Middle Rio Grande
Endangered Species Collaborative Program

Restoration Analysis and Recommendations for the Isleta Reach of the Middle Rio Grande, NM

July 2008

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Riada Engineering
Tetra Tech
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Prepared for

Middle Rio Grande
Endangered Species Collaborative Program
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July 2008

573-1590-005 (01) – Contract No. 06CR408146

Citation

Parametrix. 2008. Restoration Analysis and Recommendations for the Isleta Reach of the Middle Rio Grande, NM. Prepared for the Middle Rio Grande Endangered Species Collaborative Program, USBR Contract No. 06CR408146. Prepared by Parametrix, Albuquerque, New Mexico. July 2008.

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10 January 2008

DECISION PAPER TO COLLABORATIVE PROGRAM EXECUTIVE COMMITTEE

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This disclaimer language has been reviewed by members of the Coordination Committee. The NM Attorney General's Office, the NMISC General Counsel, and the Bureau of Reclamation's solicitor have provided editorial comments on the disclaimer.

Recommended Disclaimer:
[FUNDING AGENCY, e.g., Reclamation, Corps, NMISC, etc.], on behalf of the Middle Rio Grande Endangered Species Collaborative Program (Program), funded the work herein reported. This document fulfills or partially fulfills a contractual requirement and was sought by and provided to the Program to help meet the goals of the Program. This report is the work of a contractor and the findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the funding agency and other Program signatories. Implementation of any recommendations or formal adoption of the information is subject to further consideration by the Program.

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Acronyms and Key Terms

A

af	acre-feet
AWARDS	Agricultural Water Resources Decision Support

B

BEMP	Bosque Ecosystem Monitoring Program
BiOp	Biological Opinion
BOR	Bureau of Reclamation

C

cfs	cubic feet per second
COE	Corps of Engineer's
Corps	U.S. Army Corps of Engineers
CPUE	catch per unit effort

E

EA	Environmental Assessment
ESA	Endangered Species Act

F

FWS	Fish and Wildlife Service

G

GIS	Geographic Information System
GIS	Geographic Information Systems
GW	Groundwater

H

ha	hectares

L

LWD	large woody debris

M

m	meters
MRG	Middle Rio Grande
MRGCD	Middle Rio Grande Conservancy District

N

NMISC	New Mexico Interstate Stream Commission
NRCS	Natural Resource Conservation Service
NWR	National Wildlife Refuge

P

Program	Middle Rio Grande Endangered Species Collaborative Program

R

Reclamation	U.S. Bureau of Reclamation
RGSM	Rio Grande silvery minnow
RM	river mile
RMRS	Rocky Mountain Research Station
RPA	Reasonable and Prudent Alternative

S

silvery minnow	Rio Grande silvery minnow
SOBTF	Save our Bosque Task Force
SSPA	S.S. Papadopulos and Associates, Inc.
SWFL	southwestern willow flycatcher

T

TR	Technical Report

U

URGWOP	Upper Rio Grande Water Operations Program
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service

W

WMA	Waterfowl Management Areas

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Chapter 1 Introduction

1 What is the goal of this report and what are its primary objectives?

Parametrix received funding through the Middle Rio Grande Endangered Species Collaborative Program (Program) in Fiscal Year 2006 to develop scientifically-based restoration recommendations intended to improve the habitat and population status for two federally endangered species: the Rio Grande silvery minnow (silvery minnow) and the southwestern willow flycatcher (flycatcher). The project area is along the Middle Rio Grande between the south boundary of the Isleta Pueblo and the San Acacia Diversion Dam (see Exhibit 1-1), herein referred to as the *Isleta Reach*.

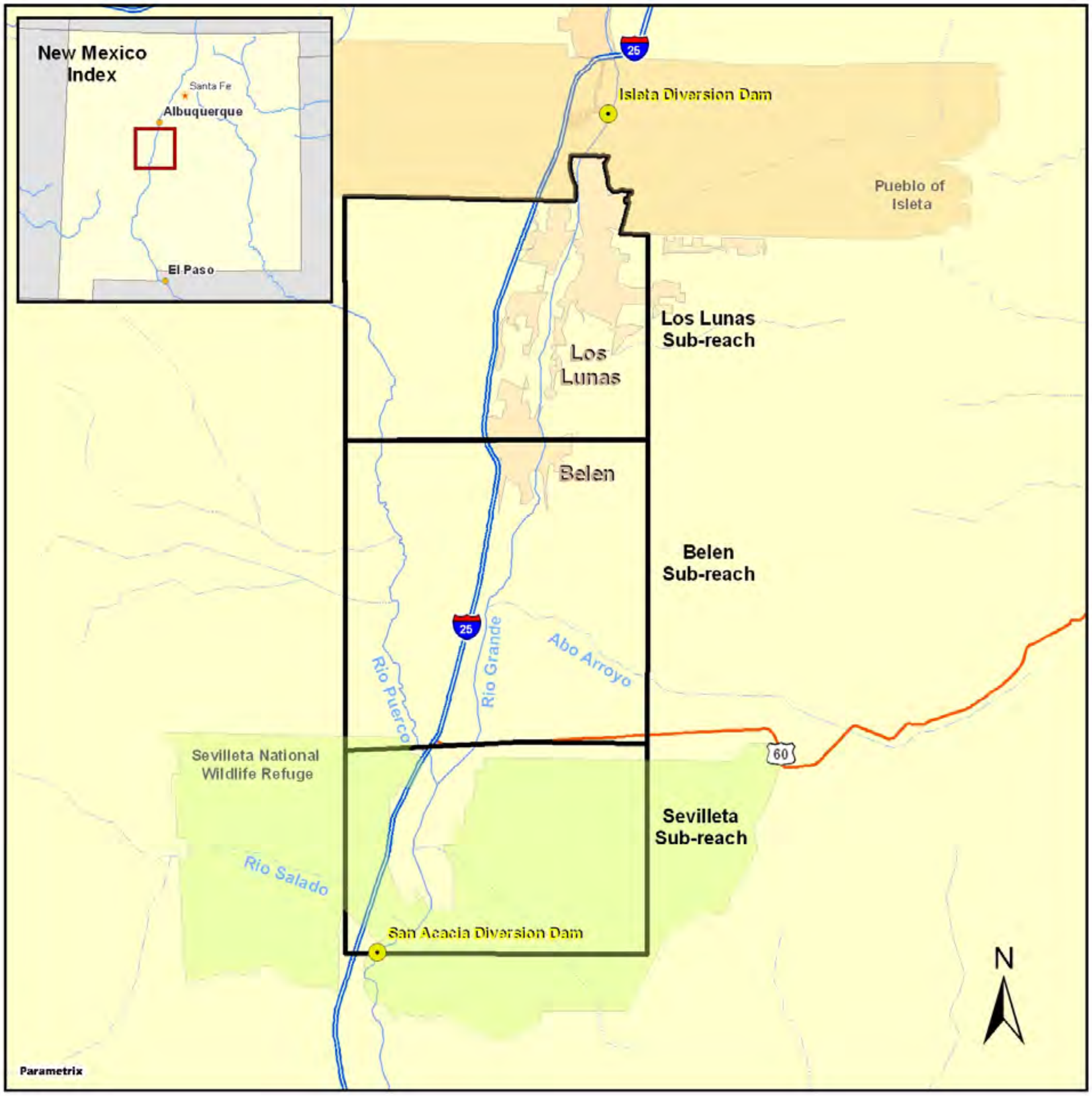
The restoration recommendations in this report are based upon review, analysis, and interpretation of existing data and reports. General project site reconnaissance was also performed, although site-specific field data collection was not part of this project. Limited site-specific data was available across the 48-mile project reach to support site-specific project recommendations. These projects, therefore, should be considered conceptual at this time. Future project sponsors will need to gather and analyze site-specific data to validate project feasibility, refine project cost and water depletion estimates, and develop detailed project monitoring plans.

The Isleta Project Reach

This report focuses on the Isleta Reach, a 48-mile reach of the Middle Rio Grande between the south boundary of the Isleta Pueblo and the San Acacia Diversion Dam.

Exhibit 1-1 shows the general geographic location of the Isleta Project Reach within the Middle Rio Grande.

Exhibit 1-1
General Project Area Map



The primary project objectives included:

- Gathering existing data, reports, and Geographic Information System (GIS) layers.
- Evaluating current conditions in the project reach through review, analysis, and synthesis of existing data, reports, and other pertinent information.

- Utilizing and building upon information and restoration recommendations from the report developed by the Program and New Mexico Interstate Stream Commission (NMISC) titled *Habitat Restoration Plan for the Middle Rio Grande* (Tetra Tech, 2004a).
- Performing site visits to become familiar with the project area conditions.
- Identifying physical, biological, legal, and policy constraints to habitat conditions and restoration potential in the project reach.
- Utilizing this information to recommend restoration approaches and assigning conceptual-level restoration projects.
- Providing adaptive management oriented monitoring criteria for evaluating recommended projects.
- Identifying data gaps and research needs.
- Organizing existing and new GIS data into a consolidated Geo-Database for use by the Program.

2 What is the focus of the Program?

The Program is a partnership involving 21 signatories organized to protect and improve the status of endangered species along the Middle Rio Grande of New Mexico while simultaneously protecting existing and future regional water uses. The two endangered species of particular concern to the Program are the silvery minnow and the flycatcher. The signatories to the Program include the following:

- Federal Agencies
- State Agencies
- Local and Municipal Government Entities
- Non-profit Organizations

- Native American Pueblos
- Universities
- Private Entities

The Program was established to help water managers and users along the Middle Rio Grande work in a collaborative manner to meet the legal requirements established by the Endangered Species Act (ESA) of 1973. The ESA established procedures and guidance to conserve species of fish, wildlife, and plants threatened with extinction. Specifically, Section 2(b) of the ESA states, “The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section.”

3 What are the goals of the Program?

The goals of the Program are described in the Public Scoping Report and Program Update dated March 7, 2005, as follows:

> Through the Program, the Signatories to the Cooperative Agreement would strive to ensure the survival and recovery of the Rio Grande silvery minnow (RGSM) [*sic*] and the southwestern willow flycatcher (SWFL) [*sic*] in the Middle Rio Grande. At the same time, the Program would seek to resolve conflicts among parties interested in, or having responsibility for, species protection and water development and management, all while complying with New Mexico state law and federal law. Responsibility for the efficiency and effectiveness of the Program, and its viability as a means for complying with the ESA, rests with all Signatories. With the formation of the federally recognized Program, the Signatories would agree to cooperate and to seek funding to achieve the following goals of the Program:
>
>> **Goal 1 –** Within the Middle Rio Grande, act to prevent extinction, preserve reproductive integrity, improve habitat, support scientific analysis, and promote

recovery of the RGSM [*sic*] and SWFL [*sic*]. The Program will strive to accomplish this in a manner that benefits the ecological integrity, where feasible, of the Middle Rio Grande riverine and riparian ecosystem. Program activities should benefit other protected species, maintain wild populations, improve the efficiency of water use and management, and provide water to sustain the RGSM [*sic*] and SWFL [*sic*].

Goal 2 – Develop agreements with water users and water management entities that will make supplemental water available, and manage the storage and release of water, in ways that contribute to the recovery of RGSM [*sic*] and SWFL [*sic*].

Goal 3 – Implement creative and flexible options under the ESA so that existing, ongoing, and future water supply and water resource management activities and projects may continue to operate and receive necessary permits, licenses, funding, and other approvals.

Goal 4 – Implement the Program consistent with—and in a manner that does not impair—pre-existing water rights and obligations while exercising creativity and flexibility to address the needs of the RGSM [*sic*] and SWFL [*sic*]. Water rights and obligations to be protected include: valid state water rights; federal reserved water rights of individuals and entities; San Juan–Chama contractual rights; the State of New Mexico's ability to comply with interstate stream compact delivery obligations; and Indian trust assets including federal reserved Indian water rights, prior and paramount, and time-immemorial water rights.

4 How does the ESA apply to the Middle Rio Grande?

On March 17, 2003, the Fish and Wildlife Service (FWS) issued a Biological Opinion (BiOp) on the effects of actions associated with the *Programmatic Biological Assessment of Bureau of Reclamation's Water and River Maintenance Operations, Army Corps of Engineers' Flood Control Operation, and Related Non Federal Actions on the Middle Rio Grande, New Mexico* (FWS, 2003a). The consultation specifically involved two Federal agencies; the U.S. Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps); and two non Federal entities, the NMISC and the Middle Rio Grande Conservancy District (MRGCD). The Fish and Wildlife Service concluded that water operations and river maintenance activities in the Middle Rio Grande, as proposed in the Biological Assessment dated February 19, 2003, are likely to jeopardize the continued existence of the silvery minnow and flycatcher and adversely modify critical habitat of the silvery minnow (FWS, 2003a).

The BiOp presents numerous Reasonable and Prudent Alternative (RPA) elements to avoid the likelihood of jeopardizing the continued existence of the silvery minnow and flycatcher and the destruction or adverse modification of silvery minnow habitat (FWS, 2003a). These RPA elements address issues of flow, habitat maintenance and restoration, captive propagation and augmentation, and water quality.

5 How does the BiOp relate to habitat restoration activities along the Middle Rio Grande?

Several RPA elements in the BiOp define "Specific Habitat Improvement Elements." Exhibit 1-2 highlights a few RPA elements presented in the BiOp that are especially relevant to habitat restoration efforts.

Exhibit 1-2

Example of "Reasonable and Prudent Alternative Elements" from the 2003 BiOp

RPA Element P	Requires that actions be conducted to prevent or minimize destruction of potential or suitable flycatcher habitat when installing pumps or groundwater wells. If this action may affect flycatcher habitat, coordinate with the FWS prior to installation.
RPA Element R	Requires that Reclamation coordinate with the FWS and parties to the consultation to complete fish passage at the San Acacia Diversion Dam to allow upstream movement of silvery minnows by 2008. Also requires additional coordination with the Pueblo of Isleta to complete fish passage at the Isleta Diversion Dam by 2013.
RPA Element S	Requires that the action agencies, in consultation with the FWS and appropriate Pueblos and coordinated with parties to the consultation, conduct habitat/ecosystem restoration projects in the Middle Rio Grande to increase backwaters and oxbows, widen the river channel, and/or lower river banks to produce shallow water habitats, overbank flooding, and regeneration of stands of willows and cottonwood to benefit the silvery minnow and the flycatcher, or their habitats. Such projects should be assessed with the goal of developing projects that are depletion neutral. By 2013, additional restoration totaling 1,600 acres (648 hectares) will be completed in the action area, with projects for the first 5 years or less emphasizing silvery minnow habitat restoration on river reaches north of the San Acacia Diversion Dam and distributed throughout the action area. The action agencies and parties to the consultation, in coordination with the FWS, shall develop timetables and prioritize areas for restoration. Projects should result in the restoration/creation of blocks of habitat 60 acres (24 hectares) or larger.
RPA Element T	When bioengineering (as described in Reclamation's 2003 Biological Assessment) cannot be used in planned river maintenance projects, habitat restoration will be implemented to offset adverse environmental impacts resulting from river alteration. Habitat restoration projects should replace the ecological functions and values of the affected area.
RPA Element U	Requires action agencies, in coordination with parties to the consultation, to collaborate on the river realignment and proposed relocation of the San Marcial Railroad Bridge project, which is necessary to increase the safe channel capacity within the Middle Rio Grande. Construction for the relocation of the San Marcial Railroad Bridge will be initiated by September 30, 2008.
RPA Element V	Requires that each year when the Natural Resource Conservation Service (NRCS) April 1 Streamflow Forecast is at or above average at Otowi, and flows are legally and physically available, the Corps shall bypass or release floodwater during the spring to provide for overbank flooding. The intent is to increase the number of backwater habitats for the silvery minnow and flycatcher. The timing, amount, and locations of such flooding each year will be coordinated with the FWS and may include compact deliveries.
RPA Element X	Requires that the action agencies, in coordination with parties to the consultation and in consultation with the FWS, shall prevent encroachment of saltcedar on the existing channel and destabilize islands, point bars, banks, or sand bars in the Angostura, Isleta, and San Acacia Reaches. These activities should not adversely affect flycatcher habitat. This action should be undertaken where reaches are dry. Projects should be examined for depletions. The goals of the projects are to be depletion neutral.

In addition, the BiOp includes two Water Quality Elements, with water quality being recognized as an important component of aquatic habitat (FWS, 2003a). RPA Element DD addresses the need to control concentrations of total residual chlorine and ammonia in concentrations below which silvery minnows will be affected. And, RPA Element EE requires a comprehensive water quality assessment and monitoring program in the Middle Rio Grande to assess water quality impacts on the silvery minnow, using data from all sources.

6 What organizations and individuals participated in this project?

Parametrix and our subcontractors (Riada Engineering, Tetra Tech, Wolf Engineering, and William J. Miller Engineering) have performed the work associated with developing this report. We have received technical support and feedback from a variety of individuals throughout the basin. We would like to specifically acknowledge the support received by the following individuals and entities:

- The Program's Habitat Restoration Workgroup.
- Kathy Dickinson, Carolyn Donnelly, Robert Padilla, Robert Doster, and Mark Nemeth; Bureau of Reclamation, Albuquerque, NM.
- Michael Porter and Tamara Massong; US Army Corps of Engineers.
- Paul Tashjian, Jason Remshardt, Terry Tedano, and Dennis Prichard; U.S. Fish and Wildlife Service.
- Dr. Nabil Shafike, Grace Haggerty, and Anders Lundahl; NMISC, Albuquerque, NM.
- Deborah Callahan, Paula Makar, Darrell Ahlers, and Francoise Leanord; Bureau of Reclamation, Technical Service Center, Denver, CO.
- Cliff Landers; Soil and Water West, Albuquerque, NM.
- Dr. Keith Kelson and Justin Pearce; William Lettis & Associates, Walnut Creek, CA.
- Mike Harvey, Mussetter Engineering, Inc.
- Dagmar Llewellyn; S.S. Papadopulos & Associates, Inc., Albuquerque, NM.
- David Gensler, Yasmeen Najmi, and Jake Grandy; Middle Rio Grande Conservancy District, Albuquerque, NM.
- Kim Eichorst; Bosque Ecosystem Monitoring Program, Albuquerque, NM.

7 How can Program participants access the GIS database developed for this report?

GIS technology was an essential tool for developing this report. Datasets were compiled into a thematically organized database and provided to the Program electronically as a geo database and as shapefiles. The GIS database is described further in Appendix A and includes descriptions of the original data sources and the data organizational structure. The GIS database and associated shapefiles will be posted to the Programs' FTP site.

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Chapter 2 Reach Description

Project Location, Landownership, and Infrastructure

1 Where is the Isleta Reach?

The Isleta Reach of the Middle Rio Grande (MRG) is located within Valencia and Socorro Counties, in the Rio Grande Valley of central New Mexico. The project reach extends approximately 48 river miles from the southern boundary of the Pueblo of Isleta to the San Acacia Diversion Dam (Exhibit 1-1). The river drops from an elevation of 4,880 to 4,654 feet through this reach.

For analytical and descriptive purposes, we have separated the Isleta Reach into three sub-reaches. The Los Lunas Sub-reach extends from the southern boundary of Isleta Pueblo to the Belen Bridge at river mile (RM) 149.5. The Belen Sub-reach extends from the Belen Bridge to the Highway 60 Bridge near Bernardo (RM 130.7). The Sevilleta Sub-reach extends from Highway 60 to the San Acacia Diversion Dam (RM 116). All river mile designations in this report reference Reclamation's 2002 river mile system.

Sub-reaches of the Isleta Reach Project Area:

For both analytical and descriptive purposes, the Isleta Reach has been divided into three "sub-reaches."

Los Lunas Sub-reach: Extends approximately 14.2 miles from the southern boundary of the Pueblo of Isleta (RM 163.7) downstream to the Belen Bridge at RM 149.5.

Belen Sub-reach: Extends for approximately 19.8 miles from the Belen Bridge (RM 149.5) to the Highway 60 Bridge (RM 130.7).

Sevilleta Sub-reach: Extends for approximately 15.4 miles from the Highway 60 Bridge (RM 130.7) to the San Acacia Diversion Dam at RM 116.2.

2 Who are the primary landowners in the project reach?

Landownership information for the project reach was obtained from the United States Fish and Wildlife Service (FWS) and the Middle Rio Grande Conservancy District (MRGCD). According to these data sources, landownership adjacent to the

All river mile designations in this report reference Reclamation's 2002 river mile system.

river is a mix of MRGCD, New Mexico Game and Fish, federal, private, and property with unverified ownership (see Exhibits B.2-1 through B.2-3 in Appendix B). From RM 166.2 to approximately RM 163.7, the Pueblo of Isleta owns the land to the west of the centerline of the Rio Grande, while MRGCD is the landowner for the eastern side of the river to the drain. Downstream from RM 163.7 (the start of the Isleta Project Reach), MRGCD has verified that it owns the majority of the floodplain to the east and west of the river south to RM 145. There are a few parcels that the MRGCD has yet to verify that it holds the property deeds. Downstream from RM 145 to the Sevilleta National Wildlife Refuge (NWR) boundary, the MRGCD ownership information is more uncertain and much of the land has not been verified as being owned by MRGCD (D. Stretch, MRGCD, personal communication, 2007). The Sevilleta NWR lands are bounded by RM 120.2 and RM 116.8.

3 What are the surrounding land uses?

Agricultural lands in the Middle Rio Grande. (Photo Credit: Parametrix)

Agriculture is the primary land use surrounding the project area. Much of the land east and west of the levees in the Los Lunas and Belen Sub-reaches are planted with a variety of crops, including alfalfa, pasture grass, hay, wheat, and corn. Some of these agricultural properties are also grazed by cattle and horses.

There are also numerous developed urban/residential areas within the project reach. The Village of Los Lunas supports a population of approximately 10,000 based upon the 2000 census data. The City of Belen supports a population of approximately 6,900 people. There are no other major communities located in the study reach; however, a few smaller villages, including Jarales, Casa Colorada, Los Trujillos, Los Chaves, Tome-Adelino, Valencia, Bosque Farms, and Peralta, are located within the project reach.

There are numerous Waterfowl Management Areas (WMA) found within the project reach. The Ladd S. Gordon Waterbird Complex is comprised of the Belen WMA (~250 acres), the

Casa Colorada WMA (423 acres), the Bernardo WMA (1,573 acres), and the La Joya WMA (3,550 acres). Each of the WMAs is managed by the New Mexico Department of Game and Fish. The La Joya WMA consists of six interconnected ponds which are divided by levee access roads. Historically, a seep fed a 30-acre wetland named Geronimo Springs. Today, the ponds are also fed by waters diverted from the Unit 7 riverside drain.

The Sevilleta NWR is approximately 227,000 acres in size. The Refuge is managed primarily as a research area and is closed to most recreational uses, with the exception of bird hunting and environmental education programs for students. In 1988, the Sevilleta NWR became the host to the Sevilleta Long-Term Ecological Research Program, which conducts a variety of research to examine long-term changes in ecosystem attributes.

4 What is the primary water use infrastructure in the Isleta Reach?

Water resource infrastructure in the Isleta Project Reach consists of two major irrigation diversion structures, spoil-bank levees, riverside drains, and irrigation returns (i.e., wasteways or outfalls). Irrigation diversion dams include the Isleta Diversion Dam and the San Acacia Diversion Dam. The Isleta Diversion Dam is located 5.5 miles upstream of the study reach and has important influence on the water management and hydrology in the project reach. The Isleta Diversion Dam is used to divert Rio Grande water into the Belen Highline Canal on the west side of the river and the Peralta Main Canal on the east. These irrigation diversions typically occur between March 1 and October 31 each year, but the Pueblo of Isleta may continue to request diversions from the Peralta Main Canal through November 15.

“Dry” versus “Wet” Year

A dry year is defined as when the Natural Resource Conservation Service (NRCS) April stream flow forecast at Otowi Gage (upstream of Cochiti Lake) is less than 80 percent of average flow. A wet year is one where the April forecast is 120 percent or higher than average.

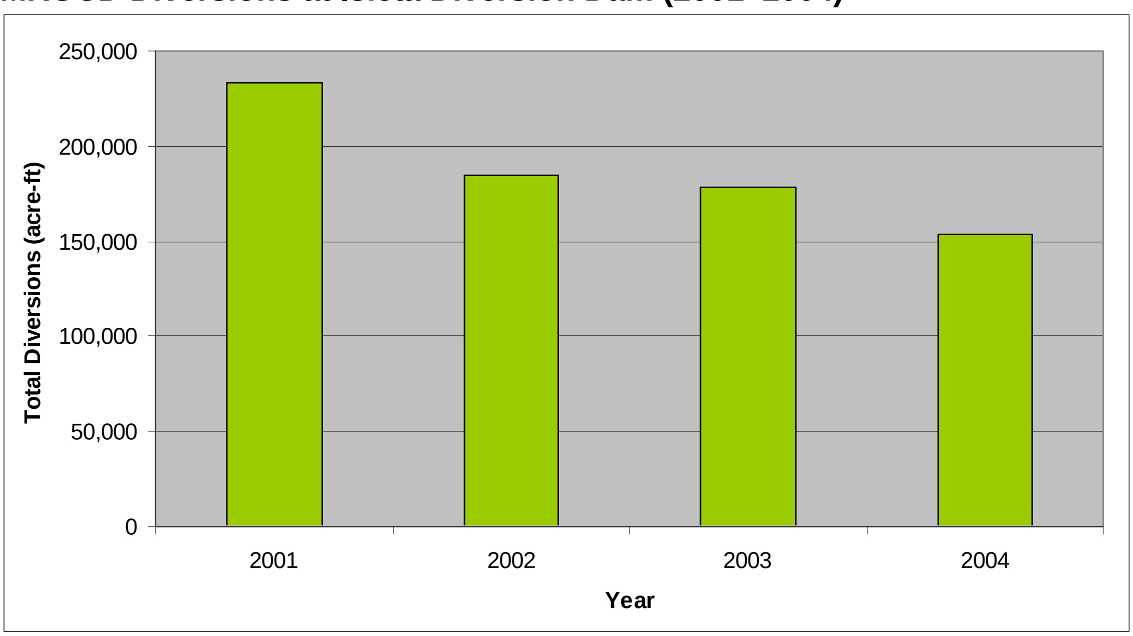
During the non-irrigation season (mid-November through February), the entire flow of the river is passed through the dam. During the irrigation season, the maximum amount of water that can be diverted into the Peralta and Belen Highline irrigation canals is approximately 700 cubic feet per second (cfs). During periods of relatively high flows, the net result of this water diversion is less significant than during lower flows.

After June 15 of each year, a significant portion of the Rio Grande flow is diverted into the Peralta and Belen Highline canals. The amount of water that actually passes through the dam after June 15 each year is largely determined by the 2003 Biological Opinion (BiOp). Although revisions to the BiOp are currently being considered, the current flow recommendations through the Isleta Diversion Dam are 150 cfs during "wet-year" conditions, 100 cfs in "average" conditions, and all flows may be diverted into the irrigation canals during "dry-year" conditions.

The amount of water diverted each year at the Isleta Diversion Dam has varied over time. Between 2001 and 2004, the MRGCD diverted between 233,600 and 153,600 acre-feet (af) annually, and the total diversions have decreased annually during this time period (Exhibit 2-1).

Exhibit 2-1

MRGCD Diversions at Isleta Diversion Dam (2001–2004)



The MRGCD's irrigation infrastructure also provides the ability to return water back to the river through irrigation wasteways distributed along the project reach (Exhibit 2-2). These drain outfalls are used by MRGCD to assist with operations and maintenance of the irrigation drains that parallel the river. Besides these wasteways, additional inflow to the river occurs from the Los Lunas wastewater treatment plant outfall at RM 159.5.

Exhibit 2-2

Drains and Wasteways Between the Isleta and San Acacia Diversion Dams

Facility	Status	River Mile
Isleta Diversion Dam		169.3
Alejandro Wasteway		166.7
240 Wasteway		165.2
Los Chaves Wasteway	Abandoned	156.7
Peralta Main Canal Wasteway		152.5
Lower Peralta Riverside Drain #1		149.6
Belen Riverside Drain		147.7
New Belen Wasteway	Abandoned	147.1
Lower Peralta Riverside Drain #2		144.7
Feeder #3 Wasteway		142.8
Storey Wasteway		140.1
Sabinal Riverside Drain		137.9
San Francisco Riverside Drain		126.8
Lower San Juan Riverside Drain		126.6
Lower San Juan Riverside Drain	Abandoned	122.2
Unit 7 Drain		116.2
San Acacia Diversion Dam		116.2

Climate and Geology

5 What is the climate in the project area?

The average annual precipitation in the project reach, as measured in Belen, is 7.60 inches. Nearly half of the precipitation occurs between the months of July and September primarily as scattered, short, high-intensity thunderstorms, while over 60 percent of the natural runoff upstream of the Rio Chama confluence occurs during the period from April to June as snow-melt runoff (USACE et al., 2007).

Relatively infrequent river flooding below Cochiti Dam occurs in response to the summer thunderstorms. During the summer, the primary source of moisture is the Gulf of Mexico. Precipitation frequently occurs with scattered thunderstorms that increase with tropical disturbances. These are short-duration, high-intensity thunderstorms that usually occur from July through September. In the fall and winter months, longer duration frontal storms occur when southward-moving frontal systems interact with residual moisture from the Gulf of Mexico.

