incised channel threaten existing spoil banks. Channel widening would be implemented to alleviate erosion at this location.

Due to the perched channel condition in the lower end of the project area, a failure of spoil bank in the Tiffany Basin area would cause rapid degradation (head cutting) of the channel upstream of Tiffany Basin. The Tiffany East Levee feature would include toe armoring to prevent failure caused by this head cutting.

4.7.7.3 *Contributions to Ecological Resources*

Ecological improvements that would be generated by the proposed alternatives include additional floodplain habitat within the floodway. Since the footprint of either levee alternative has a smaller total footprint than the existing spoil bank, additional floodplain habitat is provided by implementation of a Federal project.

Implementation of any plan that includes the rehabilitation of the spoil bank in the study area increases the capacity of the channel in this area and allows for higher volume releases from upstream reservoirs. However, the spoil bank in the study area is not the only feature restricting higher volume releases. Increasing the extent or frequency of riparian inundation by relatively small discharges (e.g., 10,000 cfs or less) would be beneficial to ecological resources along the Rio Grande. Implementation of any alternative that includes the rehabilitation of the spoil bank in the study area increases the non-damaging discharge capacity of the floodway in the San Acacia reach. This, in part, reduces current constraints on higher discharge releases from upstream reservoirs. The spoil bank in the study area is not the only feature in the middle Rio Grande valley currently limiting such increased releases. Most particularly, spoil banks along both sides of the floodway in the 20-mile-long Isleta-to-Belen reach (upstream from San Acacia) are a similar constraint. Increasing reservoir discharges, and the resultant benefits to ecological resources, would only be realized following the system-wide reduction of such limitations.

While either levee alternative and all heights provide for a net gain in floodway acreage, Alternative K at either levee height results in a long term separation of the active river channel and the larger undeveloped portion of the Rio Grande floodplain. As stated earlier the floodplain of the study area south of the Bosque del Apache refuge is not in agricultural production and only contains the LFCC and Railroad as damageable properties. While the reduction in damages to these facilities supports the investment cost of Alternative K, the long term separation of the active river channel from the floodway may preclude restoration of this area to a more stable channel configuration.

4.7.7.4 *Sedimentation*

As previously mentioned, all of the alternatives consist of engineered slopes that include slope and toe protection at critical locations, designed to limit future erosion and associated sediment load.

The alternatives without the Tiffany Basin feature would not significantly affect overall flow characteristics and sediment transport in the Rio Grande. The floodway would essentially function in the same manner with or without the project during normal flow conditions, which occur the vast majority of time.

As discussed in Section 3.1.3.3 Sedimentation, the identified aggradational trend in the Rio Grande Channel starts at approximately the city of Socorro and increases in the downstream direction. The rate of aggradation observed from the relatively short timeframe of 1972 through 2002 would continue into the future with or without a Federal project. Most sediment deposition occurs within the channel, and adjacent to the channel in the overbank areas. This has the effect of “raising” the channel more than the floodplain, creating the perched channel that exists in much of the project area.

4.8 ADDITIONAL CONSIDERATIONS OF ALTERNATIVES*

During development of value engineering and more detailed design and cost estimates of the final array of alternatives, slight modifications were made to the 43-mile levee that makes up Alternative A. Coordination with local interest groups during plan formulation revealed a desire to restore ecological function to the Rio Grande by providing a less confined river channel. While preparing more detailed design and cost estimates for the final array of alternatives and based on this input, the team investigated alternative levee alignments landward of the existing spoil bank or levee setbacks. Alternatives that include the levee extension along the west of Tiffany Basin would be considered a levee setback; however, allowing the river to overbank or meander into this area is problematic as described previously.

Two locations on the west bank within the study area and north of Tiffany Basin were presently not in agricultural production or irrigated. These locations would be located within the approximately 43 mile levee reach in Alternative A and would represent a departure from the alignment evaluated in that alternative. The proposed levee setbacks would not provide a change in benefits to those provided by Alternative A. The LFCC alignment parallels the spoil bank at both locations, therefore, any levee setback would involve also reconstructing the LFCC in the landward alignment. With the exception of these potential setback locations, the existing configuration of facilities along the majority of the study area includes the spoil bank, LFCC, irrigation drain and associated maintenance roads running parallel within a 400 foot wide corridor on the west side of the floodway. Once the segment of new LFCC in the landward alignment was functional, the existing segment would be abandoned and backfilled to prevent water depletions and entrapment of fish after overbank events. Similarly the existing spoil bank would be partially or entirely removed to allow river overbanking and, if suitable, river channel migration into the reclaimed floodway.

The northernmost setback is located approximately 5.5 miles downstream of the SADD (USBR River Mile 108) and corresponds to the Socorro Nature Area operated by the Bureau of Land Management. The setback would require realignment of the LFCC, proposed levee, and associated maintenance roads to parallel the existing irrigation drain within a 300 ft corridor. The proposed levee segment making up the setback would be approximately 13,000 feet long (2.5 mi). The end result would shift the western extent of the floodway approximately 800 feet to the west at the widest cross section. Approximately 130 acres of floodplain that are effectively disconnected from the river by the spoil bank would have restored functions associated with periodic river overbanking and, potentially, river channel migration. Since the river channel in this reach is incised, overbanking would begin at the approximately 35% exceedance stage.

Evaluation of the cost of relocating the LFCC and constructing the proposed levee in the landward alignment resulted in a negligible savings in estimated project costs of Alternative A. In a setback configuration, soil material making up the spoil bank at this location would be used to fill the abandoned length of LFCC. Material in excess of that needed to fill the abandoned LFCC would be left in place as short, staggered spoil bank sections that provide for overbank flow. Construction of the proposed levee setback at this location would make use of spoil material from other proposed levee sections thereby reducing the amount of hauling and spoil of material. Although there is additional cost for excavating and constructing a new segment of

LFCC, the expense is offset by savings in hauling of soil material and abandonment of a portion of the existing spoil bank. Given the preliminary nature of cost estimates and design this difference in cost between Alternative A and adding the setback is effectively nil. Therefore if supported by detailed design and cost, a levee setback alignment at this location would have essentially equal cost and benefits provided as Alternative A while providing ancillary environmental benefits from restoring a portion of the floodway to overbank flows above the 10% chance exceedance event.

A setback in this location would place the levee on the landward side of the Socorro Nature Area which consists of a toilet, storage building, picnic shelter, interpretive kiosk and trails, and a small demonstration wetland. These facilities would be subject to flooding without the benefit of flood fighting efforts that have prevented flooding of this area in the past. BLM was amenable to a levee setback within the northern portion of the property; however, the change in status of the developed facilities with respect to flooding was not compatible with current land management purposes.

A shorter levee setback through the northern half of the Socorro Nature Area would return to the existing spoil bank alignment north of the developed facilities so that they would remain landward of a proposed levee. The smaller levee setback alignment would be approximately 8000 feet long (1.4 mi) and be approximately 800 feet to the west at the widest cross section. Approximately 80 acres of floodplain would be restored to the floodway. This smaller setback alternative implemented as part of Alternative A has similar but slightly higher costs than Alternative A alone. Similar to the longer setback at this location, construction of the shorter levee setback would make use of spoil material from other proposed levee sections thereby reducing the amount of hauling and spoil of material. Given the short distance, however, the additional cost for excavating and constructing a new segment of LFCCexceeds the savings in hauling of spoil material and abandonment of a portion of the existing spoil bank. Additional uncaptured costs are anticipated in the form of reclamation of the abandoned sections of LFCC and mitigation of habitat removed for the footprint of the new levee and LFCC sections. This smaller setback alternative as part of Alternative A is not the NED plan due to the higher cost with equivalent benefits. This alternative is carried forward to environmental impact analysis to evaluate any environmental benefits from the alternative.

The second setback location straddles the northern boundary of the Bosque del Apache NWR (USBR River Mile 84). The proposed levee segment making up the setback would be approximately 15,700 feet long (5.7 mi) and be approximately 2,000 feet to the west at the widest cross section. Approximately 350 acres of floodplain would be restored to the floodway and active river channel. The river channel in this reach is perched by approximately 4 to 6 feet. That is, the floodplain landward of the existing spoil bank is 4 to 6 feet lower than the bottom of the river channel. A levee setback at this location and subsequent overbanking of the river would essentially create a lake that incurs water depletions and entraps fish similar to conditions discussed with the Tiffany Basin feature but on a smaller scale.

To ameliorate the detrimental effects subsequent to a setback in this reach the team proposed to fill the reclaimed floodway with soil to an elevation at the approximate 50% exceedance stage. Filling the reclaimed floodway would allow overbanking and channel migration without causing areas of large pooled water following receding river stages. Unlike Tiffany Basin which requires soil on the order of 60 million cubic yards to achieve equity, the soil needed to elevate the floodplain to existing channel elevations at this setback location (approximately 2 million cubic yards) is equal to the current quantity of spoil material for the approximately 43 mile levee in Plan A. This alternative alignment would provide for spoil of excess soil from the construction of the proposed levee on Alternative A thereby providing a beneficial use of the spoil material. Coordination with the BDANWR found this setback not compatible with refuge goals due to potential changes in local groundwater and resulting effects to vegetation as a result of repositioning the LFCC. This Setback is therefore not carried forward for further analysis..

4.9 RATIONALE FOR SELECTION OF THE RECOMMENDED PLAN*

Alternative A with a levee high of Base Levee + 4 ft is identified as the alternative that provides the highest net benefits at $6.918 million and is identified as the NED plan. Comparison of Alternatives A and K with respect to formulation criteria such as study objectives, completeness, effectiveness and efficiency has determined alternative A is the plan that meets these criteria to a greatest extent.

As previously described, Alternative A consists of the approximately 43-mile engineered levee from the SADD to Tiffany Junction. Alternative K which provides an extension of the levee in Plan A provides a lower net benefit at $6.905 million. Both alternatives meet all of the planning criteria discussed earlier in this chapter including “system of accounts”; associated evaluation criteria; environmental principles; and planning objectives. Public acceptability still needs to be determined through public review of the GRR/SEIS-II. Because of its ability to meet, to the greatest degree of those alternatives identified, all of the established criteria for evaluation, Alternative A is identified as the recommended plan to be carried forward for comparison of impacts to the environment.

The alternative levee lengths (alternatives A and K) at the Base Levee height are also carried forward for evaluation of those alternatives since construction of these alternative would have a smaller footprint. The final array of alternatives is then two levee lengths at two levee heights respectively and implementation of a levee setback as a measure applied to all four levee alternatives.

A Locally Preferred Plan (LPP) may be identified in the GRR/SEIS II if the results of a public meeting and further coordination efforts indicate that a plan other than the NED Plan is favored by local stakeholders. When the LPP is clearly of lesser scope and cost and meets the Administration’s policies for high-priority outputs, the ASA(CW) usually grants an exception for deviation. Conversely, the increased scope of any plan more expensive than the NED Plan would not warrant Federal cost-sharing participation. Thus, if the LPP is larger in scope than the NED Plan, the local sponsor would pay 100 percent of the difference between that plan and the NED Plan. No plan or alteration of the recommended plan was presented during coordination with stakeholder or the sponsor or during the public review of this GRR-SEIS II.

4.10 FINAL ARRAY OF ALTERNATIVES*

A final array of alternatives is carried forward for evaluation of effects to the human environment. The NED plan is Alternative A, a 43-mile levee from SADD to Tiffany Junction with a levee height corresponding to the Base Levee + 4 ft. Additional plans were also carried forward because they provide similar benefits for similar costs, and some potentially have long term, uncaptured ecological and other benefits. These alternatives include:

- Alternative A with a levee height corresponding to the Base Levee height is evaluated. This is the elevation stipulated by Corps guidance, but is not the NED plan because of the higher cost of disposal of excess spoil material from the existing levee.

- Alternative K (43 mile levee from the SADD to Tiffany Junction and 4 miles of levee along the east side of Tiffany Basin (Tiffany East Levee)), which provides additional insurance against potential system damage from headcutting following a levee breach, for minimal additional cost, is also brought forward for additional consideration. Alternative K also provides the additional benefits of flood protection for an additional mile of railroad track and an additional mile of LFCC. Alternative K is advanced at the same two levee heights as Alternative A, corresponding to the Base Levee and Base Levee + 4 ft exceedance height alternatives.

- Lastly a levee setback north of the Socorro Nature Area, if implemented, would be included in both Alternative A and Alternative K . Comparison of both Alternatives at both levee heights is provided with the inclusion of the levee setback. The levee setback alters the levee and LFCC footprint in area short reach and provides additional ecosystem benefits for a negligible cost difference. This plan may be preferred by local interest groups due to its restoration of some acreage to the floodway.

These alternatives are described in detail in Chapter 5 and the effects of the alternatives on the human environment evaluated in Chapter 6. For ease of reference, these are summarized below.

• No-Action Alternative (or Without-Project Alternative)	The existing spoil bank would not be replaced. (This alternative was evaluated in Chapter 3 – Future Without Project Condition.)
• Alternative A	Replace spoil bank with a **41.5-mile-long** levee at Base Levee height.
• Alternative A+4ft (the Recommended	Replace spoil bank with a **42.3-mile-long** levee at Base Levee +4 ft height. This levee is 24 feet wider at its base than Alt. A.

Plan, or Proposed Plan)	
• Alternative K	Replace spoil bank with a **44.4-mile-long** levee at Base Levee height. Terminates 4 river miles further downstream than Alternatives A and A+4ft, and encloses Tiffany Basin. The additional 4-mile section is sometimes referred to as the "Tiffany East Levee".
• Alternative K+4ft	Replace spoil bank with a **45.2-mile-long** levee at Base + 4 ft Levee height. This levee is 24 feet wider at base than Alt. K. Terminates 4 river miles further downstream than Alternatives A and A+4ft, and encloses Tiffany Basin. The additional 4-mile section is sometimes referred to as the "Tiffany East Levee".
• River Mile (RM)-108 Setback	Slight modification in the alignment of any of the four levee-construction alignments. The alignment of the new levee, LFCC, and associated maintenance roads would be shifted to the west, thus reconnecting approximately 80 acres of the floodplain with the floodway.

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CHAPTER 5 - DESCRIPTION OF THE FINAL ARRAY OF ALTERNATIVES*

5.1 DESCRIPTION OF THE RECOMMENDED PLAN*

As discussed in Chapter 4, an array of plans was advanced to this analysis of effects to the human environment because they provide similar levels of benefit for little or no additional costs. These included the NED plan (Alternative A at the Base Levee + 4 ft height), the Levee Setback (Alternative A with a setback at the Socorro Nature Area), the plan stipulated in Corps guidance (Alternative A at the Base Levee height), and Alternative K at the same two levee heights because it provides potential additional benefits against headcutting and protects additional portions of the LFCC and the existing railroad tracks in the Tiffany Basin area.

Alternative A with a levee height corresponding to the Base Levee + 4 ft is considered the recommended plan based on the evaluation of study objectives and Corps planning criteria. Alternative A is also the primary focus of this chapter because the remaining alternatives are essentially variants or extensions of the same Alternative A levee. The recommended plan entails the replacement of approximately 43-miles of the existing spoil bank along the west bank of the Rio Grande from the San Acacia Diversion Dam (SADD) downstream to a location known as Tiffany Junction. Alternative plan K extends the levee along the east side of Tiffany Basin for an additional 4 miles. Each alternative plan produces a change in area of footprint and amounts of spoil for differing levee heights corresponding to the Base Levee and Base Levee + 4 ft levee heights. Finally, a levee setback consisting of a 1.4 mile departure of the levee alignment approximately 6 miles downstream of the SADD occurs within the levee reach included in both alternatives; however, it would produce some changes in cost, spoil material quantity and floodway acreage gained for each alternative plan and height. This levee setback has a higher cost than Alternative A alone and does not produce additional Flood Risk Management benefits, therefore is not included in the recommended plan.

5.1.1 General

The recommended plan consists of rehabilitating approximately 43 miles of spoil bank along the west bank of the Rio Grande from the SADD to Tiffany Junction. This plan reduce damages from flooding to inhabitants of the west floodplain, the LFCC, and numerous railroad, irrigation, drainage, transportation, and agricultural improvements within the length of the project area. The recommended plan is the NED plan as demonstrated in Chapter 4. The levee alignment would follow the existing spoil bank, between the LFCC and the Rio Grande. The levee height is equivalent to 4 feet above the water surface elevation corresponding to the mean 1%-chance exceedance flow at the base year. The discharge for the 1%-chance flow is 29,900 cfs at the SADD, decreasing to 15,000 cfs at the downstream end of the project. The reason for the reduction in design discharge is the attenuation of flood flows as they travel downstream through the project area.

The discharge associated with the Base Levee + 4 ft elevation varies significantly throughout the project reach. However, at the upstream end of the project near the San Acacia stream gage, this elevation would correspond to approximately the 38,000 cfs water surface elevation 50% of the time. Floodplains for the 1-percent chance event for the with-project conditions are shown on Figure 5.3 through 5.9. The with-project floodplains represent Alternative A, the 43-mile engineered levee from the SADD to Tiffany Junction, which is the recommended plan.

A flood warning system will be required as part of any structural plan. The flood warning system will be incorporated into the local or county emergency response in the unlikely case of levee overtopping or failure. It is assumed that an effective and understood flood warning system would reduce life safety risk by allowing residents to evacuate the floodplain. Flood warning would also allow residents to protect structure contents by removing damageable items from the dwelling or raising them above flood stage

5.1.2 Levee Design

The new levee replacing the existing spoil bank would be trapezoidal in cross-section with a 15-foot-wide crest. Side slopes would vary between 1 vertical to 2.5 horizontal and 1 vertical to 3 horizontal, depending on the height of the levee. The levee height ranges from 1 foot at the northern end to 14 feet at the southern end and would require 3,600,000 cubic yards of random fill for construction. For levee heights greater than 5 feet, perforated pipe toe drains, discharge pipes into the LFCC, and risers as well as an 8-foot-wide by 4-foot-high inspection trench with 1V:1H side slopes would be required. In addition, a 2-foot-wide bentonite slurry trench would extend from 2 feet below the levee embankment crest to 5 feet into the foundation material. Material making up the existing spoil bank will be used to construct the new levee except for select material such as bentonite clay and rock riprap.

The levee alignment would be adjusted within the footprint of the existing spoil bank. From the SADD to Highway 380, the landward toe of the proposed levee would be aligned to the land ward toe of the existing spoil bank. This alignment provides some space to spoil excess soil on the landward side of the proposed levee. Since the footprint of the proposed levee including the spoil is smaller than the existing spoil bank, there will be a gain in floodway extent in this reach (Figure 5.1). From Highway 380 downstream the landward toe of the proposed levee would be aligned with eastern edge of the existing maintenance road and would not include any spoil on the landward side. The footprint of the proposed levee is as large as or larger than the existing spoil bank footprint along most of this reach (Figure 5.2). The alignment would provide the least amount of floodway encroachment possible.

Despite the disposal of spoil along the upper reach of the levee, approximately 1,600,000 cubic yards (92 acre-feet) of excess material would be spoiled in an approved location outside the levee footprint.

Special design features are required just below SADD to maintain the integrity of the existing and proposed features. Design discharge velocities just below the San Acacia Diversion Dam are exceedingly high because channel incision in this reach has left the historic flood plain disconnected from the channel during all but the largest flood events (e.g., 0.2%-chance event). Flood flows are thus confined to a narrow channel and at flood discharge could erode the west bank, threatening the integrity of the proposed levee. Excavation of the east bank or river terrace to essentially lower the bank to the 50%-chance exceedance water surface elevation along approximately 300 yards of river reach would effectively alleviate these erosive velocities**.** Channel widening would increase the cross sectional flow area and subsequently decrease the velocity. In addition, overbank lowering would allow river flows into higher-roughness areas, causing an overall reduction in velocity. This approach allows for effective design of riprap for the levee, and has the added benefit of restoring some functional riparian habitat in the east overbank where the excavation will be performed. This bank excavation would occur on the Sevilleta National Wildlife Refuge (SNWR) and would require placement of a temporary crossing through the river downstream of the SADD. This crossing would be removed once the excavation was complete. Revegetation of the excavated bank with native riparian and upland species would be implemented to stabilize the soil and preclude establishment of non-native invasive species.

In this same reach, immediately downstream from the SADD, high flow velocities and a limited area for levee construction also require a specialized flood-risk-management solution. Within the mile downstream from the SADD, the BSNF railroad, LFCC and an irrigation canal closely parallel each other atop the western river bank. The existing river bank and railroad embankment are adequately high to avoid being overtopped; however, they are subject to scour during high flow events. Seepage through the embankment or foundation into the LFCC may also cause sloughing of the LFCC side slope. A soil cement veneer applied to the existing river embankment would prevent scour of the river bank and damaging seepage through the LFCC side slope. Mixing cement with the existing soil forms a stronger, less permeable matrix. The soil cement would be used to accommodate the space limitations because it can be applied to the l-foot vertical to 1-foot horizontal slope of the existing embankment. Soil cement armoring would begin at the SADD and continue along the west bank of the river for approximately 1.08 miles, where it would transition to the typical earthen levee section used for the remainder of the levee alignment. Self-launching riprap would be placed along the toe of the soil cement armoring and for approximately 600 feet of the earthen levee. The riprap would launch or fall into scour holes as they might develop from channel scouring or incision.

Immediately upstream of the SADD for approximately 610 feet a concrete floodwall will be placed between the LFCC and the River to protect from high flows spilling over the bank in this area. The floodwall will be approximately 4 feet high and will terminate in high ground upstream of the SADD.

5.1.3 Seepage Control

Because the proposed levee embankment would be constructed on thick deposits of pervious materials overlain with little or no impervious material, foundation seepage would become a serious problem. It was determined that a network of subsurface seepage collector pipes and a 2 foot thick landside foundation drainage blanket would be the best alternative for levee sections five feet in height or greater. The drainage blanket will be designed to also act as a filter for the random fill to be placed on top of it. The drainage blanket will extend approximately one-third the foundation width starting from the landside toe, and will include a network of toe collector pipes and drains to control seepage and eliminate sloughing. See Figure 5.1 and 5.2 for details of the typical levee section.

Because the proposed levee will be constructed from the existing pervious materials that make up the spoil bank, a slurry trench will be placed in the center of the levee to help prevent through seepage exiting the levee toe for levee sections five feet or greater. The slurry trench will start two feet from the crest of levee and extend through the levee to the bottom of the foundation inspection trench.

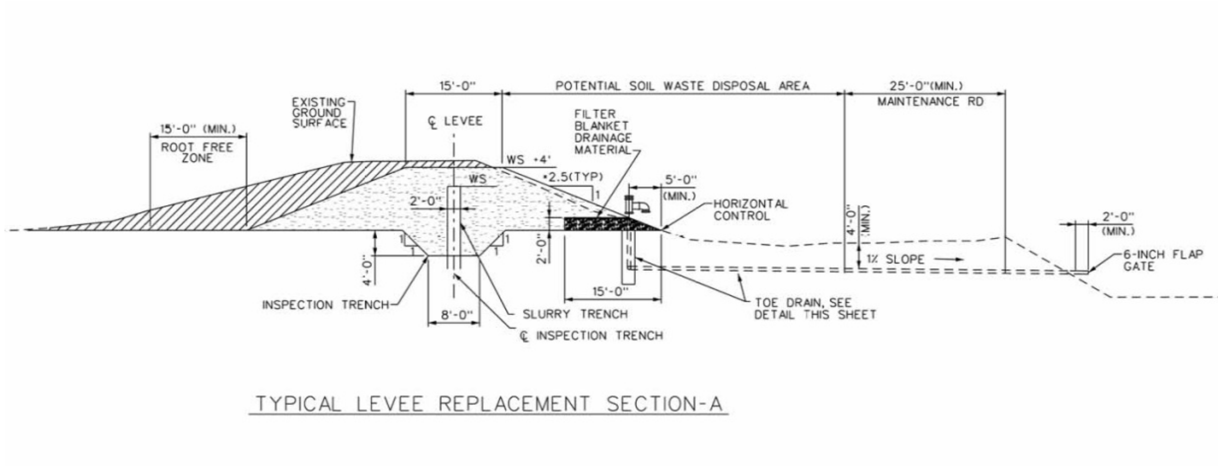


Figure 5.1 Typical Section of Smaller Levee in Northern Portion of Project

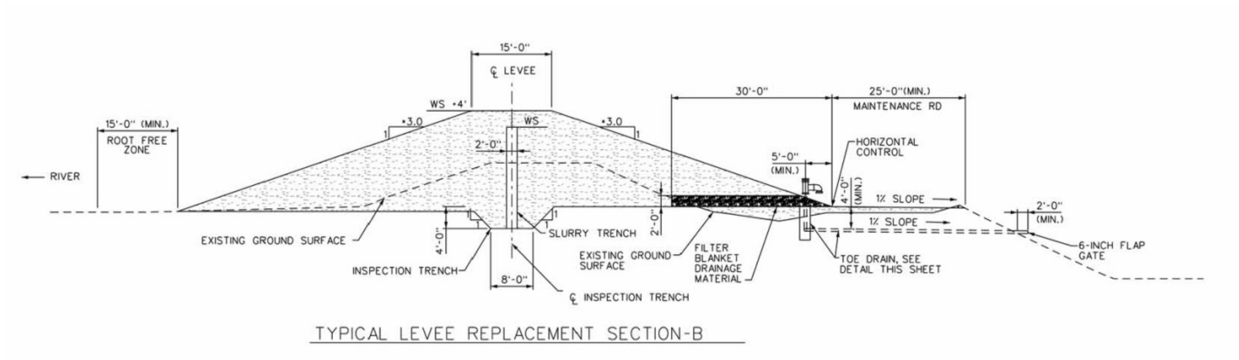


Figure 5.2 Typical Section of Larger Levee in Southern Portion of Project

5.1.4 Levee Erosion Control

Eleven segments of the new levee would require toe protection based on hydraulic analysis of scour velocities and proximity of the river channel to the proposed levee. The protected segments (see plates in Appendix F-1) range from 500 to 5,000 feet, and the total length of erosion protection is approximately 35,500 linear feet (6.7 miles). Riprap protection would blanket the riverward slope of the levee from crest to toe, and would be buried to a depth of 6.5 to 12 feet beneath the levee toe. “Launchable” riprap would be buried below the ground surface at the toe of the levee for potential scour depths greater than 12 feet but not exceeding 17 feet. Rock sizes used for riprap would vary from 0.75 to 3.5 feet depending of the velocities at potential scour locations. Coloration for rock used for riprap would vary; however, suitable material in the local area consists of dark colored basalt or grey metamorphic rock. Jetty jacks are currently located in and around the proposed project area and would continue to provide erosion protection to the proposed project.

Graded stone erosion protection revetment, known commonly as riprap, has been specified in areas judged to be susceptible to erosion and scour that could compromise the project's performance or physical integrity of the proposed levee. Existing jetty jacks located in and around the proposed project area would continue to provide erosion protection. Riprap placement (along with other forms of armament such as soil cement) has been designed to extend, rather than replace, the existing jacks in order to improve project reliability. Except for limited areas, such as where portions of existing jack tieback lines will be shortened to permit construction access, the existing jacks would remain in place to continue functioning as retards. For those limited cases where jack lines will be shortened, the ends would be re-anchored to preserve their functionality.

Appurtenant Structures

Three tributary arroyos in the project area empty into the Rio Grande from the west, crossing the LFCC and existing spoil bank: San Lorenzo Arroyo enters the Rio Grande approximately 2.5 miles downstream of the San Acacia Diversion Dam; the Socorro Diversion Channel captures the Socorro Canyon Arroyo, Nogal Canyon Arroyo, and several smaller arroyos and empties into the Rio Grande just upstream of the city of Socorro; and Brown Arroyo enters the Rio Grande approximately 3 miles downstream of Socorro. Each of these tributaries was evaluated in order to determine if closure structures were needed to prevent flood flows on the Rio Grande from escaping the floodway.

Closure structures were determined not to be needed at San Lorenzo Arroyo and the Socorro Diversion Channel. Instead, levee tie backs were designed to prevent overtopping of the interior drainage facilities at these places. It was determined that a closure structure was needed at Brown Arroyo to prevent Rio Grande flood flows from backing into Brown Arroyo for a distance of approximately 7500 feet and a depth of up to 9 feet. Brown Arroyo is confined by non-engineered spoil banks that have a high risk of failure at high flood stages. This gated closure structure will be designed to pass Brown Arroyo flood flows, while preventing longer duration Rio Grande flood flows from potentially breaching the existing interior drainage facilities.

5.1.5 Tiebacks

At the upstream end, the recommended plan would terminate (tie back) to high ground near the SADD. At the downstream end, the levee would end at the railroad embankment north of Tiffany Junction and would not tie back to high ground to the west. Analysis reveals that the extent of backwater flooding that might be expected without the levee tie back to high ground is minimal. Because the LFCC is located to the west of the railroad alignment, the levee would not cross the LFCC. The railroad embankment does not act as a flood-control feature, and the recommended plan does not include the extended levee alternatives that would protect the railroad embankment.

5.1.6 Non-Earthen Structures

A gated floodwall structure will be located where the new levee intersects the outfall channel of Brown Arroyo. The gate structure will consist of 10 sluice gates. The gates are aligned in a zigzag configuration which will allow for flows from the channel to enter directly into the gates, as Brown Arroyo inlet is skewed to the Rio Grande Floodway. In addition, there are three locations along the proposed levee alignment where flow from the Low Flow Conveyance Channel will be pumped through the levee to the river. Appropriate measures to ensure levee performance will be incorporated into the development of designs of these structures during plans and specification for this project. Included in the design of these structures will be concrete encasement, appropriate filter materials and slope protection.