6 What are the geological influences on the river in the project reach?

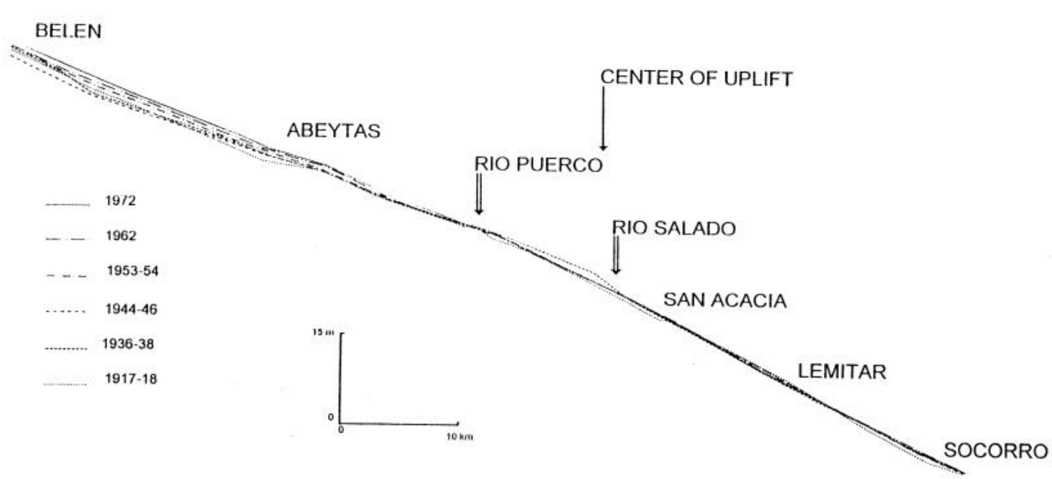
The Rio Grande rift valley extends 500 miles north to south from central Colorado through central New Mexico. Tectonic uplift and volcanism have created prominent monolithic features on a subsiding valley bottom (Crawford et al., 1993). Volcanic features associated with the rift valley include basalt fields, plateaus, mesas, volcanic intrusions and plugs, and calderas. One major volcanic control that has influenced river morphology in the Isleta Reach is the San Acacia basalt intrusion. This plug is one of several geologic constrictions in the Rio Grande Valley from Albuquerque to El Paso that dictate the position of the river in the Middle Rio Grande Valley. During extreme paleofloods, the backwater created by the constriction inundated a large area.

The Rio Puerco and Rio Salado join the Rio Grande just upstream of San Acacia, the confluence positions dictated in part by the basalt intrusion. The tributary influence on the river geomorphology over geologic time is complex. Both the Rio Puerco and Rio Salado have supplied extreme quantities of sediment (particularly fine sediment) that has altered the river location in the valley, as well as impacted the channel planform for miles downstream of San Acacia.

Another geologic control is the Socorro Uplift just north of the Rio Salado confluence caused by the expanding Socorro magma body (Exhibit 2-3). The uplift has been estimated to have risen about 20 cm (about 8 inches) between 1911 and 1951 (Reilinger et al., 1980; Reilinger and Oliver, 1976) and 1.8 mm/year between 1951 and 1980 (Ouchi, 1983). The present rate of uplift has a minimal effect on the channel morphology in this reach compared to the impacts of water resource development (including channel training activities) on channel morphology. The effects of the San Acacia Diversion Dam and river channelization on the river planform and profile over the last 50 years are probably on the order of feet rather than inches as in the case of the uplift.

Exhibit 2-3

Longitudinal Profiles of the Rio Grande from Belen to Socorro (Ouchi, 1985)



River Geomorphology

7 What are the geomorphic conditions of the project reach and how have these conditions changed in recent years?

River Geomorphology

Prior to 14th century when human alteration of the floodplain began, the river channel was generally wide and shallow with numerous large sand bars, had a braided appearance at low to moderate flows, extensive overbank flooding, and experienced avulsions that shifted the channel across the valley. In the lower sub-reach, from Highway 60 downstream, the river response to flooding was even more dynamic due to the Rio Puerco (RM 127) and Rio Salado (RM 119) tributary flood inflows and sediment loads.

In response to upstream water resource development (primarily flood control) during the past 100 years and channel training activities in the past 50 years, the Belen Sub-reach has generally been stable from a geomorphic perspective. However, this trend has the potential to change with decreased sediment loads. The river planform is essentially locked in position by dense bank vegetation, river channelization, levees, and jetty jacks. This condition is exacerbated by prolonged drought and flow management. The channel width and width-to-depth ratio are relatively uniform through this sub-reach. Channel narrowing that was instituted through channelization and bank stabilization efforts in the 1950s still occurs, but on a progressively smaller scale. This sub-reach is described as a single-thread channel with slight sinuosity (Massong et al., 2007). Sinuosity may increase slightly with time as more islands attach to banks and further channel narrowing occurs. River channel migration, however, is constrained by flow management (i.e., limited peak discharge to protect spoil-bank levees), and river banks are armored in many locations by dense, mature vegetation and/or bank stabilization structures (e.g., rip-rap, jetty jacks, etc.).

Channel Narrowing and Bed Degradation

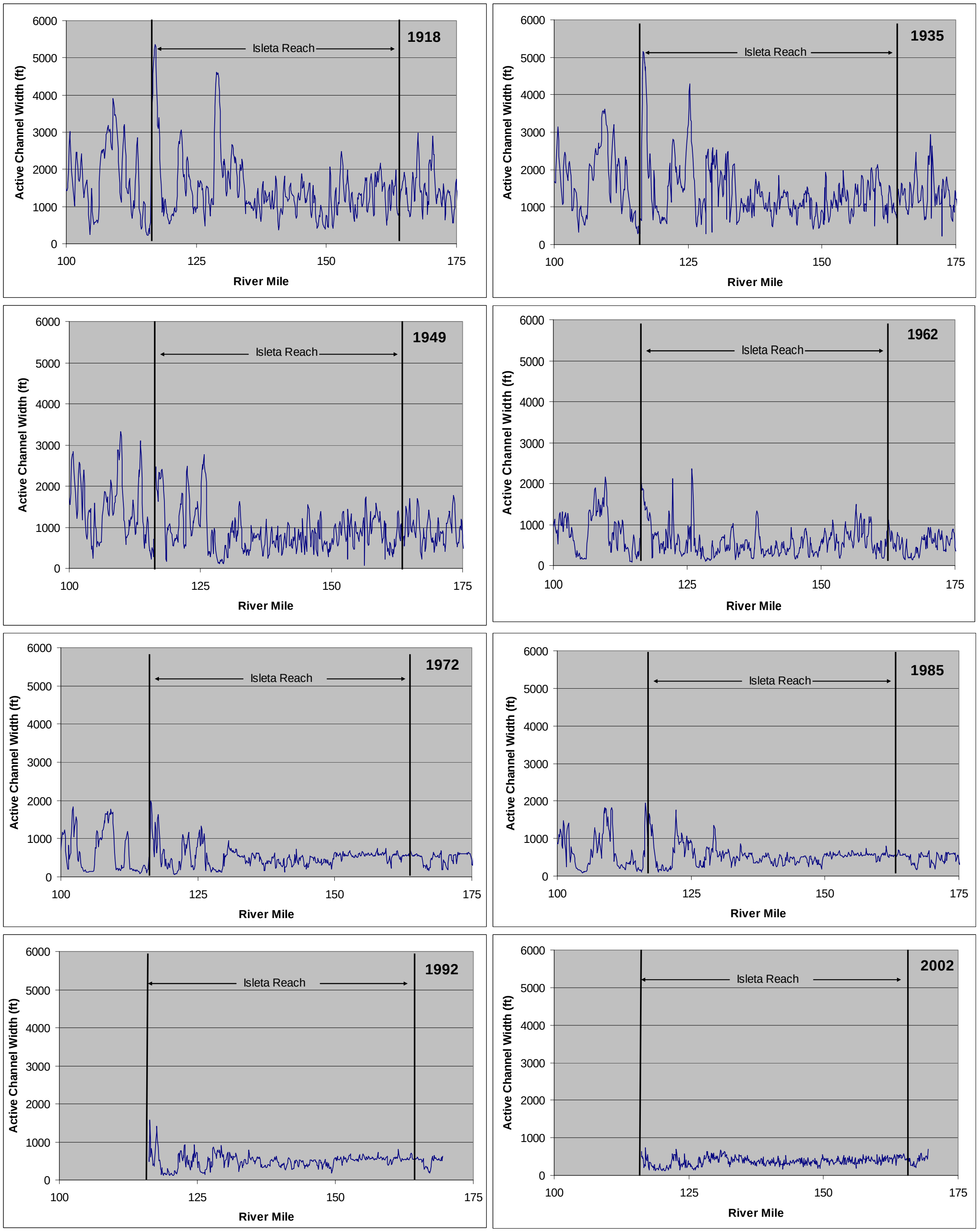
MRG channel narrowing is well documented in the recent literature (Makar et al., 2006; MEI, 2006; Massong, et al., 2006; Massong et al., 2007). The active channel in the Isleta Reach narrowed drastically following the construction of MRGCD's riverside irrigation facilities between 1918 and 1935 (Exhibit 2-4 on page 2-10). Makar et al. (2006) reports that an extended drought started in the 1940s and encouraged vegetation encroachment on bars and islands due to the lack of scour by flooding. In portions of the Isleta reach, channelization and bank stabilization initiated in the 1950s accelerated channel narrowing. Following the construction of Cochiti Dam in 1975, reduced peak discharges accelerated the encroachment of vegetation on sand bars and the evolution of sand bars into islands. Sediment accretion and island attachment to banks became more widespread. The Bureau of Reclamation (BOR) attempted to offset the narrowing trend during the period from 1960 to 1985. Makar et al. (2006) stated that "large sections of the river were mechanically cleared of vegetation to maintain flood capacity. By 1985, the active channel width widened to near the edge of the cleared floodway along much of the river." In addition to the mechanical removal of vegetation, there were higher flows in the 1980s which encouraged a wider channel.

Since 2001, the lack of significant spring flooding has resulted in significant channel narrowing and the formation of numerous stabilized islands throughout the reach (MEI, 2006). Exhibit 2-5 (page 2-11) shows the magnitude of the increase in bar area between 1992 and 2006. Vegetated bars and islands in the Belen Sub-reach have increased by a factor of 4 between 2002 and 2006, while the Los Lunas and Sevilleta Sub-reaches have seen increases of approximately 50 percent.

As the channel narrowed, the thalweg bed profile also changed.

Exhibit 2-4

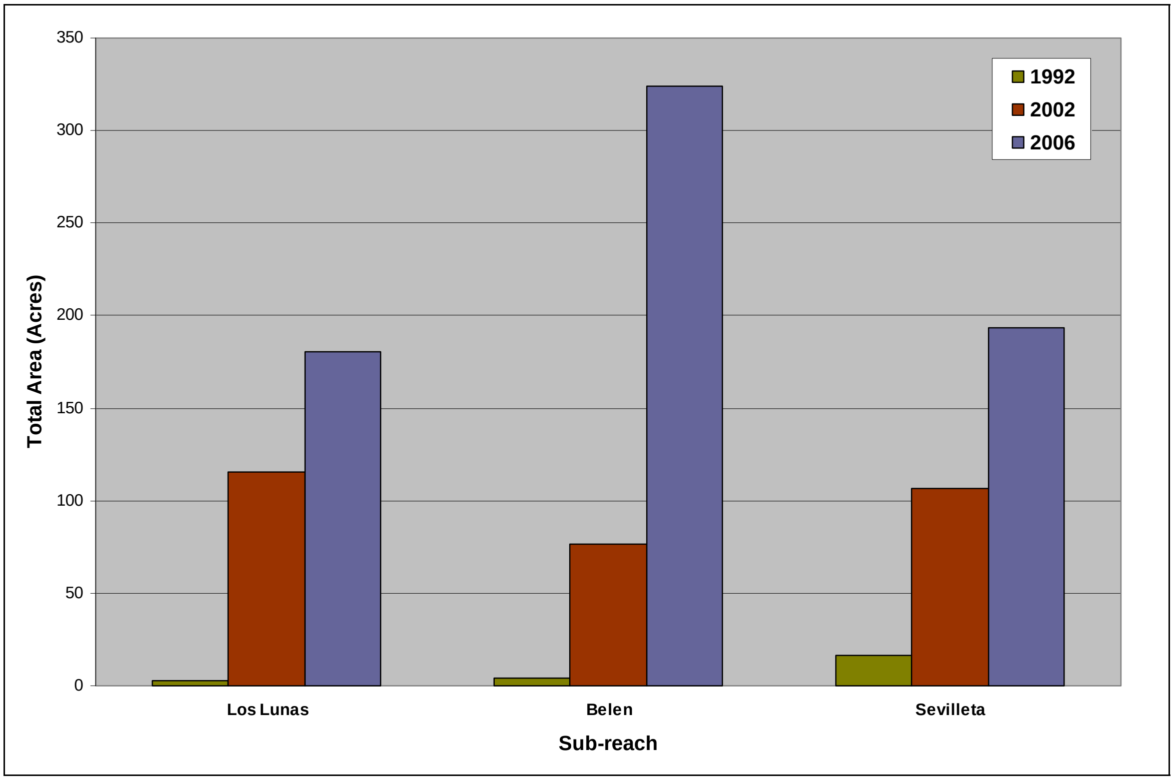
Channel Width Changes in the Middle Rio Grande – Isleta Reach[a]



[a] *Original figures from Oliver, (2004) and Makar et al. (2006) were modified by converting cross section number to river mile and focusing on the Isleta Reach.*

Exhibit 2-5

Changes in Total Area of Vegetated Channel Bars and Islands Associated with Channel Narrowing (1992–2006)

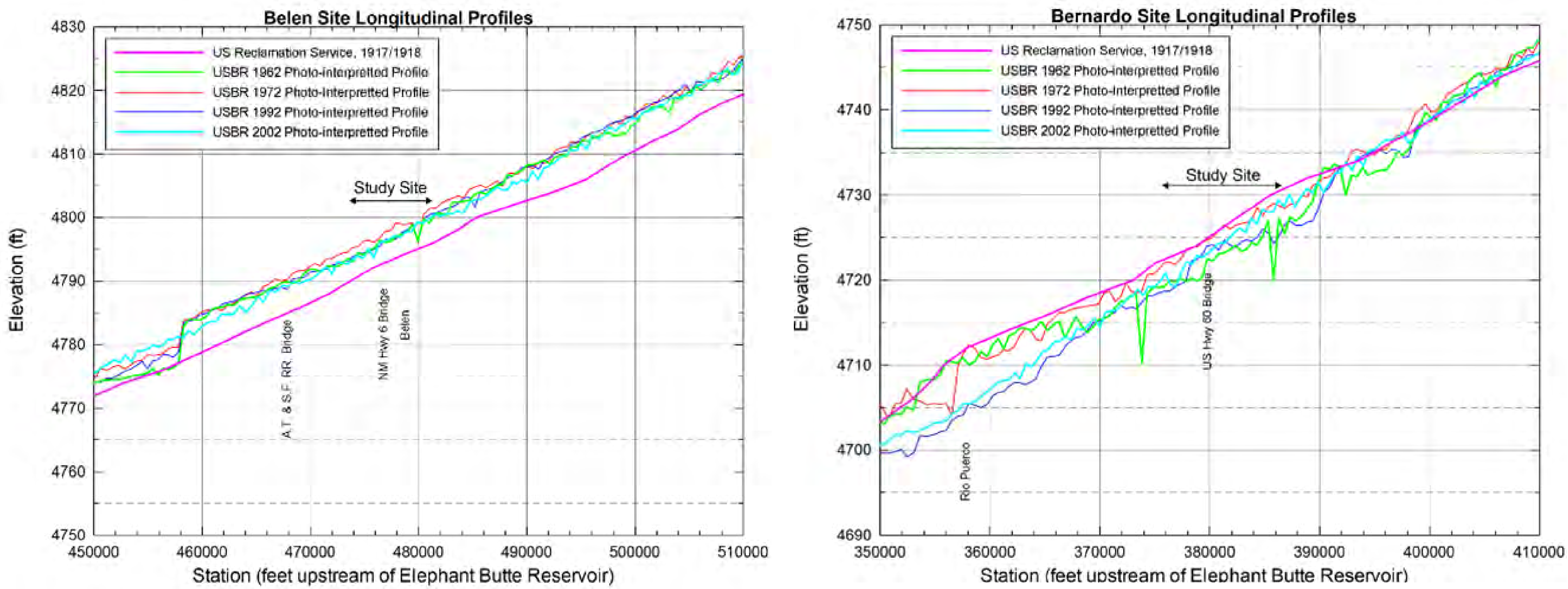


Parametrix staff modified the active channel from GIS data provided by the Bureau of Reclamation (BOR). The 1992 coverage was modified from the 1992 aerial photography which has a lower resolution than the 2002 and 2006 aerial photography. Therefore, the efforts associated with the 1992 dataset are likely to contain more errors and discrepancies. The 2002 dataset was modified according to the 2002 aerial photography provided by the BOR and the 2006 dataset was modified using GIS data associated with the 2005 inundation study and the January 2006 aerial photography.

From the Isleta Pueblo south boundary to the gas pipelines at RM 143, the river aggraded between 1918 and 1972. Since 1972, there is evidence of some slight degradation (less than 1 to 2 feet) through a portion of this reach possibly due to reduced sediment loading from upstream (see Exhibit 2-6; Massong et al., 2006; MEI, 2006). Between Highway 60 and San Acacia Diversion Dam, the influence of the Rio Puerco and Rio Salado tributaries on the bed profile is pronounced (Exhibit 2-6; Bernardo Site). Initial aggradation of the bed due to the increased sediment loading from the Rio Puerco in the late 1800s is apparent in the 1918 profile. Then subsequent degradation occurred by 1972 in response to channelization. Future episodic sediment loading from these tributaries renders prediction of the river morphology in this sub-reach difficult.

Exhibit 2-6

Average Bed Elevations for 1917/1918, 1962, 1972, 1992, and 2002 from MEI's Belen and Bernardo Study Sites (MEI, 2006, Figures B.5 and B.6)



The 1962, 1972, 1992, and 2002 profiles are average bed elevations based on normal depth calculations where water was present in the photogrammetric data.

In summary, the channel width data provided by Makar et al. (2006) clearly shows accelerated channel narrowing in the Isleta Reach over the last century. The lack of bank-full discharge from 1997 to 2005 enabled vegetation to become established on formerly mobile sand bars. As these sandbars became islands and some islands attached to the bank, the reductions in active channel width were accelerated (Exhibits 2-4 and 2-5). One of the consequences of the channel narrowing process is uniformity of channel width throughout the reach (Exhibit 2-4).

Sediment Load and Mobile Bed Characteristics

The active channel geometry is primarily a function of the bed mobility, available sediment supply, and discharge. Major changes in the Rio Grande channel morphology have occurred over the past 150 years involving aggradation and widening in the late 1800s and channel narrowing in the mid to late 1900s in response to significant changes in the available upstream sediment load.

Water and sediment storage in the upstream Rio Grande basin has greatly impacted the sediment supply within the project reach. Sediment loads in the MRG have been reduced by approximately 80 percent since the construction of Jemez Canyon, Galisteo, and Cochiti Dams (Tetra Tech, 2004a). Other watershed factors have also contributed to reduced sediment loads. Land use practices in the late 1800s such as overgrazing, timber cutting, and road construction resulted in the high sediment yields, while recent soil conservation and flow regulation measures have also reduced sediment loading to the MRG.

There are several tributaries within the project reach that still deliver large volumes of sediment to the Isleta Reach during flood events. The most notable of these include the Rio Puerco and the Rio Salado. The Rio Puerco has been ranked as one of the world's leading sediment producing fluvial systems, primarily due to the high concentrations of fine sediments (silts and clays) (Gellis, 2006). Conversely, sediments delivered from the Rio Salado are relatively coarse-grained (MEI, 2002). Both tributaries join the Middle Rio Grande in the lower fifth section of the project reach and have limited impacts on the channel morphology in most of the Isleta Reach. The major arroyos in the project reach include Arroyo Abo (RM 139), Maes Arroyo (RM 130), Arroyo los Alamos (RM 124), Arroyo de la Canada Ancha (RM 121), and Rosa de Castillo Arroyo (RM 118). The infrequent flooding from these arroyos limits the sediment contributions of the arroyos to the system.

The reduction in sediment supply to the MRG is partially offset by the reduction in sediment transport capacity corresponding to the decrease in high flows; therefore, the sediment supply delivered to the Isleta Reach is approximately in balance with the sediment transport capacity of the river. This is evidenced by a slightly degradational trend in the bed profile as shown in Exhibit 2-6 (MEI, 2006). This trend, however, should continue over time, as the sediment supply deficit is expected to be a long-term condition.

Despite the reduction in sediment supply to the reach since constructing Cochiti Dam, the channel bed material in much of the Isleta Reach is still dominated by sand (Massong et al., 2006; MEI 2002). MEI (2002) reported the average channel bed particle size (D_{50}) at Bernardo has coarsened slightly, increasing from 0.17 mm to 0.20 mm since 1970. Bed material coarsening downstream from Cochiti has reached only to north Albuquerque. The change in bed material size is not a cause or reflective of changes in channel morphology in the Isleta Reach. Similarly, a wholesale change in the channel bed forms in the Isleta Reach is unlikely, as opposed to those having occurred in longer sub-reaches downstream of San Acacia. In the Isleta Reach, it is suspected that upper regime plane bed form is more frequent in the thalweg at high flows than it was historically. As the channel narrows, more plane bed should occur in a greater percentage of the channel width.

Current Geomorphic Trends

The combination of reduced flows, decreased sediment supply, channelization, bank stabilization, and vegetation encroachment has contributed to a long-term trend of channel narrowing in the Isleta Reach (Exhibit 2-4). The process of channel narrowing is due to the altered relationship between sediment and water discharge. Subsequent vegetation encroachment in the active channel has been progressive. A less active channel associated with stabilized sandbars and bank-attached islands will also limit channel migration.

MEI (2006) suggests that a minor degradation trend may occur but that significant bed material coarsening is not anticipated because of the lack of a coarse sediment supply. Some coarsening should occur, however, through the winnowing of fines from the project reach over time. More of the sand bed material, however, is getting tied up in stabilized bars and islands. MEI (2006) reports that high flows alone will not be sufficient in the future to remove mature bar vegetation. Makar et al. (2006) characterized the river as predominantly having an active channel of uniform width in the Isleta reach. As the rate of channel narrowing decreases, the mean annual peak flows of the modern hydrologic regime will be sufficient to sustain a vegetation-free channel, but this occurs at the expense of channel diversity and elimination of slow velocity habitat. At that point in time, sand bar formation will be limited during high flows.

Surface Water Hydrology

8 What were the predevelopment hydrologic patterns of the Middle Rio Grande?

Flows in the Middle Rio Grande were typical of western rivers, a seasonal pattern of long duration high flows in the spring and early summer and low flows in the mid to late summer through winter. The low flow period is punctuated by summer and fall convective storms that infrequently result in large arroyo tributary flooding of short duration.

Historic Flood on the Rio Grande. (Photo Credit: IBWC)

Historical accounts allude to numerous large flood events in response to melting mountain snowpack in the upper Rio Grande watershed. According to historic records of flood events (newspaper accounts and gaging station data) in 1828, one of the largest floods on record flooded the entire valley below Albuquerque and was estimated at 100,000 cfs (Scurlock, 1998). Approximately 50 floods have been recorded for the main stem of the river from 1849 to 1942 (Table 17, Scurlock 1998), which are relatively well documented compared to earlier periods. Major to moderate floods (10,000 cfs or more) documented for the Middle Rio Grande (Scurlock, 1998) occurred in 1849, 1852, 1854, 1855, 1862, 1865, 1866, 1867, 1868, 1871, 1872, 1874, 1878, 1880, 1881, 1882, 1884 (two), 1885, 1886 (two), 1888, 1889, 1890, 1891, 1895, 1896, 1897 (two), 1902, 1903, 1904, 1905 (two), 1906, 1909, 1911 (two), 1912, 1916, 1920, 1921, 1924, 1929, 1937, 1940, 1941, and 1942. Floods of this magnitude occurred on an average of every 1.9 years during this period (Scurlock, 1998). In addition, there may have been other floods for which documentation has not been found. The 1874 and 1884 floods were reported to be approximately 100,000 cfs (see chronology section of Scurlock, 1998). Streamflow gaging began in 1889 at Embudo, and notable large spring snowmelt floods occurred in 1903 (18,900 cfs), 1920 (22,500 cfs), 1941 (24,600 cfs), and 1942 (18,400 cfs). Large floods from summer and fall storms were noted in 1904 (33,000 cfs), 1929 (24,000 cfs), and 1935 (15,000 cfs). During exceptionally high-flow years, flooding may have persisted through June.

Summer convective thunderstorms tend to be infrequent and short duration. While the spring floods occurred throughout the Isleta Reach, summer and fall flooding include tributary flood inflows from the Rio Puerco or Rio Salado. These major tributaries still produce infrequent large flood events that impact the project reach with substantial sediment loads and overbank flooding. These arroyo floods have relatively small volumes and peak discharges that attenuate quickly upon entering the flatter slope of the MRG channel.

Predevelopment flows in the MRG were characterized by extreme seasonal flow variability, with long duration high flows in the late spring and early summer and low flows from mid-summer through the winter. Based upon historic descriptions of the river and the environment, the long-term impacts of drought on channel morphology, vegetation composition, or survival of fish species were limited and short-lived. Like most western rivers, the endemic fauna and flora evolved in the diversity of seasonal flows. Upstream water resource development, diversion, and storage have resulted in spring peak flows that are an order of a magnitude smaller and more uniform than occurred before large-scale human occupation of the river valley. Another consequence of water resource development and full water-use appropriations is that extensive portions of the river channel downstream of the Isleta Diversion Dam is commonly dry in mid-late summer.

Historically, flood flows defined channel and floodplain morphology and habitat characteristics, as opposed to the drought conditions that define those same parameters today. From the 1700s through the 1800s, the active channel of the Rio Grande went dry infrequently. Scurlock (1998) reports that the Rio Grande was dry during the summer of 1752 and then again in 1861 and 1897, at which time it appears to become a more frequent occurrence. Under modern conditions, portions of the Rio Grande go dry intermittently between July and October on an annual basis.

9 What is the present-day hydrology of the Isleta Project Reach?

The cumulative effect of water management activities has been to reduce the spring peak discharge magnitude, frequency, duration, and volume. The effect of upstream reservoir storage has been to broaden and flatten the mean annual hydrograph. Peak flows from Cochiti Dam are limited to 7,000 cfs to prevent damage to spoil bank levees and the San Marcial railroad bridge.

The USACE (2006) defines the Isleta Reach hydrology by combining the discharge at the Albuquerque gaging station at Central Avenue and the Tijeras Arroyo flood hydrology. This represents the Isleta Reach confluence with the Rio Puerco. Downstream, the Rio Puerco and Rio Salado flood flows dominate the flood frequency analyses at San Acacia (USACE, 2004; Exhibit 2-7). It is noted in this frequency analysis that there is little difference between the 2-year flood and the 250-year flood, which results from the limiting factors of Cochiti Dam outflows (i.e., water management operations and channel capacities) being built into the flood frequency analyses. This uniformity of flooding limits the diversity of river and floodplain morphology.

Exhibit 2-7

Bosque Farms and San Acacia Flood Frequency Analyses

		USACE (2006)[a]	USACE (2004)
Probability	Return Period	Discharge at Bosque Farms (cfs) 1974–2002	Discharge at San Acacia (cfs) 1974–2002
0.99	1.0	4,200	–
0.85	1.18	5,000	–
0.8	1.25	–	4,770
0.5	2	6,000	7,380
0.2	5	7,000	11,800
0.1	10	–	15,400
0.04	25	–	19,200
0.02	50	7,050	25,000
0.01	100	–	29,900
0.007	142.9	8,000	–
0.004	250	9,000	–
0.003	333.3	10,000	–
0.002	500	–	43,500

[a] *Data is being presented with the return interval based upon the US Army Corps of Engineers (USACE, 2006) published probabilities.*

Irrigation diversion impacts flows in the Isleta Reach. The Isleta Diversion Dam is located 6 miles upstream of the start of the study reach. The average daily diversion into the MRGCD canals peaks during the month of May (Exhibits 2-8 and 2-9). The average annual river hydrograph for the Albuquerque gage, the Isleta Diversion Dam gage, and the canal diversion flows are shown in Exhibit 2-10 (page 2-20). During the irrigation season, additional water is sometimes diverted at Isleta to deliver water to MRGCD's Socorro Division (D. Gensler, MRGCD, personal communication, 2007). This practice is intended to decrease losses that would occur if the same volume of water was conveyed through the river channel before being diverted at the San Acacia Diversion Dam. The San Acacia Diversion Dam is used to divert water to MRGCD's Socorro Division.

Exhibit 2-8

Average Diversion Rate at Isleta Diversion Dam

Month	Avg. Diversion Rate (cfs)	90% C.I.
January	0	0
February	4	7.0
March	249	54.9
April	420	87.6
May	510	39.8
June	502	68.4
July	439	77.4
August	393	52.2
September	315	77.2
October	213	68.0
November	13	3.7
December	0	0

Data based upon daily average diversion rates from 2001 to 2004.

Exhibit 2-9

Total Monthly Diversions at Isleta Diversion Dam

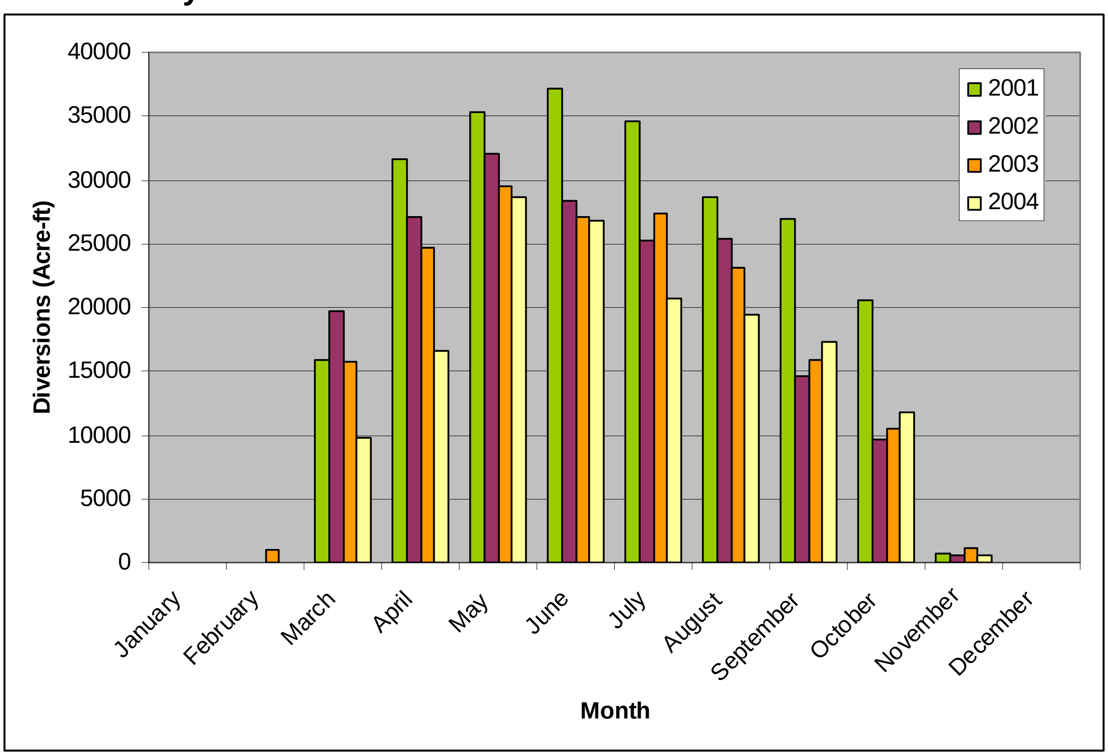
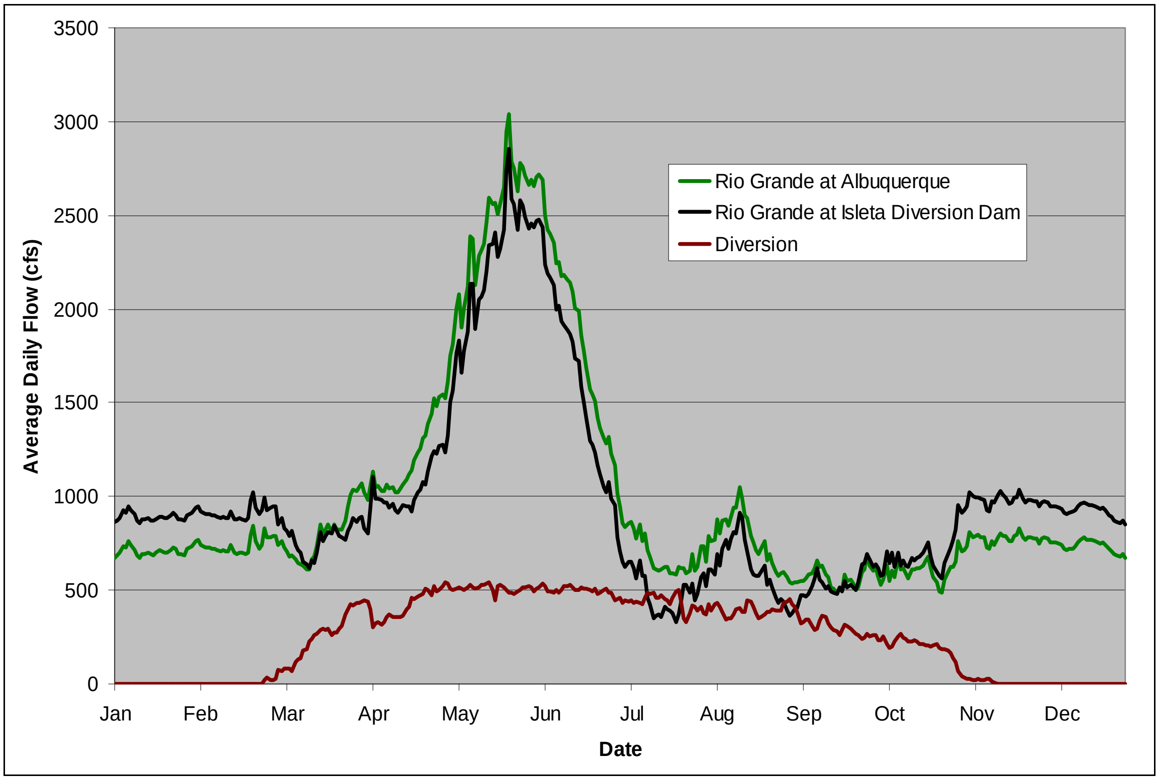


Exhibit 2-10

Average Hydrographs at Albuquerque, Isleta Diversion Dam, and the Diversions at the Isleta Diversion Dam



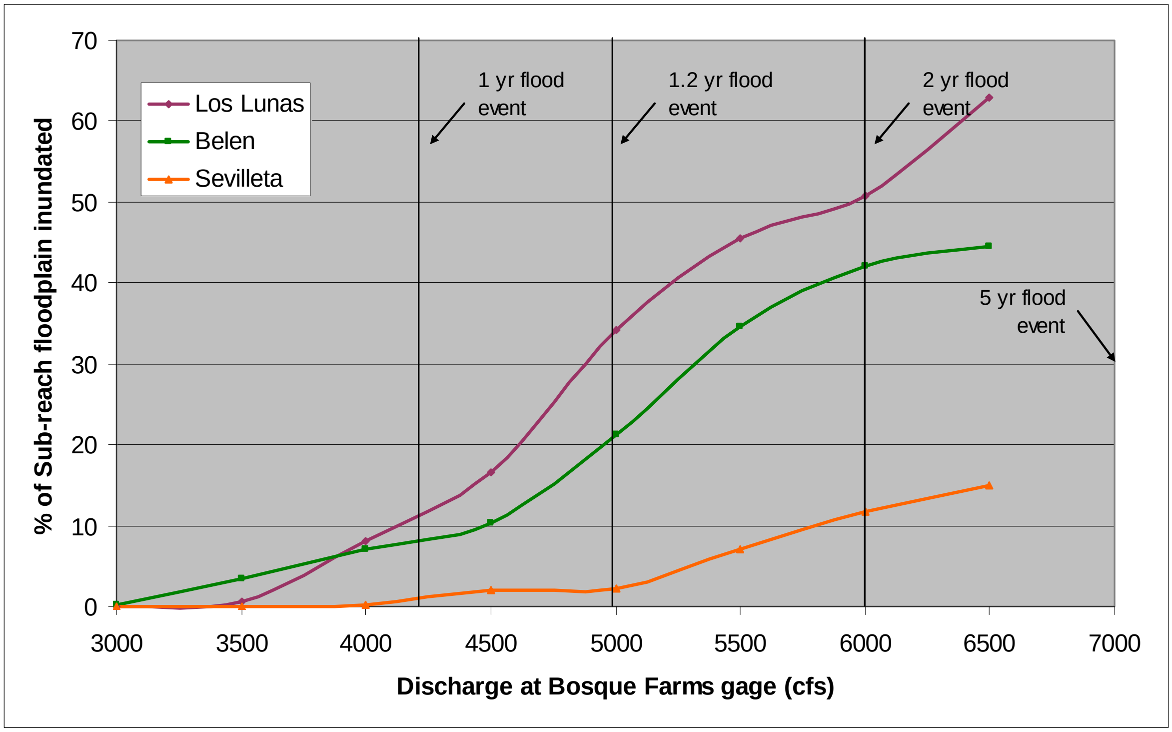
Isleta Diversion Dam data calculated from average daily flows from Albuquerque gage (1999 to 2006 data), wastewater inflows (2006 data), Atrisco drain inflows (1998 to 2004), riverside drain inflows (1998 to 2004 data,) and diversions at the Isleta Diversion Dam (2001 to 2004 data).

River-Floodplain Hydrologic Connectivity

Substantial portions of the floodplain in the Los Lunas and Belen Sub-reaches are inundated under a maximum release of 7,000 cfs from Cochiti (Exhibits B.2-4 through B.2-6 in Appendix B). The 2008 MRG FLO-2D model (250-foot grid system) predicts that 65 percent of the Los Lunas Sub-reach floodplain becomes inundated at flows of 6,000 cfs at the Bosque Farms gage (2-year flood event). The model also predicts that the Belen Sub-reach floodplain inundation starts at 3,000 cfs and that roughly 45 percent of its floodplain area is inundated at 6,000 cfs. The Sevilleta Sub-reach does not initiate overbank flooding until 4,500 cfs. At a 6,500 cfs discharge at the Bosque Farms gage, only 15 percent of the sub-reach floodplain inundated (see Exhibit 2-11).

Exhibit 2-11

Overbank Flooding Modeled by FLO-2D in the Isleta Project Reach



Overbank flooding modeled by FLO-2D. Flood frequency analyses utilize data reported by the USACE (2006).

Channel Drying

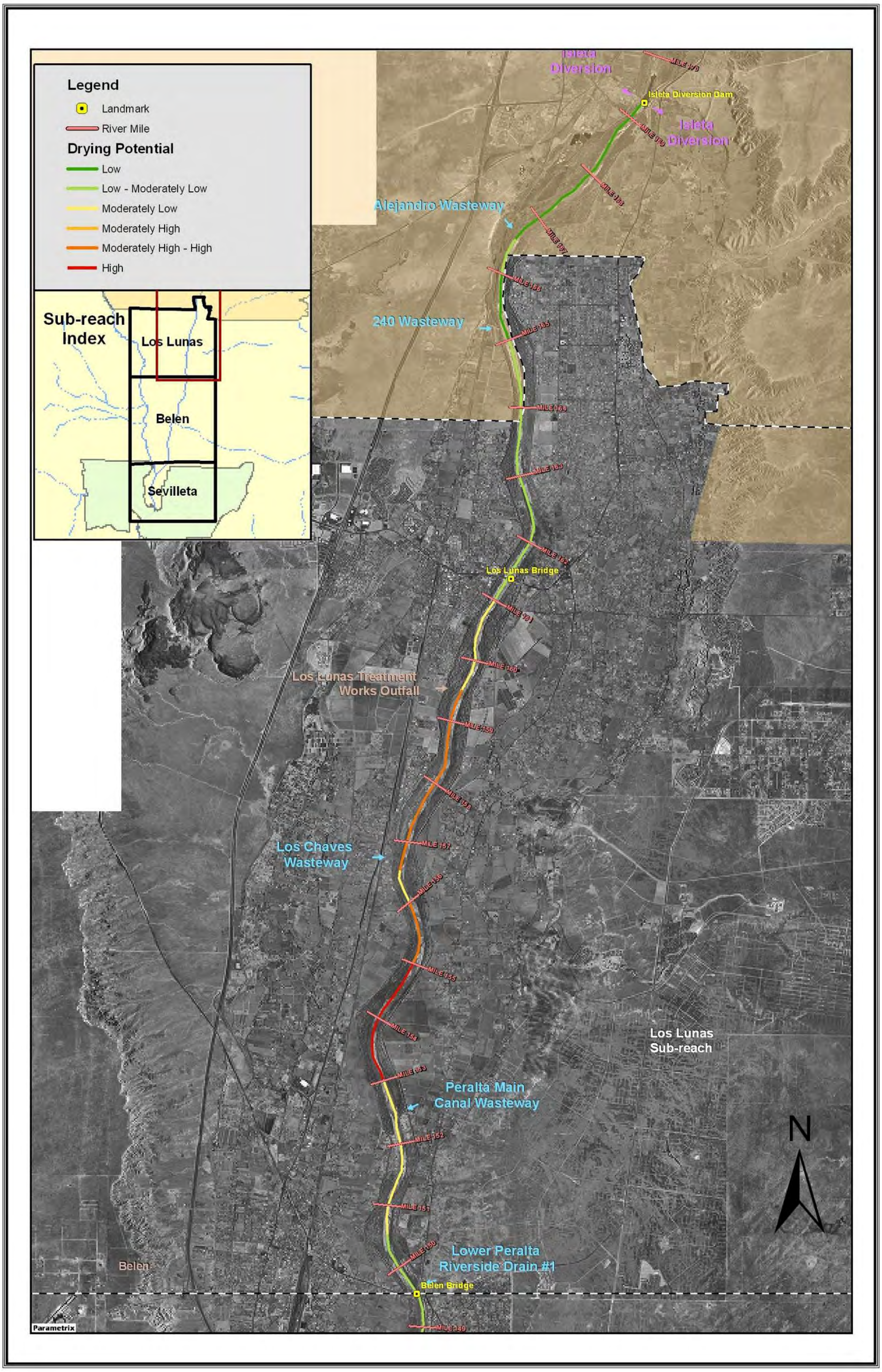
Interestingly, those reaches that have the greatest propensity for overbank flooding are also subject to channel drying after June 15. Parametrix developed GIS shape-files (using unpublished data provided by FWS) to categorize Rio Grande sub-reaches according to their potential for channel drying. The project reach was delineated into 0.5-mile segments and ranked according to six categories ranging from low to high (Exhibits 2-12 through 2-14). The only areas in the project reach identified as having more than a moderately high to high potential for drying were within the Los Lunas Sub-reach (RM 159.5 to RM 153.0). Of that 6.5-mile section of river, the lower 2.5 miles were classified as having a high potential for drying (Exhibits 2-12 through 2-14). The frequency of channel drying events is dependent upon numerous factors; including seepage losses from the active channel (see next section), seepage from the riverside drains to the river channel, drain wasteways returning water to the channel, and evapotranspiration.

In addition to the unpublished FWS channel drying maps, the New Mexico Interstate Stream Commission (NMISC) has contracted S.S. Papadopulos and Associates, Inc. (SSPA) to conduct drought monitoring through the “River Eyes” program. “River Eyes” is a cooperative, interagency river monitoring effort established in 2001 (Llewellyn et al., 2006) that monitors the Rio Grande between Cochiti Dam and Elephant Butte Reservoir, with emphasis on the reach between Albuquerque and Fort Craig. Flow measurements collected under this program are used to support federal agencies to meet March 2003 BiOp’s flow targets. This monitoring program has also been conducted to address other specific elements of the BiOp’s requirements related to river operations and to provide timely and relevant information to the Service to assist in rescue efforts for the endangered Rio Grande silvery minnow. Field activities performed by the NMISC River Eyes team have included identification of flow intermittency and ponding, stage monitoring, daily discharge, and water quality measurements. Endangered silvery minnow that might be stranded in isolated pools in discontinuous reaches or in floodplain pools can be located and possibly rescued (Llewellyn et al., 2006).

SSPA presented the 2002–2004 River Eyes data in maps similar to the channel drying maps developed by Parametrix (Exhibits 2-12 through 2-15). The SSPA 2002–2004 dataset classifies the drying potential in seven qualitative categories compared to the six used in the unpublished dataset provided by the USFWS, which results in the two datasets having minor differences. The 2005 dataset was presented in a different format than the 2002-2004 datasets and both are available from the NMISC.

Exhibit 2-12

Propensity for Channel Drying – Los Lunas Sub-reach

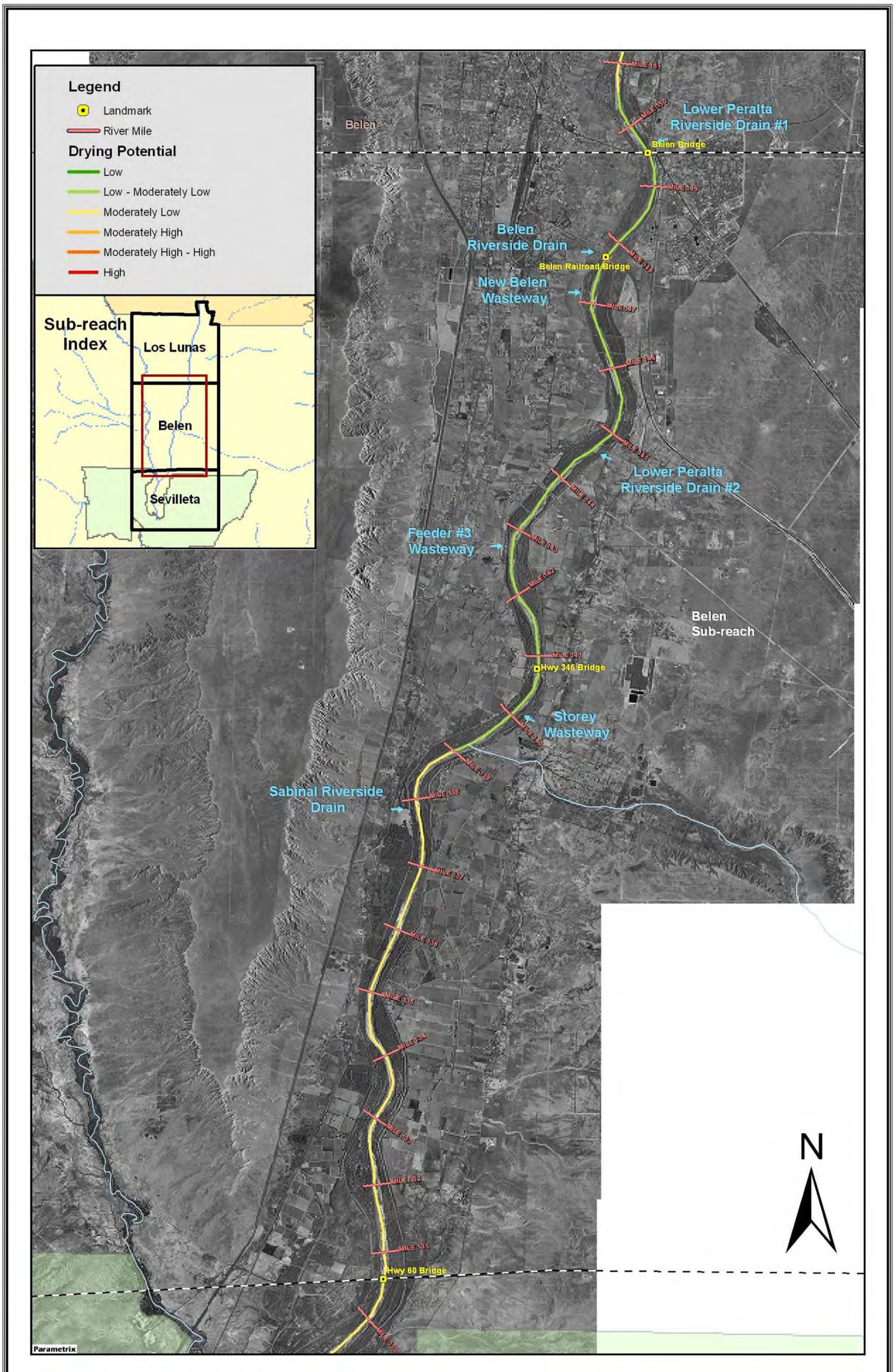


Background Photo: June 2006

The boundary of Isleta Pueblo depicted on this map is an old depiction of the boundary; however, the Pueblo of Isleta currently recognizes the eastern boundary between RM 163.7 and RM 166.3 along the Rio Grande as being the MRGCD right-of-way adjacent to the Peralta Drain.

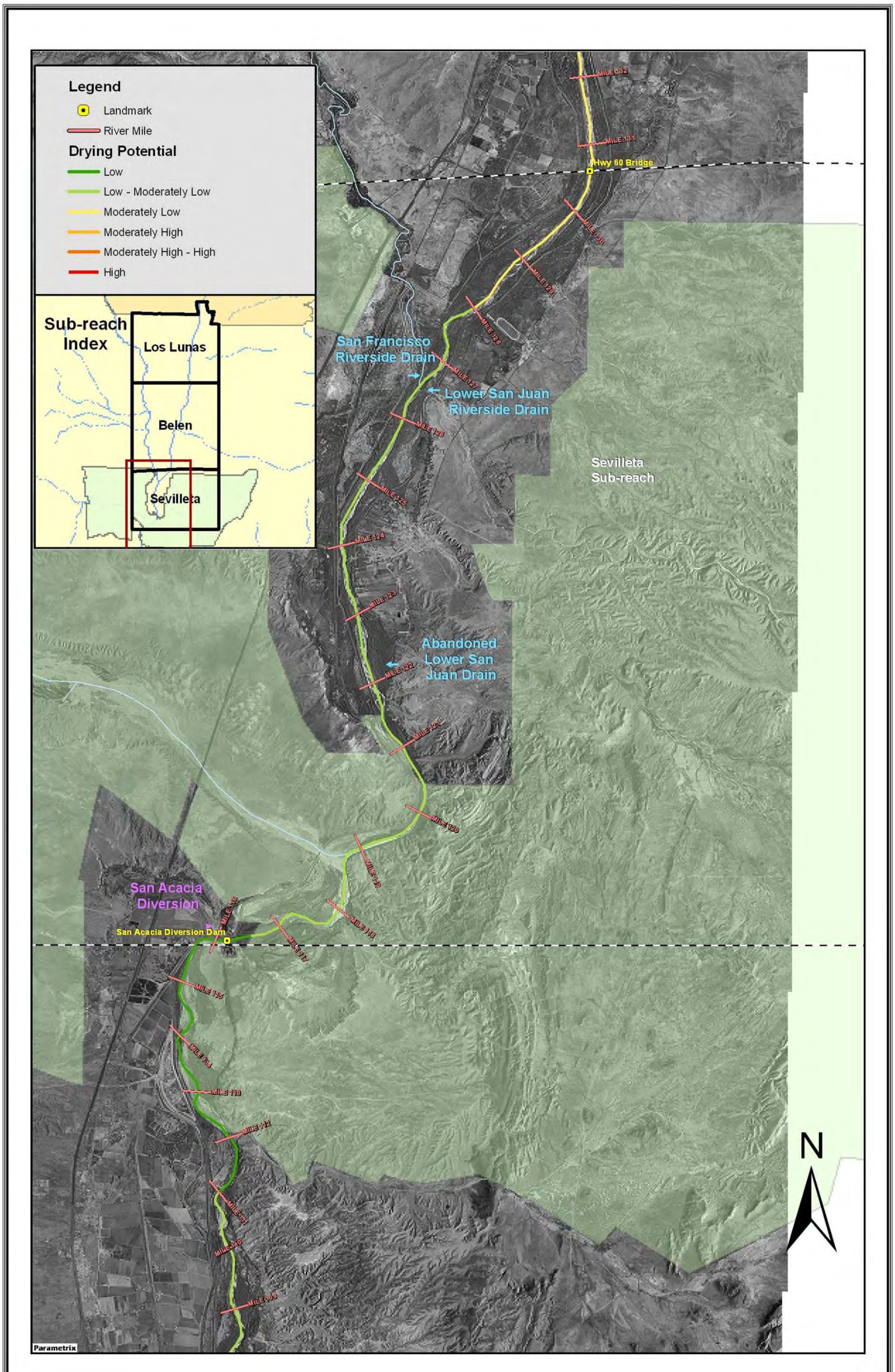
Exhibit 2-13

Propensity for Channel Drying – Belen Sub-reach



Background Photo: June 2006

Exhibit 2-14
Propensity for Channel Drying – Sevilleta Sub-reach



Background Photo: June 2006

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River Conveyance Losses

SSPA (2002) calculated seepage losses for numerous reaches throughout the Middle Rio Grande during the summer of 2001. The Isleta Reach seepage data were summarized by Parametrix by calculating weighted averages of seepage losses for the various reaches (Exhibit 2-15). Using these weighted averages, the Isleta Reach seepage losses are estimated to be 167 cfs between RM 166.1 and RM 119.4. These seepage estimates correspond closely with the channel drying categories presented in Exhibits 2-12 through 2-14) and are influenced by seepage losses from the active channel due to the underlying geology, seepage from the drains increasing channel flow, and evapotranspiration.

Exhibit 2-15

Average Seepage Losses Calculated as the Weighted Averages from Data Presented in SSPA (2002)[a]

SSPA (2002) Reach Boundary		River Mile		Average Seepage Rate (cfs/mile)	Estimated Reach Loss (cfs)
From	To	From	To		
Rio Grande at Isleta	Upstream of Wastewater Outfall	166.1	159.5	9.4	62
Upstream of Wastewater Outfall	Tome	159.5	152	6.1	46
Tome	Highway 309	152	150	2.6	5
Highway 309	Blue Cup	150	143.2	0.6	4
Blue Cup	Upstream of Lower Sabinal Drain	143.2	139.3	3.2	12
Upstream of Lower Sabinal Drain	Highway 60	139.3	134.2	2.3	12
Highway 60	Below Drain Unit 7 Extension	134.2	127.7	2.0	13
Below Drain Unit 7 Extension	San Acacia #3	127.7	122.4	-1.0	-5
San Acacia #3	San Acacia #2	122.4	119.4	6.3	19
				Total Estimated Seepage (cfs):	**167**

[a] *Average seepage rates were calculated as a weighted average of seepage losses across all of the available measurement activities provided in Table 4 in SSPA 2002. The measurement activities were measured during June, July, and August 2001 and were measured at various river discharges.*

Groundwater Hydrology

10 What data is available on riparian groundwater in the project reach?

The New Mexico Interstate Stream Commission (NMISC) has developed the Belen and Bernardo riparian groundwater models which estimate the alluvial groundwater elevations throughout the project reach. These models have the potential to be very useful for riparian restoration planning. For this project, of particular interest was the riparian groundwater model predictions associated with low-river-flow conditions because native riparian cottonwoods and willows become water stressed when groundwater levels drop below approximately 2 to 3 meters below ground level (Stromberg et al., 2005). The NMISC groundwater models indicate that depth to groundwater increases progressively downstream in the project reach. Exhibits B.2-7 through B.2-9 in Appendix B show riparian groundwater model estimates in each project area sub-reach at relatively low flows (105 cfs at Bernardo).

Although these riparian groundwater models were not calibrated to well data within the project reach (data sources were unavailable at the time the models were developed), comparisons with recently available data from groundwater piezometers in the reach indicate that the model predictions are reasonably accurate (Exhibit 2-16).

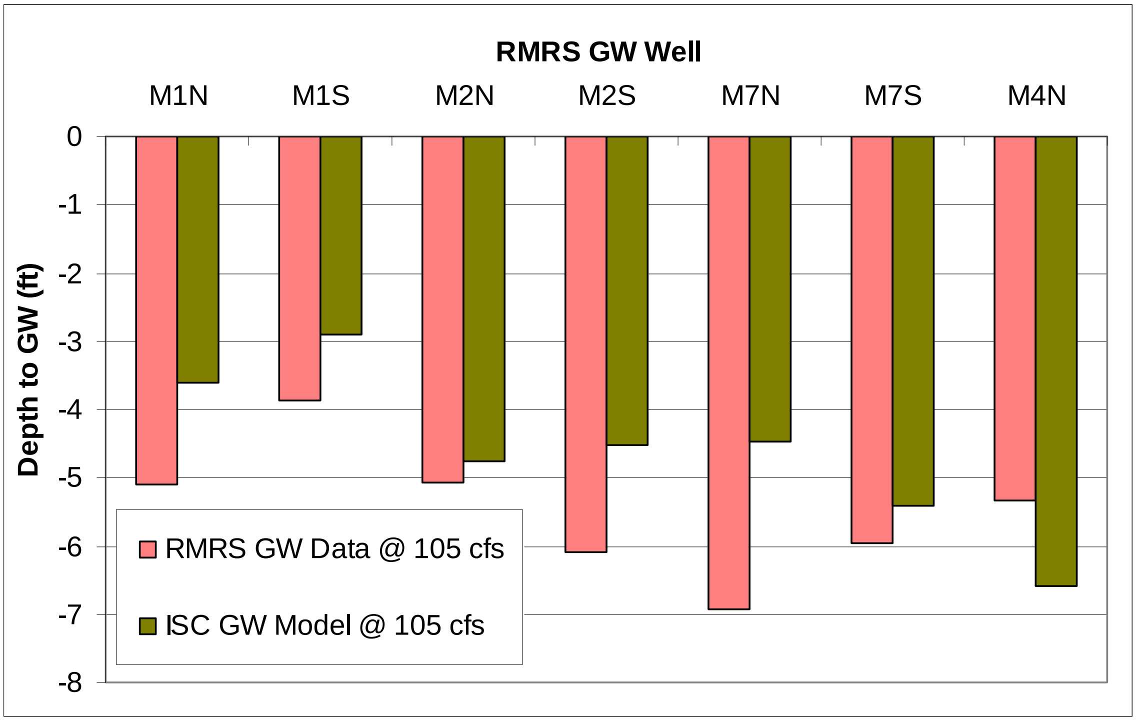
The Rocky Mountain Research Station (RMRS) maintains a series of eight pairs of shallow groundwater wells throughout the project reach (well locations displayed in Exhibits B.2-7 through B.2-9 in Appendix B). Parametrix was provided with the average weekly depth to groundwater data for each well from December 31, 2003, to December 27, 2006. A linear regression of dates with discharges (at Bosque Farms) was developed that bracketed the NMISC groundwater model target discharges (Q = 105 cfs and 2,627 cfs at Bernardo). Using the regression, an interpolated groundwater depth was determined for the specific flow (Q) that was modeled by the NMISC. The interpolated RMRS groundwater depths were then compared to the modeled NMISC groundwater depths (Exhibit 2-16).