5.1.7 Utility Relocations

Approximately 16 miles of an existing fiber optic line are required to be relocated to allow construction of the southern end of the levee. The line is operated by a local utility owner in the existing easement. It is anticipated that required relocation of this utility will be at the expense of the utility owner and the cost is not included in the project cost.

Figure 5.3 Without- and With-Project Floodplains Index

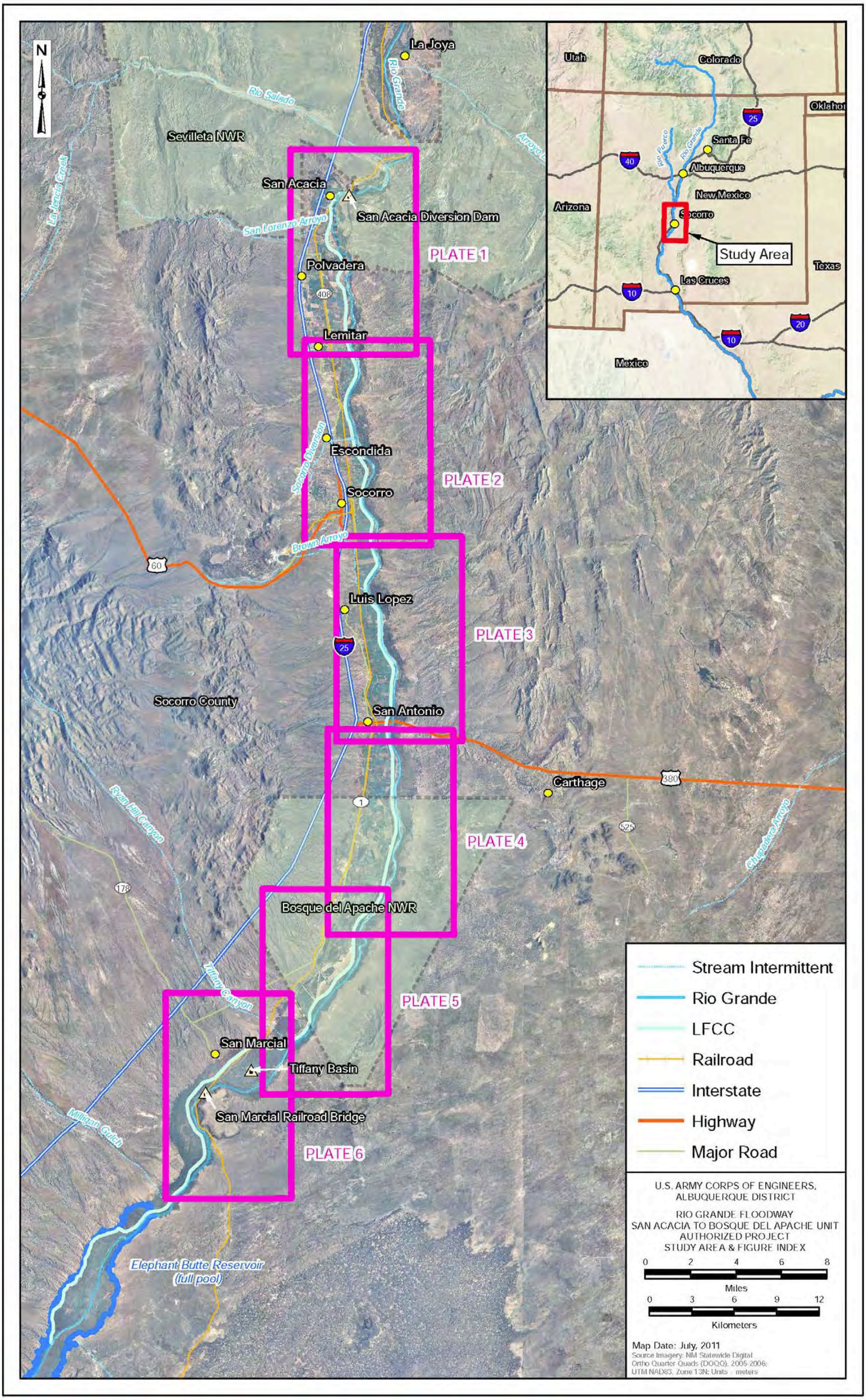


Figure 5.4 Without-Project Floodplains and With-Project Floodplains (Alternative A at Base Levee + 4 ft levee height)

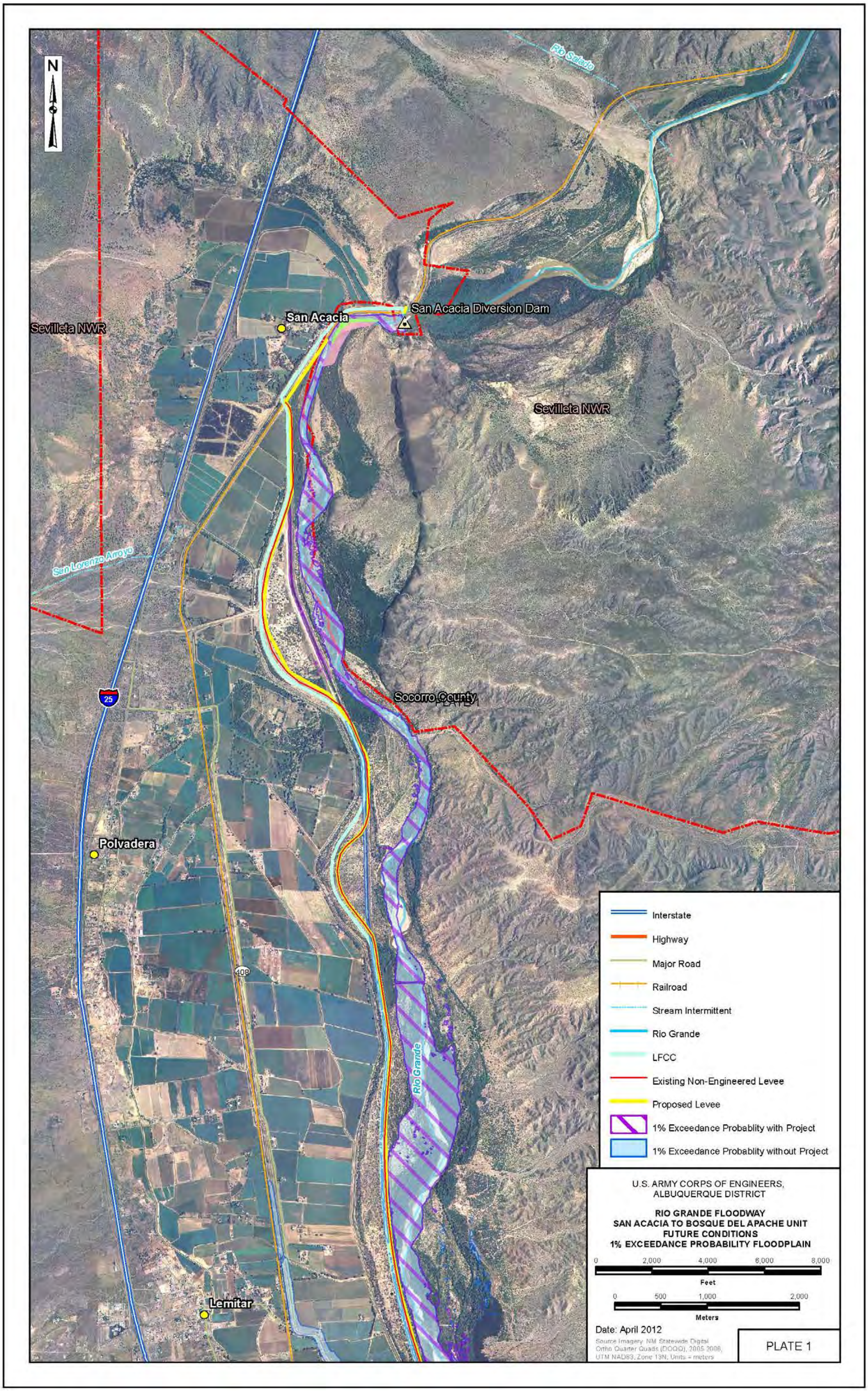


Figure 5.5 Without-Project Floodplains and With-Project Floodplains (Alternative A at Base Levee + 4 ft levee height)

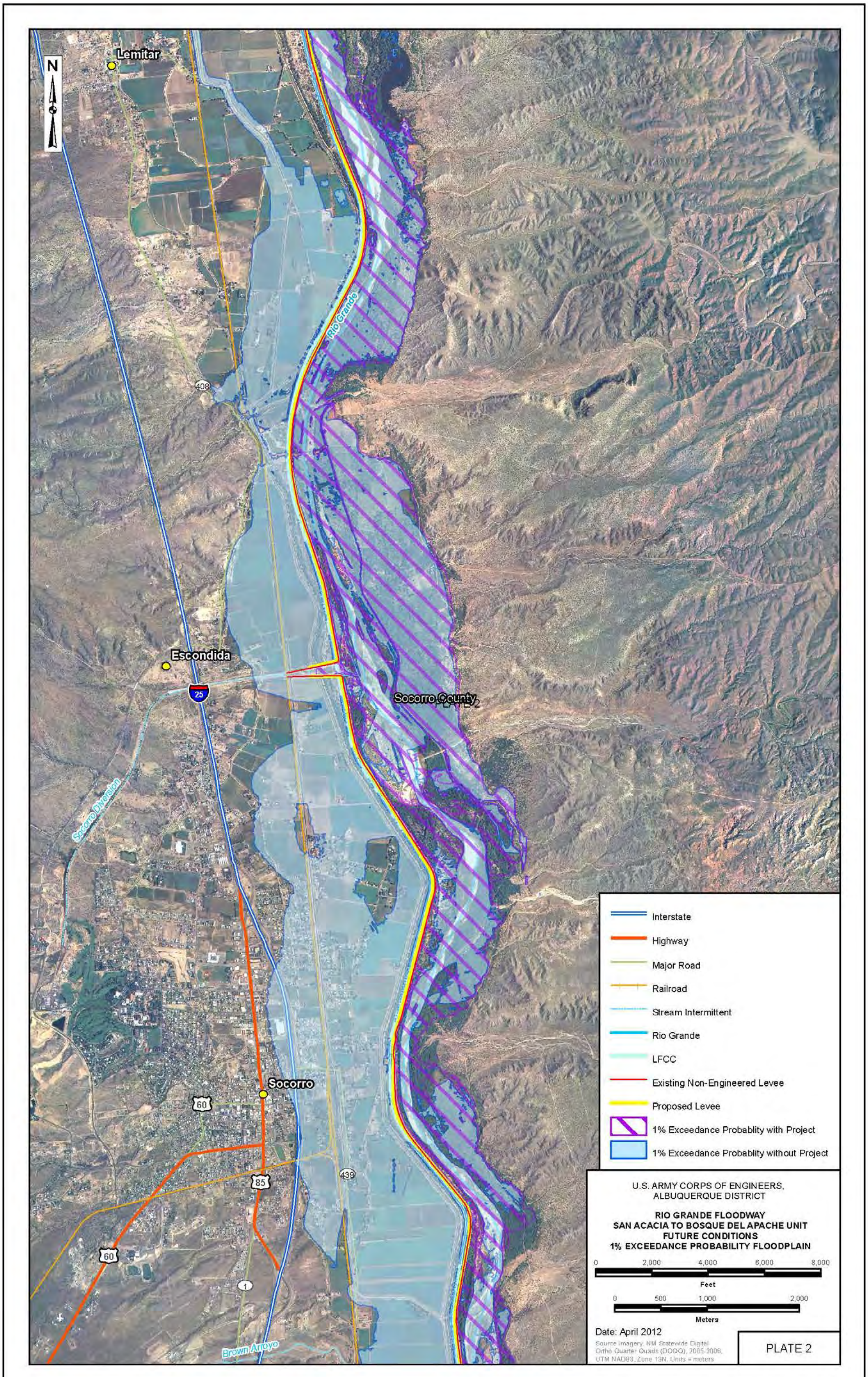


Figure 5.6 Without-Project Floodplains and With-Project Floodplains (Alternative A at Base Levee + 4 ft levee height)

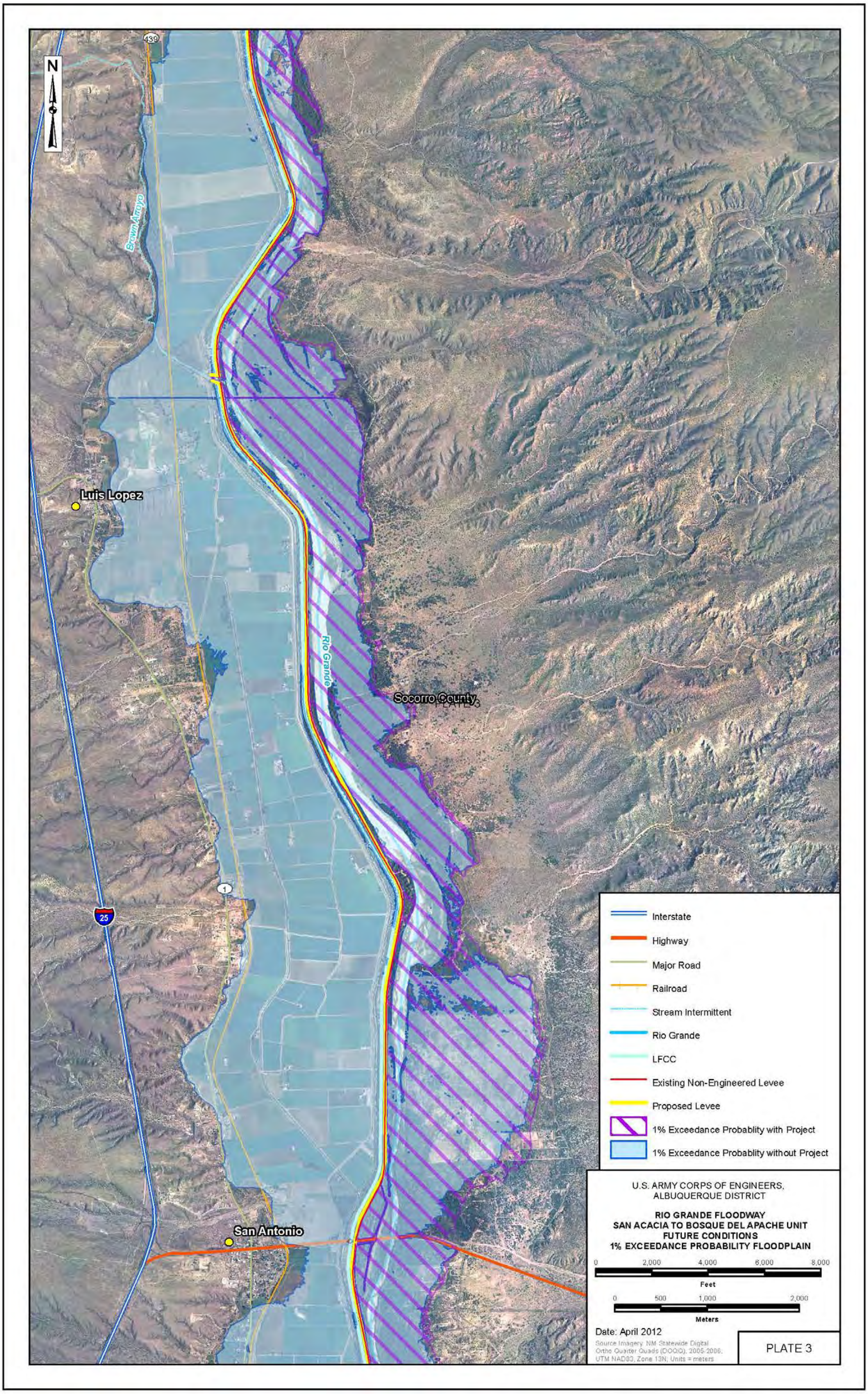


Figure 5.7 Without-Project Floodplains and With-Project Floodplains (Alternative A at Base Levee + 4 ft levee height)

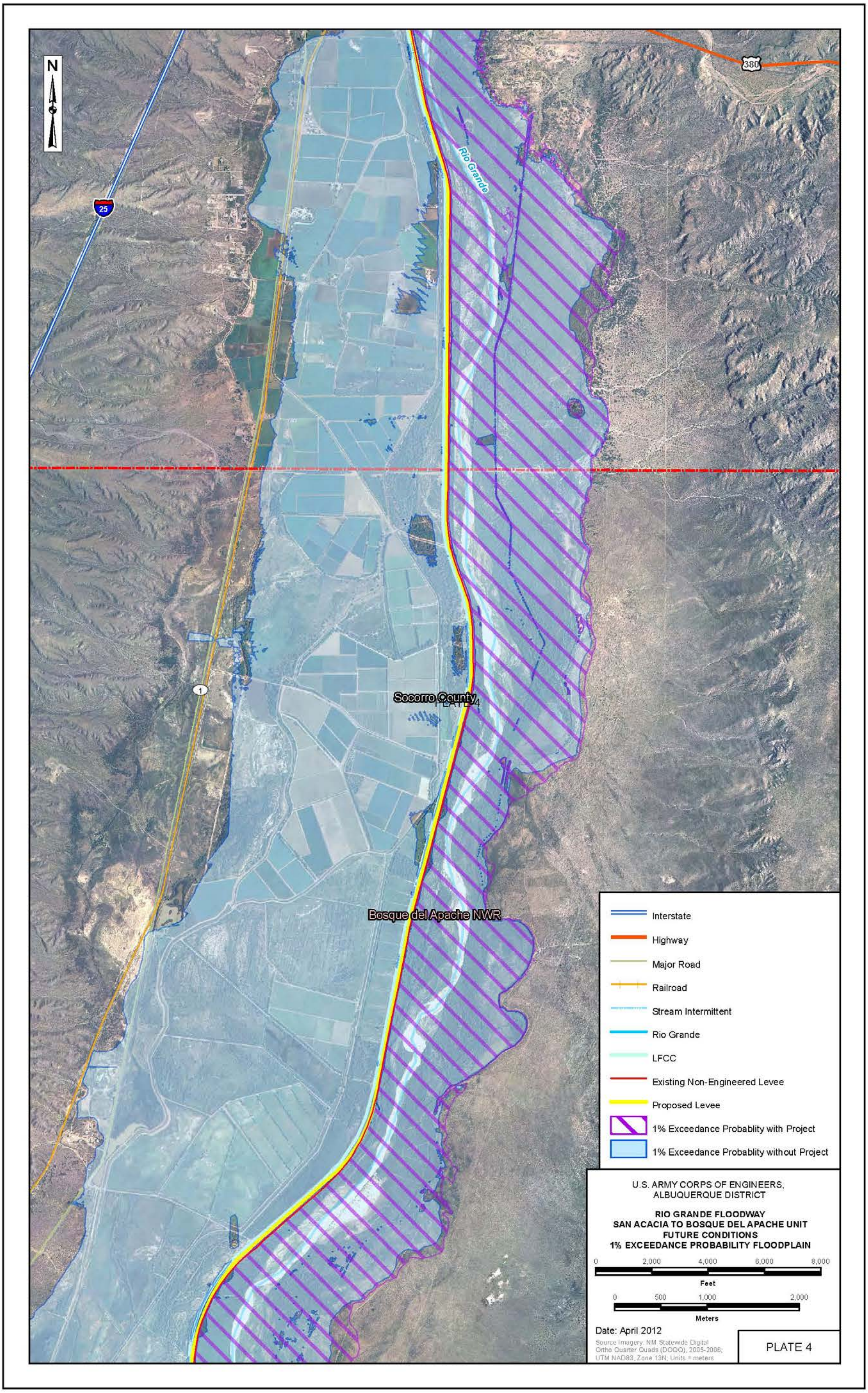


Figure 5.8 Without-Project Floodplains and With-Project Floodplains (Alternative A at Base Levee + 4 ft levee height)

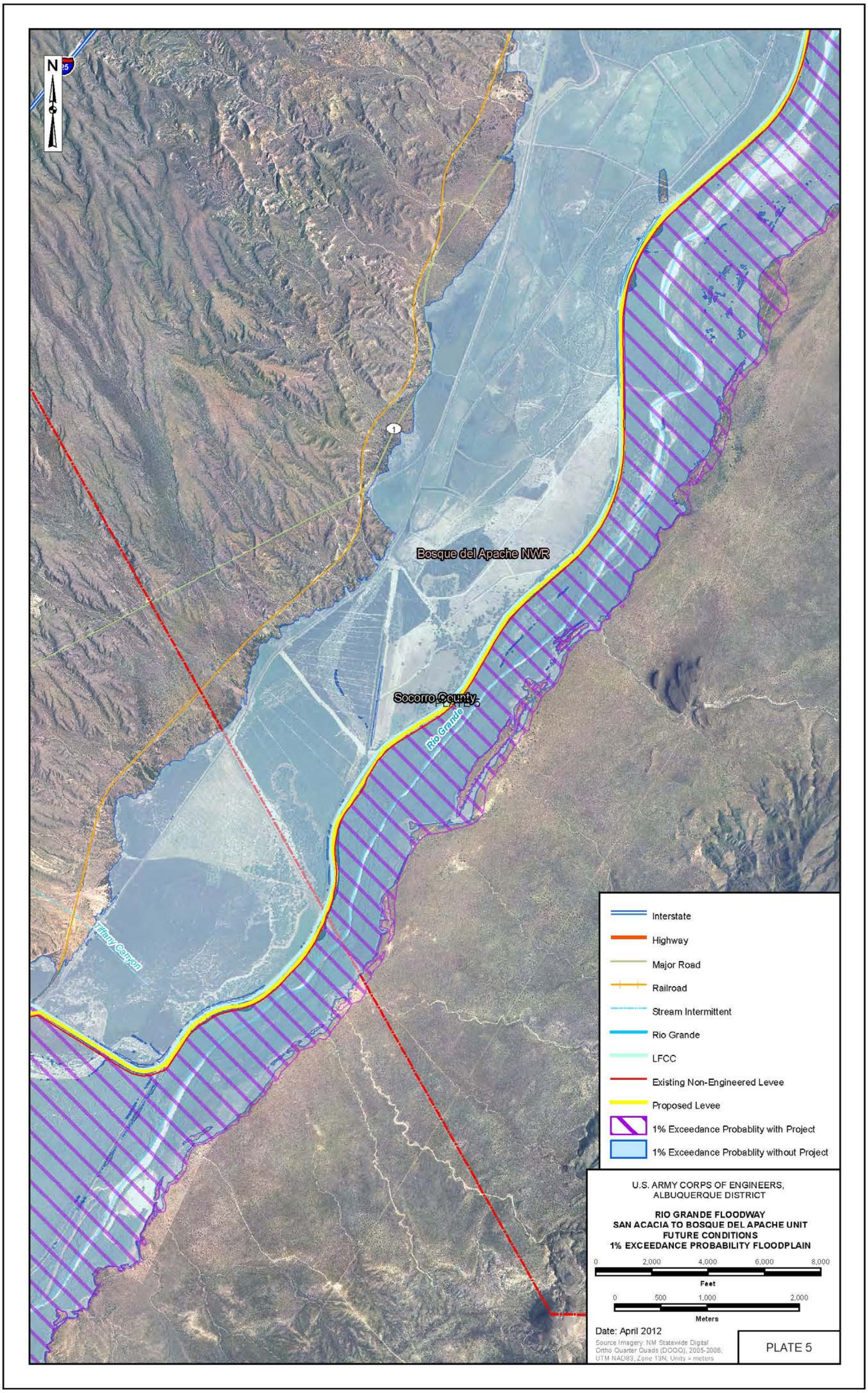
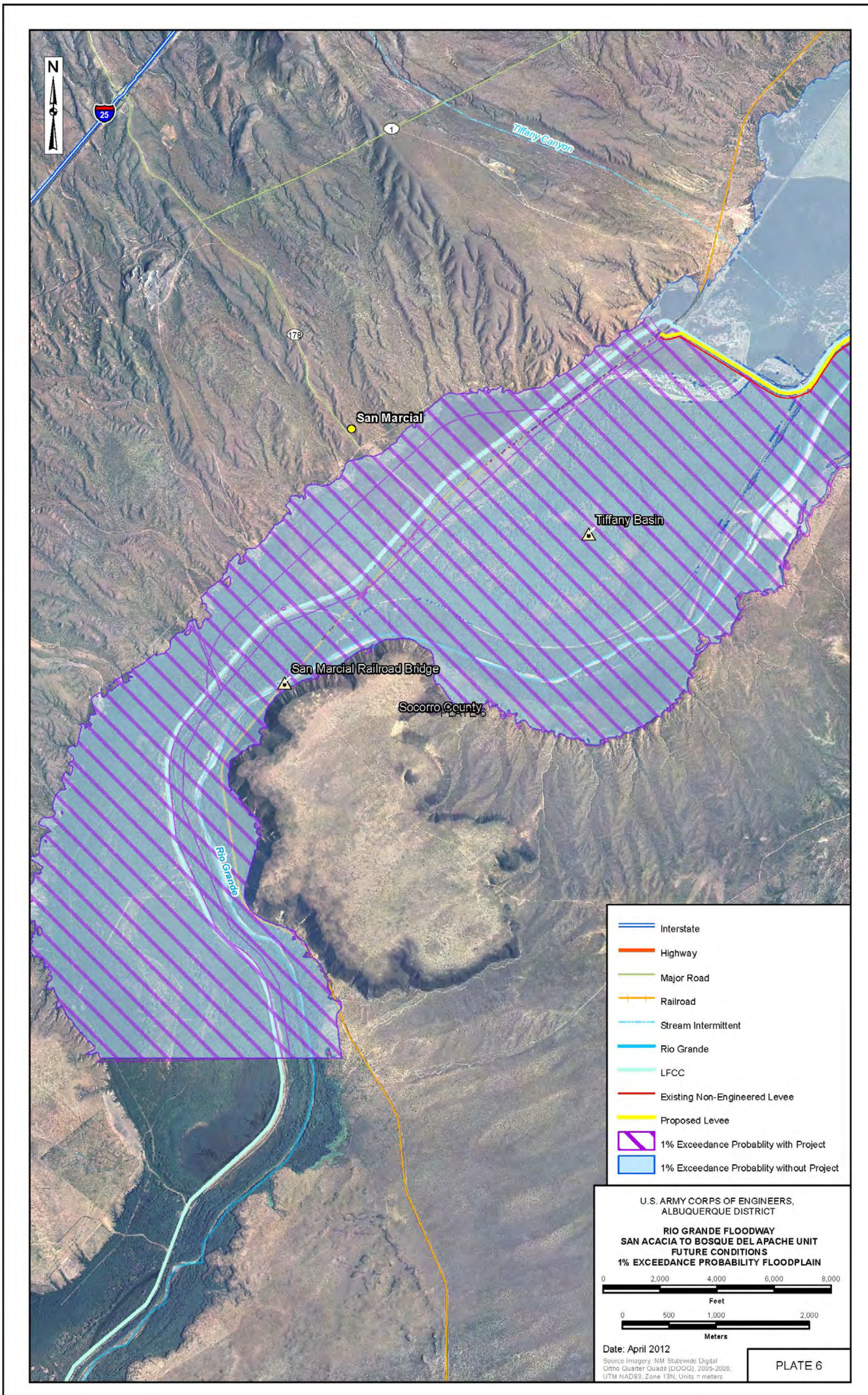


Figure 5.9 Without-Project Floodplains and With-Project Floodplains (Alternative A at Base Levee + 4 ft levee height)



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5.1.8 Other Relocations

The recommended plan would include the relocation of 765 Reclamation survey control markers.

5.1.9 Fill, Borrow, and Disposal Requirements

The design of the levee and its associated structures including the east side excavation near the SADD requires fill, borrow, and disposal materials for construction as summarized in Table 5.1.

The random fill necessary for the construction of the levee would come from the excavation of the existing spoil bank, which the proposed levee is replacing, and from the east side channel lowering just downstream of the SADD. The use of borrow sites for random fill is no longer being considered; however, borrow sites may be required as sources for select material (i.e., riprap). Additional select material that may be needed for levee construction (i.e., bentonite) would be acquired from approved commercial sources. Excavation waste not appropriate for reuse, or not required for the proposed levee construction will be spoiled in an approved location outside the levee footprint. A spoil location within the Tiffany Basin was identified as adequate for spoil subject to acquisition of the right to dispose in that area. This spoil area at the south end of the project or along the landside toe of the proposed levee where space is sufficient would allow for placement of waste fill. The is much interagency interest in improving habitat or channel morphology in the area of Tiffany Basin as stated in alternatives explored to reconnect this area to the active channel. For this reason, the area to be covered by the spoils within Tiffany Basin would only be filled to an elevation consistent with the 10%-chance exceedance water surface elevation so that spoil disposal in the area would not preclude restoration of this area in the future. The area needed for spoil is calculated to be approximately 300 acres and approximately 6.5 feet deep for the recommended plan. Screened oversized waste (large rocks) not appropriate for random fill, should be separately stockpiled for use as rip-rap thus reducing the required riprap quantity.

Table 5.1 Fill, Borrow, and Disposal Requirements, Recommended plan

Item	Quantity[1] (cy)
Random Fill	2,177,000
Bentonite Slurry	131,000
Excavation	5,387,000
Borrow	0
Disposal (Spoil)	3,013,000 Tiffany Basin
	369,000 Levee Waste Fill
	175,000 Screened Oversized Waste

[1]Quantity numbers presented are bank cubic yards (cy). No swell or compaction factor has been applied to these numbers.