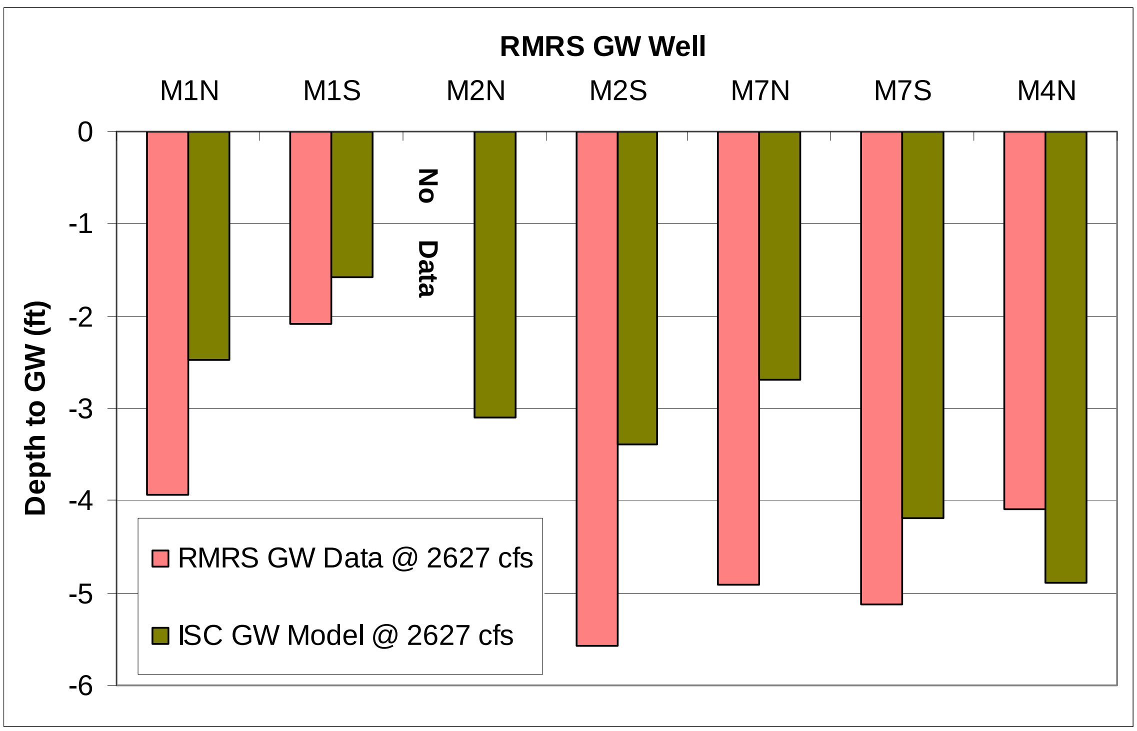
The analysis indicates that the NMISC models tend to underestimate the depth to groundwater at the RMRS well locations, although these differences were relatively minor (particularly at low river flows). For example, at 105 cfs, the NMISC model estimated that groundwater elevations in the floodplain averaged 0.87 foot higher (i.e., less deep) than seven of the eight RMRS groundwater wells. The differences between modeled and observed groundwater depths were somewhat greater at more moderate flows (Exhibit 2-16).

The Bosque Ecosystem Monitoring Program (BEMP) also maintains a series of wells at numerous locations along the Isleta Project Reach (Exhibits B.2-7 through B.2-9 in Appendix B). These monitoring locations contain five wells, including a center well and four additional wells in compass directions around the center well. The BEMP program is a long-term ecological monitoring program and data are only collected once every month. The data is too sparse for comparison with other groundwater data.

Exhibit 2-16

Groundwater Well Data Compared to the NMISC Groundwater Model at 105 cfs and 2,627 cfs





Parametrix compared the RMRS Groundwater (GW) well data for flows that were near the flows modeled by the NMISC groundwater model. The modeled groundwater depths were then compared to the groundwater depths measured at the RMRS wells.

Floodplain Soils

11 What are the general characteristics of the Middle Rio Grande floodplain soils?

The characteristics of the soils in the Middle Rio Grande floodplain are quite variable, both spatially and with depth. Extreme variability within short distances is typical for most floodplains, and the MRG floodplain is no exception. The Soil Surveys of Valencia and Socorro Counties, New Mexico (Natural Resource Conservation Service [NRCS], 2004), describes the floodplain as stratified sand and loamy sand, with pockets of gravel and thin strata of loam, clay loam, and silty clay loam.

One of the most important soil properties in the floodplain is the depth to the seasonal high water table. As mentioned in the previous section, the water table depth affects the type of plants that grow on the site and may also affect soil salinity. The depth to the upper boundary of the water table varies throughout the floodplain, and generally occurs at depths as shallow as 10 to 20 inches or as deep as several feet (C. Landers, Soil and Water West, personal communication, 2007). The occurrence of the water table is generally influenced by upper stratigraphy, distance from the river and relative elevation to the river channel, and hydraulic conductivity of the soil substrata.

Another important soil property in the floodplain is soil salinity. Floodplain deposits are generally nonsaline at the time of deposition, but soil salinization may occur in a relatively short period of time under certain conditions. Periodic flood inundation helps to reduce salt concentrations in floodplain alluvium, but leaching of salts through this mechanism has been reduced (frequency, duration) or eliminated throughout most of the project reach floodplain. Also, if the upper soil profile has medium to fine textured alluvium, and the water table rises to within 3 to 4 feet of the surface, soil moisture and the dissolved salts tend to move upward through capillary pull.

When the moisture reaches the soil surface and evaporates, salts tend to accumulate near the soil surface. This condition can be exacerbated by the relatively shallow rooting structure of herbaceous plant species, which generally draw water closer to the soil surface than deeper-rooted woody vegetation. Over time, soil salinity can become elevated to a level that restricts the growth of salt sensitive plants, including willow and cottonwood.

12 What data are available regarding soils and floodplain alluvial deposits in the project reach?

Currently, available information regarding the character and distribution of floodplain alluvium in the project reach consists of:

- Soil Surveys of Valencia and Socorro Counties (NRCS, 2004).
- Surficial Geology Maps (Lettis & Associates, 2003).

NRCS Soil Surveys

The United States Department of Agriculture (USDA) NRCS conducts soil surveys nationwide, and all of the soil parameters that affect plant growth are described and mapped in these studies. Unfortunately, the level of detail of the soil maps in the MRG floodplain is not adequate for project planning. The existing soil survey of Valencia and Socorro Counties was conducted in 1983 (although maps were digitized in 2004) when the top priority for mapping was agricultural areas. The bosque area was considered to be of lower priority at that time, and the soils were only briefly and generally described in the published report. Unlike the surrounding upland areas, no field data was collected in the bosque during development of these soil surveys, making these documents of little use to restoration planning.

Surficial geology map at RM 142. Unfortunately, this dataset was not useful for determining the soil salinity of the various surficial geologic features.

Surficial Geology Maps

The most recent and detailed surficial geology study of the MRG floodplain was conducted in 2003 (Lettis & Associates, 2003). This study delineated and classified the deposits on the basis of both genetic origin and age, as best interpreted from two sets of aerial photography (1935 and 2000). The scale of mapping was 1:24,000. Although the determination of site-specific soil properties was not an objective of this study, it was considered that this study might contain sufficient detail to predict selected soil properties, such as salinity (B. Harrison, New Mexico Tech, personal communication, 2007).

Site conditions that affect soil salinity include:

- Depth to the water table.
- Duration of the water table at different depths.
- Soil texture between the top of the water table and the soil surface.
- Surface flooding, or overflow frequency.

Since the surficial geology study did not directly map soil salinity, levels of soil salinity must be predicted from those components of the study that were mapped. In order to make a reasonable prediction for soil salinity, it must be possible to ascertain the character and distribution of those factors that affect salinity (depth to water table, duration of water table, soil texture between the water table and soil surface, and overflow frequency). However those factors, like soil salinity, were not mapped in the study. It is especially problematic that there is as much variability of soil texture within a specific map unit of the study area as there is between map units. This virtually eliminates the study from being able to reasonably predict soil salinity levels, hydraulic conductivity levels, or other soil attributes at specific sites within the total reach of the floodplain.

In summary, the soils in the MRG floodplain are extremely variable and the distribution pattern of various types of soils is very complex. There are currently no detailed soils data in the project reach. On-site observations and data collection are necessary to provide meaningful information for management decisions.

Floodplain Vegetation

13 What was the historic condition of riparian vegetation in the MRG Valley?

19th century photo looking across a broad channel to scattered mature cottonwoods on the far bank.
(Photo Credit: IBWC)

Pre-19th century Rio Grande floodplain vegetation has been described in journal entries of early European explorers. Scurlock (1988 and 1998) provides a detailed synopsis of these early journal descriptions to reconstruct a general picture of the historic vegetation conditions in the MRG floodplain. Prior to the 19th century, it is generally accepted that the floodplain supported a “patchwork mosaic” of discontinuous cottonwood gallery forests, willow wetlands, marshes, alkali meadows, oxbow lakes, and ponds (Crawford et al., 1993). The extent and distribution of these vegetation communities were strongly influenced by episodic flood events, geomorphic conditions, and human impacts.

The earliest detailed information compiled about plant species composition in the Rio Grande floodplain was documented by Watson (1912) near Albuquerque. General maps of the floodplain vegetation were published by the U.S. Reclamation Service in 1922 and by MRGCD in 1928 (Burkholder, 1928). These floodplain maps display general locations and extents of broad vegetation categories (timber woodlands, alkali, swamp and lake, etc.). Crawford et al. (1993) utilized these data in an attempt to quantify 20th century changes in some of these vegetation categories in the MRG, including in the project reach of interest to this report. According to data summaries presented in the report, the most dramatic change in the reach occurred between Bernardo and San Acacia, where a loss of nearly 20,000 acres of saltgrass meadows was estimated (Exhibit 2-17).

Exhibit 2-17

20th Century Floodplain Vegetation Changes (acres) (Modified from Crawford et al., 1993)

Year	Cottonwood Dominated Timber & Brush	Russian Olive	Salt Cedar	Saltgrass Meadow	Marsh/ Standing Water
1918					
Cochiti to Bernardo	7,053 (17,422)	–	–	–	1,392 (3,439)
Bernardo to San Acacia	353 (872)	–	–	19,677 (48,603)	59 (146)
San Acacia to San Marcial	7,354 (18,165)	–	–	–	1,089 (2,689)
Total:	**14,760 (36,459)[a]** **15,312 (37,821)[b]**	**–**	**–**	**19,677 (48,603)**	**2,540 (6,274)[a]** **1,346 (3,324)[b]**
1982, 1989					
Cochiti to Bernardo	6,543 (16,162)	335 (828)	660 (1,629)	–	267 (659)[c]
Bernardo to San Acacia	137 (338)	119 (294)	605 (1,494)	–	262 (647)
San Acacia to San Marcial	1,548 (3,823)	–	5,955 (14,710)	–	1,028 (2,538)
Total:	**8,228 (20,323)**	**454 (1,122)**	**7,220 (17,833)**	**–**	**1,557 (3,844)**

Note: Historical comparison of aerial extent in hectares (acres) of cottonwood, Russian olive, salt cedar, saltgrass meadow, and marsh for selected reaches and periods. Data for 1918 are from U.S. Reclamation Service Maps (1922); and data for 1982, 1989 are from Hink and Ohmart (1984) and U.S. Bureau of Reclamation (1993b). Recent acreages exclude 2,560 hectares (ha) (6,323 acres) of low shrub and herbaceous vegetation (mostly salt cedar and predominantly in the Bernardo to San Acacia Reach) because this vegetation classification may not have been identified in the 1918 survey.

a Planimetering by Biological Interagency Team.

b Burkholder (1928).

c Includes 91 hectares (224 acres) of wet meadow.

14 Over the past several years, the "Hink and Ohmart" vegetation classification system has been commonly used by management agencies for describing floodplain vegetation along the MRG. What is the background of this tool and how does it work?

The most widely used floodplain vegetation classification system in the MRG Basin today was initially presented by Valerie Hink and Robert Ohmart for the Middle Rio Grande Biological Survey (Hink and Ohmart, 1984). The Hink and Ohmart classification system distinguishes vegetation community types based on species dominance and canopy cover in both the vegetation overstory and understory.

A total of six structure types are used in this classification system to describe plant canopy height and percent aerial cover (Exhibit 2-18). Dominant and co-dominant tree and shrub species are listed for both the overstory (canopy) and understory layers. In both layers, any species with greater than 25 percent cover is included in the community name. The 1984 report included bosque vegetation maps between Espanola and San Acacia, New Mexico, and was developed with aerial photo interpretation and reconnaissance level field studies. Detailed transects were sampled to represent the range of species composition and aerial cover of community types.

In 2002, the Army Corps of Engineers, Bureau of Reclamation, and NMISC completed a GIS-based mapping project to update the 1984 Hink and Ohmart vegetation maps for the Upper Rio Grande Basin Water Operations Review Final EIS (USACE 2007). The technical mapping was performed by Reclamation's Technical Service Center in Denver, Colorado. Reclamation's map coverage includes the Rio Chama from below Abiquiu Dam to the confluence with the Rio Grande, and from the confluence south along the Rio Grande to the full pool elevation for Elephant Butte Reservoir. The goal of this mapping effort was to allow comparisons of vegetation change over time and evaluate impacts related to water management operations.

15 What are the primary differences between the 1984 and 2002 mapping methods?

Young cottonwood trees near RM 100. (Photo Credit: Parametrix)

Similar methods were used to map vegetation in 1984 and 2002. However, technological advances like the widespread use of Geographic Information Systems (GIS) resulted in changes in mapping precision and detail between these sources. The 2002 map was digitized on-screen over color-infrared photography in ArcGIS©, while the 1984 maps were hand drawn on Mylar over black and white photography. The use of a color-infrared photography allows a user to interpret changes in species dominance more easily than a black and white source. This probably resulted in the inclusion of more co-dominant species in canopy layers in the 2002 project, which is true for many areas within the project reach. Also, the 2002 polygons are typically smaller than individual map features in the 1984 source, pointing out a slight scalar difference. In the 1984 vegetation mapping, Hink and Ohmart mapped transition zones outside the levees (like adjacent grasslands or shrublands) while the 2002 mapping only occurred between the levees.

The 2002 vegetation mapping also included slightly more detail to the structure types presented in the original 1984 maps by adding an “s” or “f” suffix to some of the dense structure types (Exhibit 2-18). Reclamation digitized vegetation map polygons in GIS using color-infrared photography. Community types were determined using both photo interpretation and field-verification of varying degrees of intensity; however, unlike the original 1984 mapping, the 2002 mapping update did not involve data from field transects.

Exhibit 2-18

Hink and Ohmart Vegetation Classes

Structure Type	Dominant Overstory Height (feet)	Overstory Cover (percent)	Understory Cover (percent)	General Description
1s	>40	>25	25–50	Tall trees with well developed understory.
1	>40	>25	50–75	Tall trees with dense understory.
1f	>40	>25	>75	Tall trees with very dense understory.
2	>40	>25	<25	Tall trees with little or no understory.
3s	20–40	>25	25–50	Intermediate-sized trees with developed understory.
3	20–40	>25	50–75	Intermediate-sized trees with dense understory.
3f	20–40	>25	>75	Intermediate-sized trees with dense understory.
4	20–40	>25	<25	Scattered woodlands of intermediate-sized trees.
5s	<20	<25	25–50	Shrubs with medium density.
5	<20	<25	50–75	Dense shrubs.
5f	<20	<25	>75	Very dense shrubs.
6	<20	<25	<25	Sparse and/or very young shrubs.

The structure types displayed here are a modified version of Hink and Ohmart (1984) vegetation type naming convention. This modification was created by the Bureau of Reclamation for mapping updates performed in 2002. The primary differences between the original and modified naming conventions is the addition of “s” and “f” structure classes for differentiating varying levels of cover in dense stands (Types I, III, and V).

16 Has the 2002 vegetation mapping been updated since it was originally developed?

In 2005, Parametrix updated the 2002 vegetation mapping under contract with the MRGCD to revise the vegetation types according to mapping inaccuracies and recent community changes following wildfire or hazardous fuel reduction. This project was completed from the south boundary of Isleta Pueblo to Bernardo. While all the burned and cleared polygons were updated, only a subset of the untreated and unburned areas was field-verified (33 percent of polygons mapped as Structure Types 1 and 3).

Parametrix field crews also verified a subset of the 2002 mapping of the Isleta Reach in 2007. This field verification was restricted to communities with Goodding’s willow, listed as a co-dominant in the 2002 map or potential restoration project sites. Polygons that were previously field verified in 2005 were not revisited.

17 How was the floodplain vegetation mapping managed for this report?

The updated 2002 vegetation map of the Isleta Reach identifies 820 distinct vegetation stands and 15 open water areas (not including the river channel and the irrigation canals). Associated spreadsheet data was used to quantify the areal extent and distribution of dominant plant species and different Hink and Ohmart structure types across the project area.

For management utility and general analysis for this report, these 820 stands were consolidated into eight general vegetation categories. These categories are defined in Exhibit 2-19 and are displayed in sub-reach maps in Exhibits 2-20 through 2-22.

The updated 2002 vegetation map of the Isleta Reach identifies 820 distinct vegetation stands. For management utility, these stands were consolidated into eight general vegetation categories. (Exhibit 2-20 through Exhibit 2-22).

Exhibit 2-19

General Vegetation Categories and Groups

Category/Groups	Description
Alkali (Wet) Meadow	Saltgrass and alkali sacaton meadows.
Marsh	Seasonal and semi-permanent wetlands. Cattail and/or bulrush wetlands.
Native Riparian	Riparian forests and shrublands comprised only of native species.
Gallery Forest with Exotic Understory	Mature cottonwood forests with only non-native trees and shrubs growing below the canopy.
Mixed Native and Exotic Riparian	Riparian forests or shrublands composed of both native and non-native species.
Exclusively Exotic Spp.	Dense stands of non-native woody vegetation.
Xeric Shrubland	Dry sites dominated by scrubland or grassland vegetation and few riparian tree or shrub species
Xeric Woodland	Dry sites with deep sandy soils. Often cottonwood with sparse Russian olive and grass understory.
GROUP	
Highly Disturbed	Borrow pits and/or massive disturbance (e.g., fire).
Open Water	River

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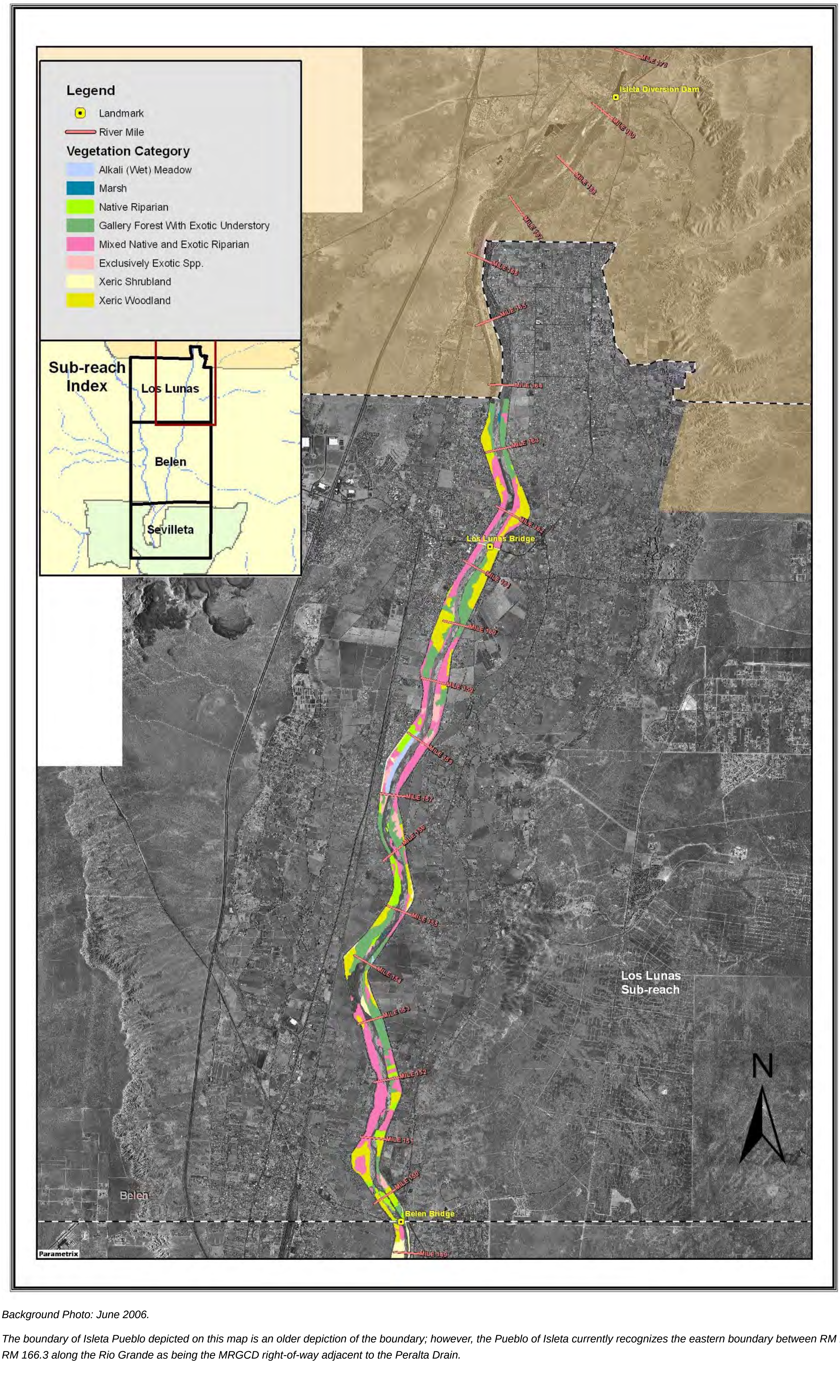
Exhibit 2-20

General Vegetation Categories – Los Lunas Sub-reach

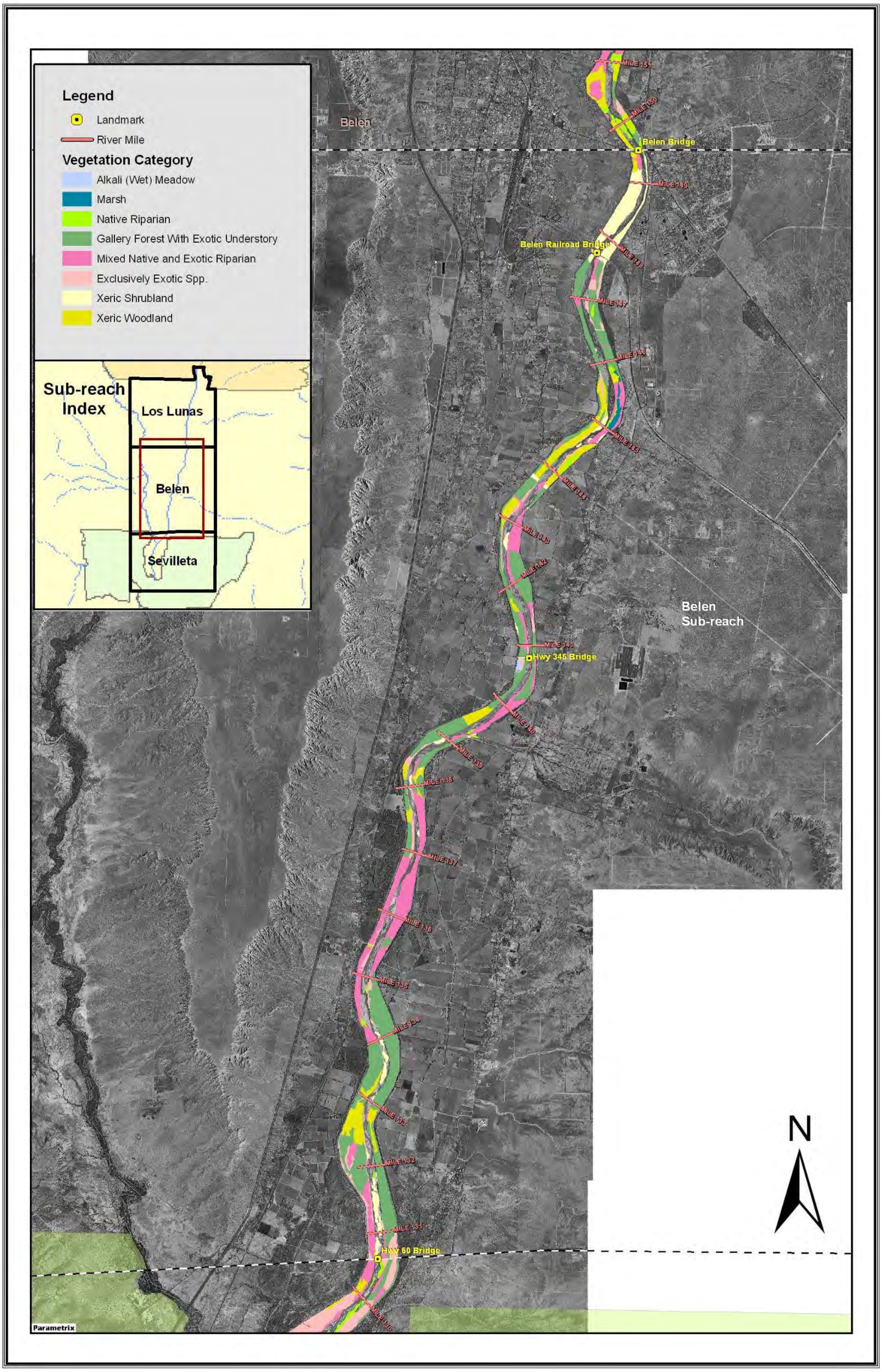


Background Photo: June 2006.

The boundary of Isleta Pueblo depicted on this map is an older depiction of the boundary; however, the Pueblo of Isleta currently recognizes the eastern boundary between RM 163.7 and RM 166.3 along the Rio Grande as being the MRGCD right-of-way adjacent to the Peralta Drain.

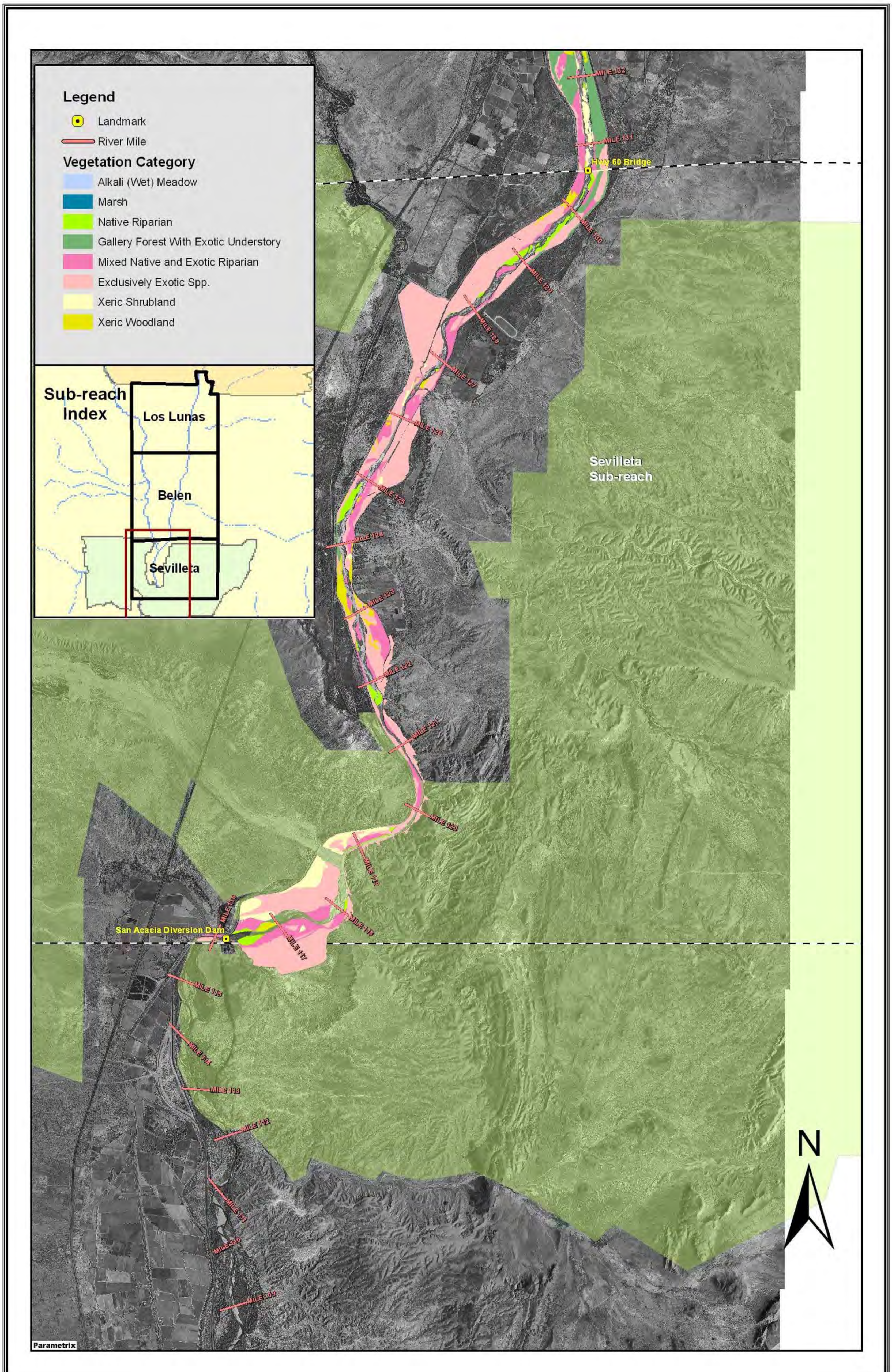
Exhibit 2-21

General Vegetation Categories – Belen Sub-reach



Background Photo: June 2006.

Exhibit 2-22
General Vegetation Categories – Sevilleta Sub-reach



Background Photo: June 2006.

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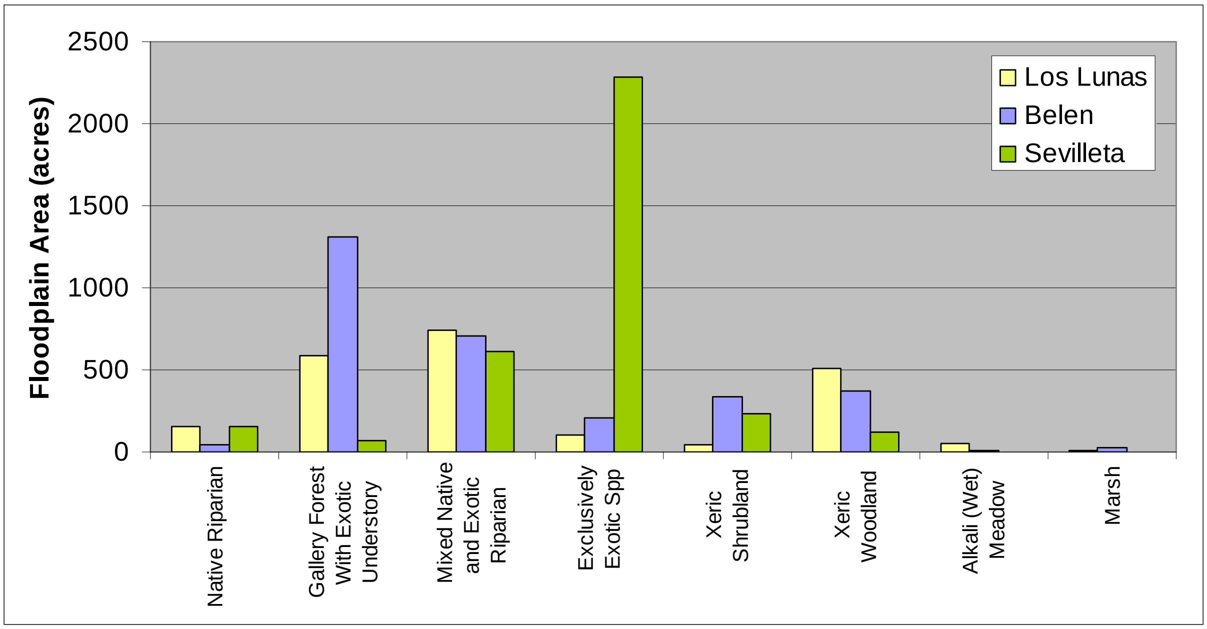
18 What is the acreage and spatial distribution of the different vegetation categories in the project reach?

With the exception of *mixed native and exotic riparian,* the spatial extent of most floodplain vegetation categories varies considerably across sub-reaches. Exhibit 2-23 shows that the Sevilleta Sub-Reach is dominated by stands of *exclusively exotic* vegetation, whereas both upstream sub-reaches currently support relatively small acreages of this vegetation category. Also notable is the relatively low spatial extent in all sub-reaches of *native riparian, alkali meadow, and marsh* vegetation.

Exhibit 2-23

Acreage Distribution of General Vegetation Categories



19 What are the dominant plant species and structure types currently in the project reach?

The updated 2002 vegetation dataset indicates that saltcedar (*Tamarix chinensis* Lour), Rio Grande cottonwood (Populus *deltoides, ssp. wislizeni*), and Russian olive (*Elaeagnus angustifolia*) are currently the most dominant plant species across all three sub-reaches. Saltcedar and Russian olive dominate more acres in the Sevilleta Sub-Reach, whereas Rio Grande cottonwood is more dominant in the upstream sub-reaches. The acres dominated by Coyote willow (*Salix exigua*) in the Los Lunas Sub-Reach is approximately twice that found in either of the two downstream sub-reaches. Goodding's willow (*Salix gooddingii*) is dominant (see sidebar definition) in relatively few stands throughout the project reach, but is an important species for the flycatcher in the MRG (Parametrix, 2008).

Dominant Species

Following the Hink and Ohmart (1984) vegetation classification system, a plant species must comprise at least 25 percent aerial cover to be considered a "dominant" species in a stand.

Non-native species including Siberian elm (*Ulmus pumila*), Mulberry (*Morus alba*), and Tree of Heaven (*Ailanthus altissima*) occur within the reach but are dominant in very few stands. This is also true for native riparian species like wolfberry (*Lycium spp.*), New Mexico olive (*Forestiera pubescens, spp. neomexicana*), seepwillow (*Baccharis spp.*), and screwbean mesquite (*Prosopis pubescens*) (Exhibit 2-24).

The vegetation structure in both the Los Lunas and Belen Sub-reaches is relatively evenly distributed between Structure Types 1, 3, 4, and 5 (Exhibit 2-25). The Sevilleta Sub-reach is dominated by Structure Type 5. The lack of herbaceous wetlands and alkali meadows throughout the entire reach is striking. Areas identified as "OP" primarily represent recently burned areas. (See Exhibit 2-19 for structure type definitions.)

Exhibit 2-24
Woody Plant Species Distribution by Sub-reach

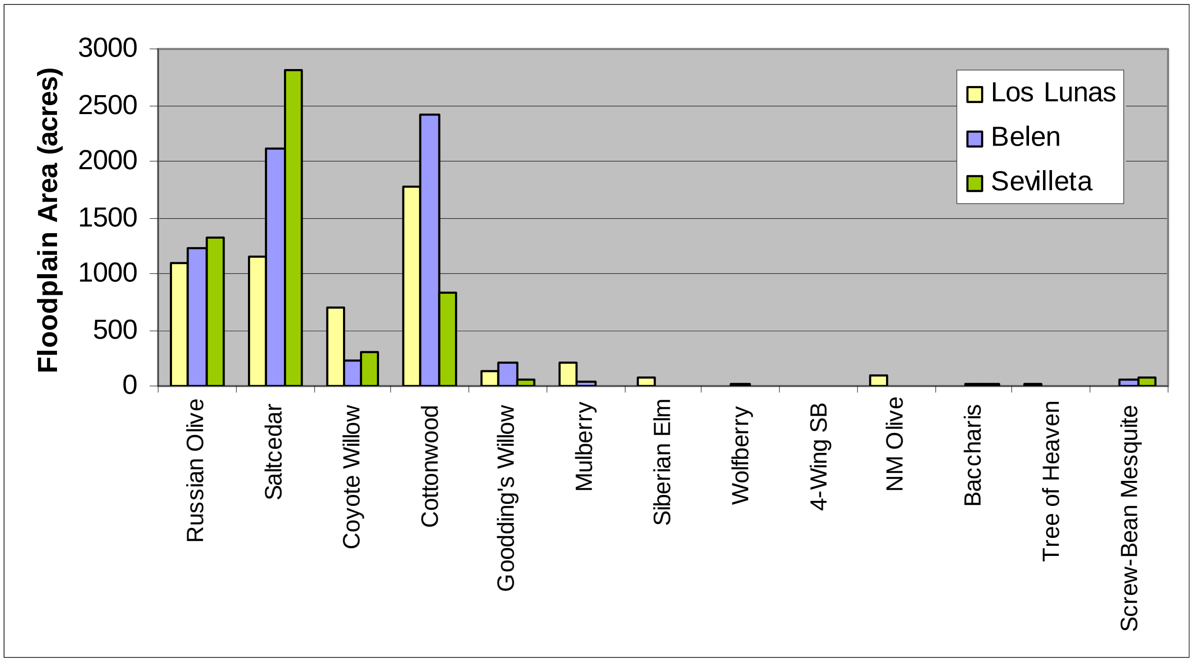
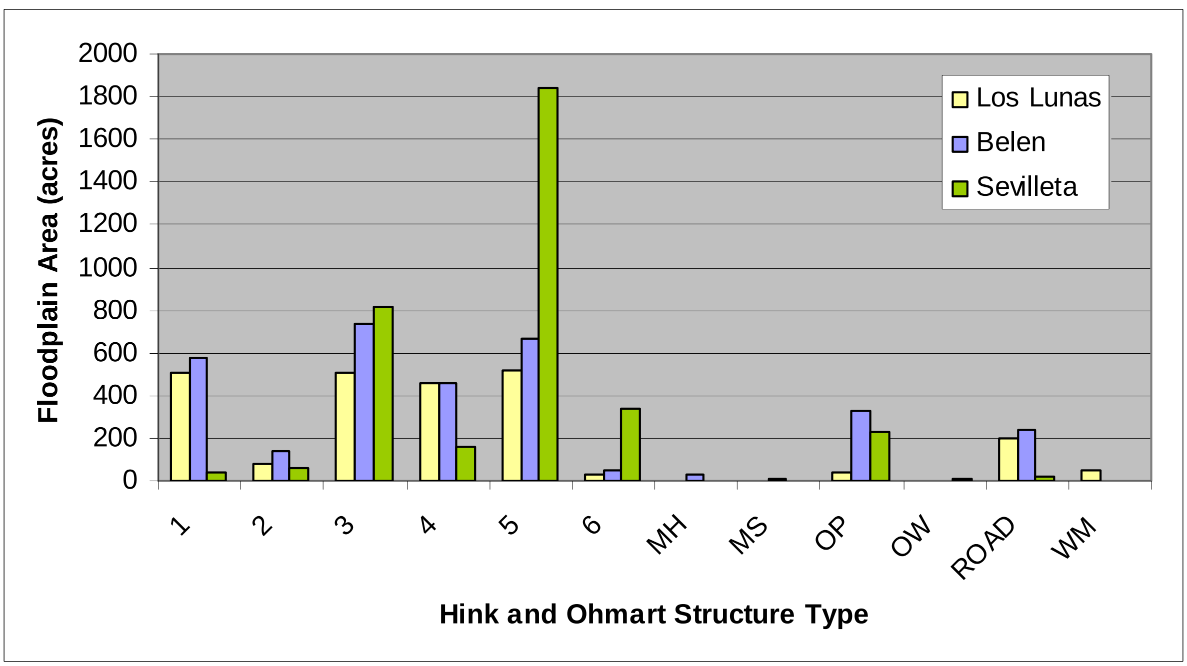


Exhibit 2-25
Vegetation Structure Distribution by Sub-reach



MH = cattail marsh, MS = saltgrass meadow, OP = Open; OW = Open water; Road = Road, WM = Wet meadow

20 How has vegetation structure and species composition changed since the 1984 mapping?

Bar charts in Exhibits 2-26 and 2-27 compare relative species composition and structure types between 1984 and updated 2002 vegetation maps. These differences should be interpreted cautiously, because the mapping methods between efforts were not identical. Nonetheless, these reach-wide data comparisons indicate that relative acreage dominated by coyote willow has declined by approximately 53 percent (28 percent in 1984 compared to 15 percent in the updated 2002 maps). Saltcedar dominance appears to have declined by approximately 8 percent, while Russian olive appears to have increased by approximately the same amount. Interestingly, the data indicates that cottonwood dominance is relatively unchanged since 1984.

Perhaps more notable are the shifts in structure type since 1984. For example, comparison of data sets indicates considerable declines in Structure Types 1 and 6, and corresponding increases in Structure Types 3, 4, and 5. The decline in Structure Type 1 (and subsequent increases in Types 3 and 5) can probably be attributed to frequent bosque fires over the past decade. The decline in Structure Type 6 (and subsequent increase in Structure Type 4) is probably due to maturation of these stands over the past two decades. These data indicate that bosque fires are generally having more influence on vegetation structure than species composition.

Belen burn site which burned in spring 2007. Photo taken facing northeast. (Photo Credit: Parametrix)

Exhibit 2-26

Shifts in Species Dominance Between 1984 and 2007

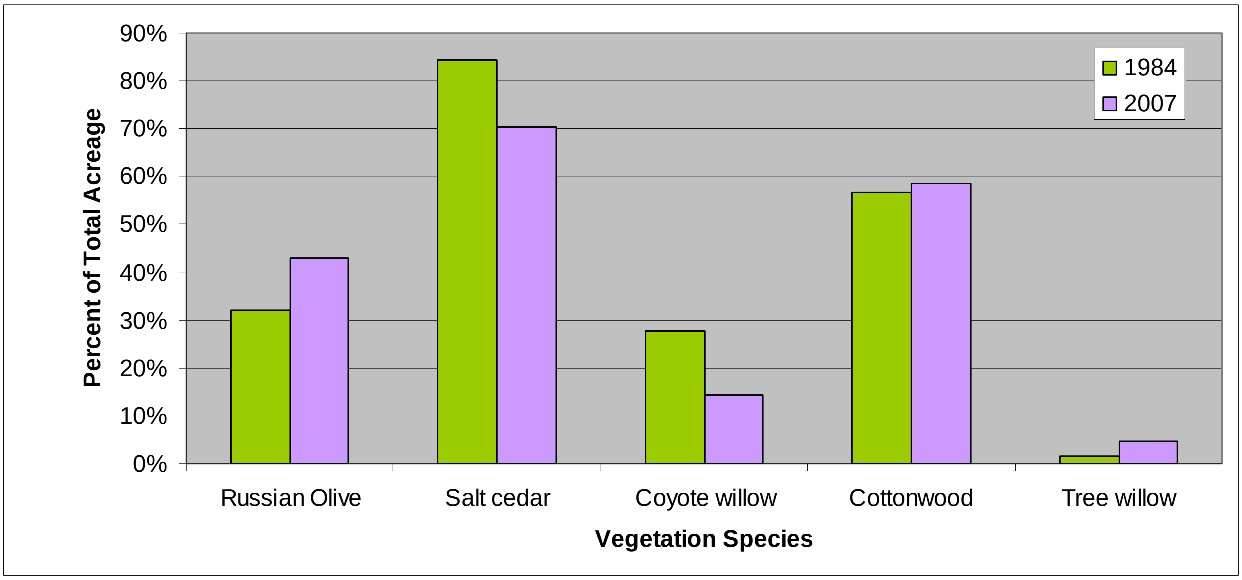
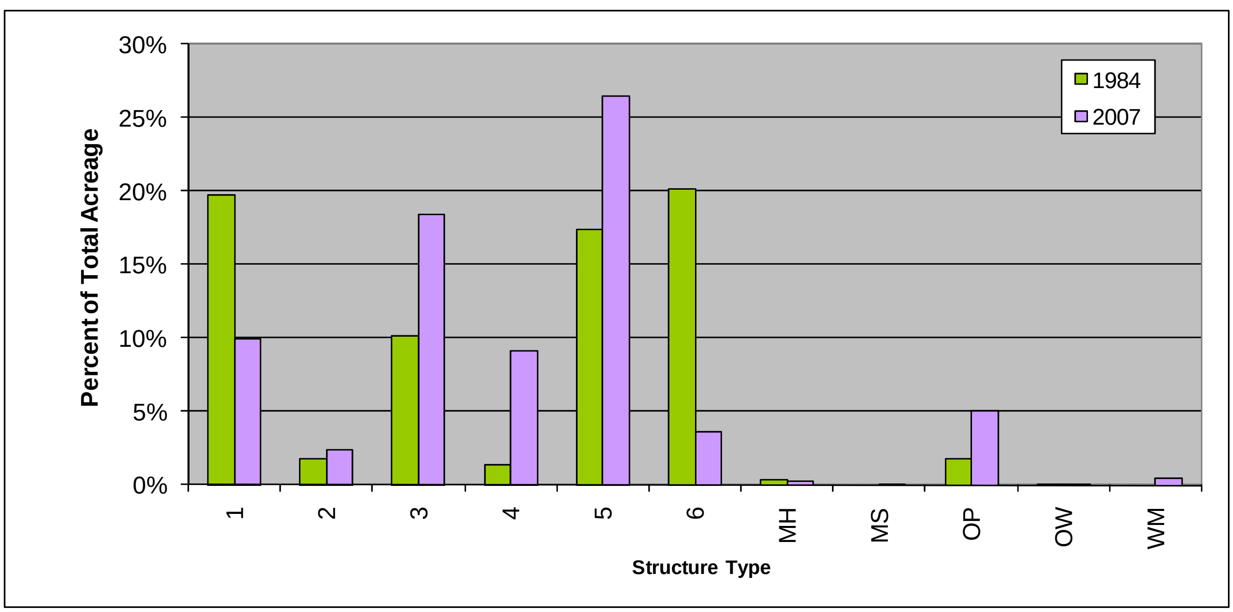


Exhibit 2-27

Vegetation Structure Changes Between 1984 and 2007



MH = cattail marsh, MS = saltgrass meadow, OP = Open; OW = Open water;, WM = Wet meadow

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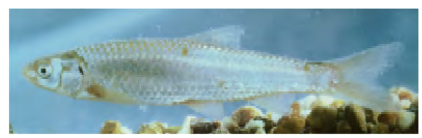
Chapter 3 Species Biology and Habitat Ecology

Rio Grande Silvery Minnow

The Rio Grande silvery minnow (*Hybognathus amarus*) is a Federal and State (New Mexico and Texas) listed endangered species (FWS, 1994; New Mexico Game and Fish, 1996; Texas Parks and Recreation, 2003). It is the primary species of concern to the Program. Ultimately, the success of habitat restoration efforts in the Middle Rio Grande (MRG) will be measured by the success to increase the size of the silvery minnow population (Tetra Tech, 2004a).



Rio Grande Silvery Minnow (Photo by Michael Hatch)

The biological characteristics, as well as the known or suspected habitat relationships of the silvery minnow, were discussed in the reach-specific habitat assessment for San Acacia Reach of the MRG (Parametrix, 2008). This assessment for the Isleta Reach includes much of that discussion, while updating key points and presenting additional information of specific importance to the Isleta Reach.

1 What is the present status and distribution of the silvery minnow?

Historically, the silvery minnow was one of the most common fish in the Rio Grande (FWS, 1994). They ranged from near the Gulf of Mexico to upstream of Española, New Mexico, on the main stem of the Rio Grande and up the Rio Chama beyond Abiquiu, New Mexico (Bestgen and Platania, 1991). The silvery minnow also occurred in the Pecos River from Santa Rosa, New Mexico, south to the confluence with the

Rio Grande. Currently, silvery minnows inhabit approximately 5 percent of their historical range, with the entire wild population limited to the reach of the Rio Grande between the Angostura Diversion Dam (downstream of the Cochiti Dam) and the Elephant Butte Reservoir delta (FWS, 2003b).

2 Where is the FWS defined Critical Habitat for the silvery minnow along the Middle Rio Grande and what are the recovery goals?

The FWS (2003b) has designated critical habitat for the silvery minnow to include 212 miles (339 km) of the Rio Grande from Cochiti Dam downstream to the utility line crossing the Rio Grande, upstream of the Elephant Butte Reservoir delta. The designation also includes the tributary Jemez River from Jemez Canyon Dam to the upstream boundary of Santa Ana Pueblo; however, the designation also includes the width of the areas bounded by existing levees or, in areas without levees, 300 feet (91.4 m) of riparian zone adjacent to each side of the bank-full stage of the MRG. All Pueblo lands are excluded from the designations. In short, except for Pueblo lands, the remaining portion of the occupied range of the silvery minnow in the MRG was designated as critical habitat.

The FWS 2007 Draft Recovery Plan for the silvery minnow defines three recovery goals:

a. Prevent the extinction of the Rio Grande silvery minnow in the Middle Rio Grande of New Mexico.

b. Recover the Rio Grande silvery minnow to an extent sufficient to change its status on the List of Endangered and Threatened Wildlife from endangered to threatened (downlisting).

c. Recover the Rio Grande silvery minnow to an extent sufficient to remove it from the List of Endangered and Threatened Wildlife (delisting).

This recovery plan also defines a set of criteria under each of the three goals. Of particular note, under the first goal and its first objective:

- Document the presence of Rio Grande silvery minnow (all unmarked fish) at three quarters of all sites sampled in the Middle Rio Grande of New Mexico during October (a minimum of 20 representative sites);

<u>or</u>

- Document sub-populations of an estimated minimum 500,000 unmarked fish each (with an assumed effective population size of 500) in the Albuquerque and Isleta Reaches of the Middle Rio Grande during October, and an estimated minimum sub-population of 100,000 in the San Acacia Reach.

3 What are the general biological characteristics of the silvery minnow?

Size: The *standard length* of most silvery minnows captured in the MRG typically has ranged from about 40 to 60 mm (1.6 to 2.4 inches; Dudley et al., 2005). Collections since 2005 in the MRG have more often reported finding silvery minnows greater than 100 mm (4 inches) standard length (M. Porter, BOR, Albuquerque, NM, personal communication, 2007).

Gravid female Rio Grande Silvery Minnow, approximately 4 inches in length, Spring 2008. (Photo by Michael Hatch)

Life Span: MRG collections from the mid-1990s to the mid-2000s indicate that the majority of wild adult silvery minnows survived only about a month beyond their first spawn (i.e., at about 11 to 13 months of age) (FWS 2007). Most of the remaining minnows rarely survive more than a month beyond their second spawning season. From these reports, silvery minnows of age 2 or older typically comprised less than 10 percent of the spawning population (FWS, 2003b).

Standard length includes the distance from the tip of the snout on a fish to the base of the caudal fin (i.e., the large swimming tail of a fish).

In contrast, historic collections from the 1800s and laboratory cultures indicate that silvery minnows can live up to about 5 years of age (Cowley et al., 2006; K. Buhl, USGS, personal communication, 2006). Since about 2005, the sample collections have found increasing percentages of larger and presumably older silvery minnows. This indicates that more silvery minnows may be living for up to at least 4 years in the MRG (FWS, 2006; M. Porter, BOR, personal communication, 2007).

Recruitment: Peak spawning rate and the highest potential for recruitment of young silvery minnow into the population are correlated with the spring peak snowmelt runoff flows. In recent years, numbers of collected eggs (and presumably spawning) has been reported to peak from mid to late May (Platania and Dudley, 2002a, 2002b; BOR, 2003). Hydrologic records indicate that peak snowmelt flood events occur between April and June, depending on the year, thus influencing the potential spring spawning period.

Spawning can continue with lower numbers of eggs released for 4 to 6 weeks following the spring flows spawning peak (Platania and Dudley, 2002a, 2002b). The minimum volume of flow needed to initiate spawning is unknown, but significant spawns have been observed with flows as low as 500 to 600 cfs. Additionally, minor spawns have been observed with no apparent increase in flow (Platania and Dudley, 2002a, 2002b). The BOR has stated that snowmelt runoff managed to provide flows of 2,500 cfs to 3,000 cfs over a period of approximately 5 days may represent the lower threshold for producing appreciable silvery minnow recruitment (M. Porter, BOR, personal communication, 2007). Data published by Dudley and Platania (2007c) indicate that silvery minnow recruitment is significantly improved at sampling sites along the MRG when peak flows at Albuquerque exceed approximately 4,000 cfs and discharge above 3,000 cfs is sustained for more than 30 days.

Lesser spawns can be associated with smaller flood events, including monsoonal peak flows, but these flows do not necessarily trigger either significant egg production or significant recruitment of young silvery minnows into the population. For example, the relatively high monsoonal runoff flows during the summer of 2006 did not result in significant silvery minnow recruitment in the Middle Rio Grande (Dudley and Platania, 2007a).

Egg Characteristics: Spawning silvery minnow broadcast eggs (i.e., pelagic release) that are slightly negatively buoyant and are kept in suspension by minor flow currents, including those generated by winds (Dudley and Platania, 1999a). These eggs may be released within inundated floodplains, backwaters, and along vegetated shorelines, when such habitats are available, or the eggs may be released in water columns in the channel. Floating eggs laid or washed into the floodplains results in the minimal downstream displacement of eggs and developing larvae (BOR and USACE, 2003).

Food Habits and Feeding: The placement of the silvery minnow mouth on the lower and front portion of their head indicates that silvery minnows generally feed along bottom and perhaps other substrates (Sublette et al., 1990). Based on information from closely related species, diets of larval and adult silvery minnows are thought to include diatoms, algae, larval insect skins, and plant material contained in bottom sediments, although algae may be more important for the early life stages (Sublette et al., 1990; Cowley et al., 2006; Shirey, 2004; K. Buhl, USGS, personal communication, 2006).

4 How might changes in biological characteristics of silvery minnows be linked to habitat changes?

Previous assessments have indicated that general habitat conditions for silvery minnows have been in decline due to increasingly channelized conditions and disconnected floodplains along much of the MRG, at least since closure of Jemez Reservoir in 1954 and Cochiti Reservoir in 1975 (Massong et al., 2006; Tashjian and Massong, 2006). These changes may have led to the shortened life spans and smaller silvery minnow sizes in samples from the mid 1990s through about 2004. While absolute data are lacking, the apparent trend of improvement in biological conditions for silvery minnows noted in the above section may be linked to recent improvements in their habitat conditions. It appears now that more silvery minnows live beyond their first and second spawning, and more often to their third or fourth spawning. Such lifecycle improvements would be expected to accompany improved conditions of floodplain connectivity and channel diversity that would provide spawning and post-spawning refuge habitat for silvery minnows. Such changes would also provide improved feeding habitat and food resources for adult minnows in the days and weeks following spawning. Beneficial habitat conditions also have accompanied the recent cycle of drought and high spring flows, which have been supplemented by recent habitat improvement efforts supported by the Program and others.

5 What are the general habitat characteristics of the silvery minnow?

The FWS (2003a) defined silvery minnow habitat as "…shallow waters with a sandy and silty substrate that is generally associated with a meandering river that includes sidebars, oxbows, and backwaters." Much of the understanding of habitat requirements for the silvery minnow, however, is limited and derived largely from field observations under contemporary conditions and comparisons to related species.

The 2003 BA for MRG water operations cautions "…that all investigations of life history and ecology of the silvery minnow have taken place within the species' contemporary range, an environment that has been dramatically altered over historic times. Observations from such investigations can easily lead to a misunderstanding of the species' habitat preferences and needs" (BOR and USACE, 2003, p. 14).

In fact, habitat use patterns, commonly interpreted as being habitat preference requirements for the silvery minnow, may be more of a reflection of survey site conditions than habitat "preferences". For example, Koster (1957) described the habitat of the silvery minnow as, "pools and backwaters of the main rivers and creeks" where they schooled and fed "largely on bottom mud and algae." Sublette et al. (1990) reported that while the silvery minnow tolerates "a wide variety of habitats, it prefers large streams with slow to moderate current over a mud, sand or gravel bottom." Bestgen and Platania (1991) observed that most silvery minnows "were captured in low velocity habitats that had sand substrate." Platania (1991) reported that "large collections" of silvery minnows occurred at sites with "a shifting sand-silt substrate." Watts et al. (2002) reported that silvery minnow more commonly used shoreline habitats with debris than open-water habitats lacking debris. Because these studies were all conducted in an altered river system, it is unknown whether the studies represent optimum habitat requirements for the silvery minnow.

Field collections of juvenile and adult silvery minnows indicate both appear to inhabit primarily low velocity, often shallow habitats (Dudley and Platania, 1997). Such habitats would be expected to reduce energy demands otherwise required for swimming in higher velocity areas. Generally low velocity areas are where sand, silt, and clay substrates tend to accumulate, and also where algae and other food items for silvery minnow of all ages tend to accumulate. Remshardt and Tashjian (2004) reported that collections of silvery minnows were least often associated with run habitat and most often associated with lateral embayments, backwater pools, isolated pools, and other low velocity habitat that included, for example, woody debris, shoreline, and other velocity breaks.

As their mobility increases with age, older silvery minnows appear to venture into higher velocity waters. Laboratory studies of the swimming abilities of silvery minnows indicate that they use low velocity zones (for example, behind large cobbles or other structures) as resting areas or refuge to escape stronger surrounding currents (Bestgen et al., 2003). Observations made at the Albuquerque Biological Park suggest that the silvery minnows commonly concentrate in low-velocity pool habitats (Tetra Tech, 2004a).

The following ranges of favorable habitat conditions for the silvery minnow were defined through a roundtable of fish and wildlife professions familiar with the biology of silvery minnows in the MRG (Exhibit 3-1). These habitat conditions are intended to provide consistency with the Draft Rio Grande Silvery Minnow Recovery Plan (2007), Dudley and Platania (1997), and Bestgen et al. (2003). These attributes are being used, at present, in the draft in-stream incremental flow model being developed to assess how flow changes can affect silvery minnow habitat conditions in the reach upstream of San Acacia Diversion Dam (M. Porter, USACE, 2008).