A portion of the spoil material will be disposed of on the landward side of the constructed levee. As seen in Figure 5.1, above, the new levee in the northern reach is substantially smaller than the existing spoil bank. Levee construction north of Hwy 380 will include spoiling of some excess soil on the landward slope to save costs for hauling the material away. The category “Levee Waste Fill” of 369, 000 cubic yards is that portion of the total disposal that will remain in the levee footprint.

5.1.10 Vegetation Management

The Corps' Engineer Technical Letter 1110-2-571 (10 April 2009) requires that no ‘woody’ vegetation be allowed to grow on the levee or within 15 feet of the riverward and landside toes of the levee. In this case, ‘woody’ vegetation is considered tree or shrub plants with trunk diameter greater than ½ inch. During construction, existing vegetation would be removed adjacent to the riverward and landside toes by root plowing or clearing and grubbing to create a vegetation management zone. Since the landward side of the levee is currently maintained as an access road, very little woody vegetation exists. Following construction, disturbed soils including levee side slopes will be seeded with native grass seed to prevent wind and water erosion. All grass plantings will be supplementally watered to assure successful establishment. A 15-foot-wide vegetation management zone along the riverward and landside toe of the levee will be permanently maintained to be devoid of trees and shrubs.

5.1.11 Real Estate Requirements

Based on the Draft Real Estate Plan (Appendix F-11), the real estate required for the levee footprint, temporary construction easement, and staging areas has already been secured by the MRGCD on behalf of Reclamation as part of previous Federally-funded projects. Therefore, LERRD credit would only apply to the following areas:

- Any staging, borrow and/or waste areas required for the project, estimated at approximately 300 acres.

- Construction near the SADD consisting of overbank excavation and channel excavation of approximately 20 acres.

The MRGCD is the underlying fee and easement owner of the majority of the land in the northern part of the project and most of the lands in the southern part of the project, according to the relevant land records of the real estate required for the project. However, ongoing litigation with the Federal Government has brought into question ownership of MRGCD assets. For that reason, the Corps has obtained signatures from both parties in order to proceed with any project that contains real property involving the lands in question.

The Flood Control Act of 1948 concluded that the flood problems of the Rio Grande Basin were severe and could be addressed under the Corps flood control management program. Due to changes within the basin over the years, including budgetary requirements, flood control management features implemented in the upper watershed, and environmental concerns the authorized levee was not constructed. In 1956, the MRGCD granted an easement to the Reclamation to construct the LFCC and resulting spoil-bank along the west bank of the Middle Rio Grande.

The MRGCD currently holds the underlying fee interest for approximately 806 acres where the proposed levee will be constructed. This area includes approximately 600 acres for the levee foot print and 206 acres for temporary construction easements 15 feet and 22 feet wide. The MRGCD will provide the Government with an authorization for entry for all lands, easements, rights-of-way, relocations, and dredged material disposal areas (LERRD) that the Government requires.

Examples of areas where MRGCD only holds easement are lands administered by the Bureau of Land Management (BLM) and the United States Fish and Wildlife Service (USFWS).

5.1.12 Construction Methods

Construction methods for the proposed plan features are summarized in the following paragraphs.

5.1.12.1 *Levee Construction*

The construction of the proposed levee would consist of removing designated sections of the existing spoil bank with heavy machinery, processing the material to obtain suitable material, placing the embankment to an elevation suitable for the excavation of the slurry trench, filling the slurry trench, and then building the remaining portion of the levee to its design specifications. All sorting and material mixing would occur within the footprint of the existing spoil bank during construction. As previously mentioned above, any waste not appropriate for use in constructing the new levee would be disposed offsite in compliance with all governing regulations. Selected materials required for construction would be acquired from commercial sources or borrowed at approved sites.

5.1.12.2 *Haul Roads, Access Roads, and Turn-Arounds*

The contractor would not be allowed to construct any new haul roads for the construction of this project. The existing haul road adjacent to and between the existing spoil bank and the LFCC would be used for the construction of the levee. Turn-arounds would be located on the levee or existing disturbed locations used for spoil bank and LFCC maintenance. Specific locations will be determined after further coordination with all parties using the levee.

5.1.12.3 *Stockpiling*

Material necessary for the construction of an engineered levee would be obtained from the existing spoil bank; however, the amount of material needed varies based on the specific levee design for each section. Some levee sections will require additional material and other sections will have a surplus. For this reason surplus material will be stockpiled until is it needed for construction of another section. Levee construction will be phased to minimize the amount of stockpile needed. Stockpiles will be located at existing staging areas or at previously disturbed areas.

5.1.13 East Bank Excavation and Access

The excavation of the east bank described in 5.1.2 to reduce high velocity flows downstream of the SADD will require specialized construction methods to access and perform the required work. A temporary river crossing downstream of the San Acacia Diversion Dam will be required to access the east bank from the LFCC service road on the west bank of the Rio Grande. The temporary crossing will consist of an earthen ramp approximately 300 feet long, with a 15 foot top width and 2.5 to 1 foot side slopes. Six 60-inch corrugated metal pipes will allow low flows through the crossing to maintain a wet river channel during construction. Best Management Practices will be used to minimize impacts to water quality for this feature and include the use of rubber cofferdams for the reduction of turbidity and ease of construction, slope protection for the culverts, and specialized grading to prevent runoff or sediment from entering the river at the location of the ramps. Rubber coffer dams will also be employed along the east bank to minimize contact between construction activities and the river waters.

Access and excavation occurs on Sevilleta National Wildlife Refuge lands on the East bank of the Rio Grande in this area. Preliminary plans have been coordinated with the refuge to include access and construction activity as well as restoration of the floodplain following excavation. Final plans for construction activity and subsequent mitigation of riparian habitat will be coordinated with the refuge.

5.1.14 Construction Schedule

The current levee plan has been divided into 14 segments based on anticipated funding and to provide manageable pieces of the project to construct: the plans and specifications for segment 1 of the levee plan would be initiated upon the completion and approval of this GRR/SEIS-II in 2012. Construction for this segment is anticipated to begin in late 2013. Subsequent segments would be constructed annually as funding is received. Phasing of the levee construction would occur generally north to south beginning at the SADD. Depending on the timing and seasonality of construction or presence of species of concern, construction of levee segments may not be contiguous or construction of concrete structures may occur prior or after earthwork has been completed in a particular levee segment.

5.1.15 Safety Assurance Review

A Safety Assurance Review (SAR) shall be conducted on design and construction activities for hurricane and storm risk management and flood risk management projects, as well as other projects where potential hazards pose a significant threat to human life. The review shall be conducted for the purpose of assuring that good science, sound engineering, and public health, safety, and welfare are the most important factors that determine a project’s fate. Expert panels external to the Corps will review the design and construction activities prior to initiation of physical construction and periodically thereafter until construction activities are completed.

This GRR/SEIS II has undergone Independent External Peer Review (IEPR). The IEPR is conducted in two phases referred to Type I and Type II IEPR per Corps guidance contained in Engineer Circular 1165-2-209. Type 1 is generally for decision documents and Type II (which is synonymous with SAR) is generally for implementation documents such as designs. A type I IEPR has been conducted for this GRR/SIES II concurrent with the public review and will included a review of public comments and Corps responses to public comments.

A Type II IEPR shall be conducted on design and construction activities. External panels will review the design and construction activities prior to initiation of physical construction and periodically thereafter until construction activities are completed. Appendix E of Engineer Circular 1165-2-209 provides guidance for reviews conducted on design and construction activities performed after the approval of a decision document. The review shall be on a regular schedule sufficient to inform the Chief of Engineers on the adequacy, appropriateness, and acceptability of the design and construction activities for the purpose of assuring that good science, sound engineering, and public health, safety, and welfare are the most important factors that determine a project's fate.

The panel's final report and the responses of the Corps shall accompany the publication of the Final GRR- SEIS II and will be published on the Albuquerque District webpage as well as the Corps Headquarters webpage at:
(http://www.usace.army.mil/Missions/CivilWorks/ProjectPlanning/CompletedPeerReviewReports.aspx)

5.1.16 Permit Requirements and Agreements

5.1.16.1 *Section 404 and Section 401 of the Clean Water Act*

The 1992 SEIS submitted to Congress contained a Section 404(b)(1) evaluation of proposed fill within waters of the United Sates in the channel of the Rio Grande; therefore, the requirements of Section 404(r) of the Clean Water Act section were fulfilled. Additionally, Section 401 Water Quality Certification for the Previously Approved Project was obtained from the State of New Mexico. The recommended plan also entails fill within waters of the United States as currently defined; however, an exemption through Section 404(r) is not being sought for the currently proposed plan. Appendix B of this GRR/SEIS-II includes an updated Section 404(b)(1) Guidelines evaluation and State Water Quality Certification (Feb. 2013).

5.1.16.2 *National Pollution Discharge Elimination System Permit*

The 1972 amendments to the Clean Water Act prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is previously approved by a National Pollution Discharge Elimination System (NPDES) permit. Stormwater runoffs from construction activities, including clearing, grading, and excavating, require preparation of a Storm Water Pollution Prevention Plan (SWPPP) under New Mexico's NPDES permit if operations disturb more than one acre of total land area. New Mexico does not have an Environmental Protection Agency (EPA) approved State Storm Water Program. The NPDES permit is submitted under EPA's Construction General Permit and the construction contractor is required to meet the provisions of this general permit. Therefore, a SWPPP would be developed and implemented for the proposed construction activities, and a Notice of Intent to implement the SWPPP during construction of the proposed project action in compliance with New Mexico's NPDES permit would be filed with the EPA. Best management practices (BMPs) would be developed in the SWPPP and implemented to reduce/eliminate pollutants. BMPs include the following: good housekeeping, performing preventive maintenance, maintaining visual inspections, prevention and response to spills, sediment and erosion control, managing runoff, training personnel, keeping records, and reporting, and any other activity-specific and site-specific stormwater best management practices that apply.

5.1.16.3 *U.S. Bureau of Reclamation Permits*

A special use permit would be acquired from Reclamation for construction and use of staging areas.

5.1.16.4 *U.S. Fish and Wildlife Service*

By the authority of the National Wildlife Refuge System Administration Act of 1966, the Endangered Species Act (ESA) of 1973, and Executive Order 8289, dated 22 November 1939, which established the Bosque del Apache National Wildlife Refuge as a refuge and breeding ground for migratory birds and other wildlife, the Refuge Manager is directed to determine the compatibility of the proposed project with refuge purposes. USFWS policy also requires that a proposed action on a refuge be consistent with refuge objectives. Therefore, in 1991, the Bosque del Apache NWR Refuge Manager prepared a Determination of Compatibility for the previously approved project (Appendix B of 1992 SEIS), finding the proposed project compatible with the purposes for which the refuge was established. New or updated Determinations of Compatibility will be obtained for the proposed project from Sevilleta and Bosque del Apache NWRs prior to the initiation of construction.

5.1.17 Operation and Maintenance Considerations

Upon completion of the San Acacia to Bosque del Apache Unit Project, it would be turned over to the sponsor for operations, maintenance, repair, replacement and rehabilitation (OMRR&R). The Corps will provide the sponsor with a manual summarizing the duties necessary for proper operation of the project.

In general, OMRR&R will consist of maintaining the vegetation management zone free of woody vegetation larger than 0.5-inch-diameter stems or trunks. The sponsor will be responsible for maintaining levee integrity by repairing runoff erosion, eliminating rodent burrows in the levee, replacing riprap lost in flow events, and inspecting and cleaning seepage infrastructure regularly. The sponsor will also be available to perform annual inspections of the levee system with Corps personnel.

The sponsor will also be responsible for operation of the SADD during flood flows such that hydraulic capacities of the floodway are maintained. This will consist of positioning existing tainter gates during high flow events. Gates at the Brown Arroyo structure will have to be shut during flood flows as well.

The sponsor's responsibility for project operation and maintenance begins when the project is turned over to the sponsor following construction, and continues indefinitely. During this phase, the community will realize the full benefits of the project, and responsibility passes from the Corps of Engineers to the sponsor. The Corps involvement after construction normally will consist of periodic routine inspections to ensure that the project is being properly maintained and is functioning as intended.

5.2 ALTERNATIVE A AT THE BASE LEVEE HEIGHT*

Alternative A at the Base Levee height would result in a lower levee that is approximately 6,500 feet shorter than the recommended plan. The upper extent of the Base Levee height for Alternative A ends approximately 6,000 feet downstream of the SADD. The downstream end of the levee would be the same as that in the recommended plan. Performance and therefore benefits are less for the lower levee as described in Section 4.6. Appurtenant structures, tie-backs and non-earthen structures would be the same but slightly smaller for the shorter levee height compared to the recommended plan. Construction methods, vegetation management, real estate and permit requirements would be the same for the shorter levee height.

The shorter levee would result in a smaller cross section and therefore a smaller overall footprint. The amount of spoil material produced by this alternative height would be significantly higher than the recommended plan, because the lower levee height requires less volume of material. This results in higher spoil disposal costs, making this alternative more expensive for less benefit than the higher Alternative A levee.

5.3 DETAILED DESCRIPTION OF ALTERNATIVE K*

As presented in Section 4.6.2 and shown in Figure 4.2, Alternative K is Alternative A with the engineered levee extending an additional 4-miles along the east side of Tiffany Basin rather than tying back on the north side of the San Marcial Railroad Bridge. The resulting levee is approximately 47 miles long and includes the same seepage and drainage appurtenances. The Alternative K Tiffany East Levee along the east side of Tiffany Basin would also consist of replacement of the existing spoil bank along the existing alignment. Alternative K would reduce flooding of Tiffany Basin as well as of approximately one mile of the LFCC and railroad track west of the basin. The feature would indirectly prevent a potential headcutting condition, water losses and negative impacts to endangered species that would occur if the spoil bank at Tiffany Basin failed.

Alternative K would provide a constructed feature preventing the reconnection of the active river channel to the former floodplain within Tiffany Basin. Although the same condition is present through maintenance and historic repair of the spoil bank, a constructed levee in this reach would represent a substantial investment in ensuring this condition persists. As described in the Tiffany sediment management features (Section s5.4.9 and 5.4.10) restoration of the active river channel and Tiffany basin is problematic and incurs unacceptable environmental consequences.

Since the Alternative K levee is a longer version of Alternative A, the alternatives only differ in scale of footprint and materials needed to construct the levee. No additional tie-backs or non-earthen structures would be required for Alternative K compared to Alternative A. Construction methods and vegetation management would be the same for Alternative K as for Alternative A. Land ownership of the existing spoil bank does not change for Alternative K; therefore, the real estate and permit requirements would be the same for each alternative.

The levee cross section for Alternative K would be the same as for Alternative A although the additional levee reach along the east side of Tiffany Basin would exceed the height and footprint of the existing spoil bank and additional soil will be needed to construct levee in this reach. The additional soil would be obtained from the upstream levee reaches and this reuse would reduce the amount of spoil material produced by Alternative A alone.

5.4 ALTERNATIVE K AT BASE LEVEE HEIGHT*

Alternative K at a levee a height corresponding to the water surface elevation for the 1%-chance exceedance flow would result in a shorter levee with lower performance and therefore benefits as described in Section 4.6. Appurtenant structures, tie-backs and non-earthen structures would be the same but slightly smaller for the shorter levee height compared to the Alternative K at Base Levee + 4 ft height. Construction methods, vegetation management, real estate and permit requirements would be the same for the shorter levee height.

The shorter levee would result in a smaller cross section and therefore a smaller overall footprint. The amount of spoil material produced by this alternative height would be significantly higher than Alternative K at Base Levee + 4 ft height.

5.5 LEVEE SETBACK AT RIVER MILE 108*

The setback located approximately 5.5 miles downstream of the SADD (River Mile 108), adjacent to the Socorro Nature Area operated by the Bureau of Land Management, occurs within the reach common to both Alternative A and K. The setback consists of realignment of the LFCC, proposed levee, and associated maintenance roads to parallel the existing irrigation drain within a 300 ft corridor. The smaller levee setback alignment would be approximately 8,000 feet long (1.4 mi) and be approximately 790 feet to the west of the existing LFCC at the widest cross section. Approximately 80 acres of floodplain would be reconnected to the floodway with implementation of the setback. Vegetation in this area would not change substantially since the current elevation does not experience inundation until river flows approximately 15,400 cfs (10%-chance exceedance flow). Additional discussion of vegetation effects is included in Section 6.2 e. The additional area in the floodway would increase floodway capacity slightly during flows that exceed this discharge.

Alternatives A and K at both the Base Levee and Base Levee + 4 ft heights would be the same when implementing the levee setback in all respects including levee performance and therefore economic benefits. Since the setback is located within the reach corresponding to Alternative A and Alternative A is part of Alternative K, any change in Alternative A due to implementation of the setback would also be included in Alternative K. Therefore further analysis of alternative that include the setback compares both levee alternatives at both levee heights.

Implementation of the levee setback would result in a small change in excavation and disposal of spoil. In general, the levee setback would lengthen any levee and LFCC by approximately 300 feet. The fill material for the Base Levee + 4 ft height exceeds the amount of excavated soil to relocate the LFCC therefore there is little change in the soil disposal amounts. Changes in the amount of spoil material would be commensurate with the additional soil needed for the extra levee length. The fill material for the Base Levee height, however, is exceeded by the amount of soil excavated by the relocated LFCC therefore the disposal is much greater. This levee setback has a higher cost than Alternative A alone and does not produce additional Flood Risk Management benefits, therefore is not included in the recommended plan.

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CHAPTER 6 - FORESEEABLE EFFECTS OF THE PROPOSED ACTION AND ALTERNATIVES*

6.1 INTRODUCTION

Chapter 5 describes the final array alternatives that were evaluated for their potential environmental effects. For ease of reference, these are summarized below.

• No-Action Alternative (or Without-project Alternative)	The existing spoil bank would not be replaced. (This alternative was evaluated in Chapter 3 – Future Without-Project Condition.)
• Alternative A	Replace spoil bank with a **41.5-mile-long** levee at Base Levee height.
• Alternative A+4ft (the recommended plan, or proposed plan)	Replace spoil bank with a **42.3-mile-long** levee at Base Levee+4 ft height. This levee is 24 feet wider at its base than Alt. A.
• Alternative K	Replace spoil bank with a **44.4-mile-long** levee at Base Levee height. Terminates 4 river miles further downstream than Alternatives A and A+4ft, and encloses Tiffany Basin. (The additional 4-mile section is sometimes referred to as the "Tiffany East Levee".)
• Alternative K+4ft	Replace spoil bank with a **45.2-mile-long** levee at Base Levee+4 ft height. This levee is 24 feet wider at base than Alt. K. It terminates 4 river miles further downstream than Alternatives A and A+4ft, and encloses Tiffany Basin. (The additional 4-mile section is sometimes referred to as the "Tiffany East Levee".)
• River Mile (RM)-108 setback	Slight modification in the alignment of any of the four levee-construction alignments. The alignment of the new levee, LFCC, and associated maintenance roads would be shifted to the west, thus reconnecting approximately 80 acres of the floodplain with the floodway.

The following features are common to all alternatives:

- 610-ft long concrete floodwall from SADD upstream to high ground.
- 1.08 miles of soil cement embankment on the west bank of the Rio Grande, downstream of SADD.
- Excavation of 12.4 acres on the east bank terrace, immediately downstream from SADD.
- Slide-gate closure structure at Brown Arroyo.
- 5.68 miles of riprap bank protection.
- 275- to 478-acre spoil deposition area at Tiffany Basin.

6.2 PHYSICAL ENVIRONMENT*

6.2.1 Climate and Climate Change

The Southwest is anticipated to warm substantially over the 21st Century, driving up evaporation rates at reservoirs and leading to earlier onset of spring temperatures and snowmelt runoff, and to reductions in late winter-spring mountain snowpack (Southwest Climate Alliance, 2012). There is little model consensus regarding changes in total precipitation across the region, although drier soil conditions are likely given warmer temperatures and droughts are expected to be more severe than historically. There is medium to high confidence that substantial parts of the Southwest region will experience reductions in runoff and stream flow in the mid- to end of the 21st Century. Changes to summer precipitation are uncertain because changes to the North American monsoon are not resolvable with current models. There is no consensus with respect to changes in the frequency or intensity of extreme winter or summer precipitation events. Some models predict a slight increase in intensity of winter precipitation events due to increased moisture carried into the region by atmospheric rivers; however, most of the impacts of enhanced atmospheric rivers will be in the Sierra Nevada, and projected changes to more interior areas are incompletely understood (Das *et al*., 2011; Dominguez *et al*., 2012). There is insufficient evidence at this time to conclude that there will be significant changes to extreme flood hydrology over the lifetime of this project.

Levee projects are designed to contain flows of a particular range of events and therefore are not susceptible to changes in frequency of flood events below the design flows. Without a change in the severity of flood events, the proposed levee project would continue to perform as designed and prevent damages from flooding as predicted despite climate change. Each levee alternative for the San Acacia to Bosque Del Apache Unit would perform as stated in Chapter 5.

6.2.2 Geology and Soils

None of the alternatives would affect the geology of the project area.

The existing spoil bank would be removed in its entirety and a new levee would be constructed on the current alignment primarily from the excavated material. Alternatives A and K would require only about 20% of the material excavated from the spoil bank to build a new levee; and Alternatives A+4ft and K+4ft would utilize about 45 to 48% of the spoil bank material. The smaller the new levee is, the greater the amount excess (waste) material that would require disposal. A portion of the excess material — 7 to 12% depending on the alternative — would be placed on the landward side of the new levee north of U.S. Highway 380. The remainder would be disposed of in the Tiffany Basin at the south end of the project area. Table 6.1 summarizes the excavated and disposed material amounts for all alternatives.

For Alternative A+4ft, the recommended plan, the area to be covered by the spoils within Tiffany Basin is calculated to be approximately 300 acres and approximately 5 feet deep. At this depth, the top of the spoil pile would be slightly lower in elevation than the channel of the Rio Grande. Potential waste spoils from other construction alternatives would be similarly deep, although the area would vary among alternatives (Table 6.1). Waste spoil disposal is larger for alternatives with a lower levee height because less material can be incorporated into the new

Table 6.1 Soil Quantities (bank cubic yards)

Item, or Disposal location	Alt. A	Alt. A+4ft (recommended plan)	Alt. K	Alt. K+4ft	Alt. A with RM-108 Setback	Alt. A+4ft with RM-108 Setback	Alt. K with RM-108 Setback	Alt. K+4ft with RM-108 Setback
Excavated from spoil bank	5,044,508	5,233,730	5,143,757	5,332,979	4,942,375	5,114,648	5,041,622	5,213,897
Excavated from eastside overbank	152,650	152,650	152,650	152,650	152,650	152,650	152,650	152,650
Used as random fill in new levee	890,949	2,176,901	916,507	2,333,123	904,523	2,200,239	930,080	2,356,461
Used in riprap toe protection (screened oversized waste)	71,277	174,152	73,321	186,650	72,362	176,020	74,405	188,518
Borrow	0	0	0	0	0	0	0	0
Disposal total [a] (% of excavation total)	4,234,933 (81.5%)	3,035,328 (56.4%)	4,306,580 (81.3%)	2,965,856 (54.1%)	4,118,140 (80.8%)	2,891,040 (54.9%)	4,189,787 (80.7%)	2,821,568 (52.6%)
Disposal quantities by location:								
Levee waste fill	381,124	656,313	377,907	650,306	360,026	608,842	356,809	602,836
Tiffany Basin	3,853,809 (2,389 ac-ft) (478 acres)	2,379,016 (1,475 ac-ft) (300 acres)	3,928,673 (2,435 ac-ft) (487 acres)	2,315,551 (1,435 ac-ft) (287 acres)	3,758,113 (2,239 ac-ft) (448 acres)	2,282,197 (1,415 ac-ft) (283 acres)	3,832,979 (2,376 ac-ft) (475 acres)	2,218,733 (1,375 ac-ft) (275 acres)

[a] Excavation – used = disposal.

levee. The lower Base Levee height (Alternatives A and K) requires approximately 1.5 million cubic yards (and 190 acres) of additional soil disposal in the Tiffany Basin when compared to the Base Levee + 4ft height for Alternatives A+4ft and K+4ft. The amount of excess soil which can be spoiled on the land side of the levee also is cut in half for the Base Levee height when compared with the Base Levee + 4 ft height. Alternatives including the realignment at RM-108 would require 12 to 30 acres less for deposition than those with similar design heights.

The spoil deposition area within the Tiffany Basin is currently vegetated by relatively dense stands of salt cedar, which has relative low wildlife habitat value (Hink and Ohmart, 1984; Thompson *et al*. 1994) . The basin lies within the 10%-chance floodplain behind a continuation of the spoil bank, and soil conditions are relatively dry in comparison with the riparian zone adjacent to the river channel. Existing vegetation would be removed prior to deposition of waste spoil material. Spoil would be deposited at an average depth of 5 feet throughout this area, rendering it suitable for upland, rather than riparian, vegetation. (Revegetation of the spoil deposition area is discussed in Section 6.4.2.5.) Should future restoration activities remove the spoil bank along the eastern side of Tiffany Basin, or other introduce river flow into the basin, the spoil deposition area would still be capable of being inundated.

As an alternative to disposal of spoil material in Tiffany Basin, the Corps will seek other locations suitable as disposal sites over the 20-year construction period. Preferably, these would entail already disturbed sites, or commercial sand-and-gravel facilities, closer to the actual construction area. If any alternate disposal site would be utilized, the Corps assures that the disposal areas will be devoid of any significant biological or cultural resources. The use of these areas would decrease the potential area of disturbance at Tiffany Basin, and would reduce the project cost.

Soil erosion resulting from construction activities could occur depending on the surface soil textures, the degree of windiness, and the amount of precipitation that occurs during and after excavation activities. However, construction and excavation specifications, and a Storm Water Pollution Prevention Plan required by New Mexico's general NPDES permit, would be developed to protect water quality from deteriorating as the result of erosion in areas affected by construction activities. For all the alternatives evaluated, almost all of the previously disturbed soils in the existing spoil bank would be reused in the construction of a new levee, or disposed of either in the Tiffany Basin disposal area, or along the landside of the levee where possible. These soils would be compacted to a greater density in order to withstand the erosive forces of runoff.

The additional size of a new levee in some areas would likely cause consolidation of the underlying material due to the additional weight of the levee materials on the foundation soils beneath the levee. Because the new levee would be smaller than the existing spoil bank along most of the alignment, consolidation and settlement of the foundation is anticipated to be minimal for the project. Areas where the new levee height is greater than the spoil bank will be evaluated for potential consolidation or settlement issues by analysis of the boring logs at those locations. The levee section would be overbuilt at locations where consolidation or settlement is deemed an issue by further analysis.

Seepage through the levee structure would be mitigated by the 2-foot-wide impervious core, or bentonite slurry trench, which would extend from 2 feet below the levee embankment crest to 5 feet into the foundation material of the proposed levee. Bentonite material would be purchased from a commercial source outside the study area.

6.2.3 Hydrology and Hydraulics

The hydrology and hydraulics of the Middle Rio Grande valley are a highly modified, controlled system, governed by water management activities and facilities. Present water management includes flood and sediment control dams and reservoirs, irrigation storage reservoirs, channel maintenance, irrigation diversions, drainage systems, and runoff conveyance systems. It is not anticipated there would be any major changes to these management activities and features as a direct result of the implementation of any of the considered plans.

The hydrology of the study area would not change solely as a result of any of the levee alternatives because they do not detain flood flows. Thus, the discharge-frequency characteristics of the basin would remain as they are. However, construction of a new levee would significantly reduce the flood risk that currently exists with the earthen spoil bank.

During large floods (greater than 11,800 cfs at the SADD) with existing conditions it is probable that the existing spoil bank would breach, allowing a large volume of water to leave the floodway. Due to the perched floodway condition that exists in much of the study area, these flows would not return to the floodway. The perched channel condition begins at approximately the City of Socorro and increases in the downstream direction. (Potential economic and ecological effects of the without-project condition are discussed in Chapter 3.)

As a direct result of levee construction, Alternatives A+4ft and K+4ft would provide flood protection equivalent to capturing the 1%-chance flood approximately 99% of the time for the base year, and protection from scour damage and sediment deposition would accrue to approximately 20,000 acres in the floodplain containing residential, business, and public properties; irrigated lands, improvements, distribution systems, and products; transportation facilities; utilities; the LFCC; drainage facilities; and the Bosque del Apache NWR. Alternatives A and K would provide a lower level of protection, capturing the 1%-chance event approximately 50% of the time for the base year. For Alternatives K and K+4ft, extending the levee along the east side of Tiffany Basin would provide protection for approximately 3,100 additional acres of floodplain area, as seen in Table 6.2, below.

Table 6.2 Approximate With- and Without-Project Floodplain Inundation Area (acres).

Alternative	**10%-chance-event floodplain**	**1%-chance-event floodplain**	**0.2%-chance-event floodplain**
Future condition, Without project	36,200	38,800	41,500
Alts. A and A+4ft	18,300[a]	20,200[a]	21,200[a]
Alts. K and K+4ft	15,200[a]	17,100[a]	18,100[a]

[a] The RM-108 setback alternative would increase these values by approx. 80 acres.

All of the evaluated construction alternatives would confine large flood flows to the floodway, thereby slightly increasing the stage and velocity within the floodway when compared to existing conditions. For the 1%-chance flood, depth in the floodway would average approximately 3 feet, reaching up to 10 feet in some low-lying areas. Average velocities within the floodway would remain relatively low at approximately 1 foot per second. Additional discussion of the potential, indirect effects of altered water depth and velocity are discussed in Section 6.5.1, Rio Grande Silvery Minnow.