Exhibit 3-1

Rio Grande Silvery Minnow Habitat Criteria for Instream Habitat Study

Environmental Attribute	Adults		Young of Year	
	Minimum	Maximum	Minimum	Maximum
Depth (cm)	5	50	5	50
Velocity(cm/s)	1	40	1	30
Debris (buffer width, cm)	0	50	0	25

6 Where do silvery minnow feed?

As noted above, algae, diatoms, and small invertebrates tend to be important food items for silvery minnows. Algae and diatom growths, as well as the small invertebrate communities they attract, tend to grow best in association with relatively stable substrates for attachment. Good examples of stable substrates would be gravel, cobble, and woody debris. These substrates also can provide locations for attachment of drifting leaf litter, another important attractor of food for silvery minnows.

During times of flood, organic materials and small invertebrates on the inundated floodplains also would likely have served as important food for silvery minnows. Woody debris and patches of gravel may have been prevalent in the historic MRG, but considerable quantities of wood have been removed during channel maintenance activities, and gravel patches have become covered with fine sediment (Tetra Tech, 2004a). Floodplain disconnection from flood inundation has also reduced the amount of woody debris and other organic debris being contributed to the river and has diminished potential for overbank feeding habitats. Together, these alterations likely have reduced the overall potential feeding areas and food availability for silvery minnows.

In the contemporary channel of the Middle Rio Grande, where the potential for floodplain connectivity and other off-channel habitats are limited, most feeding by silvery minnows would likely be limited to open-channel areas. During low flows (i.e., less than about 15 cm/sec or 0.5 feet/sec; SEPM 1984, M. Harvey, MEI, personal communication), the silvery minnow feeding habitats would be associated to a large extent with metastable sand-bed structures (e.g., stalled bedforms such as ripple troughs and dune faces). During periods with higher flows that mobilize the channel sand bed (i.e., greater than about 15 cm/sec or 0.5 feet/sec, M. Harvey, MEI, personal communication), the primary feeding sites for silvery minnows will likely become limited to shallow quiet water areas along shorelines and side channels, and backwater eddies. These lower flow feeding sites would allow detritus to accumulate and attached algal and small invertebrate communities to develop.

The adequacy of such areas and overall food resources for the silvery minnow in the MRG has not been documented for annual, seasonal, or spatial relationships. Nevertheless, restoration efforts that increase the number and distribution of areas of suitable feeding habitat should be a priority to benefit potentials for increasing food production, feeding areas, and silvery minnow recovery.

7 What are the primary constituent elements of quality habitat for silvery minnows along the MRG?

The overall understanding of required habitat relationships for silvery minnow is limited and derived largely on field observations under contemporary conditions and comparisons to related species.

The critical habitat designation proposed four primary elements of critical habitat for the silvery minnow (FWS, 2003b):

1. A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats, including backwaters, shallow side channels, pools, eddies, and runs.
2. The presence of eddies created by debris piles, pools, or backwater, or other refuge habitat with unimpounded stretches of flowing water of sufficient length to provide a variation of habitats with a wide range of depth and velocities.

3. Substrate of predominately sand and silt.
4. Water of sufficient quality to maintain natural daily and seasonally variable water temperatures in the approximate range of greater than 1 degree C (35 degrees F) and less than 30 degrees C (85 degrees F) and reduces degraded conditions (e.g., “decreased dissolved oxygen, increased pH”).

8 What are the principal reasons for the endangered status of the silvery minnows, and what habitat restoration approaches are emphasized by the Recovery Plan?

Declines in the silvery minnow population are broadly attributed to “…dewatering, channelization, and regulation of river flow to provide water for irrigation; diminished water quality caused by municipal, industrial, and agricultural discharges; and competition with or predation by non-native species” (FWS, 1994). The San Acacia Reach habitat assessment (Parametrix, 2008) pointed out that the relative contributions by each of these factors to the overall decline of the silvery minnow are difficult to gauge. While various factors may influence minnow population numbers, such as competition, predation, and water quality, the following list highlights only the habitat restoration approaches emphasized by the Silvery Minnow Recovery Plan (FWS, 2007). In particular, that plan highlights the Program’s MRG Habitat Restoration Plan (Tetra Tech, 2004a), which characterized habitat restoration needs for the silvery minnow. The MRG restoration plan concludes that the conservation and recovery of wild populations of silvery minnows in the Middle Rio Grande will require addressing, at minimum, six limiting factors currently affecting this species:

1. Sustained flows in key reaches to promote sufficient populations of wild silvery minnows.
2. Spring flow peak in mid- to late-May to stimulate spawning.
3. Establishment of channel conditions that retard downstream displacement of eggs and larvae.

4. Establishment of a sustainable population of silvery minnows in the Albuquerque Reach.
5. Establishment of suitable feeding and cover habitat for juveniles and adults.
6. Remediation of longitudinal discontinuity associated with irrigation diversion structures.

9 How are silvery minnow population numbers estimated, and what does the data indicate about their distribution along the Middle Rio Grande?

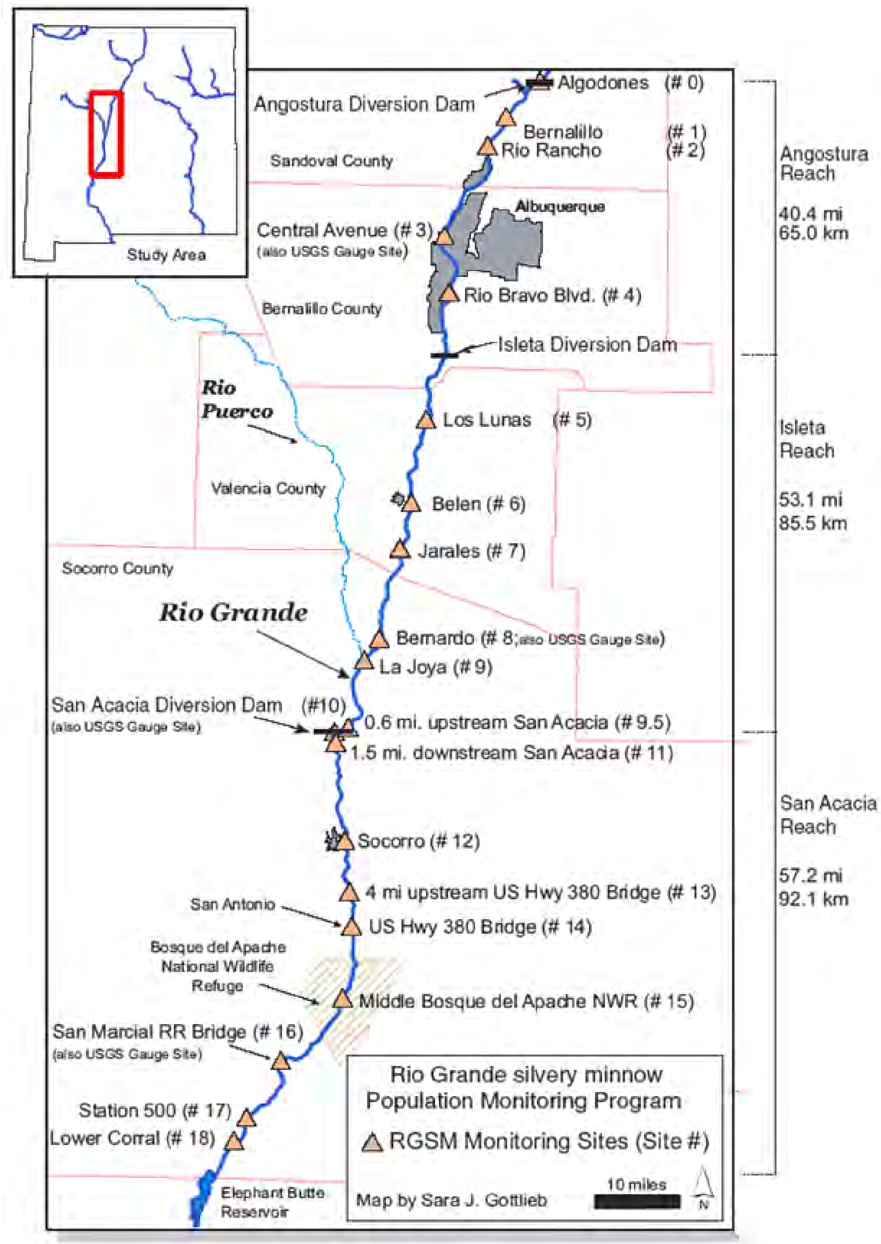
Estimating the number of small bodied fish in large rivers with limited visibility is very challenging, and can be labor intensive and costly. The sampling methods that have been applied to estimate silvery minnow population numbers in the MRG have not successfully defined silvery minnow population numbers. Instead, most of the sampling effort since the mid-1990s has been conducted to assess only silvery minnow distribution and relative abundance. Changes in the sampling results obtained using these methods have been extensively used to characterize numbers of silvery minnows in the sampled reaches of the MRG. In effect, this sampling has been used as an index to silvery minnow population changes in the MRG.

Silvery minnow sampling has been conducted since 1993 along the Middle Rio Grande primarily at a series of 20 sampling locations (Exhibit 3-2) from the Angostura Diversion Dam to south of San Marcial (Dudley et al., 2007). From 1993 to 2004, reported sampling results indicated that the majority of the silvery minnow collected commonly occurred in the San Acacia Reach. Collections from the Albuquerque and Isleta Reaches tended to be relatively minor. As such, it has been often suggested that the habitat conditions for silvery minnows in the San Acacia Reach was superior to that occurring in the other reaches (FWS, 2003a).

From 1994 to 2004, reported sampling results indicated that the majority of the silvery minnow population commonly occurred in the San Acacia Reach. Populations in the Angostura and Isleta Reaches tended to be relatively minor (FWS, 2003a, Dudley et al., 2004a).

Exhibit 3-2

Map of the Study Area and Sampling Localities (numbered) for the 2006 Rio Grande Silvery Minnow Monitoring Program (from Dudley and Platania, 2007c)



While habitat conditions in the San Acacia Reach may have been better than upstream conditions, this condition also existed at least in part due to channelized conditions in the Albuquerque (a.k.a. Angostura, see Exhibit 3-2) and Isleta Reaches that tended to promote the downstream flushing of eggs, larvae, juveniles, and adults during high flow periods. After flushed downstream through the MRG irrigation diversions, these structures blocked the displaced fish from returning upstream. This trend would deplete the population of silvery minnows in upstream reaches and contribute to the disproportionate distribution of silvery minnows observed in the San Acacia Reach.

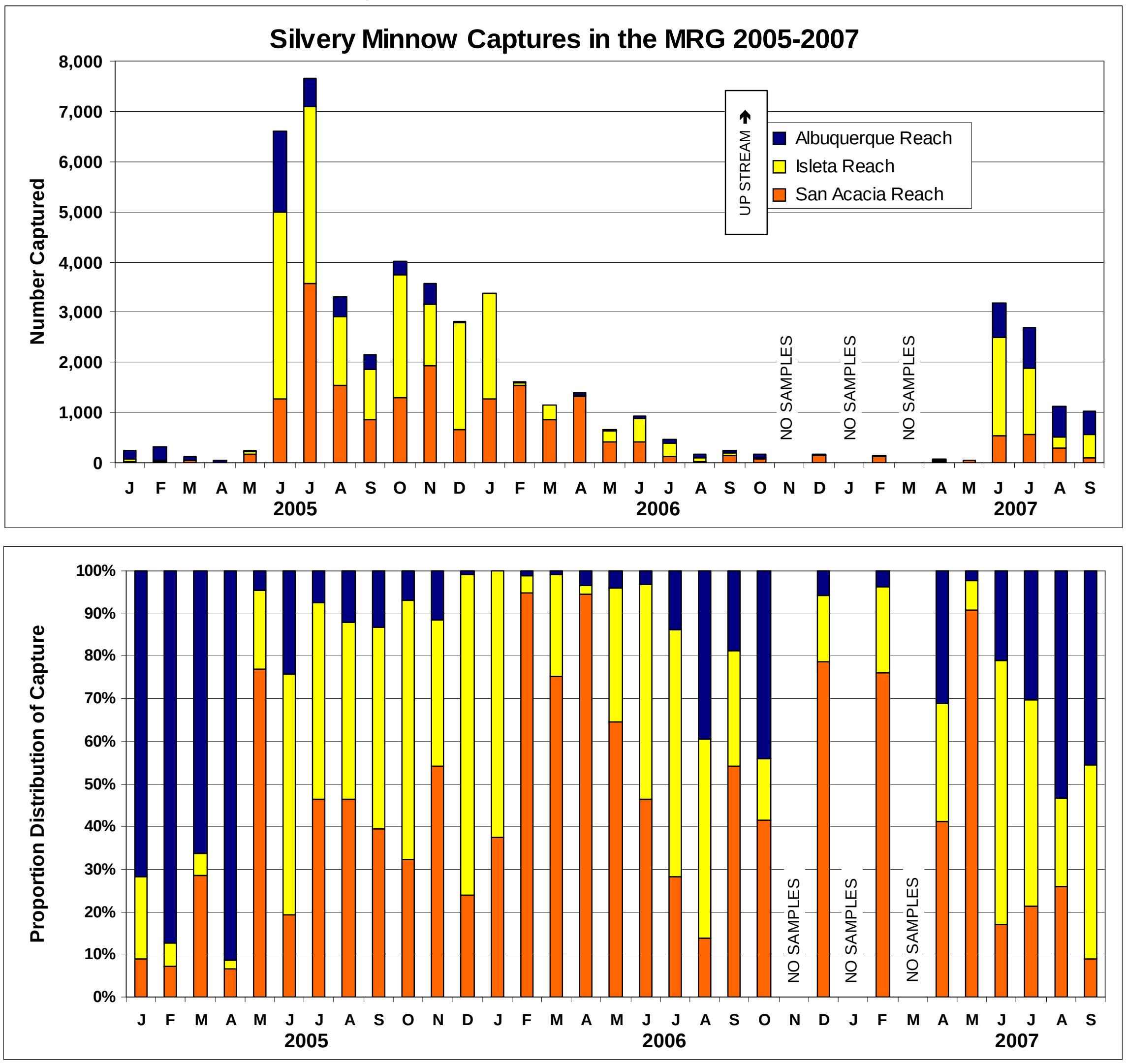
Recent monitoring data indicate that the silvery minnow distribution trend has changed in recent years (Dudley et al., 2006; Dudley and Platania, 2007a). For example, during the first four months of 2005, most silvery minnows were collected in the Albuquerque Reach (Exhibit 3-3). This altered distribution pattern may be a consequence of the decreased populations caused by drought and channel drying in the Isleta and San Acacia Reaches, coupled with stocking and transplanting of some of these populations into the Albuquerque Reach to try to minimize adverse effects caused by drying events in the downstream reaches. The relatively high spring flows in May 2005 appeared to displace a high proportion of the silvery minnow numbers downstream into the Isleta and San Acacia Reaches.

The spring flows of greater than 6,000 cfs downstream of Cochiti Reservoir in May 2005 produced a strong spawn, with a subsequent high recruitment of silvery minnows. A significant increase in the number of silvery minnows in the MRG began to appear in the June and July 2005 sample collections and proportions of the silvery minnow collections again shifted downstream to the Isleta and San Acacia Reaches (Dudley et al., 2006). Additionally, the relative proportion of silvery minnows collected in the Albuquerque Reach was greatly reduced from December 2005 through January 2007 compared to the rest of the Middle Rio Grande.

Silvery minnow sampling in the Isleta Reach found very low numbers of silvery minnows during the first 5 months of 2005 (Dudley et al., 2006; Dudley and Platania, 2007a, 2007b). Collected numbers in this reach then increased dramatically to peak in June 2005 (Exhibit 3-2). Fluctuating but relatively high sample collection numbers continued through January 2006. Relatively low numbers of silvery minnows were collected in the Isleta Reach during the balance of 2006 and into the late spring to early summer of 2007. The collections indicated strong recruitment to the population in the June and July samples of 2007, with numbers tapering off in the later samples from the reach, likely related to channel drying (Dudley et al., 2006; Dudley and Platania, 2007a, 2007b). In total, the data patterns shown in Exhibit 3-3 indicate the greatest proportions of silvery minnows in recent years were most often collected in the Isleta Reach.

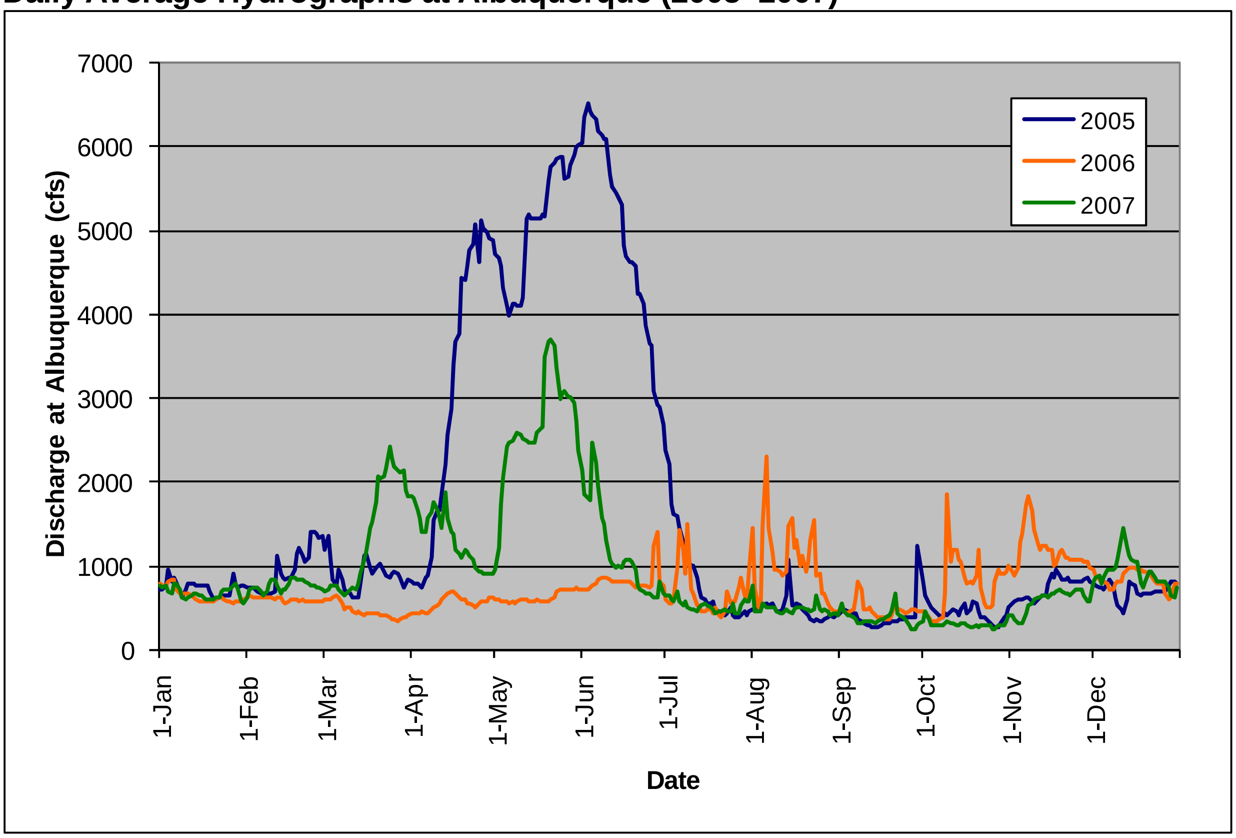
Exhibit 3-3

Silvery Minnow Sampling Summary



The below average snow-melt runoff produced a relatively minor recruitment of silvery minnows in the MRG during the spring of 2006 (Dudley and Platania, 2007b). A series of strong monsoonal storms occurred during the summer of 2006 that appeared to result in limited spawning activity and little recruitment of young silvery minnows (Exhibit 3-4). Additionally, late spring and early summer drought conditions, combined with channel drying in portions of the Isleta and San Acacia Reaches during 2006 appeared to reduce the total number of silvery minnows in these reaches. These factors tended to increase the relative proportion of the silvery minnow population collected in the Albuquerque Reach.

Exhibit 3-4
Daily Average Hydrographs at Albuquerque (2005–2007)



10 Where are silvery minnows found in the Isleta project reach?

Population Monitoring Sites

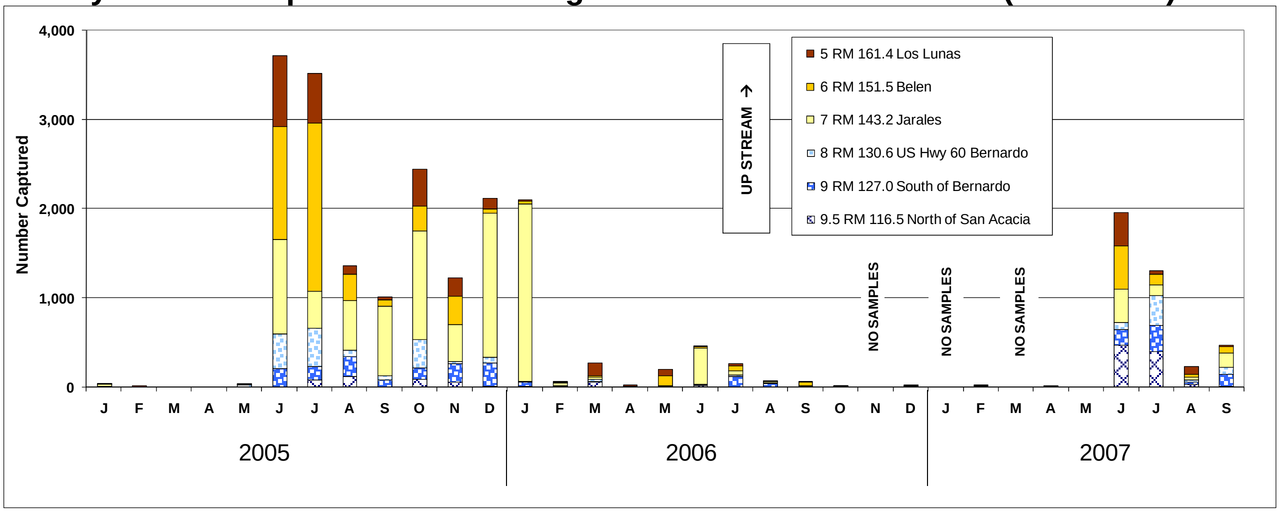
There are six long-term silvery minnow population monitoring sites in the Isleta Reach (Exhibit 3-2; Dudley and Platania, 2007b). Two sampling locations (Site No. 5 at RM 161.4 and Site No. 6 at RM 151.5) are within the Los Lunas Sub-reach. One sampling location (Site No.7 at RM 143.2) is within the Belen Sub-reach. The three remaining sampling sites (Site No. 8 at RM 130.6, Site No. 9 at RM 127.0 and Site No. 9.5 at RM 116.5) are all within the Sevilleta Sub-reach.

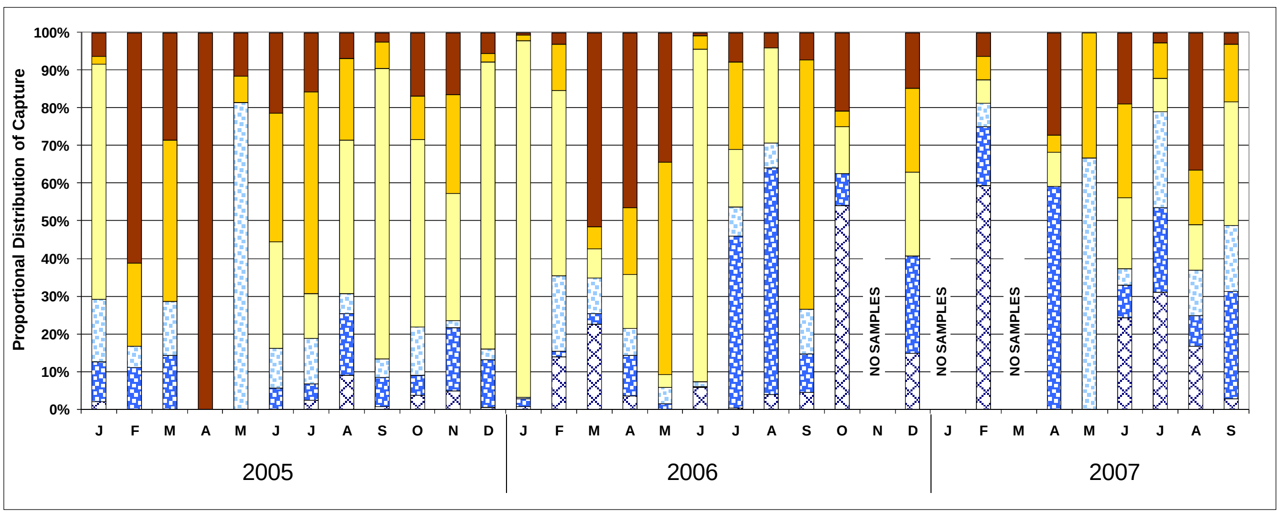
Population monitoring data between January 2005 and September 2007 (Exhibit 3-5) show that the greatest number and proportion of silvery minnows collected in 2005 were in the Los Lunas and Belen Sub-reaches. The overall silvery minnow catch rates plummeted across the Isleta Reach between January and February 2006 and did not recover until June of 2007. This relatively extreme drop over such a short time period cannot be attributed to channel drying (there is steady flow through the reach during the non-irrigation season) and cannot be attributed to downstream transport via flushing flows (there was no major flood pulse in January/February 2006). A possible explanation might be that the bulk of the silvery minnow population were schooled up in localized winter refuge habitats, for example, possibly congregating in favorable low velocity pools or habitats outside of the limited number (6) of sampling locations in this 48-mile reach.

For an unknown reason, there were only limited silvery minnows captured at Isleta Reach monitoring sites in early 2006. Their numbers, albeit small, were proportionately greater in the upstream sampling locations between January and June 2006. Their numbers then shifted later in the mid-summer and fall samplings to the downstream sampling sites. In 2007, the catch rates across sites appear more variable, but the downstream sampling locations (Sevilleta Sub-reach) usually comprised at least 50 percent of the overall reach catch rate.

Exhibit 3-5

Silvery Minnow Population Monitoring Data from the Isleta Reach (2005-2007)





2005 Rescue Locations

Segments of the river channel within the Isleta Reach have a strong propensity to go dry, particularly in a 10-mile segment within the Los Lunas Sub-reach between RM 161 downstream to RM 153 (Chapter 2). Other smaller segments, however, also can go dry. River drying in this reach results from the combined impacts of poor snowmelt runoff, agricultural diversions, and seepage losses. Also, as discussed above, the 2003 BiOp (FWS, 2003a) allows drying of this reach during climatically dry years.

The potential risk and impact to silvery minnows due to channel drying are readily apparent in the report of silvery minnow rescue and salvage during 2005 (FWS, 2006). In total, an estimated 626,444 silvery minnows were rescued from the dewatered portions of the Isleta and San Acacia Reaches during the 2005 irrigation season. Of these, 67 percent were collected from floodplains and 33 percent came from isolated wetted portions of the river channel.

Rescuing silvery minnows from a drying floodplain.
(Photo Credit: Michael Hatch)

Of the silvery minnows rescued during the 2005 irrigation season, a slight majority (an estimated 370,416; 59 percent of the estimated total number of silvery minnows rescued) were captured in the Isleta Reach (FWS, 2006). Excluding undisclosed captures along the Isleta Pueblo, the 2005 Isleta Reach rescue locations included:

- June and July rescues of approximately 57,750 silvery minnows along the east floodplain south of the Alejandro Wasteway (near RM 166).
- July rescues of approximately 33,500 silvery minnows along the east floodplain up to 2 miles north of the Los Lunas NM 49 bridge (approximately RM 161.5 to 163.5).
- July, August, and September rescues of more than 44,000 silvery minnows from the channel extending 1.5 miles north of the Peralta Wasteway (approximately RM 152.5 to 154).
- August rescues of about 24,400 silvery minnows from about 1.5 miles of channel upstream and downstream of the Mid-Valley Airpark in Los Lunas (approximately RM 157 to 158.5).

11 Why is silvery minnow habitat restoration in the Isleta Reach important?

The Isleta Reach accumulates silvery minnows that are flushed from the Albuquerque Reach during high flow events. These fish include those produced by natural spawning activities, stocked from silvery minnow culture facilities, and transplanted from downstream rescue efforts as the channel dries under the conditions defined in the 2003 BiOp (rescue efforts result in silvery minnows being transported upstream to both the Isleta and Albuquerque Reaches). Recent research found that fish assemblages in the Isleta Reach during the irrigation season resulted mostly from downstream movement of fish from the Albuquerque Reach (Cowley et al., 2007). In addition, recent sampling efforts, as described above and shown in Exhibit 3-4, frequently capture the greatest proportions of silvery minnows in the Isleta Reach, relative to either the Albuquerque or San Acacia Reaches. Isleta is also in the middle of the three major MRG sub-reaches, with each sub-reach having been assigned co equal recovery goals for *downlisting* or *delisting* under the silvery minnow Recovery Plan (FWS, 2007).

The Isleta Reach has been assigned silvery minnow restoration goals identical to those assigned to the other two major reaches under the FWS Recovery Plan for downlisting or delisting. For downlisting: "Document sub-populations of an estimated minimum 500,000 unmarked fish (with an assumed effective population size of 500) in each of three reaches of the Middle Rio Grande (Angostura, Isleta, San Acacia) in October, for five consecutive years." For delisting, it requires those numeric goals for 10 years. (An array of additional objectives and criteria also exist.)