A closure structure at Brown Arroyo (included in all levee alternatives) would prevent Rio Grande flows from backing up into Brown Arroyo. Currently, higher river stages inundate the confluence and lower portion of Brown Arroyo. For example, a 10%-chance flood on the Rio Grande would back into the arroyo approximately 3,000 ft along the arroyo channel, inundating approximately 12 acres within the arroyo, of which approximately 6 acres is a sedimentation basin. The proposed closure gate would not alter the bed elevation at the inlet, thus allowing similar inundation to occur after its installation.

6.2.3.1 *River Geomorphology and Sedimentation*

Generally, river geomorphology within the study area would not change solely as a result of the recommended plan or any of the considered alternatives. As discussed in Chapters 2 and 3, the geomorphology in this reach is mostly dependent on the smaller, more frequent discharges and their flow characteristics. These flow characteristics are not anticipated to change from the existing condition under any of the alternatives evaluated.

Larger, less frequent floods, ranging in size from greater than the 10%-chance flood up to the 1%-chance flood, would be contained within the floodway by all alternatives. Under existing conditions these large floods have the potential to erode the banks of the river channel, and to scour vegetation within the floodway. This potential, and the extent of, scouring would continue after the construction of any of the levee alternatives evaluated.

6.2.4 Water Quality

The construction of a new levee would not substantively affect sediment transport in the Rio Grande. While there would be localized changes in sediment transport characteristics in the Rio Grande compared with pre-project conditions, there would not be any significant increase in sedimentation in the floodway or within Elephant Butte Reservoir. The floodway would essentially function in the same manner with or without the project during normal flow conditions typical of most of the year. Therefore, the perceived impacts would be small. The short duration of major flood events transports insignificant amounts of sediment compared with normal floods of long duration, which are the prime conveyors of sediment.Water Quality

Construction of the San Acacia to Bosque del Apache Project was authorized by Congress in 1948. In 1993, a Record of Decision was signed for the 1992 SEIS and both documents were submitted to Congress. An appendix of the 1992 SEIS included an evaluation of effects and a Finding of Compliance relative to Section 404(b)(1) of the Clean Water Act; therefore, meeting the requirements for an exemption under §1344(r) of the Act. This exemption is not being sought for the construction of the revised proposed action that is recommended in this GRR/SEIS-II.

Corps of Engineers projects proposing the discharge of dredged or fill material into waters of the United States are developed in accordance with guidelines promulgated by the Administrator of the Environmental Protection Agency in conjunction with the Secretary of the Army under the authority of Section 404(b)(1) of the Clean Water Act. Appendix B of this GRR/SEIS-II includes a detailed Section 404(b)(1) guidelines evaluation and a finding of compliance with the requirements of the Clean Water Act. Section 401 Water Quality Certification has been obtained from the New Mexico Environment Department (see Appendix B), and conditions of the permit will be incorporated into pertinent construction contract specifications.

For alternatives brought forward for analysis of effects, construction activities associated with any of the earthen levee alternatives would not significantly affect water or sediment quality in the Rio Grande because the majority of the construction activity would not involve direct contact with water in the Rio Grande or in the LFCC. Further, construction specifications, such as those listed below, would be designed to protect surface water quality. Disturbance of native habitat adjacent to the project area would be avoided except where removal of vegetation within the levee footprint and vegetation management zone is required. Fouling or polluting of water would not be permitted. Wash waters and wastes would be processed, filtered, or otherwise treated prior to evaporation or removal from the area.

Some of the activities associated with project features other than the earthen levee would take place in or near the Rio Grande, and, therefore, would present opportunities for water quality degradation if precautions are not taken. The following impacts are anticipated as a result of these activities.

During excavation of the east bank near the SADD, the existing river bankline would be maintained until all other excavation is completed to minimize the potential for erosion into the river. A temporary river crossing would be installed to access the east bank from the maintenance road on the west bank. The crossing would be constructed on one-half of the river at a time and place culverts so that a constant river flow is maintained. The temporary river crossing to access the eastside overbank area would require the placement of six 60-inch-diameter, 30-foot-long corrugated metal conduits and approximately 1,000 CY of random fill. Standard and specific best management practices (listed below) would be followed during dewatering, and placement / removal of temporary fill.

Construction activities in or immediately adjacent the Rio Grande channel would be scheduled during low-flow conditions and no impoundment of water would occur. The construction and removal of the temporary crossing as well as the east bankline may create a minor and temporary increase in turbidity. No significant surface water, ground water, or sediment quality impacts would likely result from any of these construction activities.

The following paragraphs summarize potential impacts from the placement of fill into waters of the United States. No wetlands, as defined in Section 404(b)(1) of the Clean Water Act, have been identified within the affected area of any of the construction alternatives. Details regarding the proposed plan can be found in Appendix B to this GRR/SEIS-II. All quantities apply to areas where work would be performed below the ordinary high water mark (OHWM). All work in areas below the OHWM would be performed only during the annual low-flow period. Placement of all fill material would be onto non-inundated substrates. For all levee alternatives, all waste spoil material would be disposed at sites above the OHWM.

Considering only those areas where levee construction would be below the OHWM, approximately 9.5 acres of the current open floodway area would be filled by earthen levee material, soil-cement embankment, and the Brown Arroyo closure gate in Alternatives A+4ft or K+4ft; however, about 15.4 acres of floodway area would be gained due to removal of the old spoil bank and by channel excavation along the east bank. Therefore, within the area of below the OWHM, these levee alternatives would result in a net gain of approximately 5.9 acres.

For the smaller levee Alternatives A and K, approximately 1.4 acres would be filled by the construction of similar project features, and 42.33 acres would be newly exposed, resulting in a net increase in area below the OHWM of 40.9 acres.

The inclusion of the RM-108 setback alternative would not alter the affected area of waters of the United States.

Riprap placement along the toe of the new levee below the OHWM would occur on 2.5 miles of the riverside toe under all of the alternatives, and would require approximately 13,376 cubic yards (cy; 16.3 acre-feet) of basalt. The area of riprap placement below the OHWM would entail approximately 2.1 acres. At all locations, the majority of the riprap volume would be buried below the substrate. All excavation and placement of buried riprap would only be performed during lower river flows, when the substrate in not inundated.

Considering the relatively minor net effects described above, none of the levee construction alternatives would adversely affect water quality and waters of the United States.

Finally, the 1972 amendments to the Clean Water Act prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by a National Pollution Discharge Elimination System (NPDES) permit. Storm water runoff from construction activities, including clearing, grading, and excavating, disturbing more than one acre of total land area, require preparation of a Storm Water Pollution Prevention Plan (SWPPP) in accordance with the EPA Construction General Permit. Six major phases of the NPDES/SWPPP process are: (1) site evaluation and design development; (2) assessment; (3) control selection and plan design; (4) certification and notification; (5) construction / implementation; and (6) final stabilization/ termination. Best management practices would be developed in the SWPPP and implemented to eliminate/reduce pollutants to include the following: good housekeeping; performing preventive maintenance; maintaining visual inspections; prevention and response to spills; sediment and erosion control; managing runoff; training personnel, keeping records, and reporting; and any other activity-specific and site-specific storm water best management practices that apply.

The following are construction specifications, best management practices, and stipulations typically associated with Section 404 permits and Section 401 water quality certifications that would be complied with during construction of any of the levee alternatives to protect water resources from degradation:

1. Stream flow would be maintained at all times during construction and the streambed contoured so that fish can migrate through the project area during and after construction.

2. Silt curtains, cofferdams, dikes, wattles, straw bales and other suitable erosion control measures would be employed to prevent sediment-laden runoff or contaminants from entering the watercourse.

3. Work would be performed below the elevation of the ordinary high water mark only during low-flow periods. Flowing water must be temporarily diverted around the work area, but remain within the existing channel to minimize erosion and turbidity and to provide for aquatic life movement. Diversion structures must be non-erodible, such as sand bags, water bladders, concrete barriers, or channel lined with geotextile or plastic sheeting. Dirt cofferdams are not acceptable diversion structures.

4. All asphalt, concrete, drilling fluids and muds, and other construction materials will be properly handled and contained to prevent releases to surface water. Poured concrete will be fully contained in mortar-tight forms and/or will be placed behind non-erodible cofferdams to prevent discharge contact with surface or groundwater. Wastewater from concrete batching, vehicle washdown, and aggregate processing would be contained, and treated or removed for off-site disposal. Dumping of any waste material in or near watercourses is prohibited.

5. Fuel, oil, lubricants, hydraulic fluids and other petrochemicals would be stored westward of the LFCC and at least 100 feet from surface water (including ditches, drains, and the LFCC). The fuel storage facility must have a secondary containment system capable of containing twice the volume of the product. Appropriate spill clean-up materials such as booms and absorbent pads must be available on-site at all times during construction.

   Fueling of wheeled construction vehicles would not be permitted in the construction area or near the LFCC. Only tracked vehicles may be fueled within the construction area via a fuel tender with a maximum fuel capacity of 500 gallons, thereby minimizing the consequences of any accidental spill. Refueling of all vehicles and equipment must be performed at least 100 feet from surface water.

6. All heavy equipment used in the project area must be pressure washed and/or steam cleaned before the start of the project, and again just before leaving the project area. All heavy equipment will be inspected daily for leaks. A written log of inspections and maintenance must be completed and maintained throughout the project period. Leaking equipment must not be used in or near surface water. Any petroleum or chemical spills would be contained and removed, including any contaminated soil.

7. Only uncontaminated earth or crushed rock would be used for backfills, and for the temporary river crossing.

8. Water quality would be monitored during bankline and in-channel construction to ensure compliance with State water quality standards for turbidity, pH, temperature, and dissolved solids.

9. Excavated trenches must be backfilled and compacted to match the bulk density and elevation of the adjacent undisturbed soil.

10. The temporary river crossing would be located perpendicular to and at a narrow point of the channel to minimize disturbance. Heavy equipment must be operated from the bank or work platforms and not enter surface water. Heavy equipment must not be parked within the stream channel.

11. All disturbed areas that are not otherwise physically protected from erosion will be reseeded or planted with native vegetation.

12. A copy of the water quality certification must be kept at the project site during all phases of construction. All contractors involved in the project must be provided a copy of the certification and made aware of the conditions prior to starting construction.

Executive Order 11990, Protection of Wetlands, requires all Federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. Wetlands are defined as areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Given the design considerations and construction best management practices discussed above, construction of any of the levee alternatives would conform to Executive Order 11990.

6.2.5 Air Quality and Noise

No significant short- or long-term deterioration of air quality is anticipated to result from construction of any of the levee construction alternatives. Protection provisions, as summarized below, would be included in all construction contracts and would be consistent with Federal, State, and county regulations.

Construction equipment would intermittently increase the concentrations of CO, NO_x, SO_2, particulates because they are the primary exhaust products from diesel engines. Dust from excavation and vehicle movement during construction would temporarily increase the concentration of airborne particulate matter locally. These short-term CO, NO_x, SO_2, and particulate emissions have been generously calculated to total approximately 48, 118, 11, and 10 tons, respectively. Because construction would be implemented in phases over 10 to 14 years, the annual emissions of these pollutants would be equal to or less than 4.8, 11.8, 1.1, and 1.0, respectively. Because the proposed project area lies within attainment areas for criteria pollutants, the General Conformity Rule does not apply. However, it is worth noting that even if the proposed project area was located in a non-attainment or maintenance area for any criteria pollutants, according to EPA and State standards, annual estimated emissions for these contaminants as a result of proposed construction activities would be defined as *de minimus* for all alternatives evaluated.

Excavations, embankments, stockpiles, haul roads, access roads, staging areas, borrow areas, and all other work areas within or outside of project boundaries would be required to be maintained to prevent hazardous or nuisance airborne particulate matter. Sprinkling water or other approved temporary dust suppression methods, such as chemical treatment, light bituminous treatment, or similar methods, would be used to control dust. Sprinkling, if permitted, would be repeated at such intervals as to keep all parts of the disturbed area at least damp at all times. Dust control would be performed as work proceeds and whenever a dust nuisance or hazard occurs. Required permits for construction and associated clearing and grubbing activities would be obtained. Burning is prohibited at or near the proposed project site.

No significant short- or long-term deterioration of sound quality is anticipated as a result of the proposed project or the alternative levee construction plans. There would be an increase in noise levels in the immediate vicinity of construction activities due to operation of heavy machinery. Because of the low wavelength frequency of diesel engines, the sound level should not be excessive, and, therefore, would not be obtrusive along much of the proposed project corridor. Precautions as stated in Section 6.5.2 would be taken to minimize possible direct noise disturbances to Southwestern Willow Flycatchers during critical times.

6.3 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE ENVIRONMENT*

A Phase 1 Environmental Site Assessment for San Acacia to Bosque del Apache Flood Control Project was completed 1 September 2005. No significant changes have occurred to the proposed project area and there is no evidence of apparent contamination. Therefore, neither the proposed actions nor any of the alternatives considered would affect or exacerbate any HTRW environments.

6.4 BIOLOGICAL ENVIRONMENT*

6.4.1 Aquatic Habitat and Inundated Floodway

6.4.1.1 *Changes Due Altered Floodplain Inundation*

(a) 1%-Chance-Event Floodplain

The existing spoil bank has been estimated to fail at discharges in the range of the 20%-chance flood event (11,800 cfs) at San Acacia. Currently, spoil bank failure would result in inundation both within the current floodway and throughout the floodplain west of the LFCC. A breached or damaged spoil bank would be quickly repaired or rebuilt along the existing alignment by the Bureau of Reclamation.

Without the proposed project, damages to ecological resources from the 1%-chance flood event (29,900 cfs at San Acacia) are expected to occur both within the current floodway and throughout the floodplain west of the spoil bank. The estimated inundated area of the 1%-chance flood totals approximately 38,800 acres (see Table 6.2). Affected plant communities in the floodplain west of the spoil bank include: rural and suburban yards; agricultural fields and edges; upland Chihuahuan desertscrub; and wetland and riparian communities managed at Bosque del Apache NWR. These plant communities may be subjected to prolonged inundation, substrate scouring, or extensive sediment deposition. Additional stress may result from extended inundation, depending on the tolerance of plant species within each community.

Although periodic floodplain inundation outside of the existing floodway has the potential for providing allocthonous material to the Rio Grande, historic and existing land uses west of the spoil bank alignment also present potential threats to water quality. Following a spoil bank breach, floodwaters would likely be of lower quality and could result in the introduction of potential contaminants (sewage, petroleum products) to the river, and, therefore, may not be considered beneficial to aquatic habitat and organisms.

For Alternatives A and A+4ft, all flow for the 1%-chance event would be contained within the current floodway, and is estimated to inundate approximately 20,200 acres. The potential for flooding, and concomitant ecological damages, would be eliminated from approximately 18,600 acres of the floodplain west of the spoil bank alignment.

Within the floodway, however, indirect but potentially adverse impacts to riparian and aquatic communities would still occur following levee construction. Currently, the 1%-chance flood event has the potential to scour the substrate and remove, or otherwise damage, vegetation within the Rio Grande floodway. This dynamic process is inherent in sand-bed river systems in the Southwestern U.S., and one to which riparian vegetation is adapted. Periodic bankline scouring is essential for maintaining a mosaic of riparian vegetation patches of varying ages. After construction of Alternatives A or A+4ft in the study area, the water surface elevation of the 1%-chance event would increase in the Rio Grande floodway by approximately 2.5 feet near Escondida to nearly 5 feet near Tiffany Junction. Water depths would decrease downstream from there, largely due to transient storage afforded by the 2,000-acre Tiffany Basin and areas of Elephant Butte Reservoir outside of the active floodway.

Because of the rarity of the 1%-chance event, quantitative data on ecological impacts are not available for the Southwestern United States. Potential impacts likely include the physical destruction of vegetation from high flow velocities, substrate scouring, and/or sediment deposition; the temporary displacement of both terrestrial and aquatic animals; and the death (primarily through drowning) of animals that cannot escape floodwaters. Qualitatively, we believe that these indirect ecological effects within the floodway following construction of any of the levee alternatives would be as extensive as and similar to the without-project condition. Although inundation, scouring and sediment accretion are natural processes of sand-bed rivers such as the Rio Grande, the recovery of plant and animal communities following the 1%-chance flood would occur over five to ten years depending on subsequent weather and hydrologic conditions. Scouring within the river channel would maintain dynamic aquatic habitat patches for fish and other aquatic organisms. .

(b) 10%-Chance Event Floodplain

The more probable 10%-chance flood event (approximately 15,400 cfs at San Acacia) also is expected to result in spoil bank failure and extensive inundation—about 36,200 acres—of the valley west of the LFCC (see Table 6.2). Because spring runoff floods would be regulated by upstream reservoirs, this event would most likely result from rainstorm activity downstream from Cochiti Dam, and, therefore, would be of short duration. Therefore, resultant ecological effects from scouring, deposition, and inundation would be significantly less than for the 1%-chance event. The resulting mosaic of habitat patches would provide aquatic and terrestrial habitat.

After construction of Alternatives A or A+4ft, the 10%-chance event would be contained to about 18,200 acres of the floodway. The with- versus without-project differential in depths and velocities of the 10%-chance events are nominal; therefore, the potential for, and extent of, adverse effects would be similarly small. The magnitude of the event is within the range of unregulated snowmelt and thunderstorm flows recorded in the Middle Rio Grande over the past 100 years, and is well within the flow regime to which native riparian species (cottonwood, willow) have adapted.

(c) Tiffany East Levee (Alternatives. K and K+4ft)

Under Alternatives K and K+4ft, the additional, 4-mile-long Tiffany East levee section would replace the existing spoil bank bordering the floodway. A competent levee here would prevent inundation of land, the railroad track, and the LFCC from Tiffany Junction south to the San Marcial Railroad Bridge, approximately 3,100 acres. Without replacement of this spoil bank, the water surface elevation of the 1%-chance event in this area would to decrease due to the transient storage afforded by those 3,100 acres. If replaced by a new levee, flood flows would be restricted to the floodway, and depths and velocities would remain high until flow reached the railroad bridge at the downstream end of the new levee.

Currently, the Tiffany spoil bank would fail at the 10%-chance flow event (and, perhaps, at a lower discharge). Therefore, vegetation within the Tiffany Basin—primarily salt cedar, with scattered stands of Goodding and coyote willow—is considered to be within the 10%-chance floodplain. The periodic failure of the spoil bank would trap sediment, water, and fish within the depression of the Tiffany Basin. Replacement of the spoil bank with a new Tiffany East levee would preclude inundation of vegetation within approximately 2,000 acres of the Tiffany Basin.

6.4.1.2 *Changes in Floodway Area Due to Feature Footprint*

To determine the potential change in floodway area under the different alternatives, the footprints of project features—including the basal extents of the both the Base Levee and the Base Levee + 4ft—were measured on geo-referenced aerial photography from 2010. This was reviewed to estimate the potential changes to the floodway area due to increased fill (earthen levee or soil cement) or removal of spoil bank material. (The direct effects to existing vegetation within the footprints of proposed features are discussed in Section 6.4.2 below.)

(a) Effects Common to All Alternatives

Immediately downstream from the SADD, a soil cement embankment would be installed along the western terrace of the river for approximately 1.08 miles. Approximately two-thirds of the embankment would lie within Sevilleta NWR. The foot of this embankment would fill approximately 2.0 acres of the current floodway. On the eastern bank of the river in the same reach, excavation of the terrace would add 3.1 acres to the floodway area, including the active channel. Therefore, the net change to floodway area along the first 1.1 miles of the project would be an increase of 1.1 acres.

For all levee alternatives, Corps' biologists have proposed refinements to the design of the vegetation-free zone to reduce flow along the levee to reduce erosion while providing slackwater habitat for the silvery minnow. Specifically, the surface of the vegetation-free strip would gradually undulate (rising 2 vertical feet every 200 linear feet) to decrease velocities along the toe when inundated by regulated flows. These slackwater areas would be sloped to drain away from the levee to facilitate silvery minnow (all age classes) movement back toward the main river channel. The principle alteration to floodplain flow patterns would be reducing the tendency for erosion adjacent to the levee that creates channels and pools that may be isolated as the river recedes.

(b) Alternative A+4ft Levee

From the northern end of the proposed earthen levee to Bosque del Apache NWR (approximately 28 miles), the base width of the proposed A+4ft levee would be equal to or less than that of the existing spoil bank (by an average difference of about 25 ft; range 0-80 ft). Therefore, following construction, upstream from Bosque del Apache NWR, the area of the floodway would increase by a net amount of 82.3 acres primarily due to the smaller footprint of the proposed earthen levee (Table 6.3).

Through Bosque del Apache NWR, the footprint of the proposed levee would encroach on an additional 8.7 acres of the current floodway. Due to variation in the alignment of the existing spoil bank, the proposed levee would occasionally fall landward of the existing riverward toe, resulting in a minor gain of about 0.6 acres. Therefore, throughout Bosque del Apache NWR, the proposed levee would result in a net loss of 8.1 acres of the floodway.

Within the 1.5-mile reach immediately downstream from Bosque del Apache NWR, the riverward toe of the A+4ft levee would remain to the west (landward) of the existing spoil bank toe. This would result in a small gain of about 0.8 acres to the floodway area.

Table 6.3 summarizes the expected changes to the existing floodway and 10%-chance floodplain areas. Throughout the entire length of the proposed levee, the net change to floodway area as a result of levee construction would be a gain of approximately 74.9 acres. Considering this net gain in active floodway area, and the distance that the levee alignment is set back from the channel, construction of the levee along the proposed alignment would have no direct effect on aquatic habitat within the study area.

(c) Alternative A Levee

The footprint of the smaller Alternative A levee would be equal to or smaller than that of the existing spoil bank throughout the most project area. The Base Levee structure would encroach on the floodway only along a 1.1-mile reach within BDANWR, entailing 0.9 acres. Over the 41 miles where it parallels the active channel, the Alternative A levee would increase the floodway area by approximately 199 acres. The structure would also increase the area of the 10%-chance floodplain within Tiffany Basin by 2 acres.

Table 6.3 Net Change in Floodway and 10%-Chance Floodplain Area from Construction of Levee Alternatives.

Reach	Reach length (mi.)	Alternatives A+4ft and K+4ft		Alternatives A and K	
		Net change area (ac.)	Type	Net change in area (ac.)	Type
Start to BDANWR[a]	28.3	+82.3	Floodway	+175.4	Floodway
BDANWR	11.3	-8.1	Floodway	+25.7	Floodway
BDANWR to 2133+00	1.5	+0.8	Floodway	+5.2	Floodway
Net change in floodway	*41.1*	*+74.9*		*+205.4*	
Sta. 2133+00 to RR track (north end of Tiffany Basin)	1.1	-1.2	10%-chance floodplain	+2.0	10%-chance floodplain
Total (net)	42.2	+73.7		+207.4	

[a] Values for this reach include consideration of the soil-cement embankment, eastside overbank excavation, and earthen levee.

(d) Alternative K and K+4ft Levees

Under these alternatives, the new levee would continue to parallel the floodway for an additional four miles, beginning at approximately 1.5 downstream from BDANWR. The riverward toe of the new levee would be set at 15 feet west (landward) of existing riparian vegetation. Therefore, the expected change in floodway area for Alternatives K and K+4ft would be similar to that of Alternatives A and A+4ft, respectively.

(e) River Mile 108 Setback

Under this alternative, the LFCC and new levee alignment would be shifted to the west no closer than 250 feet from an existing riverside drain. This 250-foot distance was selected to avoid the removal of a band of dense, healthy cottonwoods between the proposed alignment and the riverside drain to the west. The majority of the vegetation between the existing and proposed alignments consists of sparse and aged cottonwoods with scattered salt cedar shrubs.

Inclusion of the River Mile 108 setback in any of the levee alternatives would allow for the additional inundation of approximately 80 acres within the floodway by flows greater than the 10%-chance flood event. Vegetation composition within the 80-acre area would not be expected to change significantly since inundation would occur infrequently. that is, at flows greater than 11,800 cfs at the SADD. However, some geomorphic changes from river channel meandering may occur in the long term without threatening the levee in its new alignment. The setback would support ecosystem dynamics for creating riverine and riparian habitat over a long period by allowing erosion of the west bankline and development of in-channel bars. The long-term effect would locally increase the area of dynamic aquatic and terrestrial habitats patches.

Currently, the LFCC is the lowest point in the valley's cross-section throughout the study area from Escondida to Elephant Butte Lake. Throughout that reach, groundwater from both east and west of the river, as well as seepage from the river channel itself, drains to the LFCC. There is uncertainty about potential future changes to the shallow groundwater table following the relocation of the LFCC. There is a distinct possibility that shifting the LFCC closer to the band of healthy cottonwoods may lower the water table in the immediate vicinity, therefore adversely affecting the most valuable riparian vegetation in the setback area.

6.4.2 Riparian Vegetation and Wildlife

As described in Chapter 2, several studies in the various plant communities within the floodway of the Middle Rio Grande valley have documented their use and relative value to wildlife. Many of these studies (Hoffman, 1990; Thompson *et al.*, 1994; HAI 2010) have used a common riparian vegetation classification system (from Hink and Ohmart, 1984) and have documented the utilization of various floristic/structural communities for birds (see Table 1 in Appendix F-4 of this GRR/SEIS-II) and, to a lesser extent, small mammals. These relationships form the basis for determining the relative impacts of project alternatives on wildlife given the extent and type of affected plant communities. The footprints of project features—including the basal extents of the both the Base Levee and the Base Levee + 4ft—were superimposed on geo-referenced aerial photography from 2010 and on riparian vegetation coverage mapped in 2007 (Parametrix, 2008). This was reviewed to estimate potential changes to vegetation types due to the project features.

6.4.2.1 *Habitat Effects Common to All Alternatives*

Along the base of the 1.08-mile soil-cement embankment, vegetation would be temporarily removed from a 20-foot wide strip immediately landward of its base to allow for construction access. Coyote willow and seep-willow occur throughout nearly half of this 1.8-acre area, and the remainder consists of salt cedar. Approximately two-thirds of the affected area lies within the Sevilleta NWR.

The east bank excavation will lower 12.4 acres of the upland terrace to reduce the potential velocity and erosive capability of the 1%-chance flood event. The excavated area is entirely within the Sevilleta NWR and is currently vegetated by salt cedar of varying density, and a 0.8-acre stand of sparse coyote willow near the bank. Following excavation, 3.1 acres of the area will be sufficiently lowered to become part of the Rio Grande channel (*i.e.*, will lie below the water surface elevation of the 50%-chance discharge), and the 9.27 acres will remain suitable for upland vegetation.

(For convenience, the effects of the various alternatives on vegetation within the Tiffany Basin is discussed in Section 6.2.2, Geology and Soils.)

6.4.2.2 *Habitat Effects from New Levee Footprint*

Where the footprint of the proposed, Alternative A+4ft levee extends beyond the riverward toe of the existing spoil bank, riparian vegetation within the floodway would be permanently removed. This would directly affect 8.7 acres n BDANWR. Of these 8.7 acres, 8.6 acres are dominated by salt cedar (Table 6.4). Some of this vegetation is within currently (2012) occupied

Southwestern Willow Flycatcher breeding territories (discussed in Section 6.5.2). Along the levee alignment on the north end of Tiffany Basin, less than 0.1 acre of vegetation would be directly affected by removal, all of which consists of grasses or short salt cedar.

The footprint of the Alternative A levee would encroach on approximately 0.9 acres of existing riparian vegetation within the floodway. All of this vegetation consists of salt cedar.

Table 6.4 Summary of Vegetation Effects Due to Levee Construction Alternatives.

	Alt. A+4ft Levee			**Alt. A Levee**		
Reach	**Vegetation removed due to levee footprint (ac.)**	**Vegetation altered in Vegetation-free Zone (ac.)**	**Total**	**Vegetation removed due to levee footprint (ac.)**	**Vegetation altered in Vegetation-free Zone (ac.)**	**Total**
Start to BDANWR	0.0	4.9	4.9	0.0	0.0	0.0
BDANWR	8.7	21.6	30.3	0.9	3.4	4.3
BDANWR to Sta. 2133+00	0.0	1.0	1.0	0.0	0.0	0.0
Subtotal for floodway	8.7	27.5	36.2	0.9	3.4	*4.3*
Native-dominated	*<1%*	*10.2%*	*7.9%*	*0%*	*<1%*	*<1%*
Mixed	*0%*	*13.5%*	*10.2%*	*0%*	*1.2%*	*<1%*
Non-native-dominated	*99.0%*	*71.9%*	*78.6%*	*100%*	*98.0%*	*98.4%*
Herbaceous / bare	*<1%*	*4.5%*	*3.3%*	*0%*	*<1%*	*<1%*
Sta. 2133+00 to RR track (10%-chance floodplain in Tiffany Basin)	1.4	1.9	3.3	< 0.1	0.5	0.5
Total	10.1	29.4	39.5	0.9	3.9	4.8

The effects under levee Alternatives K and K+4ft differ only from Alternative A and A+4ft in their impact on vegetation within the 10%-chance floodplain in Tiffany Basin. The riverward toe along this reach would be aligned to be 15 feet landward of the existing spoil bank, assuring that additional riparian vegetation within the floodway would not be adversely affected. On the landward side of the new levee, approximately 10.0 or 11.6 acres of vegetation (primarily salt cedar) within the 10%-chance floodplain of the Tiffany Basin would be displaced by the footprints of the Alternative K or K+4ft levees, respectively.