Overall, the patterns for silvery minnow distribution seen in sampling collections from 2005 to 2007 and the rescue efforts of 2005 reflect the critical need to maintain base flows in the river channel, or, at minimum, a reliable watered refuge habitat during periods of drought in this reach. These patterns also point to needs for providing broad-scale improvements to in-channel habitat diversity in the Isleta Reach. Gradually extending the descending limb of the hydrograph following spring peak flows can also be important for improving the ability of silvery minnows to return to the channel as floodwaters recede from inundated floodplain areas.

Drying channel.
(Photo Credit: Michael Hatch)

The shifting patterns for silvery minnow distribution exemplified in sampling collections from 2005 to 2007 points to the importance of the continued presence of channel flows and watered habitat in this reach during periods of drought, which is a critical habitat component for silvery minnows. In fact, a recent population viability workshop for the silvery minnow pointed to drying of the Isleta Reach (and San Acacia Reach) as likely to be the most important single factor in determining the persistence of silvery minnows in the MRG (Conservation Breeding Specialist Group, 2008). As discussed in Chapter 4, however, the Isleta Reach holds unique restoration opportunities in the MRG to develop restoration projects with significant potential to mitigate impacts to silvery minnows from reach drying. Restoration projects could develop wetted refuge habitat in such times using the numerous drains and wasteways in the Isleta Reach that return irrigation water to the river.

Southwestern Willow Flycatcher

Southwestern willow flycatcher. (Photo Credit: http://sbsc.wr.usgs.gov/cprs/research/projects/swwf/cprsmain.asp)

The southwestern willow flycatcher (flycatcher, *Empidonax traillii extimus*) is the second of two special status animal species of particular emphasis to the Program. The flycatcher is listed under both Federal and State of New Mexico regulations as endangered and is viewed as an important indicator of the health of southwestern riparian ecosystems.

The chapter sections provided below aim to provide relevant information needed to guide flycatcher habitat restoration concepts in the Isleta Reach. The biological characteristics and the known or suspected habitat relationships of the flycatcher were discussed in detail in the reach-specific habitat assessment for the San Acacia Reach of the MRG (Parametrix, 2008). The following sections highlight and update key points from that discussion, while focusing primarily on presenting information of specific importance to the Isleta Reach.

12 What are the general biological characteristics of the flycatcher?

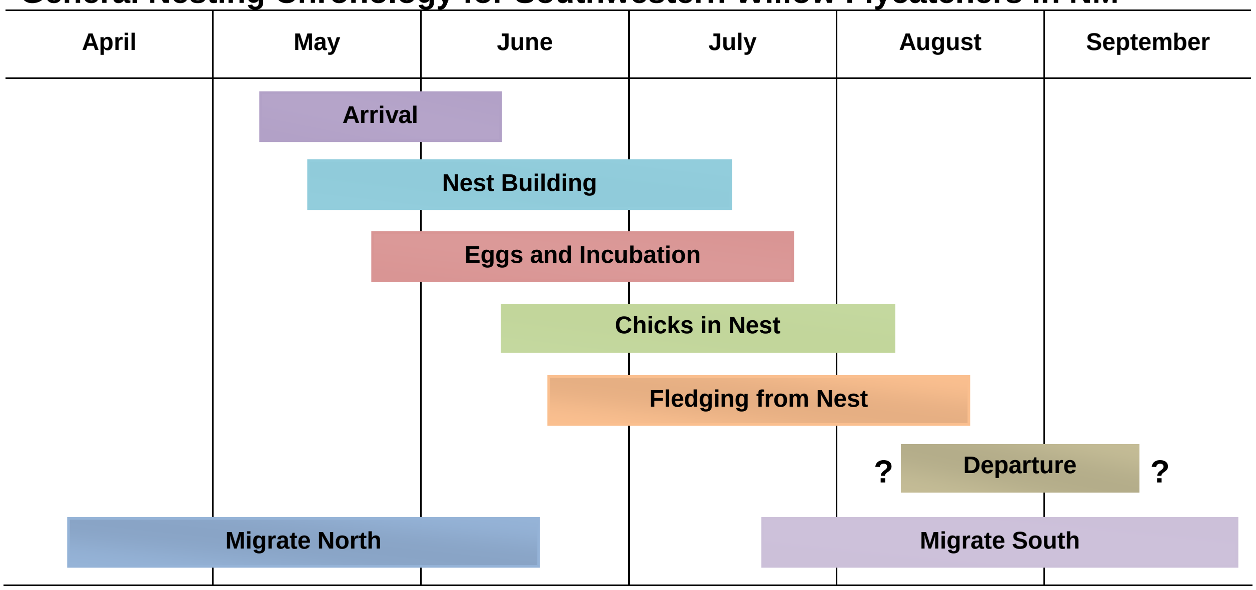
The flycatcher is a small passerine (perching) bird about 15 cm (6 inches) long and has a life span of generally 1 to 3 years, with some individuals living 4 to 7 years (Langridge and Sogge, 1997; Paxton et al., 1997; Netter et al., 1998).

> The southwestern willow flycatchers are distinguished from the other ten North American flycatcher species by several characteristics, including morphology, song type, habitat use, structure and placement of nests, ecological separation, genetic distinctness, and breeding range, which is confined to the southwestern United States.

Flycatchers, which winter in Neotropical areas of southern Mexico and Central America, begin to arrive on New Mexico breeding sites in early May (Exhibit 3-6). These birds tend to return to the same general breeding area each year, but not necessarily to the same nesting site or territory (FWS, 2002). Some individuals, however, will migrate to new breeding areas, even in entirely different watersheds (FWS, 2002). In New Mexico, flycatchers build nests and lay eggs in late May and early June, with young being fledged by early July;

however, these characteristics are locally affected by altitude, latitude, and re-nesting attempts. Second broods or nesting attempts can occur into August. The adults and juveniles begin their southern migration in July through August, 3 to 4 weeks after completion of nesting (Exhibit 3-6).

Exhibit 3-6
General Nesting Chronology for Southwestern Willow Flycatchers in NM[a]



[a] *Adapted from BOR and USACE, 2003; Sogge, 2000; and FWS, 2002.*

13 What are the food and feeding habits for the flycatcher?

Understanding the food habits and prey base of flycatchers is still evolving (Drost et al., 2001; DeLay et al., 2002). As a group, flycatcher species catch insects on the wing and glean prey from foliage and the ground. Their food includes spiders, flying insects, and ground- and vegetation-dwelling insects (Beal, 1912; McCabe, 1991). Dietary data from study sites in New Mexico, Arizona, and California indicate that the most common invertebrates in feces of southwestern willow flycatcher included bees, wasps, leafhoppers, beetles, lady bugs, dragonflies, and damselflies (Drost et al., 2001; DeLay et al., 2002). These insect groups tend to hover or crawl on branches, behaviors that would make them “easy prey” for flycatchers. Of note, the majority of these insects have only terrestrial stages. Typically, only a minor component of the flycatcher diet is composed of invertebrates with obligate aquatic stages, such as dragonflies and damselflies (DeLay et al., 1999, 2002; Drost et al., 2001).

Flycatchers also occasionally consume small fruits, such as elderberries (*Sambucus canadensis*) or blackberries (*Rubus* species), although this is not considered an important food source during breeding season (McCabe, 1991). Drost et al. (2001) suggests that since flycatchers appear to be dietary generalists, they are unlikely to encounter food shortages. In contrast, DeLay et al. (2002) concluded that flycatchers are selective and could be susceptible to stochastic or deterministic declines in their insect food base. Owen and Sogge (2002) studied the physiological conditions of the flycatcher in native- and exotic-dominated stands and found that invertebrate communities associated with some saltcedar-dominated and mixed native-saltcedar vegetation communities "may provide better energetic/dietary conditions than native habitat". Whether these results can be extrapolated or applied to the MRG or other flycatcher breeding areas requires additional investigation.

14 What is the present status and distribution of the flycatcher?

As well as being listed as *endangered* in Federal and State of New Mexico regulations, the flycatcher is also listed as *endangered* by the states of Colorado, California, Texas, and Utah. The State of Arizona includes it on its draft list of *Wildlife of Special Concern* and the State of Nevada considers this bird to be a *Species of Conservation Priority*.

In total, present day nesting habitat for this species ranges from west Texas through New Mexico and southern Colorado; west through Arizona, southern Utah, and Nevada; and into southern California (Moore and Ahlers, 2006b). The total range over which the flycatcher habitat occurs today is generally similar to its historical range, but the quantity and quality of its breeding habitat and its population numbers have declined. The Rio

Grande from the headwaters in Colorado to the Pecos River confluence in Texas supports greater than 10 percent of the range-wide total for identified flycatcher territories, with essentially all of those territories now confined to the MRG (FWS, 2002; Moore and Ahlers, 2006b). Thus, the MRG ecosystem is important to maintaining the viability of the overall flycatcher population.

15 What are the general characteristics of the nesting habitat for flycatchers?

Both native and non-native woody riparian species provide nesting habitat for flycatchers (FWS, 2002):

- Thickets of trees and shrubs used for flycatcher nesting range in height from 6 to 98 feet.
- Nest sites typically have dense foliage from the ground level up to approximately 13 feet above ground, although dense foliage may exist only at the shrub level or as a low dense canopy.
- Nest sites typically have a dense canopy, but nests may be placed in a tree at the edge of a habitat patch, with sparse canopy overhead.
- Average patch size used as the breeding territory by a single pair of flycatchers is 2.7 ± 0.2 acre of dense, riparian vegetation.
- Average total vegetation patch size, with one or more breeding flycatchers, averages 21.2 acres, with the majority of sites toward the smaller end—the median patch size is 4.4 acres.
- Mean patch size of breeding sites supporting 10 or more flycatcher territories is 62.2 acres.
- Flycatchers nest in patches as small as 0.25 acre along the Rio Grande and as large as 175 acres in the upper Gila River in New Mexico (Cooper, 1997, as cited in FWS, 2002).

Nest sites typically have dense foliage from the ground level up to approximately 13 feet above ground, although dense foliage may exist only at the shrub level or as a low dense canopy.

Across the breeding range for flycatchers, nesting success rates appear comparable whether flycatchers nest in native vegetation or saltcedar-dominated habitats.

- Approximately half of the flycatcher nesting territories documented throughout its range in 2001 consisted of greater than 90 percent native plants (Sogge et al., 2003), with approximately 90 percent of these territories being in habitats of willow (*Salix* spp.), saltcedar (*Tamarix* spp.), or boxelder (*Acer negundo*) as the dominant tree species.
- Across its breeding range, nesting success rates have been reported to be comparable for flycatchers nesting in either native vegetation or saltcedar-dominated habitats (Sferra et al., 2000).
- Occupied sites usually consist of dense vegetation in the patch interior, or an aggregate of dense patches interspersed with openings, with this dense vegetation occurring most often within the first 10 to 13 feet aboveground.
- In almost all cases, slow-moving or still surface water and/or saturated soil are present at or near breeding sites during wet or non-drought years.

In almost all cases, slow-moving or still surface water and/or saturated soil are present at or near breeding sites during wet or non-drought years.

Flycatchers generally place their nests within small-diameter stems and twigs, typically in upward-pronged, multi-twig "cup" structures (McCabe, 1991). This type of twig structure is readily found among most young willows, shrubs, and trees. However, as some willow species mature and grow in height, the prevalence of this twig structure and the suitability of these willows for flycatcher nesting can decline over time. In contrast, the twig structure of saltcedar changes very little over time, such that the small diameter stems that provide suitable nest locations tend to persist in maturing saltcedar (M.K. Sogge, USGS, personal communication, 2007).

A flycatcher nest in Goodding's willow. (Photo Credit: Darrell Ahlers)

16 What are the characteristics of the habitat used by migrating flycatchers?

The riparian woodlands along the Middle Rio Grande appear to be important stopover habitats for migrating flycatchers to feed along the Rio Grande migration corridor. The most common native vegetation used as stopover habitat by migrating flycatchers is coyote willow (*Salix exigua*). As such, coyote willow habitats should be actively monitored, maintained, preserved, and restored where necessary to help protect endangered flycatchers (Yong and Finch, 1997).

Southwestern willow flycatcher breeding habitat along the Rio Grande, near San Marcial, NM.
(Photo Credit: http://sbsc.wr.usgs.gov/cprs/research/projects/swwf/sanmarc.asp)

17 Where is designated critical habitat for flycatchers along the Middle Rio Grande and what are the recovery goals?

The Isleta Reach falls within the Middle Rio Grande Recovery Unit, which extends along the Rio Grande from Otowi Gage to Elephant Butte Dam (FWS, 2002). In October 2005, the FWS designated critical habitat for flycatchers along three separate segments of the MRG Recovery Unit. The reaches extend from the south boundary of the Pueblo of Isleta downstream 44.2 miles to the north boundary of Sevilleta; from the south boundary of Sevilleta downstream 27.3 miles to the north boundary of Bosque del Apache; and from the south boundary of Bosque del Apache downstream 12.5 miles to the overhead power line near Milligan Gulch. The designation excludes areas within the active pool of Elephant Butte Reservoir, Rio Grande State Park, the Pueblo of Isleta, and Sevilleta and Bosque del Apache NWRs, due to ongoing efforts with each of these areas to manage habitat to benefit flycatchers, as well as due to additional regulatory considerations (FWS, 2005).

The numbers of flycatcher nesting territories within the MRG Recovery Unit have continued to exceed the goal of 100 territories established in the flycatcher recovery plan. Most of the nesting territories, however, occur in the San Acacia Reach between the power line near Mulligan Gulch and the Elephant Butte Reservoir. This downstream end of the MRG Recovery Unit has been consistently the most productive reach of the MRG for flycatchers; 84 percent (655 of 778 nests) of the nests observed within the MRG from 1995 through 2006 occurred in this area (Moore and Ahlers, 2006b). Most new nests in the MRG, especially in recent years, have been added within the Elephant Butte Reservoir delta (Moore and Ahlers, 2006b).

By comparison, there are relative few flycatcher territories in the Isleta Reach. Restoration efforts in the Isleta Reach aimed at expanding flycatcher territories are important because the existing flycatcher habitat in and around the Elephant Butte delta are vulnerable to changes in reservoir pool levels. Restoration in the Isleta Reach, therefore, may be important to ensure MRG recovery goals are achieved over the long-term.

Flycatcher Suitability Model

The BOR developed a flycatcher nesting habitat suitability model in 1998 to provide information for the Biological Assessment associated with the LFCC realignment study (R. Doster, BOR, personal communication, 2007). This habitat suitability model, which continues to be refined (D. Callahan, BOR, personal communication, 2007), was developed based on the vegetation classes developed by Hink and Ohmart (1984) but also accounted for distance to surface water.

18 What are the specific correlates of successful nesting habitat for flycatchers along the MRG?

Historical characterizations of flycatcher nesting habitat along the Rio Grande include descriptions primarily of thickets of willows (*Salix* spp.) and seepwillow (*Baccharis* spp.) with an overstory of scattered cottonwood (*Populus deltoides* var. *wizlensii*) (Phillips, 1948; Unitt, 1987). Current observations of breeding habitat used by flycatchers along the Rio Grande report nests in both native and non-native plant communities. In addition to nesting in both Goodding’s and coyote willows, flycatchers along the MRG will build nests in saltcedar and occasionally Russian olive and seep willow (Moore and Ahlers, 2003; White, 2006; Exhibit 3-7).

Exhibit 3-7

Summary of Species Used for Nest Substrate Along the MRG, 2004–2005

Vegetation Species	Percent
Goodding’s Willow	42.3
Coyote Willow	17.7
Saltcedar	34.1
Russian Olive	5.8
Seep Willow	1.2

Most breeding territories for flycatchers along the Rio Grande occur in young and mid-aged riparian vegetation dominated by dense growths of willow at least 10 feet high, or with other riparian woody species (Ahlers et al., 2002). Within these willow patches, nests have been commonly found in individual saltcedar trees, especially in older and taller willow patches, where an understory of saltcedar provides more suitable nesting sites. Ahlers et al. (2002:S-5) suggested for the MRG that flycatchers "may key-in on areas dominated by native vegetation, but often select exotic vegetation, particularly saltcedar, as their nest substrate." Breeding flycatchers have been found nesting in the saltcedar dominated patches on the Sevilleta NWR (Ahlers et al., 2002); however, recent data also indicate that Goodding's willow is also a preferred nesting substrate (White, 2006; Exhibit 3-7).

Flycatchers "…may key-in on areas dominated by native vegetation, but often select exotic vegetation, particularly saltcedar, as their nest substrate" (Ahlers et al., 2002).

Moore and Ahlers (2006b) analyzed the relationship of flycatcher nest placement and nesting success for all of the MRG and various environmental factors. Key relationships found include:

- Willow dominated the vegetated habitat surrounding 80 percent of flycatcher nests in the MRG.
- Willow was the woody species most commonly used for flycatcher nesting substrate.
- Flycatcher nesting success was nearly equal whether the nests were in native willow or non-native saltcedar nest substrate or nesting habitat.
- Most flycatcher nests (nearly 90 percent) were constructed less than 50 meters (m) from water, while relatively few (less than 10 percent) were greater than 100 m from water.
- Percent nesting success was approximately equal for nests either less than (53 percent) or greater than (56 percent) 100 m from water.
- From 2004 to 2006, the greatest proportion of flycatchers (42 percent) appeared to favor nest site locations in habitats saturated all season. Flycatcher nests were equally distributed (28 percent each) between locations either flooded all season or dry all season. Few nests (2 percent) were in habitats that were dry after being flooded or saturated early in the season.

Nesting Success

Nesting success is defined in this report as successful fledging of at least one chick from the nest of a pair of flycatchers.

- For these nests, nesting success was greatest where the territory was dry all season (86 percent success for 14 nests). Nesting success was about equal for the other three conditions of flooding and drying (52 to 53 percent for 643 nests).

19 Where do flycatchers nest in the Isleta project reach and how successful have these nests been?

Surveys by the BOR observed a total of 285 flycatchers in 2005 and 431 in 2006 along the Middle Rio Grande (Moore and Ahlers, 2006a, 2006b). Most (78 percent in 2005 and 73 percent in 2006) were classified as resident flycatchers (Moore and Ahlers, 2006a, 2006b). The largest concentration of breeding territories along the Middle Rio Grande occurs within the delta of Elephant Butte Reservoir in maturing stands of native species, especially Goodding's willow (*Salix gooddingii*) and coyote willow (*Salix exigua*), often mixed with a cottonwood (*Populus deltoides* var. *wislizenii*) overstory, mature saltcedar (*Tamarisk chinensis*), and Russian olive (*Elaeagnus angustifolia*) (Moore and Ahlers, 2006a, 2006b).

The largest concentration of breeding territories along the Middle Rio Grande occurs within the delta of Elephant Butte Reservoir in maturing stands of native species, especially Goodding's willow (*Salix gooddingii*) and coyote willow (*Salix exigua*).

The BOR actively monitors flycatcher populations in the Isleta Reach. They divide the Isleta Reach into two sub-reaches: (1) Belen Reach, from the south boundary of Isleta Pueblo downstream to the confluence of the Rio Puerco and Rio Grande; and (2) Sevilleta/La Joya Reach, from the confluence of the Rio Puerco and Rio Grande downstream to San Acacia Diversion Dam. The reach between Isleta Pueblo and the Rio Puerco includes 36 survey sites that were surveyed in 2002 and again 2004 through 2007. Survey sites between the Rio Puerco and the San Acacia Diversion Dam includes 9 sites that have been surveyed from 1999 to 2007. Currently, each site is surveyed three times during each year.

Territories versus Nesting Pairs

A territory is an area defended by a pair of flycatchers or, in some cases, a single male.

A nesting pair is a male and female flycatcher that establish a nest within a territory.

Total numbers of flycatcher nesting territories found between the south boundary of Isleta Pueblo and the Rio Puerco have remained minimal, with one territory found in 2002, zero in 2004, four in 2005, and one in 2006 (Moore and Ahlers, 2006a, 2006b). Exhibit 3-8 shows that downstream of the Rio Puerco, flycatcher numbers have increased from 4 territories and 4 nesting pairs in 1999 to 21 territories and 15 nesting pairs in 2006 (Moore and

Ahlers, 2006a, 2006b). This dropped to 14 territories and 8 pairs in 2007 (R. Doster, BOR, personal communication, 2008). No flycatchers were fledged from nests in the Belen Reach in 2006, whereas 20 fledged from nests in the Sevilleta/La Joya Reach (Moore and Ahlers, 2006a, 2006b). In 2007, again no flycatchers were fledged in the Belen Reach and only 10 from the Sevilleta/La Joya Reach, which is half the 2006 number (R. Doster, BOR, personal communication, 2008).

Exhibit 3-8

Summary of 2005–2007 Flycatcher Monitoring Results From the Isleta Reach (Moore and Ahlers, 2006a, 2006b; R. Doster, BOR, personal communication, 2008)

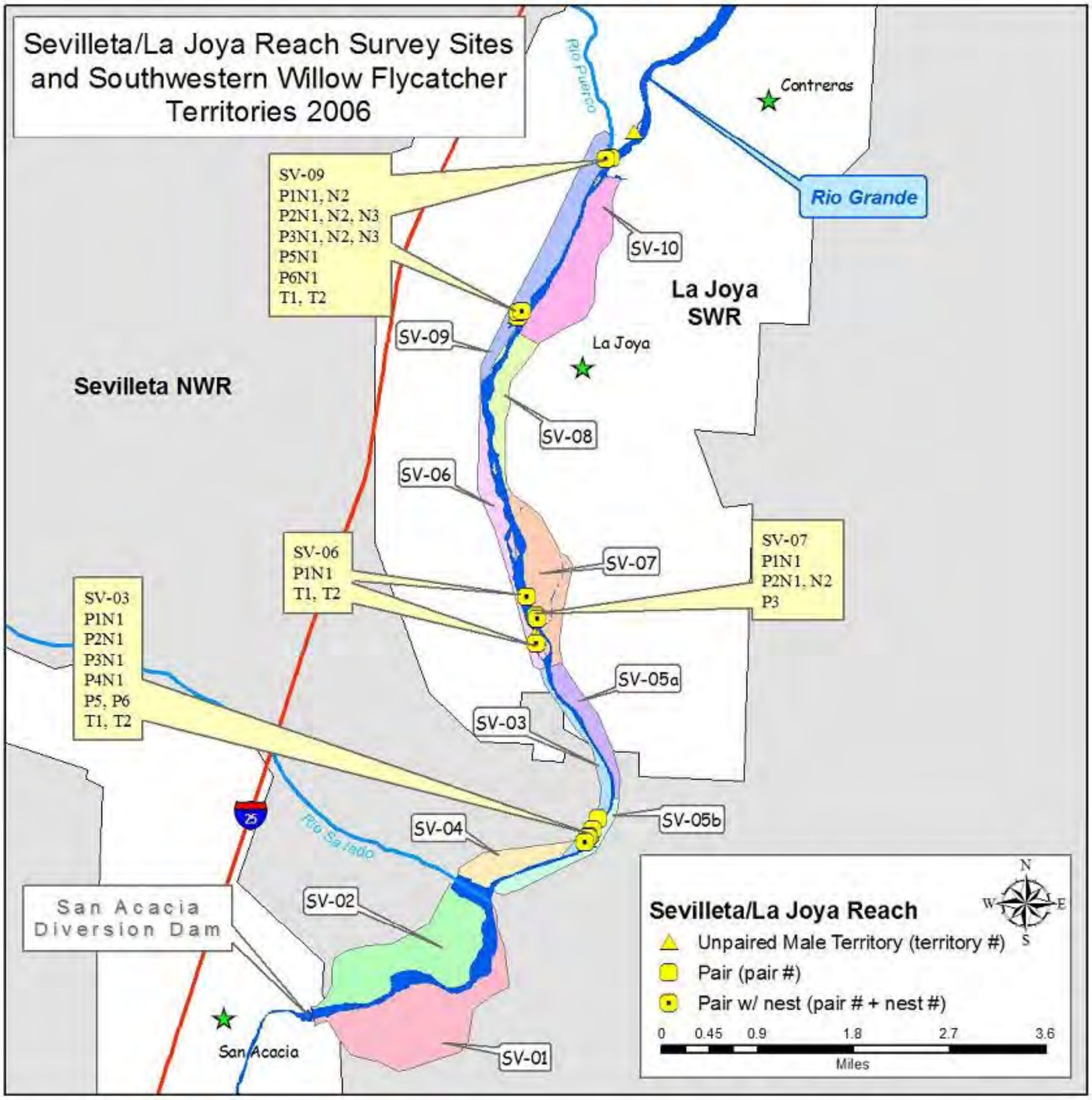
Belen Reach	**2005**	**2006**	**2007**
Flycatchers observed	30 (29♂ 1♀)	28 (28♂ 0♀)	44 (43♂ 1♀)
Breeding pairs	1	0	1
Resident flycatchers	4 (3♂ 1♀)	1 (1♂)	9 (8♂ 1♀)
Number of territories	4	1	10
Nests found	2	N/A	2
Documented successful nests	1	N/A	0
Young fledged	2	N/A	0
Sevilleta/La Joya Reach			
Flycatchers observed	30 (20♂ 10♀)	57 (42♂ 15♀)	32 (24♂ 8♀)
Breeding pairs	10	15	8
Resident flycatchers	27 (17♂ 10♀)	36 (21♂ 15♀)	22 (14♂ 8♀)
Number of territories	17	21	14
Nests found	10	18	6
Documented successful nests	1 (6 unknown)	8 (2 unknown)	4
Young fledged	3	20	10

20 What are the habitat characteristics of flycatcher nest sites in the Isleta Reach?

Flycatcher nest sites in the Isleta Reach are generally clustered in four locations: near the Rio Puerco confluence, near the La Joya Fish and Game Refuge, near the confluence with the lower San Juan irrigation drain return, and within the Sevilleta National Wildlife Refuge (NWR) upstream of the Rio Salado confluence (Exhibit 3-9).

Exhibit 3-9

Flycatcher Nest Sites in the Isleta Reach (Moore and Ahlers, 2006a)



Except for the nest sites at Sevilleta NWR, most of the Isleta Reach nest sites are located near the active river channel, and in years with adequate snowmelt runoff, may be temporarily inundated (or within 50 m) by slow moving flood water. GIS data provided by BOR indicates that nests at Sevilleta NWR are in relatively mature stands of monotypic saltcedar (Exhibit 3-10). Nests in exclusively exotic vegetation declined from four in 2006 to two in 2007. Flycatcher nests at other Isleta Reach sites are primarily in dense stands of either mixed native-exotic vegetation or purely native vegetation. Nest sites in mixed native-exotic vegetation declined between 2006 and 2007 surveys, with 7 nests in 2006 and only 2 nests in 2007. Flycatchers nesting in purely native vegetation declined from 4 nests in 2006 to only 1 nest in 2007. The total number of nests in the reach declined from 17 pairs in 2006 to 6 pairs in 2007 (Exhibit 3-10).

Exhibit 3-10

Vegetation Surrounding Flycatcher Nests in the Isleta Reach

<table>
<tr><th>Vegetation Category</th><th>Hink and Ohmart Vegetation Type</th><th>Year</th><th>Number of Nests</th></tr>
<tr><td rowspan="6">Exclusively Exotic Spp.</td><td rowspan="2">Russian olive-Saltcedar, Type 3</td><td>2006</td><td>0</td></tr>
<tr><td>2007</td><td>2</td></tr>
<tr><td rowspan="2">Saltcedar, Type 4F</td><td>2006</td><td>4</td></tr>
<tr><td>2007</td><td>0</td></tr>
<tr><td rowspan="2">Total</td><td>2006</td><td>4</td></tr>
<tr><td>2007</td><td>2</td></tr>
<tr><td rowspan="6">Mixed Native and Exotic Riparian</td><td rowspan="2">Russian olive-Coyote willow-Cottonwood, Type 5</td><td>2006</td><td>3</td></tr>
<tr><td>2007</td><td>1</td></tr>
<tr><td rowspan="2">Russian olive-Coyote willow, Type 3</td><td>2006</td><td>4</td></tr>
<tr><td>2007</td><td>1</td></tr>
<tr><td rowspan="2">Total</td><td>2006</td><td>7</td></tr>
<tr><td>2007</td><td>2</td></tr>
<tr><td rowspan="6">Native Riparian</td><td rowspan="2">Coyote willow-cottonwood, Type 5</td><td>2006</td><td>1</td></tr>
<tr><td>2007</td><td>1</td></tr>
<tr><td rowspan="2">Coyote willow, Type 5</td><td>2006</td><td>3</td></tr>
<tr><td>2007</td><td>0</td></tr>
<tr><td rowspan="2">Total</td><td>2006</td><td>4</td></tr>
<tr><td>2007</td><td>1</td></tr>
<tr><td rowspan="2">Other</td><td rowspan="2">Open Water*</td><td>2006</td><td>2</td></tr>
<tr><td>2007</td><td>1</td></tr>
<tr><td colspan="2" rowspan="2">Total</td><td>2006</td><td>17**</td></tr>
<tr><td>2007</td><td>6**</td></tr>
</table>

**The "open water" category from the Hink & Ohmart classification is an artifact of the 2002 GIS layer. At the time, this site was an unvegetated sandbar. Personal observations of the site in 2007 indicated a mixture of Russian olive, saltcedar, and coyote willow.*

***There are discrepancies in the data provided to Parametrix by the BOR compared to their published reports (Moore and Ahlers, 2006a, 2006b). These discrepancies are primarily regarding the total number of nests observed in the Isleta Reach during 2006 (17 vs. 18) and 2007 (6 vs. 8). We contacted D. Ahlers at BOR and he is trying to resolve the issue.*

21 Why is flycatcher habitat restoration in the Isleta Reach important if MRG recovery goals have already been attained?

As stated previously, the reach downstream of the power lines near Mulligan Gulch (10 miles downstream of San Marcial railroad bridge) to the Elephant Butte Reservoir has been consistently the most productive reach of the MRG for flycatchers; 84 percent (655 of 778 nests) of the nests observed within the MRG from 1995 through 2006 occurred in this area (Moore and Ahlers, 2006b). Most new nests in the MRG, especially in recent years, have been added within the Elephant Butte Reservoir delta (Moore and Ahlers, 2006b). Due to the steady and substantial increase in the number of nests concentrated within the delta since 2003, the numbers of flycatcher nesting territories within the MRG Recovery Unit have continued to exceed the goal of 100 territories established in the flycatcher recovery plan. From 2003 to 2006, the numbers of nests observed during the surveys of the MRG by the BOR have totaled 111 nests, 187 nests, 143 nests, and 168 nests, respectively, for each over those 4 years (Moore and Ahlers, 2006b).