6.4.2.3 *Changes Due to the Vegetation-Free Zone*

The Corps' Engineer Technical Letter 1110-2-571 (10 April 2009) requires that no woody vegetation be allowed to grow on the levee or within 15 feet of either toe of the levee. This prevents root penetration into the levee that can compromise its structural integrity, and it allows for unobstructed visual inspections on a periodic basis. Although this area is referred to as the "Vegetation-free Zone," the term is somewhat a misnomer because grasses are allowed to grow within this zone: only woody plant species are restricted.

During construction, existing vegetation would be removed to accommodate the levee and the Vegetation-free Zone adjacent to the riverward toe. Vegetation removal in preparation of construction would include the removal of the above-ground stems, root crowns and roots greater than 0.5-inch in diameter. Removal methods may include clearing and grubbing, scraping, or root-plowing and raking. Following construction, a 15-foot-wide zone along the riverward toe of the levee would be permanently maintained to be devoid of trees and shrubs through periodic mowing.

Vegetation removal and clearing-and-grubbing activities for the Vegetation-free Zone—and for all proposed construction—would only occur between August 15 and April 15 to avoid disturbance of nesting migratory birds. Vegetation removal outside of that period would only be performed after a survey by a biologist confirms that disturbance to nesting migratory bird species would be avoided.

For the proposed, Alternative A+4ft levee, a total of 27.5 acres of existing riparian vegetation would be removed to establish the Vegetation-free Zone. The majority of that affected acreage (21.6 ac.) would occur within BDANWR where the proposed levee is wider than the existing spoil bank. Most (72%) of the riparian vegetation to be removed is dominated by salt cedar; 10% is principally native woody species, and about 14% is a mixture of native and non-native species. Along the 1.3-mile portion of this levee at the downstream end, about 2 acres of sparse salt cedar would be removed within the Tiffany Basin.

Because the Alternative A levee is 20 to 24 feet narrower than the proposed levee, most the Vegetation-free Zone can be accommodated in the area exposed after removal of the existing spoil bank. A total of 3.4 acres of salt cedar would be removed from the riparian zone (again, all within BDANWR). At the southern terminus, 0.5 acres sparse salt cedar would be removed.

For Alternatives K and K+4ft, an engineered levee would replace the existing spoil bank between Tiffany Basin and the active Rio Grande floodway along an additional 4 miles of the project reach. The riverward toe along this reach would be aligned to be 15 feet landward of the existing spoil bank, creating the requisite Vegetation-free Zone in the space formerly occupied by the spoil bank. For both alternatives, a Vegetation-free Zone would be required on the landward side of this levee segment; therefore, herbaceous vegetation would replace about 7.5 acres of riparian shrubs (primarily salt cedar) currently in the 10%-chance floodplain within the Tiffany Basin.

For the RM-108 setback alternative, a Vegetation-free Zone would be created when the levee alignment is shifted to the west, away from the current riparian zone. This would reduce the potential loss of 0.6 acres of riparian vegetation if the RM-108 setback is included in the Alternative A, A+4ft, K, or K+4ft levees.

6.4.2.4 *Mitigative Vegetation Establishment*

This section summarizes the mitigation plan for the proposed Alternative A+4ft levee, which is detailed in Appendix F-4 of this GRR/SEIS-II. The mitigation plan includes requirements in the Programmatic Biological Opinion (USFWS 2013b; see Appendix C of this GRR/SEIS-II) for the project.

The Corps' Planning Guidance Notebook (ER 1105-2-100) describes the process and content of mitigation plans to be included in feasibility-level reports. This mitigation plan also conforms to the requirements contained in Section 2036 of the Water Resources Development Act of 2007.

(a) Recommended Mitigation Measures

The following are the recommended revegetation measures that would compensate for unavoidable losses of fish and wildlife resources for the proposed plan, including listed species and their designated critical habitat. Revegetation methods are described in detail in Appendix F-4.

Measure B: Willow bank stabilization — In the proposed plan, a 3.1-acre portion of the eastside terrace (vertically) below the Overbank Excavation area would be excavated. Currently, this area is inundated by discharges larger than the 20%-chance event. The area is within the Sevilleta NWR and is currently vegetated by sparse salt cedar and, at the lowest elevation, sparse coyote willow.

After excavation, approximately 2.00 acres would lie below the water surface elevation of the 50%-chance event (which also defines the Ordinary High Water Mark in this reach), and would be part of the active channel of the Rio Grande. The upper 1.08 acres of the excavated area would occupy the zone of inundation of the 20%- to 50%-chance discharges. It is recommended that willows be planted throughout the upper 1.08-acre portion of this area to help stabilize the bank in this degradational reach, and to replace riparian vegetation usable by fish and wildlife. Coyote willow whips would be planted at a density of 300 stems/acre.

Measure S: Riparian shrub planting in the area gained from spoil bank removal — The basal width of the existing spoil bank is frequently wider than that of the proposed levee, especially in the northern (upstream) portion of the reach. A total of 85.75 acres is expected to be exposed following construction, of which approximately 50.61 acres would lie within 15 feet of the riverward levee toe and be managed as part of the Vegetation-free Zone. The remaining 35.14 acres would also require planting to minimize erosion, to minimize colonization by invasive weed species, and to provide wildlife habitat. Approximately 7.66 acres of the area gained after removal of the spoil bank would be suitable to plant with willow whips (300 stems per acre) and rooted stems of other riparian shrub species ("tall-pots", 50 stems per acre).

Measure G: The majority of the area gained after removal of the spoil bank is currently vegetated by salt cedar, and the soil appears too dry to easily revegetate with native riparian shrubs. Therefore, these 27.81 acres would be seeded with appropriate native grass and herbaceous species. Species planted will vary throughout the project area depending on local soil type and moisture. In actively managed areas, species in a given seed mix will be approved by the managing entity (*e.g.*, Bureau of Land Management, Sevilleta NWR, Bosque del Apache NWR).

Measure T: Along the base of the proposed soil cement embankment at the northern end of the project, approximately 1.82 acres of riparian shrubs would be removed to accommodate construction access. This area would be replanted with willow whips (300 stems per acre) and rooted stems of seep-willow (*Baccharis* sp., 50 stems per acre).

Measure D: Riparian shrub and tree planting —Within the reach near the Bosque del Apache NWR, breeding Southwestern Willow Flycatchers currently occupy much of the riparian zone. The footprint of the proposed levee and attendant Vegetation-free Zone would displace approximately 39.3 acres of riparian vegetation consisting primarily of dense saltcedar. Approximately 8.4 acres of the removed vegetation consists of suitable or moderately suitable flycatcher habitat (Ahlers et al. 2010). This measure entails planting 42.74 acres of coyote willow and other shrub species, along with cottonwood and Goodding willow poles to provide no more than 30% tree canopy cover, in order to recreate shrub nesting habitat.

Two alternative locations were analyzed for tree and shrub plantings. Measure D1 entailed planting vegetation within the Rio Grande floodway. Site preparation would require the removal of dense saltcedar. Planted areas would likely be inundated by fairly low discharge rates; however the extent and duration of inundation would vary annually. To assure sufficient root growth to reach the varying depth to the water table in this area, plantings would require supplemental watering (through buried perforated pipes). As described in Appendix F-4, this alternative measure was not considered to be cost effective, and is not recommended for implementation.

Measure D2 entailed the planting of trees and shrubs just west of the LFCC within irrigable portions of the BDANWR. Here, site preparation would be easier and the depth to the water table is more consistent. The capability to irrigate planted areas not only facilitates high survival and growth of planted grass and woody material, but also provides a mechanism for enhancing germination of local, wind-blown tree and shrub seeds, thus increasing the expected stem density. Plant material would include Rio Grande cottonwood and Goodding willow poles planted at 30 per acre, coyote willow whips planted at 300 stems per acre, and tall-pots of other shrub species planted at 100 stems per acre.

(b) Cost Effectiveness / Incremental Cost Analysis

Corps regulations require that mitigation plans be analyzed for cost-effectiveness and incremental benefits expected from contemplated measures. Analysis of cost-effectiveness, in general, compares the relative costs and benefits of alternative plans. The least expensive plan which meets the restoration objective is usually selected. "Incremental cost analysis" is the technique used by the Corps to develop cost-effective mitigation plans. This method is particularly well suited for the analysis of a series of features, each entailing successively greater benefits and costs. Incremental analysis calculates the cost per unit of output gained by each successive feature, allowing the planning team to determine the point of diminishing returns. The final selection of a recommended alternative also may be influenced by non-economic considerations, such as, specific output targets, budget constraints, impacts to other environmental resources, and opportunity costs.

To compare the cost effectiveness of various restoration measures, an environmental output unit is required. An output unit is the quantification of expected improvement in target functions or values, such as increased productivity or habitat suitability. Sufficient long-term monitoring has been conducted in habitats with1in the river corridor of the Middle Rio Grande valley of New Mexico that the relative value of various riparian types is well known for bird communities. Avian densities have been determined for a large variety of riparian communities based on their floristic and structural characteristics. Avian density values were used to determine the abundance of breeding-season birds within a given area of affected habitat types, as well as proposed post-construction plantings. (See Appendix F-4, Section 4.3.3 for detailed information.) Although a common index of bird abundance was used to characterize the value of all habitat types, it should be acknowledged that grassland and shrub habitats support a different suite of bird species, and that each type is necessary to mitigate for unavoidable effects.

The costs of vegetation planting measures were estimated using MCASES Version MII software. All costs include material and installation, weed-control maintenance, success monitoring, contingency, contract supervision and administration, and sponsor operation and maintenance (OMRR&R). All costs were annualized over the expected life of the project and the *average annual cost* served as model input for each measure. Summer bird abundance (also an average annual value) served as the habitat output value in the incremental cost analysis. IWR-Plan software was used to perform cost effectiveness and incremental cost analyses. Results are summarized and Figure 6.1 and Table 6.5.

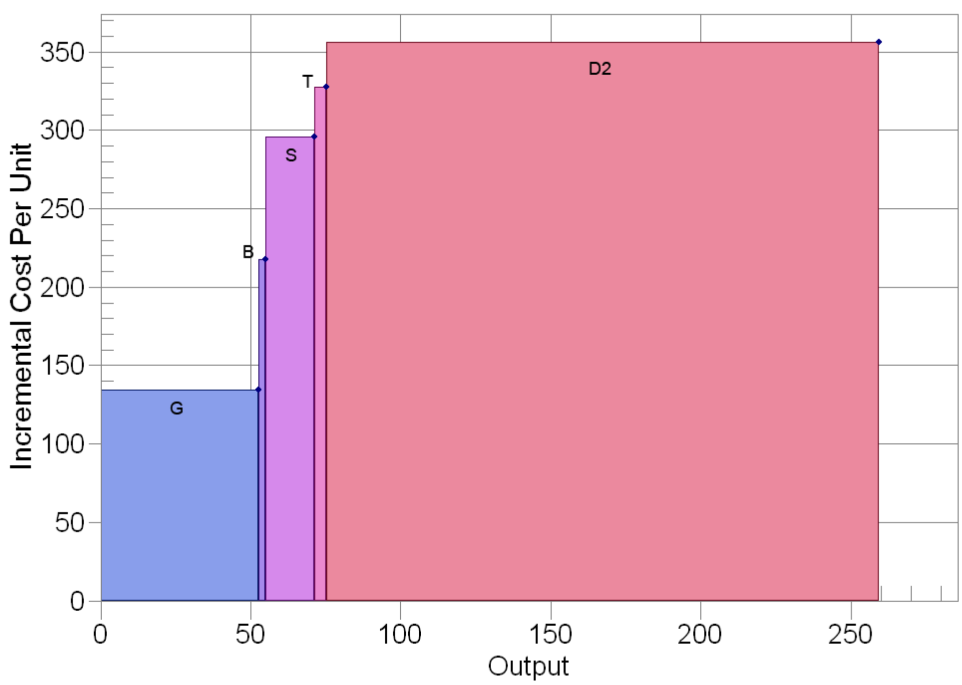

Figure 6.1 Incremental Cost Per Unit of Output (Bird Abundance).

Table 6.5 “Best buy” Plans from Incremental Cost Analysis, Implementation Costs, and OMRR&R Costs.

Code	Measure	Cumulative annual cost	Cumulative bird abundance	Average annual cost	Incremental annual cost	Incremental bird abundance	Incremental cost per bird abundance unit	Implementa-tion cost	Cumulative implementa-tion cost	Operation & maintenance cost
--	No Action Plan	$0	0	$0	$0	0	$0	$0	$0	$0
G	Grass seeding in area gained from spoilbank removal	$7080	52.8	$134	$7,080	52.8	$134	$139,670	$139,670	$33,320
B	Willow bank stabilization (Channel excavation area)	$7581	55.1	$138	$5014	2.3	$218	$9,920	$149,600	$0
S	Shrub planting in area gained from spoilbank removal	$12,404	71.4	$174	$4,823	16.3	$296	$97,290	$246,880	$9,180
T	Replacement of temporarily disturbed riparian shrubs	$13,681	75.3	$182	$1,277	3.9	$327	$25,220	$272,100	$2,180
D2	Riparian shrub and tree planting – landside	$79,435	259.6	$306	$65,664	184.3	$356	$1,049,800	$1,321,890	$283,400
Not cost effective:										
D1	Riparian shrub and tree planting - floodway	--	--	--	$81,622	147.5	$553	$1,418,080	--	--

Incremental cost analysis utilizes the average annual cost of each measure. Implementation costs entail the total dollar expenditure for planting, and monitoring for five years. OMRR&R costs entail the total expenditure for maintenance and monitoring in years 6 through 15 following planting.

The model added measures in ascending order of their incremental cost per unit of output. Measure G entails seeding to establish grass and herbaceous vegetation and had the lowest incremental cost per unit. Measures B, S, and T entail the establishment of shrubs in various portions of the project area, and their incremental cost per unit output increases with successively dense planting prescriptions. All additive solutions shown in Figure 1 and Table 2 were determined to be cost effective and "best buy" solutions. Measures S and D2 together provide the target 50.4 acres of shrub habitat determined to be necessary in the Programmatic Biological Opinion (USFWS 2013b). Therefore, the Corps recommends that all proposed revegetation measures be included in the mitigation plan.

6.4.2.5 *Project Features With Incidental Benefits to Fish and Wildlife Resources*

The following planting activities were included in project features to minimize the potential for post-construction erosion and reduce the potential for colonization by invasive species based on State of New Mexico water quality, air quality, and invasive species regulations. However, the resulting habitats also provide incidental benefits to wildlife (included Table 6.6).

Grass seeding along 77.9 acres of the riverside corridor of the Vegetation-free Zone: The 15-foot-wide corridor along the riverside toe of the proposed levee would be seeded with suitable riparian grass species following the requirements of Engineer Technical Letter (ETL) 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (USACE 2009).

Grass and shrub seeding of the Eastside Overbank Excavation area: Immediately downstream from the San Acacia Diversion Dam, approximately 9.27 acres along the east bank of the river would be excavated to form a terrace that more efficiently conveys the 10%-chance and less frequent events, and lowers velocities of the design event along the western bank in this reach. This area within the Sevilleta NWR would is currently vegetated by relict stands of salt cedar of varying densities. Channel degradation in this reach has been sufficient to remove this area from the immediate riparian zone; that is, the area is above the water surface elevation of the 20%-chance event. Even after the proposed terracing, the growing season water table would likely be sufficiently deep to prevent the establishment of native riparian vegetation. Seeding is proposed to establish upland grasses and shrubs (e.g., four-winged saltbush, with winterfat and Woods' rose) suitable to the sandy substrate.

Grass and shrub seeding at Tiffany Basin spoil deposition area: Excess soil material from the excavated spoil bank would be deposited within a 300-acre area located at Tiffany Basin. The area is currently vegetated with salt cedar of varying density, and is not inundated by flows smaller than the 10%-chance event. The fill material would be revegetated to minimize erosion, to decrease the potential for colonization by invasive weeds, and to replace shrubby wildlife habitat. Following fill deposition, the disturbed area would be seeded with a mixture of grass, herbaceous and shrub species.

6.4.2.6 *Compensatory Value of Proposed Features and Mitigation Measures*

The Corps' *Planning Guidance Notebook* and Section 2036 of WRDA 2007 state that losses of fish and wildlife resources will be mitigated in-kind, or include compensatory measures that provide no less than the in-kind condition, to the extent possible. In the proposed project, a relatively large area of shrub-dominated habit will be converted to grassland per the requirements of ETL 1110-2-571, and the unsuitability of some areas to support native shrub species (as opposed to exotic salt cedar). Woody riparian vegetation has been included in mitigation measures to more fully compensate for the unavoidable effects on those habitat types in general, and Southwestern Willow Flycatcher breeding habitat specifically. Table 6.6 summarizes the area and relative bird abundance of habitats affected by the proposed project and revegetated areas (including both recommended mitigation measures and incidental wildlife benefits). Bird abundance is a measure of the indirect adverse or beneficial effects to wildlife habitat due to the respective alteration or creation of a specific riparian plant community type. The overall post-project bird abundance of 959 represents a 35% increase above the existing value of 712.

Table 6.6 Vegetation and Channel Habitat Affected by the Recommended Plan, Area Revegetated (acres), and Comparable Bird Abundance Values.

	Affected areas					Revegetated areas	
Habitat type	Temporarily disturbed vegetation (soil cement installation)	Vegetation altered in Vegetation-free Zone	East side overbank & channel excavation	Tiffany Basin spoil deposition area	Area lost due to footprint of levee, soil cement, and floodwall	Area gained by spoil bank removal & channel excavation	Other revegetated area
RIPARIAN VEGETATION:							
Native-dominated shrub/tree	0.4	2.8	0.8	--	0.9	7.7	45.6
Mixed native/exotic shrub/tree	0.5	3.7	0.0	--	0.0	0.0	0.0
Exotic-dominated shrub	1.0	19.8	0.0	--	12.1	0.0	0.0
Herbaceous / bare	0.0	1.3	0.0	--	0.0	27.8	75.9
Total Riparian Vegetation	1.8	27.6	0.8	0.0	13.0	35.5	121.6
UPLAND VEGETATION:							
Native-dominated shrub/tree	0.0	0.0	0.0	300.0	0.2	0.0	309.3
Mixed native/exotic shrub/tree	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exotic-dominated shrub	0.0	0.9	11.6	0.0	15.2	0.0	0.0
Herbaceous / bare	0.0	1.1	0.0	0.0	1.0	0.1	1.9
Total Upland Vegetation	0.0	1.9	11.6	300.0	16.4	0.1	311.2
RIO GRANDE CHANNEL:	0.0	0.0	0.0	0.0	0.6	2.0	0.0
Total (ac.)	1.8	29.5	12.4	300.0	30.0	37.6	432.7
	373.7					470.3	
Bird abundance	3.5	65.7	20.0	600.0	22.8	199.8	759.6
	712.0					959.4	

6.4.3 Invasive Plant Species and Noxious Weeds

The majority (90% or more, see Table 6.4) of vegetation removed to facilitate construction of any of the new levee alternatives currently consists of exotic-dominated or mixed native-exotic shrub stands. Treatments to minimize colonization by invasive plant species and noxious weeds would be included in the construction contract specifications and in the operation and maintenance requirements. All methods of treatment during establishment and later maintenance would be subject to the approval of local land management agencies, including Bureau of Land Management, Sevilleta NWR, and Bosque del Apache NWR.

In all planted areas, invasive weeds would be treated with manually applied, appropriate and approved herbicides when needed over the first 10 years following planting. Treatment would be applied to germinated or resprouted herbaceous species and saltcedar. Periodic mowing prescribed for maintenance of the Vegetation-free Zone would also facilitate the control of invasive species.

6.5 SPECIAL STATUS SPECIES*

6.5.1 Rio Grande Silvery Minnow

After construction of a new levee, flows ranging from the 20%-chance event (11,800 cfs at San Acacia) and higher would be confined to the existing floodway. Rio Grande silvery minnow are small fish that cannot swim against high velocities for extended periods. Post-construction water depths and velocities estimated by hydraulic modeling were reviewed to evaluate potential, indirect effects on silvery minnow. Average with-project water depth in the overbank area would increase by 1 to 2 feet for the 10%-chance flow, and 2.5 to 5 feet for the 1%-chance flood. For both events, extensive shallow (2 feet or less) areas would still occur within the floodway. Likewise, with-project velocities (*e.g.*, Figure 6.2) indicate that relatively slow-flowing (<2 ft/sec) areas are extensive enough to provide refugia for the silvery minnow during the 1%-chance flood, as well for more frequent discharge events. Corps' biologists have proposed refinements to the design of the vegetation-free zone to reduce flow along the levee to reduce erosion while providing slackwater habitat for the silvery minnow. These slackwater areas would be sloped to drain away from the levee to facilitate silvery minnow (all age classes) movement back toward the main river channel. The principle alteration to floodplain flow patterns is designed to reduce the tendency for erosion adjacent to the levee that creates channels and pools that may become isolated as the river recedes. Corps staff will coordinate with Refuge staff to refine these measures to address potential impacts to silvery minnows. The proposed topography of the Vegetation free Zone would function at all levels of inundation at the toe of the levee. Summarizing, for all the final-array alternatives, sufficient slackwater areas would remain after levee replacement to avoid flushing silvery minnow from the San Acacia reach.

(a)

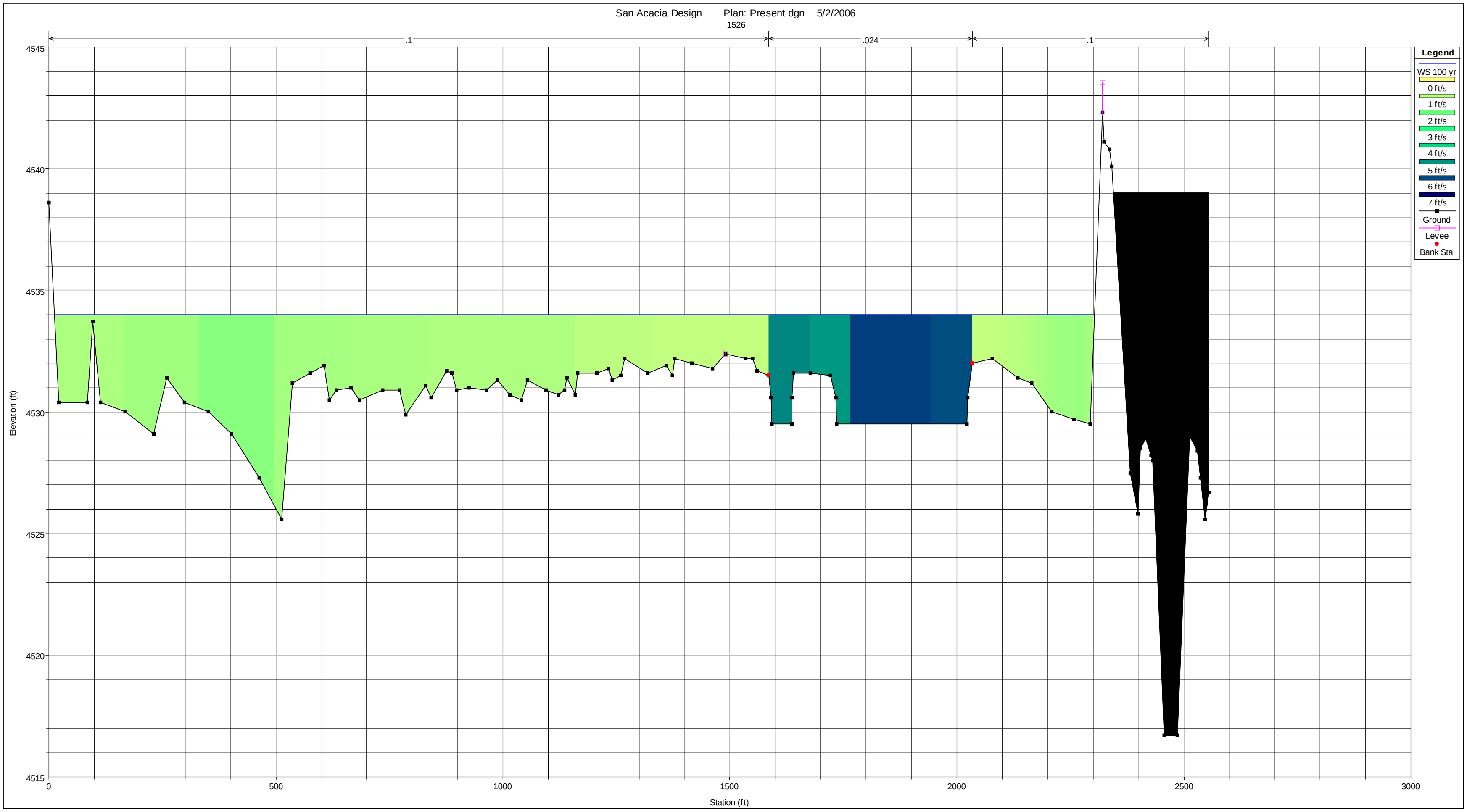

Figure 6.2 Cross-Sections (Looking Downstream) Depicting Water Depth and Velocity During the 1%-Chance Flood Event.

(a) About one mile downstream from the San Acacia Diversion Dam (continued).

(b)

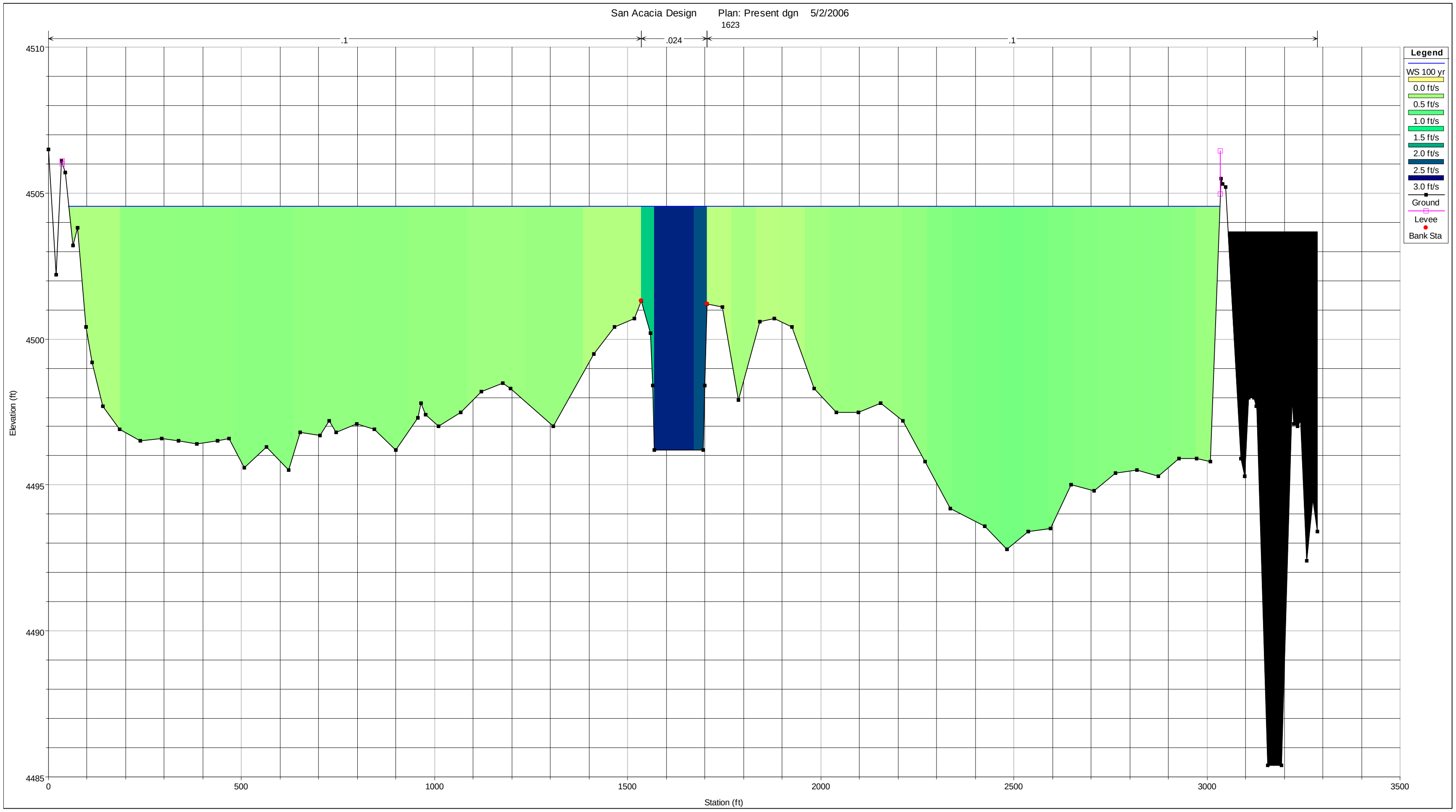

Figure 6.2, continued. (b) Near the southern boundary of BDANWR, after proposed levee construction.

Construction of the Alternative A+4ft or K+4ft levees would increase the area of the floodway in the project area by approximately 73.4 acres. Similarly, construction of the Alternative A or K levees would result in a net increase of approximately 207.4 acres within the floodway. When inundated, these areas would provide additional foraging, spawning, and nursery habitat for the silvery minnow, and improve critical habitat constituent elements (instream habitat, substrate).

Implementation of any of the earthen-levee construction activities alone would not adversely modify the constituent elements of silvery minnow critical habitat (hydrologic regime, instream habitat, substrate, water temperature, and water conditions).

Quality silvery minnow habitat depends on fluvial geomorphic processes continually reshaping in-channel and adjacent floodplain habitat. Flows greater than 3,000 cfs mobilize sediment, reshaping the channel and floodplain to produce suitable aquatic habitat for silvery minnows and other fish populations. The current spoil bank system contains these dynamic processes within the floodway; adjacent lands outside the levees are no longer connected to the floodplain. During a 1%-chance flood event, a breach of the existing spoil banks would inundate extensive portions of the floodplain. With any of the levee alternatives evaluated here, flood volume (and power) would be concentrated within the floodway, increasing the potential for scouring, deposition, and dynamic habitat creation. Maintenance of suitable silvery minnow critical habitat remains dependent on routing flow within the existing floodway to maximize fluvial processes during flood events.

For all levee construction alternatives, riprap would be used for erosion protection along a total of 30,000 linear feet (approx. 5.68 miles) of the riverward slope and toe. Riprap would be installed in the areas most susceptible to scour during large flood events. Although minnow critical habitat extends up to the levee (including riprap) during higher flows, water velocities during such flows are above suitable values for the minnow. Therefore, levee erosion-control features are not likely to adversely affect any constituent elements of silvery minnow critical habitat as the placement of riprap is entirely within the overbank terrace, except for the bankline immediately downstream from San Acacia Diversion Dam (discussed below).

Riprap would be buried at the levee toe to a depth of 1 to 12 feet. Buried riprap may be inundated at higher flows, but will not contribute to, or adversely affect, aquatic habitat. Buried riprap may be partially exposed by erosion in the future. Changes in aquatic habitat quality caused by exposing riprap at the levee toe would be offset by corresponding geomorphic processes forming point bars on the opposite bank. The buried riprap at most sites would not affect the hydrologic regime (i), instream habitat (ii), fine sediments for substrate (iii), water temperature (iv) or water conditions (v).

For the 1%-chance flood event, water velocities along the western bankline immediately downstream from the San Acacia Diversion Dam (SADD) may reach 17 fps. Although overbank excavation on the east bank would reduce flood velocities along the west bank to approximately 14 fps, these flood flow velocities would still be considerably higher than quality silvery minnow habitat.

Under all levee alternatives, along 1.1 miles of the western bankline downstream from the SADD, soil cement would be used to protect the vertical bankline and railroad. Soil cement placement may directly replace up to 0.6 acres of the active channel, and silvery minnow critical habitat. Placement of soil cement would require partial dewatering of the adjacent river channel. This area of the channel is generally unsuitable for silvery minnows and other small fish species due to the very high water velocities. Soil cement may provide a solid substrate supporting attached algae, but otherwise provides little usable habitat. The area of silvery minnow critical habitat that would be affected by the placement of riprap below the 5,660-cfs OHWM immediately downstream of San Acacia Diversion Dam would be offset by the East Bank Excavation (Appendix B), which increases the area below the OHWM by approximately 3.1 acres.

Riprap erosion protection may affect, and is likely to adversely affect, silvery minnows in the river. Best management practices would be implemented during in-channel riprap placement to minimize effects to the silvery minnow and other fish species. This erosion control may affect, and is likely to adversely modify silvery minnow critical habitat constituent elements ii and iii (instream habitat and fine sediments for substrate). The riprap would not affect the hydrologic regime (i), water temperature (iv) or water conditions (v).

The U.S. Fish and Wildlife Service (USFWS) issued a Programmatic Biological Opinion on the proposed project on February 28, 2013 (USFWS 2013b; see App. C of the GRR/SEIS-II). The USFWS concurred with the Corps that the recommended plan would likely adversely affect silvery minnow and its designated critical habitat. The USFWS determined that the recommended plan is not likely to jeopardize the continued existence of the minnow.

The USFWS anticipates incidental take of 436 silvery minnows in the form of harassment during installation of silt curtains or cofferdams for construction of the temporary river crossing, the floodwall and soil cement embankment, and the sluice gates at Brown Arroyo. The following terms and conditions were specified in reasonable and prudent measures to minimize the potential for take of the minnow.

- Coordinate development of silvery minnow habitat with the USFWS's New Mexico filed office prior to implementation. If habitat is proposed to be developed on National Wildlife Refuge lands, the Corps will also coordinate with the USFWS's Refuges. If applicable, the Corps will obtain Refuges approval before proceeding.

- For bankline construction, the Corps, in coordination with the USFWS, will establish and implement a design standard applicable to deployment of erosion control screens (e.g., silt curtains or wattles, etc.) that insure protection of water quality. For in-river construction, the Corps, in coordination with the USFWS, will establish and implement a coffer dam design standard applicable to prevent fish access to the construction site and insure protection of water quality. Coffer dams and erosion protection screens will be inspected daily to maintain the connection to the substrate and will be removed following construction.

- Prepare and implement a silvery minnow habitat mitigation and adaptive management plan for the San Acacia Reach. The plan will include Best Management Practices for construction to minimize effects to the silvery minnow, and its critical habitat. The adaptive management section will provide recommendations for silvery minnow and habitat monitoring focused on reproduction and recruitment. The plan will identify specific areas for habitat management with a schedule for completing construction of a minimum of 13.5 acres of silvery minnow critical habitat possessing the primary constituent elements. The habitats shall be constructed prior to, or immediately following, the loss of critical habitat due to specific construction activities in the proposed action. The plan will be reviewed and approved by the USFWS and should be completed by December 31, 2014.

- Fish sampling will be conducted by biologists that possess a Section 10(a)(1)(A) permit, and report to the USFWS in accordance with the permit.

- Monitor groundwater pumping for construction activities in the floodway to determine its effect on aquatic habitats. Oxygen content in excavated groundwater will be measured to ensure no hypoxic conditions occur. The Corps will develop a groundwater pumping plan prior to riprap placement. The timing, rate, water volume, and receiving area will be formulated to aerate groundwater to eliminate impacts to aquatic life, riparian vegetation and river levels to the extent possible. The Corps would immediately confer with the USFWS if hypoxic conditions occur in the Rio Grande as a consequence of groundwater pumping to the river (including runoff across the floodplain).

- Assure that water used for dust suppression does not reduce water availability for silvery minnow; assure the quality of water used for dust suppression; use water from sources other than those used by silvery minnow; if water must be removed from the low flow conveyance channel, assure no impact to the low flow conveyance channel pumping program.

- Monitor pH as part of the soil cement construction. Samples from the river channel, within the coffer dam, and on the soil cement to detect changes due to soil cement through the curing process. Monitoring data will be reported to the USFWS to demonstrate complete curing of the soil cement will not alter river pH upon contact with the surfaces.

- Prepare and implement a study to document water temperature daily and seasonally upstream and downstream where river is in contact with riprap. Water temperature conditions associated with the riprap blankets will be monitored upstream and downstream daily and seasonally to determine the water temperature effects associated with the riprap in silvery minnow habitats. The Corps will evaluate the thermal effects of riprap and slackwater habitat on river water temperature to ensure no detrimental effects to silvery minnow occur.

- Each Corps construction contract will include requirements that ensure the contractor’s compliance with all pertinent terms and conditions of the USFWS’s Incidental Take Statement; pertinent information on the presence or locations of silvery minnow; and requisite work restrictions. As needed, the Corps will formally update pertinent information and requirements throughout the duration of the contract.

- Report to the USFWS finding of any injured, rescued, or dead silvery minnows associated with project activities.

- Develop an Operation and Maintenance (O&M) manual, in coordination with the USFWS's New Mexico field office, prior to turning the project over to the project sponsors.

- Include in the O&M manual requirements that the project sponsor integrates endangered species monitoring and measures protective of endangered species and their habitats during its O&M activities; recommendations to coordinate with Service's New Mexico field office regarding any emergency repair work; and coordinates with and reports to the USFWS's New Mexico field office on its O&M activities. These requirements will include standard Corps' best management practices (BMPs), the BMPs developed specifically for this project, and avoidance periods.

Additionally, the Corps would implement the following best management practice during construction: Qualified fisheries biologists would evaluate measures to exclude fish from in-channel construction areas. Cofferdams and silt curtains would be deployed by Corps biologists from the shoreline into the channel to exclude fish from construction areas where possible. If appropriate, biologists would coordinate with USFWS personnel to seine areas prior to placement of barriers in the construction area.

6.5.2 Southwestern Willow Flycatcher

The entire riparian zone within the study area is designated as critical habitat for the Southwestern Willow Flycatcher (flycatcher; see Figures 2.3 and 2.4). Formal protocol surveys of the study area have been conducted annually since 1996 by the Bureau of Reclamation. Between San Acacia and BDANWR, occasional, isolated breeding territories have been established; however, occupation has not persisted for more than one or two years at a given location. Most recently, 10 territories were present in the floodway near Socorro in 2012 (Moore and Ahlers, *In prep*.) Flycatchers have regularly nested in the riparian zone from the northern boundary of BDANWR downstream into the headwaters of Elephant Butte Reservoir. Within BDANWR specifically, three flycatcher territories occupied the banks of the Rio Grande in 2008. The number of flycatcher territories in this reach increased to 20 in 2009, 34 in 2010, and 49 in 2012. Flycatchers have regularly nested (ranging from 2 to 14 territories) in the floodway adjacent to Tiffany Basin.

For all levee alternatives, the 5.9 acres of riparian vegetation (and critical habitat) that would be cleared to accommodate and maintain the Vegetation-free Zone upstream from Bosque del Apache have not been occupied by breeding flycatchers in recent years. Within BDANWR, much of the riparian vegetation that would be removed to accommodate the wider footprint of the Alternative A+4ft or K+4ft levees (8.7 acres) and the associated Vegetation-free Zone (21.6 acres) lies along the landward edge of currently (2012) occupied flycatcher territories. The narrow, 15-foot width of the proposed clearing is minimal in the context of the wider riparian corridor that ranges from 350 feet to well over 2,000 feet in this reach.

Under levee Alternatives K and K+4ft, an engineered levee would replace the existing spoil bank between the Tiffany Basin and the active Rio Grande floodway. The riverward toe of the new levee would be aligned to be 15 feet landward of the existing spoil bank, assuring that riparian vegetation within the floodway would not be adversely affected. Suitable, and frequently occupied, Southwestern Willow Flycatcher breeding habitat borders the riverward side of this levee segment. As stated, no vegetation would be lost due to the footprint of the new levee or the Vegetation-free Zone on the riverward side.

The USFWS issued a Programmatic Biological Opinion on the proposed project on February 28, 2013 (USFWS 2013b; see App. C of the GRR/SEIS-II). The USFWS determined that proposed action is likely to adversely affect the flycatcher, but is not likely to jeopardize the continued existence of the flycatcher. Additionally, the USFWS concluded that the project is not likely to adversely modify or destroy designated flycatcher critical habitat.

The USFWS anticipates take of 11 flycatcher territories in the form of disturbance due to traffic within 0.25 mile of flycatcher territories, loss of suitable habitat due groundwater changes during riprap blanket installation and loss of 8.41 acres of flycatcher critical habitat due to construction of the levee and the Vegetation-free Zone. The following terms and conditions were specified in reasonable and prudent measures to minimize the potential for take of the flycatcher.

- Conduct flycatcher protocol surveys covering the floodway west of the Rio Grande channel from 0.5 mile north of San Acacia Diversion Dam to the San Marcial railroad bridge. These surveys shall commence in the breeding season prior to anticipated construction in a given segment of the action area, and shall continue annually through the third breeding season following construction in each given segment.

- Conduct flycatcher protocol surveys performed by biologists that possess a Section 10(a)(1)(A) permit, and report to the USFWS in accordance with the permit.

- Monitor groundwater pumping for construction activities in the floodway to determine its effect on riparian habitats.

- Conduct flycatcher protocol surveys within critical habitat located within 0.25-mile west of the Low Flow Conveyance Channel canal, from the San Acacia Diversion Dam to Tiffany Junction. These surveys will be conducted for a single breeding season, and should be commensurate in time to flycatcher surveys within the floodway for a given construction-segment of the action area.

- The Corps will monitor groundwater-surface water interaction and dynamics in the San Acacia reach per 3.5 below; and will assist resource management agencies in the analysis, modeling, planning, and adaptive management of activities relating to future sediment, habitat, and flow issues.

- Construction may occur throughout the calendar year; however, no construction would be performed within 0.25 mile of occupied flycatcher territories during the breeding season; that is, from the date of the second protocol survey of the season through August 15. Construction traffic may continue year-round along the LFCC maintenance roads.

- Each Corps construction contract will include requirements that ensure the contractor's compliance with all pertinent terms and conditions of the USFWS's Incidental Take Statement; pertinent information on the presence or locations of flycatchers; and requisite work restrictions. As needed, the Corps will formally update pertinent information and requirements throughout the duration of the contract.

- If traffic or other proposed action activities do occur within the 0.25-mile radius of a breeding territory, then those territories/nests will be monitored according to standard protocols, but at least every two weeks to determine continued occupancy.

- Coordinate development of 50.4 acres of flycatcher habitat with the USFWS's NMESFO prior to implementation. If habitat is proposed to be developed on National Wildlife Refuge lands, the Corps will also coordinate with the USFWS's Refuges. If applicable, the Corps will obtain Refuges approval before proceeding.

- Prepare and implement a flycatcher habitat mitigation and adaptive management plan for the San Acacia Reach. The plan will include Best Management Practices to minimize effects to the flycatcher, and its critical habitat. The plan will identify specific areas for habitat management with a schedule for completing development of 50.4 acres of dense riparian shrub habitat possessing primary constituent elements of critical habitat. The habitats shall be developed prior to, or immediately following, the loss of critical habitat due to specific construction activities of the proposed action. The plan will be reviewed and approved by the USFWS and should be completed by December 31, 2014.

- Assure that the water used for dust suppression will not harm nesting or migrating flycatchers.

- Utilize results obtained during implementation of reasonable and prudent measures to limit effects on flycatcher habitat.

- The uncertainty surrounding the impact of the levee project-exacerbated sediment accumulation on flycatcher habitat will be clarified through a program of monitoring, modeling, and scientific analysis conducted by the Corps once construction has started. Methods for calculating the habitat area that may be at risk due to aggradation follow:

    - Mitigation of habitat is described as creating or managing the number of acres to provide a functioning flycatcher habitat for the duration of the project. Creation of newly built habitat is not necessarily required.

    - Calculation Methods: Corps, in coordination with the USFWS's New Mexico Ecological Services Field Office shall determine distance from levee that vegetation may be affected by increased depth to the water table.

    - Corps shall project surface aggradation from USACE's 50 yr projections and estimate the future ground elevations.

- Corps shall compare information gained from 3.5.1 and 3.5.2 with most current suitable and moderately suitable habitat information.
- Based on a program of monitoring, modeling, and scientific analysis, the Corps shall determine and develop commensurate mitigation for the duration of the project.

Additionally, the Corps would implement the following best management practice during construction: Vegetation removal and clearing-and-grubbing activities would be performed between August 15 and April 15. Between April 15 and August 15, vegetation removal would only be performed if inspection by a qualified biologist determines that neither flycatchers nor their active nests are present within 500 feet of the vegetation patch to be removed.

6.5.3 Interior Least Tern

The Interior Least Tern is a vagrant in the study area, occasionally present along the Rio Grande in central and southern New Mexico. Its principal foraging and resting areas would be along the river channel, or, perhaps, at managed areas of BDANWR.

The majority of the construction activities associated with the proposed action and the various alternatives would be limited to the current spoil bank alignment. Should a tern occur within the project area, the alignment is sufficiently far from the river channel that active construction and related traffic would not interfere with the bird’s foraging or resting activities. Construction along the immediate bank of the channel would only occur in the northernmost mile of the alignment, and would take place during the winter, low-flow period, when terns are not present in New Mexico.

Given the relatively rare occurrence of terns in the study area, and the low disturbance factor of the potential construction activities, the implementation of the proposed or any of the final array of alternatives would not affect the Interior Least Tern. The USFWS concurred that the proposed project would not likely adversely affect the tern (USFWS 2013b).

6.5.4 Pecos Sunflower

The privately-owned stand of Pecos sunflower is located on the east side of the Rio Grande; that is, on the opposite side of the river from all proposed or alternative levee construction activities. None of the proposed actions or alternatives would affect the Pecos sunflower.

6.6 CULTURAL RESOURCES*

Very few changes are required to update the information contained in the 1992 SEIS regarding cultural resources background or concerns. The recommended plan has a negligible potential to affect historic properties. The construction area consists of the existing spoil bank levee, access roads, and other previously disturbed areas. A culture history for the San Acacia to San Marcial reach project area is contained in Appendix F-8 of this GRR/SEIS-II.

In 2007, the Corps conducted a search of the New Mexico Historic Preservation Division (NMHPD), Archaeological Records Management Section's (ARMS) New Mexico Cultural Resource Information System (NMCRIS) database and found that 210 archaeological sites occur within the general vicinity of the MRGCD spoil bank levee alignment; however, these historic properties occur in areas of sufficient distance from the levee construction area that they would not be affected by the levee rehabilitation or they can be avoided. In 2012, a search of the NMCRIS database (data as of January 31, 2012) was conducted to review and verify archaeological site data. Determinations of eligibility for potential nomination to the National Register of Historic Places have not been made for the majority of the archaeological sites in the area, therefore, they are considered eligible until an official determination is made. Of the 210 archaeological sites in the general vicinity of the 43-mile project area, a total of 85 sites occur within or immediately adjacent the Area of Potential (flooding) Effect (APE) as depicted in Figures 5.3 – 5.9. Of these, approximately 35 are located on the west side and 50 are located on the east side of the existing MRGCD spoil bank levee. These 85 sites, including the prehistoric pueblo ruins such as San Pascual (LA487) and Qualacu (LA757), have potentially been affected by historic flooding.

The Corps and Reclamation continue to manage river flows within their control to avoid effects to archaeological sites within or immediately adjacent to the floodplain (USACE, 2005, 1998). Under all of the future with- and future without project scenarios, including the recommended plan, there is no change in the potential for effects from future flooding to these sites nor to sites located downstream of the project area. Hydrology and hydraulic analysis for all of the Alternative A and Alternative A+ 4ft scenarios, including the recommended plan, show no change to flooding seasonality. As noted in Section 6.2.3 above, the hydrology and hydraulics in the Middle Rio Grande valley are highly modified and controlled, and discharge-frequency characteristics of the basin would remain as they are. Average flood flow velocities within the floodway would remain relatively low. There would be a negligible change to volume and duration of flood flows. This would include a slight increase in stage (approximately 6-inches) and flood flow velocities, primarily within the main channel rather than along the margins of the floodplain (as depicted in Figure 6.2). Therefore the project alternatives including the recommended plan would result in a negligible change from flooding related effects that have occurred in the past.

The Corps has conducted archaeological surveys of the levee alignment and other areas of the recommended plan's construction area and one of the considered alternatives (Doleman, 1997; Chapman and Actis, 2007). With the exception of the existing historic 1930s MRGCD irrigation and spoil bank levee system and Reclamation's 1959 LFCC, both eligible for nomination to the National Register of Historic Places, no archaeological sites, historic properties, or features were identified within the proposed levee construction area or access routes. For the 43-mile San Acacia to San Marcial reach, the Corps is of the opinion that reconstruction of the levee would result in an adverse effect to historic properties. On November 5, 1997, the SHPO concurred with the Corps' determination of adverse effect to historic properties for the then recommended alternative (NMHPD Consultation No. 054093) which followed the same alignment as the current Alternative A and Alternative A+4ft levees. However, the Corps submitted additional documentation to the SHPO for mitigation of the adverse effect to the MRGCD levee and Reclamation's LFCC (Berry and Lewis, 1997; Van Citters, 2000; Dodge and Santillanes, 2007). The SHPO has also concurred that it is highly unlikely that historic properties or cultural materials of significant antiquity or archaeological integrity would occur within areas of the Rio Grande's historic active channel (NMHPD Consultation No. 92670).

Consistent with the Department of Defense's American Indian and Alaska Native Policy signed by Secretary of Defense William S. Cohen on October 20, 1998), and based on the State of New Mexico Indian Affairs Department and Historic Preservation Division's 2011 and 2012 Native American Consultations List, government to government tribal scoping letters describing all facets of the project including the recommended plan, and inviting consultation were sent to ten Native American Tribes/Pueblos that have indicated they have concerns within Socorro County (Appendix F-8). These ten tribes include the Pueblo of Acoma, Pueblo of Isleta, Pueblo of Ysleta del Sur, Comanche Indian Tribe, Fort Sill Apache Tribe, Hopi Tribe, Kiowa Tribe, Mescalero Apache Tribe, Navajo Nation, and White Mountain Apache Tribe. To date, the Corps has received no tribal concerns regarding the proposed project (Appendix F-8). No Traditional Cultural Properties are known to occur within or immediately adjacent to the recommended plan's construction area.

On May 26, 2011, Corps archaeologists conducted a site visit to the proposed San Acacia overbank lowering area (immediately downstream of the SADD), a new construction feature of all of the levee alternatives, to verify the location of known archaeological resources in relation to the proposed construction area. For this feature's construction area, the Corps is of the opinion that improvements to the river channel that include the placement of riprap on the outside of the river bend adjacent to the BNSF railroad grade, and the lowering and shaping of the overbank area on the inside of the river bend to reduce river flow velocities, would result in no effect to historic properties. On September 12, 2012, the SHPO concurred with the Corps' determination of no effect for this project area (NMHPD Consultation No. 092670; Appendix F-8).

In 2012, Corps archaeologists determined that they needed to conduct a site visit to verify site conditions for two elements of the recommended plan (located in the same immediate area near the SADD) and to conduct an archaeological survey for the proposed use of the Tiffany Basin spoil area as described below.

- Floodwall and Levee Tie-in: One part of the recommended plan calls for the construction of a concrete floodwall and levee tie-in to a hillside immediately adjacent to the BNSF railway grade and northeast of the SADD. On February 29, 2012, Corps archaeologists conducted a site visit to the area immediately adjacent to and northeast of the SADD and BNSF railway grade, where the levee and new concrete floodwall will tie in to the hillside. The site visit verified that this area was previously disturbed by quarrying and construction activities.

- Rehabilitation of USBR Facilities: Construction activities near the SADD also include the in-kind replacement of the USBR's five existing 7 ft by 7 ft CBC Conveyance Channel headworks that divert river water to the LFCC. These features were constructed in the 1950s by the USBR to manage river flow to Elephant Butte for compact deliveries. Construction will add one 5 foot diameter arch corrugated metal pipe extension, 65 feet in length, to the headworks of the Socorro Main Canal. This entire area has been previously disturbed. The Area of Potential Effect (APE) for the floodwall/tie-in and the rehabilitation of both headworks is approximately 2.7 acres in size. Both the 1930s

SADD and the USBR’s 1950s LFCC and headworks and Socorro Main Canal headworks are historic structures.

- Use of Tiffany Basin as a Spoil Area: The existing 43-mile spoil bank levee contains more earthen materials than is necessary to the construct the new engineered levee; therefore, the excess earthen materials need to be removed. During planning for the proposed project, the Corps determined that approximately 300 acres would be necessary for disposal of excess earthen materials, and have preliminarily chosen a location known as the Tiffany Basin for waste disposal. This proposed spoil area, located in the northern portion of Tiffany Basin, is a low basin adjacent to the river that sits lower than the Rio Grande channel. The proposed spoil area is approximately 300 acres; the APE is approximately 377 acres.

On February 29, 2012 and March 1, 2012, Corps archaeologists conducted a pedestrian archaeological survey of the spoil area in Tiffany Basin. No historic properties were observed during the Corps’ survey with the exception of three isolated occurrences, which were recorded in the field: 1) one small scatter of rocks; 2) one small standing, thin-walled metal pipe; and 3) one historic Clorox bleach bottle. The Corps determined these three isolated occurrences are not eligible for nomination to the National Register of Historic Places. Due to the extreme thickness of vegetation, Corps archaeologists were unable to survey the entire Tiffany Basin spoil area APE; however, utilizing a series of historic maps and aerial imagery, the Corps’ investigation determined that the majority of the spoil area in Tiffany Basin was significantly disturbed within the last 100 years by two processes: the existence of the Rio Grande active river channel and floodplain within the current APE, and intensive ground disturbance due to farming and to USBR construction activities between 1951-1959 that included blading and bulldozing for vegetation removal.

Since the proposed construction area for the floodwall and levee tie-in near the SADD has been previously disturbed, the Corps is of the opinion that construction of this part of the project will result in no historic properties affected. The proposed rehabilitation of the USBR facilities and the Socorro Main Canal headworks has also been previously disturbed, and the Corps is of the opinion that in-kind rehabilitation of these facilities will result in no adverse effect to historic properties. Based on the negative results of the Corps’ archaeological survey and investigation of historic mapping and aerial imagery, the Corps is of the opinion that the use of the Tiffany Basin spoil area would result in no historic properties affected (Everhart and Van Hoose, 2012). On April 17, 2012, the SHPO concurred with the Corps determinations (NMHPD Consultation No. 094140; Appendix F-8).]

Additional archaeological survey and Section 106 consultation with the SHPO, Native American tribes, and if necessary, the Advisory Council on Historic Preservation, may be required if other alternative/option areas and rights-of-way are included in the project in the future, such as Alternative K, Alternative K+4ft, and the River Mile-108 setback. No known historic properties occur in the immediate vicinity of these project areas. For alternatives that include the River Mile-108 setback, use of the area would likely result in no historic properties affected. Alternatives K and K+4ft that include the construction of an approximately 4-mile engineered Tiffany East Levee that would replace the existing spoil bank, along the same, existing alignment, would likely result in no adverse effect to historic properties. Both the River Mile-108 setback, and Alternatives K and K+4ft occur in portions of the Rio Grande's historic active channel and have been subject to numerous historic flooding events in the past, both prior to and subsequent to the construction of the existing spoil bank. Prehistoric and historic properties that may have been in the area before and after the spoil bank was constructed have likely been washed away or buried in river sediments. Therefore, it is highly unlikely that historic properties or cultural materials of significant antiquity or archaeological integrity would occur in these areas. Potential historic properties that may occur in the vicinity of the Alternative K and K+4ft levees would include the historic communities of Val Verde and La Mesa, the buried remnants of the San Marcial town site, the Val Verde (irrigation) Ditch, the 1862 Civil War Val Verde Battle site, and the alignment of the El Camino Real de Tierra Adentro National Historic Trail.

All undisturbed areas of considered alternatives that may potentially be affected by project related construction activities in the future would be surveyed for the presence or absence of historic properties. All known historic properties would be avoided to the extent possible and newly discovered sites, if found, would be assessed in accordance with 36 CFR Part 60.4 to determine their significance. In most cases, it would be possible to relocate the alignment of a proposed construction road or other impact area in order to avoid known archaeological sites or those that may be discovered during future investigations for any of the alternatives. If avoidance is not possible, the Corps, in consultation with the SHPO and Native American tribes, shall develop a data recovery plan and the approved recovery plan would be implemented prior to initiation of any ground disturbing activities. Pursuant to 36 C.F.R. 800.13, should previously unknown artifacts, cultural features, or historic properties be encountered during construction, work would cease in the immediate vicinity of the resource. A determination of significance would be made, and consultation with the State Historic Preservation Officer and Native American tribes that have concerns in the area would be conducted to determine the best course of action. All Corps construction contracts include a discovery clause.

6.7 INDIAN TRUST ASSETS*

No Indian Trust Assets have been identified within the project area (see Section 2.6 above).

6.8 SOCIOECONOMIC ENVIRONMENT*

6.8.1 Demography

Population growth in the City of Socorro in recent decades has primarily been due to expansion of college and governmental research programs, and to reactivation of the area's mining industry. The population growth in Socorro County is flat over the decade leading up to the 2010 census (down insignificantly from 18,078 reported in the 2000 census to 17,866 in the 2010 census). It is also anticipated that communities in the unincorporated areas of the valley will lose population to incorporated communities such as Socorro. These projections are considered accurate for the future, even without the implementation of a Federal project. As most of the county's population is outside of the floodplain in the study area, it's unlikely that any project implementation will affect population growth within Socorro County or the City. There is no significant correlation between any proposed project's features and population growth in the study area. New development or improvements of existing development would be proportionate within and outside of the existing floodplain regardless of construction of a Federal project.

6.8.2 Flood Hazards

Benefit determination for the post-project condition is computed by changing the proposed levee height to remove damageable property from lesser magnitude events. As expected, higher levee heights afford greater protection to the areas susceptible to flooding.

Table 6.7 Average Annual Damages for Benefit Categories by Levee Height for Plan A.

LAND USE CATEGORY	Average Annual Damages (x $1,000 August, 2010 price level)					
		Residual Equivalent. Ann. Damages				
	EAD	**Base**	**Base + 1'**	**Base + 2'**	**Base + 3'**	**Base + 4'**
Residential	$ 2,199	$ 1,059	$ 444	$ 176	$ 65	$ 23
Commercial	$ 5,594	$ 2,234	$ 933	$ 367	$ 133	$ 47
Public	$ 120	$ 79	$ 49	$ 34	$ 22	$ 13
Apartments	$ 1	$ 1.9	$ 0.7	$ 0.3	$ 0.1	$ 0.04
Outbuildings	$ 77	$ 36	$ 15	$ 6	$ 2	$ 0.1
Streets, Roads	$ 1,894	$ 600	$ 414	$ 260	$ 154	$ 127
Utilities	$ 61	$ 20	$ 14	$ 8	$ 5	$ 4
Railroad	$ 193	$ 56	$ 41	$ 27	$ 16	$ 13
Vehicles	$ 343	$ 101	$ 69	$ 55	$ 33	$ 28
Agriculture	$ 101	$ 14	$ 9	$ 11	$ 7	$ 6
Irr. Drains	$ 36	$ 12	$ 8	$ 5	$ 3	$ 2
LFCC	$ 6,366	$ 1,937	$ 1,297	$ 877	$ 519	$ 72
Recreation	$ 822	$ 30	$ 17	$ 10	$ 10	$ 10
East Bank	$ 272	$ 275	$ 274	$ 275	$ 275	$ 275
Emergency Costs	$ 158	$ 14	$ 9	$ 6	$ 4	$ 3
TOTAL	**$ 18,237**	**$ 6,469**	**$3,594**	**$ 2,117**	**$ 1,248**	**$ 623**

Alternative K includes the upstream levee plus the Tiffany East Levee extension. The purpose of the extension is to protect the railroad track from flooding that may occur in the Tiffany Basin. The Tiffany Basin has no damageable properties outside of a length of railroad track that forms the western border of the Tiffany Basin.

Alternative K+4ft provides similar net benefits to the equivalent levee in Alternative A+4ft. It would appear that, in some cases, Alternative K+4ft provides even more net benefits and could be the plan which maximizes net benefits consistent with the flood risk management goals of this project. However, it is not desirable to cut the Tiffany Basin off from the Rio Grande floodway without substantial mitigation costs. Cutting Tiffany Basin off from the Rio Grande perpetually would require extensive mitigation of over 2,000 acres of land that once received river flows (albeit sporadically).

Flood risk benefits are sensitive to levee heights, and not to a levee's horizontal alignment, except where a levee moves landward of a particular piece of damageable property, relative to the Rio Grande. That isn't expected in any of the project alternatives analyzed.

Table 6.8 Comparison of Costs and Equivalent Annual Benefits for Alternative Levee Heights.

Levee Height	**Equivalent Avg. Annual Benefit and Avg. Annual Cost (x $1,000, Aug 2010 Price Level)**		
	Benefits	**Cost**	**Net Benefits**
No Action	0	0	0
Base Levee	12,160	10,073	2,086
Base Levee + 1 ft	15,023	10,385	4,638
Base Levee + 2 ft	16,500	10,712	5,788
Base Levee + 3 ft	17,370	10,860	6,510
Base Levee + 4 ft	17,995	10,973	7,022

Executive Order 11988, Floodplain Management, requires all Federal agencies to reduce the risk of flood loss; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Floodplain values include the attenuation of the extent of flooding, which (1) reduces the risk of flood loss; (2) minimizes the impacts of floods on human safety, health, and welfare; and (3) supports wetlands, fish and wildlife. Construction of any of the levee alternatives would conform to the requirements of Executive Order 11988.

6.8.3 Induced Damages

Infrared aerial photographs of the Rio Grande east bank were examined to determine the extent, if any, of induced damages that would be caused by construction of levee Alternatives A+4ft and K+4ft on the west bank. The inventory on the east bank was evaluated to compute the expected annual damage in the without-project and with-project condition, for both the present and future condition. The east bank inventory was generally aggregated into two geographic areas. The first area on the east bank is the small community of Pueblito, immediately upstream of Socorro. The second area is northeast of the Village of San Antonio, consisting of residential and commercial structures along Bosquecito Road.

The additional increment of induced flooding is minor at cross sections containing damageable property, which is roughly five inches at the 10%-chance exceedance event for properties along Bosquecito Road in the future hydraulic condition only. In the present, with-project condition the levee on the west bank on the Rio Grande showed no water surface increase until the 2%-chance exceedance event. The events that will produce induced flooding begin at the 10%-chance exceedance event and end at the 1%-chance exceedance event plus 4 feet, where any proposed project's capacity is exceeded on the west bank.

Pre- and post-project floodplains on the east bank were evaluated to determine the change in equivalent annual damages (EAD) attributable to the proposed project. The start of damages was assumed to be the 10%-chance exceedance event. The proposed levee projects do not have a measurable impact to the damageable property in the present condition, but have a minor impact in the future. The without-project EAD is $272,000, and the with-project EAD is $273,000. The results indicate that the EAD induced by the proposed project is minor at approximately $3,000. The damage analysis is based on 22 structures currently present in the eastern floodplain. These damages are not considered adequate to constitute a taking in terms of real estate acquisition. Potential damages would be even less from the construction of levee Alternatives A and K.

Aerial photos of floodplains downstream of the downstream extent of the proposed project were examined to determine the extent of induced flooding downstream attributable to the project. No properties were found, which was verified during field investigations. Additionally, downstream flooding is more likely to occur because of a change in the Elephant Butte Reservoir stage rather than the Rio Grande flood stage.

6.8.4 Land Ownership

Federal interest in the lands under and adjacent to the levee would remain as they are today. Reclamation would continue to operate and maintain the LFCC, the USFWS would continue to operate and maintain Sevilleta and Bosque del Apache NWRs, and the Bureau of Land Management (BLM) would continue to own and maintain the Socorro Nature Area. All lands located within the floodway would remain in their current status and would continue to be subject to periodic flooding. Therefore, with the implementation a Federal project, it is anticipated there would be no changes in land ownership within the study area in the future.

6.8.5 Land Use and Classification

No substantial changes in land use are expected from any of the levee construction alternatives.

6.8.5.1 *Water Management Facilities*

(a) Irrigation

The MRGCD network of diversion dams, storage reservoirs, canal headings, irrigation canals, rehabilitated old irrigation ditches, and Reclamation’s LFCC all serve to provide irrigation water to the study area. The MRGCD has provided this service for over 70 years, and none of the alternatives would this service in the future. Similarly, Reclamation's Elephant Butte Reservoir, downstream of the study area, has provided irrigation and water supply storage for southern New Mexico, Texas, and Mexico for over 80 years, and would continue to do so into the foreseeable future. Although the LFCC would be substantially less susceptible to damage from flooding, repair would be expected to occur almost immediately after a flood to ensure its continued operation. Therefore, it can be concluded that with the implementation of a Federal project, future changes in irrigation facilities or activities would be limited to potential changes in the LFCC maintenance.

(b) Flood Risk Management

It is expected that the sponsor would maintain the proposed levee to design standards. However, due to the aggradational state of the lower two-thirds of the project, the flood hazard is expected to increase in the future, even with the proposed levee.

It is also expected that all additional flood risk management improvements operated by the City of Socorro, the USFWS, and BLM would be maintained in the future to their current operating condition. No other flood risk management projects are known to be in the planning stages within the San Acacia study area.

(c) Water Conservation and Delivery

The dominant water conservation and delivery structure within the study area is Reclamation's LFCC. Reclamation initiated a planning study of the LFCC in 1996, with the objective of identifying potential changes to the LFCC configuration, operation, or both, to fulfill their water conservation and delivery responsibilities (USBR, 2000). Since that time, these studies have been halted and the draft EIS for the proposed action canceled (USBR, 2007b). As established by a 2007 Record of Decision (USBR, 2007c), Reclamation will continue operating the LFCC as a passive drain for subsurface flows with zero diversion from the Rio Grande.

(d) Operation and Maintenance of Rio Grande Floodway

Reclamation has operation and maintenance responsibilities within the Rio Grande floodway through the study area. They would continue to provide sediment removal and erosion and flood risk management in the future, similar to their past operations. It is not expected that these responsibilities or actions would change with the implementation of a Federal project. Therefore, future with-project conditions would result in Reclamation continuing to spend an estimated $2 million annually maintaining the LFCC, as well as additional time and funds to maintain the main river channel through the study area.

6.8.5.2 *Transportation Facilities*

The primary transportation facility within the area is the BNSF railroad. The BNSF bridge at San Marcial is a significant obstacle to the efficient passage of unregulated flood flows in the Rio Grande. The BNSF has no plans to replace this structure in the near future. They do recognize the flood risk, but currently consider it to be acceptable. If the channel continues to aggrade in the future, that sediment could accumulate to block flows at the bridge. However, it is Reclamation's intention to maintain the channel such that the current capacity of the bridge is not further reduced. Their maintenance program will continue into the future until the structural integrity of the bridge deteriorates to the point it must be replaced. However, this is not expected to occur within the next 50 years, which is the period of analysis covered by this report. Therefore, it can be concluded, that with a Federal project, the railroad bridge would continue to function as it does under current conditions.

6.8.5.3 *Specialized Land Use*

(a) Sevilleta National Wildlife Refuge

Future with-project conditions of this NWR are expected to remain similar to those conditions that exist today on the refuge.

(b) Bosque del Apache National Wildlife Refuge

The Bosque del Apache NWR would receive substantial benefits in the event of a large magnitude flood that is contained by the proposed levee. A majority of the fields, impoundments, and extensive water distribution facilities that provide habitat for myriad wildlife species, would be protected. Recreational and educational opportunities at the refuge would be preserved.

(c) Prime and Unique Farmland

The Farmland Protection Policy Act (P.L. 97-90) requires agencies to determine and minimize adverse effects to prime and unique farmlands when undertaking Federal actions. No prime or unique farmlands occur within the project area and affected floodplain of the San Acacia to Bosque del Apache Unit project.

6.8.6 Environmental Justice

Implementation of the Federal project would reduce the risk of flooding and associated property and agricultural losses to households disproportionately of a minority group and with income below poverty level compared with New Mexico and the United States. As discussed in Section 2.7, 21 to 27 percent of the residents in the study area were classified as living in poverty, a higher percentage than in New Mexico (14 percent) or in the US (10 percent) (U.S. Census Bureau, 2009a). The financial losses from flooding, or the annual cost of insurance to offset the losses, present a significant financial burden especially to the low income households. For those residents living in poverty, the loss would be catastrophic. In the case of the Rio Grande floodplain in Socorro County, NM, individuals below the poverty line would pay a disproportionate share of the impact from a major flooding event without the project because flood insurance or losses due to flooding place an additional burden on their already limited income.

For the Alternative A+4ft, flood risk is reduced for more frequent events in over 95% of the private residences and public infrastructure. Alternative A+4ft or K+4ft, with or without the setback at River Mile 108 would realize the same benefits to residential households. Alternatives at the Base Levee + 4ft height would likely meet FEMA criteria for levee certification which would result in lower costs for flood insurance for households on the west bank. Alternatives A or K with or without the RM-108 setback would realize a reduction in flood risk for the most frequent events but have only a 50% assurance of reduction in flood risk for the 1%-chance flood event. The lower levee height does not meet FEMA criteria for levee certification and therefore would not result in lowered insurance rates for affected households.

The population within the study area at risk of flooding and effected by reduced flood risk though implementation of a Federal Project is disproportionately of a minority group and with income below poverty level compared with New Mexico and the United States. Census tract 9783.03 is within the Rio Grande floodplain west of the river and makes up just under half the areal extent of the study area. When compared to Socorro County, New Mexico and the United States this tract is made up of a much larger proportion of residents of Hispanic or Latino ethnicity. Median Household income for this tract is slightly higher than that of the county but lower than New Mexico and the U.S. The percent of population with income below the poverty level is 21% compared to 27% for the County and 14% and 10% for New Mexico and the U.S. respectively. The study area outside of census tract 9783.03 is included in census tract 9781 which includes all of Socorro County East of I-25. Tract 9781 has similar median income but a slightly higher number of individuals with income below poverty level (25%).

6.9 AESTHETICS*

The future with-project conditions of the aesthetic value of the proposed project area would change in minor aspects but retain moderate to high visual quality. Existing aesthetic characteristics of the study area, including the irrigated fields, riparian forest, woodlands, and river channel, would not change in the future with implementation of a Federal project. Minor changes could be seen in that the proposed levee in the northern reaches (the SADD south to Highway 380) would be considerably shorter (smaller) and therefore present less of a visual obstruction between the river and riparian habitats within the floodway and occupied or agricultural land of the former floodplain. The vegetation management zone within fifteen feet of the riverward side of the levee would change in that it would remain sparsely vegetated whereas shrubs and trees grow up to the toe of the existing spoil banks.

Figures 6.3 and 6.4 depict the current spoil bank in the study area and a recently constructed levee in the Albuquerque area. Following replacement of the existing spoil bank in the San Acacia reach, the engineered levee would very appear similar to the spoil bank, especially after vegetation matures in the area affected by construction.

Figure 6.3 Low-Flow Converyance Channel, Gravel Maintence RoAd, and Existing Spoil Bank Looking North From the Escondida Bridge Over the Rio Grande.

Figure 6.4 Riverside Drain, Dirt Maintenance Road, and the Engineered “Albuquerque West Levee” (Constructed in 2009), Looking North From the I-25 Bridge Over the Rio Grande. (A 2005 Fire Severely Damaged the Riparian Vegetation East of the Levee.)

6.10 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES*

Regulations implementing NEPA (40 CFR 1502.16) require an EIS to discuss any "irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented."

The recommended plan consists principally of labor, fuel, and structural material (*e.g.*, concrete, steel, pipe), and ancillary equipment). The earth and rock used in constructing the new levee would be reusable and are not considered an irreversible or irretrievable commitment of resources. Vegetation and associated wildlife displaced by project construction would be reestablished or compensated for and, consequently, would not be an irreversible or irretrievable commitment of resources.

The presence and current function of the LFCC are governed institutionally, and will continue until regulations and objectives are changed. The recommended plan would not, and cannot, change these conditions. However, it would save a significant irreversible and irretrievable commitment of human, physical, and monetary resources that would result from high magnitude flooding and associated repair. The continued existence of the LFCC is irrelevant to the degree of flood protection to be provided, although the frequency of inoperability due to flood damage is relevant.

The effects of alternative levee designs effects on various attributes would be similar to that of the recommended plan, varying in degree in direct proportion to the size, extent, and level of flood risk damage reduction of the respective structures.

Under the No-Action alternative, the status quo would be maintained in the absence of the recommended plan.

6.11 CUMULATIVE EFFECTS*

Cumulative impacts are those which result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions. This section discusses effects on property currently outside the spoil banks and floodway habitat in the study area. The effects of the San Acacia to Bosque del Apache Unit levee rehabilitation project are examined relative to other activities which have affected Rio Grande hydrology and channel morphology. The discussion primarily relies on information presented in this GRR/SEIS-II and other summary reports (*e.g.*, Crawford *et al*., 1993; Berry and Lewis, 1997; Mussetter Engineering, Inc. 2002; Dodge and Santillanes, 2007; USACE and Reclamation, 2007; USFWS 2013b). Section 6.8.5 of this GRR/SEIS II discusses potential effects on water management and transportation facilities in the study area. Additional discussion of cumulative impacts for endangered species as a function of federal and state water operations are the subject of current consultations (Reclamation 2013; USACE 2013).

Historically, the Middle Rio Grande valley was an aggrading river with a shifting sand substrate and had a braided, slightly sinuous pattern (see Section 2.2.3). Localized flooding of large portions of the floodplain occurred every few years (Section 1.4.1). Typically, the river would accumulate sediment, effectively raising the bed above the adjacent terrain, causing river to leave its elevated channel and scour a new course (avulsion). In this manner, the channel migrated freely throughout the geologic floodplain between the flanking alluvial terraces. The channel was stable for sufficiently long periods that cottonwood/willow-dominated riparian woodland developed along the banks and on islands and point bars (see Section 2.4). Ponds and marshes were common, especially in oxbows and in areas of high groundwater discharge.

The major existing flood damage control structures along the Middle Rio Grande valley include spoil bank and engineered levees, and several dams. Prior to 1900, spoil bank emplacement was limited to particularly flood-prone areas such as Alameda, Bosque Farms, and San Marcial. The majority of the existing levee network resulted from extensive multi-purpose water development projects (Berry and Lewis 1997). Between 1930 and 1935, an extensive system of spoil banks was constructed in association with the development of riverside drains between Bernalillo and San Acacia by the local flood control authority, the MRGCD. During the 1950s and 1960s, additional levees were emplaced between Velarde and Bernalillo by Reclamation in association with channelization activities and, in the San Acacia reach, the construction of the LFCC. The Corps has replaced spoil banks with engineered levees along the river at Albuquerque (approximately 20 miles, completed in 1956) and along the west bank at Corrales (11 miles, completed in 1997). In addition to the proposed San Acacia to Bosque del Apache Unit, the Corps is currently investigating levee rehabilitation along 20 miles of both banks in the river from Albuquerque downstream through Belen. In general, the placement of spoil banks and engineered levees along the Rio Grande has had the effect of restraining the river's tendency to avulsion and widespread lateral meandering throughout the floodplain.

With adequate maintenance, the existing spoil banks have proven to be effective flood control measures for relatively small river discharges. In the San Acacia reach, spoil bank failure would likely occur at discharges in the range of the 20%-chance event (11,800 cfs) at San Acacia. Even discharges in the 5,000 to 6,000 cfs range for an extended period could result in weakening spoil banks due to seepage and piping of water.

Because the purpose of the existing spoil banks is to protect extensive landward properties and structures from flood damage, they will continue to be maintained by local interests regardless of the Corp's involvement in rehabilitation and replacement with engineered levees. An indirect cumulative effect of the proposed project would be the continued containment of small discharges within the existing channel and floodway (see Chapter 3).

Several water control structures regulate river flow along the Middle Rio Grande and its tributaries. The Corps maintains four flood control dams within the Rio Grande basin in New Mexico: Abiquiu Dam on the Chama River, Galisteo Dam on Galisteo Creek, Jemez Canyon Dam on the Jemez River, and Cochiti Dam on the main stem. All four dams are operated in conjunction to provide regulated peak flows of 7,000 cfs at Albuquerque (USACE 2011). Discharges above this level begin to impinge upon the safe containment of flows within the floodway by spoil banks in the downstream reach.

The direct effect of flood control operations is the decreased magnitude of discharges resulting from spring snowmelt and summer thunderstorm events when the discharge above Cochiti Dam exceeds the operational channel capacity of 7,000 cfs. Flood discharges are uncontrolled from runoff produced by precipitation events downstream from Cochiti Dam, and from the large Rio Puerco and Rio Salado drainages. Indirect effect of decreased flood magnitude during flood control operations is the cumulative loss of dynamic riparian habitat. The 7,000 cfs operational channel capacity supports geomorphic process for renewal of riparian habitat through scouring and deposition.

A direct effect of the proposed San Acacia to Bosque del Apache Unit levees would be the enhanced level of safety and well-being provided to communities located on the floodplain west of the Rio Grande. The potential for loss of life, injury, emotional trauma, and economic losses that accompany major flooding would be significantly reduced. A higher level of flood protection would support current trends for increased development and urbanization within the historical floodplain. The increasing population in the study area results from birth and survival rates, immigration, increased border and military installation activities, increased manufacturing in a free trade zone, and increased availability of agricultural and industrial jobs, as well as affordable housing, and a high standard of living (USFWS 2013b). Increasing urbanization and development within the historical floodplain will continue (USFWS 2001, 2011c, 2013).

Irrigated land may decrease in the Middle Rio Grande valley as a function of market forces and urbanization (USFWS 2013b). Because irrigation uses over 75 percent of surface river water, a reduction in agricultural land use may have impacts on future water demands. Changes in irrigation use may also have significant impacts on surface and groundwater hydrology, agricultural economic activities, and population growth.

Another direct effect of the proposed San Acacia to Bosque del Apache Unit levees would be the enhanced flood protection for the Low Flow Conveyance Channel and Bosque del Apache NWR. A higher level of flood protection to Bosque del Apache NWR would continue the regional high wildlife, educational, and recreational use that aquatic resources on this refuge provide.

The proposed levees would support the safe transport of larger flows that overbank to create floodplain habitat for silvery minnows, and support riparian vegetation for flycatchers. The proposed levee construction would not affect the hydrologic regime, and the proposed levee alignment is distant from the active river channel (USACE 2012). The footprint of the proposed levee would be smaller than the existing spoil bank, and would be aligned to minimize the amount floodway encroachment, resulting in a gain in floodway area (USACE 2012). Levee construction would increase the floodway area by approximately 71.5 acres. About 36.2 acres of the increased floodway area would be suitable for establishing native riparian habitat. There will be a loss of 0.56 acres of high velocity aquatic habitat (active channel) downstream from the SADD (soil cement wall and riprap), that would be offset by 3.5 acres of floodplain habitat at the east-side excavation. Therefore, construction is not likely to adversely affect Rio Grande silvery minnow or its designated critical habitat. Implementation of levee construction activities in concert with Conservation Measures, are not likely to adversely affect the flycatcher or its designated critical habitat.

The cumulative effect of the proposed San Acacia to Bosque del Apache Unit levees would be continued development in the historical floodplain, with the potential for increased flow within the floodway for ecosystem benefits for endangered species.

6.12 SUMMARY OF THE RECOMMENDED PLAN

As stated at the start of this chapter, Alternative A at the Base Levee+4 ft height emerges as the recommended plan. It is the NED plan that meets all Corps planning criteria. It provides significant reduction in flooding risk from the 1%-chance and 10%-chance flood events while avoiding the potentially detrimental effects of isolating Tiffany Basin and incurring associated high mitigation costs for doing so.

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CHAPTER 7 - POST AUTHORIZATION CHANGES

This GRR/SEIS-II is the final response and determination that the recommended plan is within the delegated approval authority of the Division Commander in compliance with Engineer Regulation 1105-2-100, Appendix G, Section III for projects authorized prior to the Water Resources Development Act of 1986. With all changes from the authorized plan incorporated, the recommended plan is the National Economic Development (NED) pan, which maximizes net economic benefits consistent with protecting the Nation's environment. The following sections provide a comparison of the 1948 Authorized Project to the recommended plan and describe necessary changes from the Authorized Project.

7.1 OVERVIEW OF THE AUTHORIZATION; THE COMPREHENSIVE PLAN

The 1948 Authority contained in House Document 243 provides a comprehensive plan for coordinated development, by the Corps and Reclamation, of water resource and flood risk management on the Rio Grande commencing near Truth or Consequences (formerly Hot Springs) at about River Mile 123 extending upstream to the lower end of the Rio Grande Canyon about 14 miles upstream from Española, New Mexico at about River Mile 394. What is now known as the San Acacia to Bosque del Apache Unit makes up the downstream reach of the Middle Valley from the confluence of the Rio Puerco to Elephant Butte Reservoir. The comprehensive plan included: construction of three dams; channel rectification; dredging of the river; and levee enlargement and construction. Those flood risk management components that correspond to the San Acacia to Bosque del Apache Unit include: dredging 20 miles of the river channel upstream from the head of Elephant Butte Reservoir; channel rectification; and enlargement of local levees or construction of new levees. A November 1947 agreement delegated responsibility for channel rectification and dredging to the Bureau of Reclamation and flood control dams and levees for local flood protection to the Corps of Engineers.

House Document 243 describes the phasing of construction of the various flood risk management components starting with construction of one or more of the upstream dams to reduce flood flows and capture sediment. Channel dredging would be concurrent with construction of the first dam. Channel rectification would then proceed, taking advantage of channel degradation provided by clear water releases from upstream dams. Finally, levee enlargement and construction would take place and accommodate the previous work. The construction schedule is provided in Appendix E of House Document 243, Schedule of Construction:

> *…It is probable that construction of the work included in the Flood Control Phase of the Plan may require as many as 16 years to complete. The three flood control dams could be constructed within two years but it is probable that their construction period may spread over as many as six years. Consequently, six years is being used in this report as the time for dam construction. Dredging of the 20 miles of channel above Elephant Butte Reservoir should first be accomplished concurrently with the construction of the first of the major dams preferably Chamita Dam. It is assumed that the dredging will continue as*

> *original construction is complete or 16 years after dredging is started. Other channel rectification and levee work should start upon completion of the three dams or six years after the original start of construction and continue for ten years, the time considered as required to completely stabilize the channel. This will make a total construction period of 16 years for the Floodway Project …*

According to the plan of implementation, levee improvements were the last portion of the flood control phase and predicated on the results of the other components. In particular, levee location would depend on channel rectification which did not have a predetermined alignment. The specific design and location of channel rectification is dependent on river channel degradation provided by construction of upstream dams. Appendix E of House Document 243 provides for channel rectification without specifying location or alignment:

> *Concurrent with the progressive degradation of the stream channel it is proposed to assist the degradation by dredging, by removal of hard spots and by making cutoffs or otherwise aligning the channel as required. At the same time the degradation work is to be progressing, stabilization of the channel would also be accomplished by installing pile dikes, tree retards, sills, revetments, groins or such other control works as would be required to develop a stabilized channel in the desired location.*

The authorization anticipated changes to the condition and location of the Rio Grande channel as a result of completion of these efforts and provides for this in House Document 243, Appendix E Planning, paragraph 107, which states: "*The alignment of any new or constructed levees would depend upon the location of the river channel at the time the work would be planned in detail.*"

Similarly, levee sizing and length would be dependent on river channel condition from both dredging and once the degrading action of clear water releases from upstream dams and channel rectification was complete. House Document 243 states:

> *Dredging of 20 miles of the river above the head of Elephant Butte Reservoir is one part of the channel rectification program which should be definitely required and which should be accomplished concurrently with the construction of the Chamita or Chiflo Dam, whichever is constructed first. The existing floodway through this reach of the river is filled with sand which was deposited mostly by the 1937 and 1941 floods. The Rio Puerco which enters the Rio Grande approximately 35 miles upstream of from this reach also carries in large quantities of sediment which are now being deposited in the area. These sediment deposits have raised the river bed several feet… This aggrading of the stream bed in this location is a natural result of the creation of Elephant Butte Reservoir.*

House Document 243 goes on to say:

> *The combination of all the features previously described in this appendix forms the flood control phase of the plan. The coordinated operation of all these features would perform the following flood control functions… b. Lower the river bed through the process of degradation by the retention of from 80 to 90 percent of the sediments carried by flood*

> *waters on the Jemez Creek, Rio Chama and upper Rio Grande and by channel improvement and rectification work. By storing sediments and releasing clear water from the reservoirs degradation of the stream bed through the Espanola and Middle Valleys would be accomplished. The storage of sediments would, in time, also reduce the amount of sediments now being deposited in or near the head of Elephant Butte Reservoir [San Acacia to Bosque del Apache Unit]. …. the final, results and time required for degradation may vary from those arrived at in the [Control of Sediment] studies. A definite trend is indicated, however, and it is logical to expect that there would be a degrading action all through the Middle Valley. The Studies indicate that as much as 20 years might be required to lower the river bed to a 1936 condition if river action alone is depended upon to accomplish the desired results. It is estimated that with the assistance given by channel improvement work the time required for lowering the river bed to where it was in 1936 would be not more that 10 years…*

Based on these descriptions, the river channel in the reach corresponding to the San Acacia to Bosque del Apache Unit would be returned to a 1936 state or at least provide a channel bottom at the same elevation that it was in 1936. This condition would greatly improve the capacity of the river channel to convey flood flows through the San Acacia to Bosque del Apache Unit. However, the dredging work was never completed and further, the river channel in the lower reach of the San Acacia to Bosque del Apache Unit has continued to aggrade over the 60 years between the authorization and the current GRR/SIES II. Since the river channel was not lowered as described in the 1948 authorization, the current design of levees would need to compensate for floodway capacity that was not realized. This capacity is provided in the 1948 authorization as passing safely a flood event of 40,000 cfs and San Acacia diminishing to 30,000 cfs at San Marcial.

For the reasons stated above, House Document 243 does not provide a detailed design for levees in the San Acacia to Bosque del Apache Unit. The authorization instead provides for the capacity and cross section the levee should be built to. As described in the 1948 report, House Document 243, levees had been constructed by local interests through parts of the Española and Middle Valley of the Rio Grande. The levees were not uniform as to grade, section or standard of construction and it was proposed to modify and supplement the existing levees. New grades would be established in accordance with the requirements for safely passing a Standard Project Flood of 40,000 cubic feet per second (cfs) for the San Acacia to San Marcial reach. The proposed levees would be constructed to standard section, with 10-foot crown, 3 on 1 side slopes and with a freeboard of three feet above maximum water surface. Sixty miles was listed as the length of levees that needed improvement but the exact location with the Middle Valley was not described. The authorization anticipated changes to the condition and location of the Rio Grande channel as a result of completion of these efforts and provides for this in House Document 243, Appendix E Planning, paragraph 107, which states: "*The alignment of any new or constructed levees would depend upon the location of the river channel at the time the work would be planned in detail.*"

The following paragraphs discuss the recommended plan as it relates to the information provided in the authorization found in House Document 243 for Flood Risk Management features in the

San Acacia to Bosque del Apache Unit (Table 7.1). Specific comparison is provided for those metrics found in House Document 243. These metrics are enumerated in Section 7.1, above.

Table 7.1 Comparison of Project Features

	1948 Authorized Plan[1]	**Recommended Plan**
Design event	Standard project flood 40,000 – 30,000 cfs	0.2%-chance exceedance probability 29,900 – 15,000 cfs
Duration of Inundation Anticipated	3 to 4 days	100 days
Provisions for Uncertainty	3 feet of freeboard above mean water surface elevation of the 1%-chance exceedance probability	Risk-based analysis used to provide an assurance of levee performance
Levee Performance	-Not Applicable-	98.9 % assurance of passing a 1% exceedance probability flow event
Level of Protection	1% exceedance probability	-Not applicable-
Cross-Section	Trapezoidal	Trapezoidal
Construction	Non-zoned earth fill	Compacted random fill with impervious core
Length	60 miles within the Middle Valley[1]	43 miles San Acacia to Bosque del Apache Unit only
Levee Height	14.0 feet average	2 to 14 feet
Earth Fill	7.3 million cy	2.5 million cy
Impervious Fill	None	82,600 cy
Required Borrow	800,000 cy	None
Seepage Control	Not identified	2-foot wide bentonite trench and drainage blanket, perforated pipe (subdrain system), and outlet pipe to the LFCC
Top Width	10 feet	15 feet
Side Slopes	3H:1V	Varies (2.5H:1V; 3H:1V)

[1] 1948 Authorization identified 60 miles of levee requiring improvement within the Middle Valley but did not identify limits.

7.1.1 Changes in the Scope of the Authorized Project

The current GRR/SEIS-II incorporates several changes that have occurred since the 1948 Authorized Project. The changes include the following:

- Rectification of the Rio Grande channel has been undertaken by the Bureau of Reclamation as outlined in the 1948 authorization and construction of the Low Flow Conveyance Channel was completed under the same authority.
- A longer period of record for hydrological data is now available to allow improved and updated hydrological analysis.
- A levee design modification is necessary to address long duration flows. Any proposed plan would have to incorporate design features to prevent seepage through the levee due to prolonged flow against the riverward toe.

- The Corps has departed from the use of the freeboard methodology to account for uncertainty, relying instead on a probabilistic determination of flood risk and levee design.

- Three species were listed as threatened or endangered since 1994 (the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, and Pecos sunflower — each occurring within the study area, two with critical habitat).

Unlike in the formulation of the Authorized Project, risk-based analysis was applied in the formulation of the recommended plan. This required consideration of the joint effects of the uncertainties associated with the hydrologic, hydraulic, and economic variables. Similar to the Authorized Project, the recommended plan consists of rehabilitation of the existing spoil bank. The metric of maximizing net benefits was used to determine levee design. As described in Chapter 4, multiple levee lengths and heights were evaluated to determine the plan that maximizes net benefits consistent with protecting the Nation's environment.

7.1.2 Changes in Project Purpose

The project purpose of flood risk management has not changed from the Authorized Project.

7.1.3 Changes in Local Cooperation Requirements

Cost-sharing requirements for the non-Federal sponsor are in accordance with the Water Resources Development Act (WRDA) of 1986 as amended specifically for the San Acacia to Bosque del Apache Unit of the Rio Grande Floodway by WRDA 1992 (Public Law [PL] 102-580). Pertinent language contained in these acts is as follows:

> *Based on current laws and regulations, the basic requirements for non-Federal participation in flood control projects are as follow:*
>
> - *Provide a cash contribution equal to 5 percent of structural flood control features.*
>
> - *Provide all land, easements, rights-of-way, relocation, and disposal areas (LERRDs).*
>
> - *If the sum of the above two items is less than 25 percent of the costs assigned to flood control, non-Federal sponsors will pay the difference in cash. If it is greater than 25 percent, total non-Federal costs shall not exceed 50 percent of total project costs assigned to flood control. Contributions in excess of 50 percent will be reimbursed by the Federal Government to the non-Federal sponsor.*

Although cost-sharing for new flood risk management projects was modified in WRDA 1996, that provision does not apply to projects like the San Acacia to Bosque del Apache Unit that were authorized prior to 1996.

A major damage category for the study outside of structures and their contents is damage to the LFCC. The WRDA 1992 (Public Law [PL] 102-580) authorizes the Corps to identify the portion of project benefits attributable to Federal properties. The following is an excerpt from Section 102 of the WRDA 1992:

> *(s) RIO GRANDE FLOODWAY, NEW MEXICO.--Notwithstanding any other provision of law, the project for flood control, Rio Grande Floodway, San Acacia to Bosque del Apache Unit, New Mexico, authorized by section 203 of the Flood Control Act of 1948 (Public Law 80-858) and amended by section 204 of the Flood Control Act of 1950 (Public Law 81-516), is modified to more equitably reflect the non-Federal benefits from the project in relation to the total benefits of the project by reducing the non-Federal contribution for the project by that percentage of benefits which is attributable to the Federal properties; except that, for purposes of this subsection, Federal property benefits may not exceed 50 percent of the total project benefits.*

The analysis indicated that 40.7 percent of the benefits are attributed to Federal properties. The non-Federal sponsor would be required cost share only those portions of the benefits attributable to the non-Federal properties or 59.3 percent of the total project cost. With a cost share of 75 percent Federal to 25 percent non-Federal, the Sponsor would be required to pay an adjusted cost share of 14.8 percent of the total project cost.

7.1.4 Changes in the Location of the Project

The location of the project has not changed from the 1948 Authorized Project, which extended from the Española Valley to the upper end of Elephant Butte Reservoir, a total of 181 miles. The study area of the San Acacia to Bosque del Apache Unit is incorporated in the area of consideration stated in the authorization. The location of levees for replacement was not specified in the 1948 authorization. House Document 243, Appendix E Planning, Paragraph 107, which states: "*The alignment of any new or constructed levees would depend upon the location of the river channel at the time the work would be planned in detail.*" The recommended plan (approximately 43 mile-long levee at the Base Levee + 4 ft height) is the project "planned in detail" as noted in the authorization with consideration of previously completed components of the Rio Grande Floodway, specifically: Cochiti, Abiquiu, Galisteo and Jemez Canyon Dams, channel rectification, and the LFCC.

7.1.5 Design Changes

The change from the freeboard-based design presented in the 1948 Report (and also in the 1989 Reevaluation Report) to the risk-based approach to design used for the current recommended plan makes the comparison of the Authorized Project and the recommended plan difficult because each methodology essentially produces two different levee designs with similar features.

Table 7.1 presents a comparison of the major design features of the recommended plan to those criteria presented in the 1948 Authorization.

7.1.6 Changes in Economic Analysis

New hydraulics and hydrology – The 2010 analysis that informed the levee design in the recommend plan includes factors that weren't evaluated in 1948, such as an updated hydrologic model using a longer period of record, the perched channel, and significant sediment accumulations over the study time period. These factors substantially alter the future without- and future with-project conditions. Sediment accumulations have the effect of increasing future damages for a given flow and of attenuating any project's performance in the future with-project condition. There was also significant evaluation of the impact of a proposed levee on the east bank of the Rio Grande, and on downstream properties, such as the San Marcial Railroad Bridge.

New economic evaluation guidance – The Corps' shift from a deterministic, point-estimate of damages and benefits attributable to specific-frequency events to an evaluation incorporating concepts of risk and uncertainty has had the impact of increasing damages and benefits attributable to projects. Merely shifting from a deterministic model to a risk and uncertainty-based model may cause an increase in Equivalent Annual Damages and benefits. The biggest boost to EAD comes from the variability surrounding the probability at which economic damages begin (the "start of damages" condition).

Another factor serving to increase EAD and claimable benefits came from Economic Guidance Memorandum 04-01 (USACE 2003), which provided generic depth-damage relationships for residential structures and contents. Studies conducted prior to the memo used Flood Insurance Administration (FIA) claims data to populate depth-damage relationships, whereas the newer curves use research conducted by the Corps' Institute for Water Resources' that evaluated factors such as warning time, inundation duration, etc. The curves were developed for nation-wide applicability, and per the Economic Guidance Memorandum, site-specific depth-damage relationships, content valuations, and content-to-structure ratios are not required to be developed when using these newer curves. The newer curves also differ from prior studies in that non-zero damages start at -2' for a one-story, no basement structure, which is the predominant residential structure type in the study area.

New floodplain inventory of damageable properties and NED benefits – Changes to the nature of the economic evaluation have taken place. In the present evaluation, outbuildings referred to material storage sheds, shelters for vehicles, and covered storage, like hay storage buildings. In some cases, a storage shed on a residential property would merely be coded "Residential" during the field inventory. The outbuildings category served as a catch-all to identify structures and contents where ownership and use (public or commercial) were not easily identifiable.

There was a significant change in the calculation of recreation damages and benefits, largely due to the use of visitation data and the inclusion of specialized recreation values during the winter, when visitation is significantly higher due to the Bosque del Apache National Wildlife Refuge's unique role as winter home for migratory waterfowl.

The agricultural damages and benefits changed from 1947 to 2010, which is largely attributable to new crop budget data showing increased input costs, and to changes in acreage in production.

7.1.7 Changes in Total Project First Costs

The total estimated cost of the Rio Grande Floodway to include all flood control phase elements for the entire Rio Grande Basin was presented in the House Document 243 as $10,160,000. The Federal cost was estimated at $10,000,000. The non-Federal share of $160,000 reflected the costs of rights-of-way for project construction. The levee improvements for the entire Middle Valley were presented as $900,000 (1947 price levels). However, what proportion of that amount corresponds to the San Acacia to Bosque del Apache Unit in not evident. Without this breakdown of the costs from the authorization, a direct comparison based on project costs is not possible.

7.1.8 Changes in Project Benefits

Benefits from damageable properties and transportation costs presented in the 1948 authority were described for the entire Middle Valley and did not separate any costs that can be compared to the San Acacia to Bosque del Apache Unit. Therefore comparisons of benefits from the Authorized Project and the recommended plan are not possible.

7.1.9 Benefit-to-Cost Ratio

For the benefit-cost analysis in this GRR/SEIS-II, the project costs were amortized over the 50-year period of analysis using the 2010 Federal discount rate of 4.375 percent. The benefit/cost ratio for the recommended plan is 1.62. There was no benefit/cost ratio provided for a levee specific project in the 1948 Authorization.

7.1.10 Changes in Cost Allocation

Table 7.2 presents the allocation of cost among the project purpose for the recommended plan. The costs were allocated to the single purpose of flood risk management. Under Corps authority, this project is subject to a 75% Federal to 25% local sponsor cost share percentage. This cost share is adjusted benefits in accordance with WRDA 1992 to reflect the proportion of Federal to non-Federal benefits from the project.

Table 7.2 Costs Relating to the Recommended Plan

Item	Recommended Plan (x $1000) (October 2013 Prices)	
	Federal	Non-Federal
Construction (Flood Risk Management)	$243,184	
LERRDs		$993
Total Investment Cost (Flood Risk Management)	$243,184	$993
Mandatory 5% Cash	($12,200)	$12,200
Subtotals	$230,984	$13,193
Additional Cash to Provide Minimum Non-Federal Share of Total Project Costs	($48,600)	$48,600
Subtotals	$182,384	$61,793
Percentage of Total Cost-Shared Amount	*75%*	*25%*
Adjustment due to Benefits to Federal Properties	$25,200	($25,200)
TOTALS	$207,584	$36,593
Percentage of Total Cost-Shared Amount	*85.01%*	*14.99*

The detailed costs provided for the recommended plan differ from the estimates presented in Chapter 4 (Tables 4.9-4.11) due to refinement of construction design and quantities, additional real estate analysis and changes from a 14-year to a 20-year construction schedule. The cost estimates figures in Tables 4.9 through 4.11 are based on preliminary cost estimates that were used to compare alternative plans.

7.1.11 <u>Changes in Cost Apportionment</u>

Also presented in Table 7.2 is the apportionment of costs between the Federal Government and the non-Federal sponsor.

Based on the cost-sharing requirements provision of WRDA 1992 (PL 99-662), the non-Federal cost-sharing minimum requirement of 25 percent for the recommended plan is adjusted to reflect the benefits attributed to Federal properties (i.e. BDANWR, LFCC). The benefits attributed to Federal properties are 40.1% of the proposed project leaving 59.9% of the benefits attributed to non-Federal properties. Thus, the apportionment was adjusted to reflect a 85.01 – 14.99%

(59.9% multiplied by 25%) percent sharing of the costs between the Federal Government and non-Federal sponsor, respectively, in accordance with WRDA 1992.

7.1.12 Environmental Considerations in Recommended Changes

Potential effects of the 1948 Authorized Project were not determined in any fashion comparable to current practice. Since no design or footprint of a specific construction project was presented in the authorization, a determination of effects to the environment is not possible. Effects from the recommended plan would presumably be very similar and are presented in Table 7.4 below.

Primary, long-term impacts entailed the unavoidable loss or degradation of certain resources due to the levee footprint. Short-term effects were related to construction activities, and may have included a qualitative impact assessment for minor resources.

Table 7.3 Project Effects of the Recommended Plan

Resource	Recommended Plan
Riparian vegetation	Comparable acreage (for same 43-mile portion of levee).
Jurisdictional wetland	0 acres (The southern 10.5 miles of levee are not in the recommended plan).
Upland grass/shrub (in borrow areas)	0 acres (No borrow areas are required in the recommended plan).
Federally listed species	May affect, but not likely to adversely affect the Southwestern Willow Flycatcher and its critical habitat. May affect, and would likely adversely affect the Rio Grande silvery minnow and its critical habitat.
Cultural resources	No adverse effect to historic properties; adverse effect determination to be completed for waste disposal locations.
Recreation	Temporary impairment due to limited access during construction.
Fisheries; water quality; air quality; land use; water salvage and conveyance; sediment transport	Not appreciably effected or appreciably altered.

7.1.13 Public Involvement

Previous public coordination in this study has consisted of a public meeting held on July 1979, and inter-agency coordination with Reclamation, the USFWS, the New Mexico Office of the State Engineer, and others. The 1992 SEIS was distributed to approximately 120 Federal, State, and local government agencies, and private individuals. The public notice solicited comments and information to evaluate the probable effect of the proposed action (54-mile levee) on the public interest. A Draft for the 1999 LRR was completed and distributed for public review and comments. The public notice solicited comments and information on the modified action being proposed (43-mile levee, replacement of the railroad bridge at San Marcial, and sediment basin at Tiffany).

During plan formulation and preliminary design of the currently recommended plan, numerous formal and informal meetings were held with Reclamation, the USFWS, the Bureau of Land Management, Bosque del Apache NWR, Sevilleta NWR, the MRGCD, the NMISC, other pertinent State and local agencies, and environmental organizations.

Public concerns as well as those of the coordinating resource agencies helped guide the development and formulation of the array of alternative plans presented in this GRR/SEIS-II. During the study, coordination within the Middle Rio Grande community was accomplished through Middle Rio Grande Endangered Species Collaborative Program (MRGESCP), Middle Rio Grande Levee Task Force, reservoir operation and water delivery functions. The MRGESCP is a partnership involving 16 current signatories organized to protect and improve the status of endangered species along the Middle Rio Grande (MRG) of New Mexico while simultaneously protecting existing and future regional water uses. The levee task force was created to study the status of levees in the Middle Rio Grande valley. Flood risk management issues as well as environmental or ecosystem health issues were communicated through these organizations and incorporated into the project objectives.

The lack of integrity of the existing spoil bank in the study reach and other locations in the Middle Rio Grande reach dictate the upper limits of releases from upstream dams. These limitations impact water delivery, sediment movement and floodplain ecosystem function. The Corps, as a member of these coordinating groups and involvement in water delivery effort for several years, is aware of the issues surrounding flood risk management levees in the study reach. Consideration of environmental impacts, endangered species requirements and river function was incorporated into the design of the current study.

In addition to many informal conversations with stakeholders, the Corps hosted an information and scoping meeting on 14 January 2011 for several stakeholder and interest groups to present the array of alternatives and tentatively selected plan. The group included members of the Save Our Bosque Taskforce, Audubon Society, Wild Earth Guardians, Rio Grande Restoration, the Water-Culture Institute, Bureau of Reclamation, and representatives from Senators Bingaman and Udall's offices. The input received from the meeting included additional forecasting of future conditions and evaluation of levee setbacks as presented in the GRR/SEIS¬II.

A notice of intent to prepare an SEIS was published in the Federal Register on March 2, 2012. The draft GRR/SEIS-II was submitted to the U.S. Environmental Protection Agency (USEPA) and was made available for public review and comment from April 27 through July 11, 2012. A notice of availability of the draft document was published by the USEPA in the Federal Register on April 27, 2012. The District published notices of availability in the Federal Register (also on April 27) and in local newspapers. A public meeting was held in Socorro on May 22, 2012. Chapter 9 and Appendix G of this GRR/SEIS-II includes additional detail on public involvement and comments.

A public meeting was held on 22 May 2012 at the Socorro city council chambers to coincide with the public review of the GRR/SEIS-II. There were eight attendees from interested citizens and agencies. No official comments were received during the public meeting. The attendance list and comments received during the public review period are included in Appendix G. The notice of this meeting appeared in the Santa Fe New Mexican (3 publications), The Albuquerque Journal (4 publications) and Socorro El Defensor-Chieftain (I publication). Notices of availability of the public document for review appeared in each of the same newspapers. Paper copies of the document were made available at the Socorro City Library and the Corps office in Albuquerque. Electronic copies on compact disk were sent to approximately 50 stakeholders and agencies as well as made available on the Corps website.

Public concerns as well as those of the participating resource agencies helped guide the development and formulation of the array of alternative plans presented in this GRR/SEIS-II. Additional engineering, design, and cost estimating were completed for each alternative and ultimately resulted in the conclusions presented in this GRR/SEIS-II.

7.1.14 Funding Since Authorization

Funding information for the San Acacia to Bosque del Apache Unit project is presented in Table 7.5, below.

Table 7.4 Funding Information

FUNDING HISTORY 23 March 2011

FY	Federal Funding								Non-Federal Funding		Activity
	General Investigations			ARRA 9693134		Construction General					
	Appropriation	Allocation	Expenditures	Allocation	Expenditures	Appropriation	Allocation	Expenditures	Cash	Expenditures	
											AE&D
1987	500,000.00	350,000.00	244,554.18								CCS 651
1988	390,000.00	390,000.00	323,825.69								
1989	450,000.00	250,000.00	361,273.69								
1990	287,000.00	317,000.00	359,626.46								
1991	263,000.00	351,000.00	367,541.07								
1992		0.00	1,178.91			3,000,000.00	450,000.00	389,371.80			CCS 511
1993						6,000,000.00	225,000.00	177,379.83			
1994						9,000,000.00	6,100,000.00	216,173.83			
1995						1,000,000.00	-4,858,000.00	369,005.62			
1996						0.00	-200,000.00	454,646.14			
1997						100,000.00	545,000.00	570,839.05			
1998						280,000.00	293,000.00	309,015.24			
1999						750,000.00	337,000.00	346,572.94			
2000						600,000.00	515,000.00	400,084.53			
2001						600,000.00	73,000.00	233,726.58			
2002						300,000.00	162,000.00	132,459.86			
2003						800,000.00	642,000.00	619,371.00			
2004						600,000.00	488,000.00	536,216.76			
2005						600,000.00	548,000.00	541,996.43			
2006						700,000.00	966,000.00	950,544.92			
2007						800,000.00	800,000.00	789,703.20			
2008						800,000.00	749,000.00	428,521.68			
2009						766,000.00	766,000.00	614,872.19			
2009 ARRA Funding				550,000.00	0.00						
2010				-199,624.21	309,287.51	756,000.00	756,000.00	732,549.42			
2011				0.00	0.00		530,000.00	451,757.97			CR funding
	1,890,000.00	1,658,000.00	1,658,000.00	350,375.79	309,287.51	27,452,000.00	9,887,000.00	9,264,808.99	0.00	0.00	
Project/Study Name:	Rio Grande Floodway, San Acacia To Bosque del Apache, NM							PWI No:	074778	CCS 511	

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CHAPTER 8 - CONCLUSION AND RECOMMENDATIONS

The recommended plan consists of rehabilitating approximately 43 miles of spoil bank along the west bank of the Rio Grande from the SADD to Tiffany Junction. This plan would provide performance equivalent to conveying the 1-percent chance event with a 33.6-percent level of confidence. It would also reduce damages from flooding to inhabitants of the west floodplain, the LFCC, and numerous railroad, irrigation, drainage, transportation, and agricultural improvements within the length of the project area. The recommended plan is the NED Plan. The levee alignment would follow the existing spoil bank, between the LFCC and the Rio Grande. The levee design height is equivalent to 4 feet above the water surface elevation that corresponds to the 1%-chance flow in the base year condition. The discharge for the 1%-chance flow is 29,900 cfs at the upstream end, decreasing to 15,000 cfs at the downstream end of the project. The reason for the reduction in discharge is the attenuation of flood flows as they travel downstream through the project area. The results from the additional analyses conducted and presented in this GRR/SEIS-II have not changed the sponsor's favorable support of this project.

The recommended plan is the National Economic Development (NED) Plan, which maximizes net economic benefits consistent with protecting the Nation's environment. This GRR/SEIS-II document fulfills the requirements of the Corps planning and policy as well as requirements under NEPA for evaluation of alternatives and selection of a recommended plan.

Primary, long-term environmental impacts entailed the unavoidable loss or alteration of certain resources due to the levee footprint. Short-term effects were related to construction activities, and may have included a qualitative impact assessment for minor resources.

A Biological Assessment for the proposed action was completed in May 2012 and a final Programmatic Biological Opinion was issued by the U.S. Fish and Wildlife Service (Service) in February 2013 (USFWS 2013; see Appendix C of the GRR/SEIS-II). The mitigation plan developed as part of this report includes requirements in the Biological Opinion, as well as coordination with the Sevilleta and Bosque del Apache National Wildlife Refuges. The total mitigation cost for the recommended plan is $1,049,800. A summary of mitigation measures and their costs is described I Seciton 6.4.2.4 of this report. More detailed information can be found in Appendix F-4, Mitigation Plan.

The recommended plan will be constructed in 20, 1-year phases. A revised cost estimate wasprepared for the recommended plan in more detail and updated to reflect program year (FY 2013) price level. The "Program Year" project cost estimate was used to develop costs for each of the phases of construction. Interest during construction was computed for each phase using equal, mid-monthly payments at the FY 2013 interest rate (3.75%). Table 8.1 presents project costs (to include interest during construction) and benefits (to include benefits during construction) computed prior to the base year (2032) and during the period of analysis. The total investment cost and equivalent average annual benefits in Table 8.1 below, differs from that presented in previous tables due to the update and calculation of interest during construction.

Table 8.1 Costs and Equivalent Annual Benefits for the recommended plan (x $1,000 Oct 2013 price level).

Construction Costs (x $1,000)	
Total Investment	$362,080.93
Avg. Ann. Cost (3.75%, 50 yr. Period of Analysis)	$15,436.85
OMRR&R	$618.02
Total Avg. Ann. Cost	$16,054.87
Project Benefits (x $1,000)	
Equivalent Avg. Ann. Benefits	$32,181.41
Benefit/Cost Ratio	2.00
Net Benefits	$16,126.54

8.1 VIEWS OF THE NON-FEDERAL PROJECT PARTNER

The MRGCD and NMISC have affirmed their intent to participate in the project. The results attained in the additional analyses conducted and presented in this GRR/SEIS-II have not changed the sponsor's favorable support of this project. The sponsors have the state-chartered responsibility for providing flood risk management to the Middle Rio Grande Valley, and recognize the importance to their constituents of proceeding with this project. Recent council resolutions were provided by both sponsors indicating their support and willingness to cost share in the implementation of the San Acacia to Bosque del Apache Unit Project. The Corps has received statements of financial support from the MRGCD and NMISC which continue to show interest and support for this project.

8.2 STUDY MILESTONES

The following table (Table 8.2) indicates the schedule for the remaining milestones for the study.

Table 8.2 Schedule of Project Milestones

Milestones	**Date**
Final GRR-SEIS II approval	January 2014
Notice of Availability in Federal Register	January 2014
Sign Record of Decision if appropriate	February 2014
Construction Contract Award (phase 1)	April 2014

8.3 DISTRICT ENGINEER'S RECOMMENDATIONS

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 Rio Grande Floodway, San Acacia to Bosque Del Apache Unit, New Mexico meets all requirements for implementation under Federal and Corps regulation. The recommended plan includes rehabilitating approximately 43 miles of spoil bank along the west bank of the Rio Grande from the San Acacia Diversion Dam to Tiffany Junction. This plan would provide performance equivalent to conveying the 1-percent chance event with a 33.6-percent level of confidence. It would also reduce damages from flooding to inhabitants of the west floodplain, the Low Flow Conveyance Channel, and numerous railroad, irrigation, drainage, transportation, and agricultural improvements within the length of the project area. The recommended plan is the NED Plan. The levee alignment would follow the alignment of the existing spoil bank, between the LFCC and the Rio Grande. The levee design height is equivalent to 4 feet above the water surface elevation that corresponds to the Base Levee + 4 ft. The discharge for the 1%-chance flow is 29,900 cfs at the upstream end of the project, decreasing to 15,000 cfs at the downstream end. The reason for the reduction in design discharge is the attenuation of flood flows as they travel downstream through the project area. The Recommended Plan is described in greater detail in Chapter 5.

I recommend that the flood risk management improvements in the Rio Grande Floodway, San Acacia to Bosque Del Apache Unit 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 $225,065,000. 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 Rio Grande Floodway, San Acacia to Bosque Del Apache Unit Project, and the non-Federal sponsors comply with applicable Federal laws and policies, including but not limited to:

a. Provide a minimum of 14.99 percent, but not to exceed 50 percent of total project costs as further specified below:

    1. Provide 14.99 percent of costs in accordance with the terms of a project partnership agreement entered into prior to advertisement of the first phase of construction for the project;

    2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of preconstruction engineering and design, and phase 1 construction costs;

    3. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

    4. 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 project;

5. Provide, during construction, any additional funds necessary to make their total contribution equal to at least 14.99 percent of total construction costs;

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

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

d. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 USC. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project partnership agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

g. 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 performance that the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. 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 USC 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. 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 Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

j. Give the Federal 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;

k. 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;

l. 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 completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 USC 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141 - 3148 and 40 USC 3701 - 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 USC 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 USC 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 USC 276c *et seq.*);

n. 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 USC 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsors with prior specific written direction, in which case the non-Federal sponsors shall perform such investigations in accordance with such written direction;

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

p. Agree, as between the Federal 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

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

I certify that the planning activities have been implemented in accordance with Corps 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. Consequently, the recommendations may be modified. However, prior to transmittal to the Congress, the Sponsors, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

10 Oct 2013

Date

Antoinette R. Gant

Antoinette R. Gant
Lieutenant Colonel, U.S. Army
District Commander

CHAPTER 9 - PREPARATION AND COORDINATION

9.1 PREPARATION

This Draft GRR/SEIS-II was prepared by the U.S. Army Corps of Engineers, Albuquerque District. The Product Delivery Team and principal preparers included:

Jerry Nieto, P.E. – Project Manager
Mark Doles – Planner
Sarah Beck – Biologist
Rob Browning – Economist
Corina Chavez – Civil Engineer
Bryce Davis – Cost Engineer
William DeRagon – Biologist
Darrell Eidson, P.E. – Hydraulic Engineer
Gregory Everhart – Archaeologist
Danielle Galloway – Biologist
Pablo Gonzales – Cost Engineer
Ryan Gronewold, P.E. – Hydraulic Engineer
Bruce Jordan – Geotechnical Engineer
Ariane Pinson – Technical Writer/Editor
Michael Porter – Biologist
Michael Prudhomme – Cost Estimator
Mark Turkovich – Real Estate
Steven Wagner – Environmental Engineer
Vince Vigil – Hydraulic Engineer

Tetra Tech, Inc, prepared preliminary versions of Chapters 1 through 3:

Ira Artz – Project Manager
Michael Marcus
Mark Horner

9.2 TECHNICAL EVIEW

The Corps' Quality Control Reviewers included:

Julie Alcon, Environmental Resources
Ondrea Hummel – Ecology and NEPA/ESA compliance
Tamara Massong – Hydrology and Hydraulics
Kathy Skalbeck – Planning
Will Trujillo, P.E. – Geotechnical Engineering
Justin Reale – Environmental Engineering
Jonathan Van Hoose – Archaeologist
Ariane Pinson –Technical Writer/Editor
Timi Shimabukuro – Economics
Ben Alanis – General Engineering
Glenn Roybal – Cost Engineering
Karen Kennedy – Real Estate

Agency Technical Review was performed by Corps employees not associated with the project:

Marc Masnor – ATR Team Lead/Plan Formulation
Michelle Horn – Cultural Resources
Ethan Thompson – Hydrology and Hydraulics
Rhonda Sallee – Real Estate
Brian Harper – Economics
Ed Rossman – Recreation/Sociology
Sandra Stiles – Environmental/NEPA
Jim Neubauer – Cost Engineering

Independent External Project Review Team are non-Corps scientists and engineers hired to review the documents:

Mr. Paul Bovitz	Biology/Ecology
Dr. Patrick Creegan	Civil/Cost Engineering and Geotechnical/Structural Engineering
Mr. Elvidio Diniz	Civil Works Planning and Hydrologic/Hydraulic Engineering
Dr. David Jaffe	Hydrologic/Hydraulic Engineering
Dr. Roger Mann	Economics

9.3 PUBLIC COORDINATION AND REVIEW

Agencies and other entities contacted formally or informally in preparation of this GRR / SEIS-II included:

Burlington Northern Santa Fe Railroad
City of Socorro
Middle Rio Grande Conservancy District
New Mexico Audubon Society
New Mexico Department of Game and Fish
New Mexico Environment Department
New Mexico Interstate Stream Commission
New Mexico Office of the State Engineer
Middle Rio Grande Endangered Species Collaborative Program
Save Our Bosque Taskforce
U.S. Bureau of Land Management, Socorro Field Office
U.S. Bureau of Reclamation, Albuquerque Area Office
U.S. Environmental Protection Agency, Region 6
U.S. Fish and Wildlife Service, Bosque del Apache National Wildlife Refuge
U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge
U.S. Fish and Wildlife Service, New Mexico Ecological Services State Field Office
Water Culture Institute
WildEarth Guardians

A notice of intent to prepare an SEIS was published in the Federal Register on March 2, 2012. The draft GRR/SEIS-II was submitted to the U.S. Environmental Protection Agency (USEPA) and was made available for public review and comment from April 27 through July 11, 2012. A notice of availability of the draft document was published by the USEPA in the Federal Register on April 27, 2012. The District published notices of availability in the Federal Register (also on April 27) and in local newspapers. A public meeting was held in Socorro on May 22, 2012. Appendix G of this GRR/SEIS-II includes additional detail on public involvement, as well as all public comments and Corps responses.

CHAPTER 10 - REFERENCES*

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