Breeding territories within the reservoir delta are supported by hydrologic conditions that could change drastically with rising or falling lake levels. Two or three consecutive years of above average snowmelt runoff, for example, could raise the lake level to the point that extensive areas of riparian willow habitat could die under anoxic conditions. Conversely, if lake levels (and associated groundwater) dropped significantly, extensive areas of riparian vegetation could die from water stress. The sensitivity of salicaceous species (e.g., willows and cottonwoods) to relatively minor differences in groundwater elevations are well documented (Amlin & Rood, 2002; Bennet & Simon, 2004; Bhattacharjee et al., 2006; Busch & Smith, 1995; Horton & Clark, 2001; Johnson, 2000; Lite & Stromberg, 2005; Mahoney & Rood, 1998; Scott et al., 1993; Scott et al., 1996; Shafroth et al., 1998; Stella, 2006; Stromberg, 1993), so the impact of such reservoir elevation scenarios on existing flycatcher habitat are not unrealistic.

Given that such a high percentage of the MRG nest sites are vulnerable to lake level changes, we suggest it would be prudent to implement restoration projects further upstream (including the Isleta Reach), where the potential for dramatic changes in annual groundwater levels are less likely.

Another important consideration is the fact that flycatchers nest in early seral riparian vegetation with a relatively short life span. Flood disturbance in unregulated river systems are constantly creating new patches of riparian habitat as others grow older and transition to later successional plant communities. The extent of this process is greatly reduced along regulated rivers, and as discussed in Chapter 2, willow dominated habitats in the Isleta Reach have declined dramatically since the floodplain vegetation was mapped by Hink and Ohmart (1984). Even in the unlikely event that lake levels at Elephant Butte remain stagnant over the next 10 to 20 years, it is predictable that much of the suitable flycatcher habitat now present between Mulligan Gulch and Elephant Butte Reservoir will become less suitable as the vegetation becomes older and more decadent. Without a mechanism to ensure replacement of these aging habitats, it is also predictable that the number of nesting flycatchers in these areas will decline. This latter point is an issue not only near the reservoir delta, but everyplace where river regulation prevents extensive natural recruitment of new native riparian vegetation. As long as the flycatcher is listed as a federally endangered species, therefore, it is incumbent upon us to ensure timely replacement of these habitats over space and time within designated critical habitats in the MRG Recovery Unit.

The flycatcher recovery plan emphasizes the need first to reestablish the physical integrity of rivers, specifically restoration and maintenance of primary functions of flow and sediment dynamics.

Next, it focuses on restoring the vegetation communities needed for flycatcher habitat. These communities require specific hydrologic and geomorphic conditions, including floods, sediments, and persistent water.

Actions to accomplish this will require adaptive management techniques involving both passive and active restoration techniques. In the next chapter (Chapter 4), we discuss issues and opportunities for implementing different habitat restoration techniques, and provide additional data to guide site selection for flycatcher restoration projects in the Isleta Reach.

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Chapter 4 Restoration Issues and Opportunities

The following narrative describes Parametrix's interpretation of some of the most important issues requiring attention in order to successfully improve habitat conditions for the silvery minnow and flycatcher in the Isleta Reach. The information provided here will serve as the foundation for the restoration recommendations in Chapter 5, and the associated adaptive management and monitoring criteria described in Chapter 6.

The restoration issues and opportunities described herein are based upon extensive review of existing reports and data collected by others, as well as general field observations made by the Parametrix project team. The restoration issues and opportunities described below, therefore, were developed based upon our interpretations of these information sources and by applying our "best professional judgment." It is our expectation that not all readers will concur with everything stated in this chapter, but at a minimum, we hope that our narrative will foster professional, meaningful dialogue aimed at restoring key ecological elements that benefit the flycatcher and the silvery minnow.

Issues and Opportunities: Vegetation Encroachment and Channel Narrowing Effects on Silvery Minnow Habitat

1 What is the extent of channel narrowing in the Isleta Reach and how does it affect silvery minnow habitat?

The Rio Grande channel morphology and aquatic and riparian habitat evolved over time to the suite of diverse flow conditions that encompassed high spring floods and late summer low-flow conditions punctuated by thunderstorm floods. The current seasonal hydrograph is now much different than the historical seasonal hydrograph in terms of the magnitude, frequency, duration, and timing of both spring and summer peak flows. As the magnitude, frequency, and duration of flooding has diminished, so has the active channel in the Isleta Reach.

Recent channel narrowing has become more extensive throughout the reach as the cumulative result of vegetation encroachment, vertical accretion of the vegetated bars, and eventual attachment to islands and banks.

Historical channel narrowing can be attributed to a combination of pilot channel development, river relocation, and channel incision. Recent channel narrowing has become more extensive throughout the reach as the cumulative result of vegetation encroachment, overbank sediment deposition within the vegetation, vertical accretion of the vegetated bars, and eventual attachment to islands and banks.

Accretion:

a. Slow addition to land by deposition of water-borne sediment.

b. An increase of land along the shores of a body of water, as by alluvial deposit.

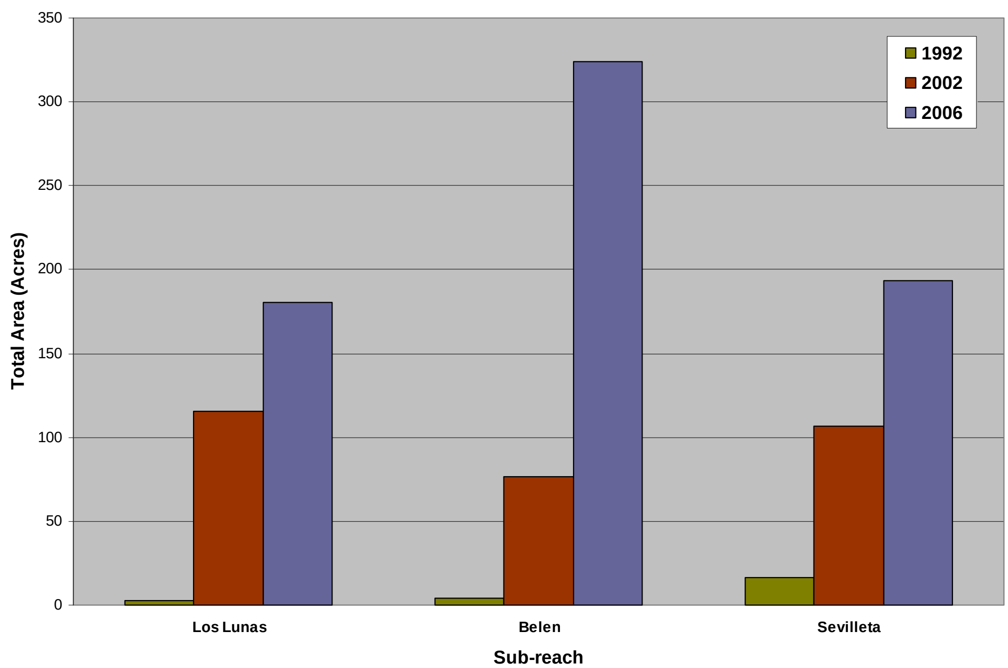
(The American Heritage Dictionary of the English Language, Fourth Edition. Houghton Mifflin Company, 2004).

The Bureau of Reclamation (BOR) reports that channel narrowing in the Isleta Reach has increased dramatically since 2001 and is attributed primarily to vegetation encroachment into the active channel (Massong et al., 2007). The rate of vegetation encroachment into the active channel since 2002 has been most dramatic in the Belen Sub-reach, but is also increasing steadily in the other sub-reaches (see Exhibits 4-1 and 4-2 and Chapter 2, Geomorphology Section).

Exhibit 4-1 shows the magnitude of the increase in vegetated bar acreage between 1992 and 2006. Vegetated bars and islands in the Belen Sub-reach have increased by a factor of 4 between 2002 and 2006, while the Los Lunas and Sevilleta Sub-reaches have seen increases of approximately 50 percent. Some of these bars have accreted and attached to the river bank (MEI, 2006) and are accelerating the channel narrowing process (Massong et al., 2007). Extreme channel narrowing may adversely affect aquatic habitat by confining flows, increasing flow velocities, and reducing channel bed form heterogeneity (Exhibit 4-3).

Exhibit 4-1

Approximate Acreage Increase of Vegetated Bars in the Isleta Reach (1992–2006)



Parametrix modified the active channel from GIS data provided by the Bureau of Reclamation. The 1992 coverage was modified from the 1992 aerial photography which has a lower resolution than the 2002 and 2006 aerial photography. Therefore, the efforts associated with the 1992 dataset are likely to contain more errors and discrepancies. The 2002 dataset was modified according to the 2002 aerial photography provided by the BOR and the 2006 dataset was modified using GIS data associated with the 2005 inundation study and the January 2006 aerial photography.

Exhibit 4-2

Vegetation Growth and Island Accretion between 2002 and 2006 at RM 129.5

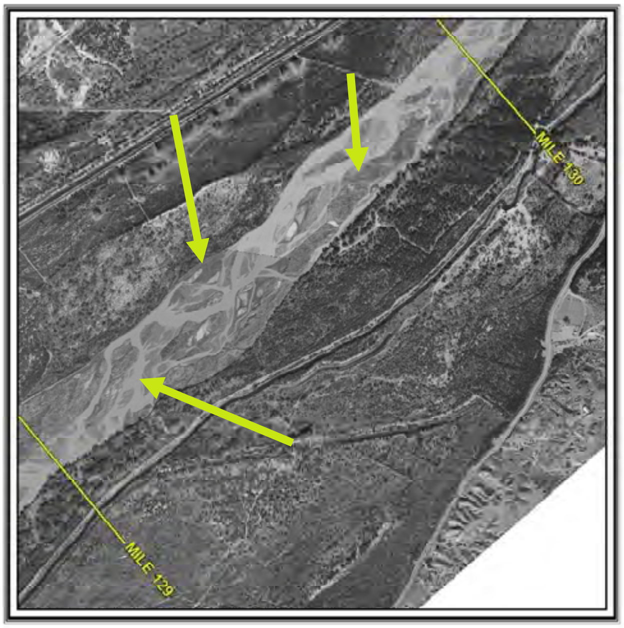


Photo taken in 2002 (approximately 500 cfs).

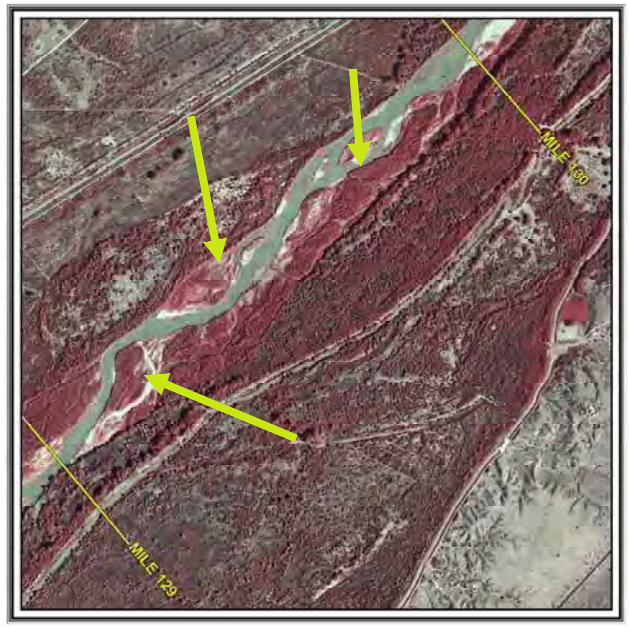
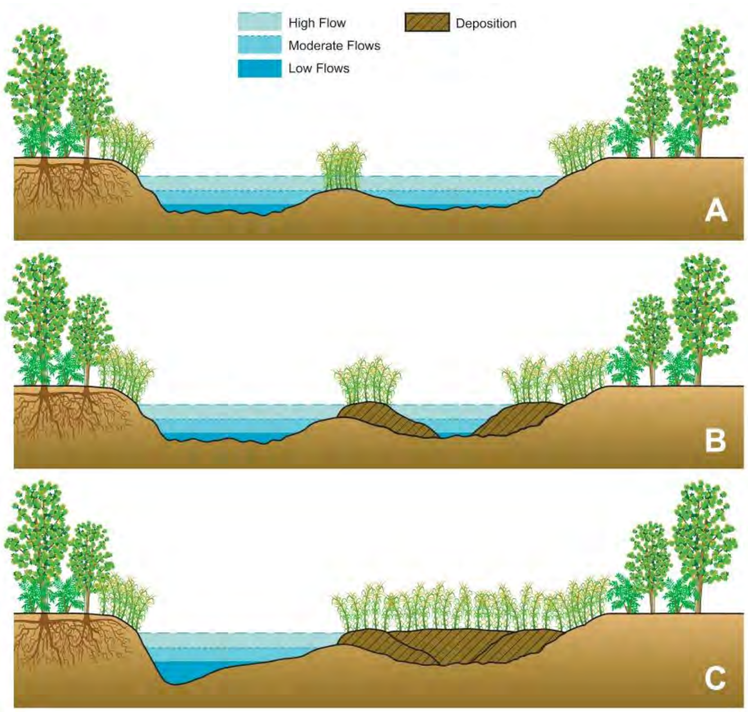


Photo taken in 2006 (approximately 300 cfs).

The trend highlighted in this exhibit is occurring throughout the Isleta Reach.

Exhibit 4-3

Conceptual Drawing of Island Accretion, Bank Attachment, and Channel Narrowing Process



Panel A (top) illustrates a wide channel with diverse bed forms. Panel B (middle) shows that the island in the center of the channel has accreted and becomes inundated only at high flows. Riparian vegetation is also beginning to encroach near the existing bank, facilitating sediment deposition and reducing the inundation frequency of the channel to the right. The vegetated bars eventually become "bank-attached" and eventually accrete to the point where high-flows may not inundate (Panel C). The channel in Panel C illustrates the flow contained in the remaining narrow channel has higher flow velocities and less bed-form diversity than either Panel A or B.

Fish biologists working in the MRG are concerned channel narrowing (as displayed in Exhibit 4-3) has the potential for diminishing channel habitat diversity and nursery habitat availability for the minnow (Dudley and Platania, 1997; Remshardt and Tashjian, 2005; S. Platania, personal communication, 2007; M. Porter, USACE, personal communication, 2007). For example, in their study of silvery minnow habitat characteristics, Remshardt and Tashjian (2005) reported that reaches where vegetated bars and islands were infrequently inundated tended to have more uniform flow velocities and less diverse channel bed characteristics. Platania and Dudley (1996) reported that river segments with more channelized/confined flows had significantly fewer silvery minnows than channels with more heterogeneous flow velocities and bed forms.

We hypothesize that the island accretion, bank attachment, and channel narrowing processes contribute to decreasing aquatic habitat heterogeneity in the Isleta Reach. As this trend continues, it may significantly reduce habitat availability for all life-stages of the silvery minnow. We further hypothesize that restoration treatments aimed at destabilizing bank-attached bars and islands will locally reverse this trend, improving aquatic habitat diversity and nursery habitat availability for the silvery minnow and other native fish.

2 Don't vegetated channel bars provide important nursery habitat for the silvery minnow?

When vegetated floodplains and channel bars are inundated by snowmelt runoff, these areas are considered important nursery and refuge habitat for fish, including the silvery minnow (Dudley and Platania, 2007d; Pease et al., 2006; M. Porter, USACE, personal communication, 2007; Remshardt and Tashjian, 2004). Pease et al. (2006) cite a few reasons why these flooded habitats may provide important nursery grounds:

- Water velocities are reduced in these habitats, so eggs, larvae, and juvenile fish may avoid downstream displacement;

- Water temperatures are generally higher and food production is higher in the presence of inundated riparian vegetation and other organic and inorganic material (i.e., invertebrates, detritus, algae, etc…), and;
- Inundated floodplains provide more complex habitat and structural refugia than the main river channel (multiple authors cited by Pease et al., 2006).

Vegetated bars, however, typically become inundated less frequently over time because the vegetation traps sediment, causing the bars to vertically accrete (i.e., rise in elevation). This process has been occurring to some degree in all reaches of the MRG, including the Isleta Reach (Massong et al., 2007; MEI, 2006). For example, in their Middle Rio Grande channel bar dynamics study, MEI (2006) states that:

> …it appears that on average the vegetated Level-1 mid channel bars in the Albuquerque reach experienced about 1.5 feet of vertical accretion during the 2005 runoff event. The degree of vertical accretion has significant implications with respect to the magnitude and frequency of future inundation. On average, an increase in elevation of 1.5 feet on a Level 1 mid-channel bar surface will increase the magnitude of the flow required to inundate the bar from about 1,500 to 4,000 cfs and would reduce the average annual duration of inundation from about 20 to 4 days. The deposition that occurred during the 2005 runoff period is very consistent with the evidence of vertical accretion seen in the bar stratigraphy at all of the [MRG study, sic.] sites.(MEI, 2006, p. 4.57).

Level-1 Mid-Channel Bars

Level 1 mid-channel bars form from further vertical accretion onto Level 2 braid bars of sand and/or gravel, generally accompanied by a number of mud drapes. The mud drapes appear to enhance the establishment of perennial vegetation on the Level 1 mid-channel bars (MEI, 2006).

3 What management alternatives exist for addressing channel vegetation encroachment and its impact on channel narrowing?

The below average snow-melt runoff and periodic channel drying that occurred between 1997 and 2004 facilitated woody vegetation encroachment onto channel bars, and the lack of adequate scouring flows allowed the vegetation to become firmly established. The vegetation growth is variable across the bars, but field observations indicate many bars support high density vegetation exceeding 6 feet in height. At this point, high flows alone will not be sufficient to remove well established vegetation from these bars (MEI, 2006).

Destabilizing bars with well established woody vegetation, therefore, will require aggressive mechanical intervention. For example, mulching tractors and/or bulldozers or other appropriate heavy equipment would be needed to remove stems, branches, and root systems of woody vegetation in order to destabilize targeted channel bars. Many of the targeted bars may require additional mechanical treatment (i.e., lower the bar elevations) so that subsequent snow-melt runoff and/or summer storm flows can more effectively scour and re-mobilize the bar alluvium.

Vegetation encroachment, however, will be an on-going issue in the Isleta Reach, particularly in channel sections that are subject to periods of frequent and prolonged drying. This indicates that the Program may need to consider a long-term management plan to circumvent on-going channel vegetation encroachment. We recommend that vegetation removal and bar destabilization activities, as described above, be implemented on an experimental basis in reach segments where island accretion and/or bank attachment have already occurred (see Chapter 5). If monitoring indicates that this approach is producing the desired effects (i.e., improved channel habitat characteristics), then an adaptive management strategy should be considered by the Program that would apply similar treatments to accreted bars throughout the project reach on a routine basis.

4 At one time, the Bureau of Reclamation cleared channel vegetation as part of their annual river maintenance activities. What is the background of this and when and why was it discontinued?

In the past, the BOR actively engaged in mowing and destabilizing vegetated bars in the Middle Rio Grande and the Lower Rio Chama (BOR, 1993b). Annual vegetation clearing and island removal was especially concentrated in the “Middle

Reach," which extends from the downstream boundary of Cochiti Pueblo to the confluence with the Rio Puerco. This was done for purposes of maintaining and improving floodway capacity for the passage of high flows. It was also done in some locations to protect levees and other riverside infrastructure (BOR, 1993b).

The island destabilization treatments implemented by BOR's Socorro Field Division typically involved mowing vegetation and, on "smaller" bars, physically redistributing the bar sediment across the channel with a bulldozer (M. Gonzales, BOR, Socorro Field Division, personal communication, 2008). These activities began in the 1960s (Makar et al., 2006) and peaked in the 1980s (K. Martin, BOR, personal communication, 2008). This routine activity was halted in 1994, primarily due to limited financial resources and because of environmental concerns, including potential impacts to the silvery minnow (K. Martin, BOR, personal communication, 2008). The BOR's River Maintenance Program staff has indicated a strong interest in re-instating this practice for the dual benefit of improving aquatic habitat and improving flood conveyance capacity (K. Martin, BOR, personal communication, 2008; R. Padilla, BOR, personal communication, 2008).

5 Are we proposing removal of all vegetated bars in the Isleta Reach?

As stated previously, vegetated channel bars (and floodplains) are thought to provide important nursery habitat for the silvery minnow as the minnow become inundated by sustained moderate and high flows associated with snowmelt runoff. Historically, these vegetated bars may have been proportionately less important because desirable channel habitat attributes for the silvery minnow would have been provided by the wider, more braided channel and its abundant oxbows, backwater channels, and off-channel marshes and wetlands. Now that these diverse channel and aquatic habitats are essentially gone from the Isleta Reach, inundated islands and vegetated bars appear to (temporarily) contribute to channel habitat diversity after becoming inundated during moderate and higher flows.

> We hypothesize that removing accreted islands in strategic locations will result in localized improvements in aquatic habitat diversity (e.g., secondary channels, bed form, and depth and flow velocity heterogeneity).

Therefore, rather than an indiscriminate destabilization program, we suggest that vegetated bars be selectively targeted for this treatment, with prioritization given to vegetated bars that are infrequently inundated (e.g., fail to inundate when flows exceed approximately 3,500 cfs; see Exhibit 4-4). To be clear, the purpose of destabilizing these vegetated islands or attached bars would be to prevent the condition illustrated in Step C of Exhibit 4-3 (above). This could be accomplished by mechanically removing vegetation (stems and roots) and lowering bar elevations to allow subsequent flows to scour, erode, and remobilize these previously stabilized bar sediments. Bar lowering could be accomplished by redistributing the bar alluvium laterally and longitudinally with a bulldozer. The management objective would be to increase the channel width to depth ratio, allowing channel bar mobility, reducing the overall channel depth and increasing the flow velocity heterogeneity across the channel.

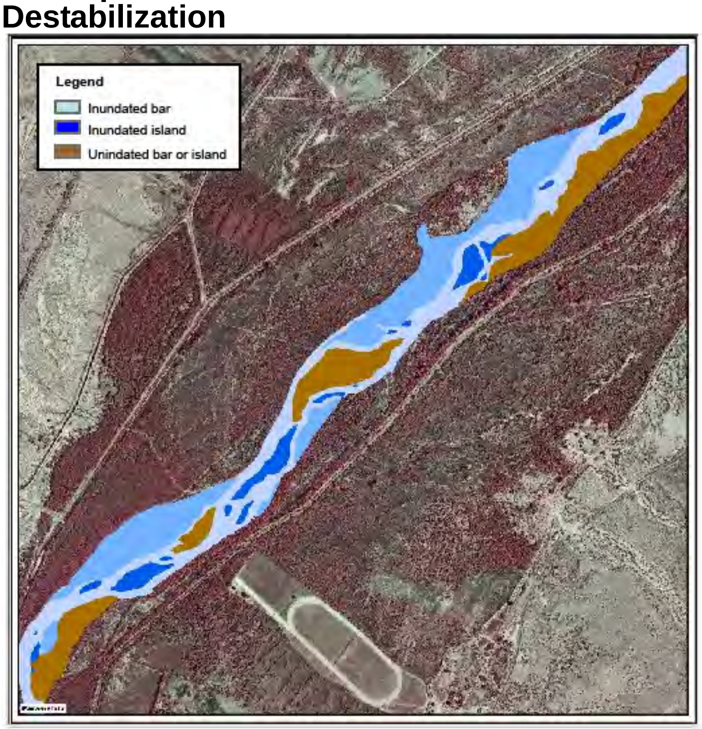
Sediment Management Associated with Bar/Island Destabilization

The bar and island destabilization treatment is intended to release sediment currently stored/stabilized by channel vegetation. We hypothesize that releasing this stored sediment through a combination of adaptive management actions, will improve reach-wide fluvial geomorphic processes and aquatic habitat for the silvery minnow.

Since the existing data (see Chapter 2) indicates a sediment deficit through this reach, we strongly discourage physically removing the bar sediments from the river channel as this would predictably exacerbate the channel narrowing trends in the reach.

Exhibit 4-4

Conceptual Illustration of Potential Sites for Vegetation Removal and Bar Destabilization



Vegetated bars highlighted in "brown" represent sites that no longer inundate at flows less than 3,500 cfs. Bars in "light blue" and islands in "dark blue" represent sites that do currently inundate at flows less than 3,500 cfs and may provide important silvery minnow nursery habitat. Under the proposed restoration approach, the brown areas shown in this conceptual drawing serve as potential targets for experimental vegetation removal and bar destabilization treatments.

We hypothesize that removing accreted islands in strategic locations will result in localized improvements in aquatic habitat diversity (e.g., secondary channels, bed form, and depth and flow velocity heterogeneity). It will also provide channel habitat for different life-stages (larval fish, young of year, adult fish) of silvery minnow. This treatment could have the additional benefit of releasing sediment for mobilization into the channel that is otherwise stabilized by vegetation. As stated previously, we recommend that this treatment first be implemented on an experimental basis in reach segments where island accretion and/or bank attachment have already occurred (see Chapter 5). If monitoring indicates that this approach is producing the desired effects (i.e., improved channel habitat characteristics), then an adaptive management strategy should be considered by the Program and BOR's River Maintenance Program that would apply similar treatments to accreted bars throughout the project reach on a routine basis.

6 What assumptions are we making about the effectiveness of this restoration approach?

This restoration treatment assumes that channel confinement induced by accreting bars is promoting localized channel bed erosion. Some have stated (T. Massong, USACE, personal communication, 2007) that they believe that there is a reach-wide trend towards channel incision, and that removing accreted islands or vegetated bank-attached bars may not reverse this trend. However, we have seen no conclusive evidence (e.g. longitudinal profile) that the project reach upstream of the Sevilleta Sub-reach is undergoing reach-wide incision. We and others (M. Harvey, MEI, personal communication, 2007) believe that channel bed erosion observed in the Belen Sub-reach is probably a localized effect of channel narrowing driven by vegetation encroachment and island accretion.

The aquatic habitat benefits from vegetation removal and bar destabilization treatments are presented here as hypotheses and need to be validated in the field. As with most restoration concepts described in this report, we are assuming that without a commitment to adaptive management, any benefits attained from these specific treatments will be relatively short-lived. Without considerable changes in sediment inputs and hydrology vegetation encroachment, bar stabilization, island accretion, and channel narrowing will surely continue.

7 Can woody vegetation encroachment into the active channel be controlled using managed flow releases from Cochiti Dam?

There is considerable effort on other regulated rivers (e.g., Trinity River CA; Lower San Joaquin River, CA; Lower Tuolomne River, CA; and Bill Williams River, AZ) to evaluate the potential for prescribing managed flows to scour seedlings from the active channel before their growth restricts this process (Bair, 2003; Stella, 2006; Stella et al., 2004; Wilcox et al., 2006). Riparian seedlings have flexible stems and are able to withstand flow sheer stresses up to a certain threshold beyond which the seedlings may be physically dislodged from the bar substrate. However, once their root systems are well established it becomes increasingly difficult to provide managed flows sufficient to scour these woody plants from the bar substrate. The cohesive properties of the bar substrate (i.e., gravel, sand, silt) also plays a central role in the ability of flows to scour these seedlings. Thus, determining the ability of managed flows to perform this scouring function is site specific, and results from investigations in other river basins should be applied carefully to the Middle Rio Grande.

Authors of the *Conceptual Restoration Plan for the Active Floodplain of the Rio Grande, San Acacia to San Marcial* (Tetra Tech, 2004b) hypothesize that the 2-year flow (≈ 5,600 cfs) should be sufficient to scour first year, and possibly second year, woody riparian seedlings from the active channel. Unfortunately, there have been no field studies along the MRG to validate their hypothesis, although MEI (2006) has performed some hydraulic modeling to begin assessing this general issue. MEI (2006) used outputs from a HEC-RAS hydraulic model to calculate sheer stress under a range of flows, including several cross-sections in the Isleta Reach.

Maximum calculated sheer stresses associated with cross-sections between Belen and La Joya study sites were 0.12 lb/ft² and 0.2 lbs/ft². MEI (2006) suggests that these sheer stresses would be insufficient to scour bar vegetation, citing bioengineering literature that reports plant material on its own can tolerate sheer stresses up to 1.0 lbs/ft².

It should be pointed out, however, that the bioengineering literature cited by MEI (2006) does not address sheer stress thresholds of riparian seedlings. Rather, the field of river bioengineering typically focuses on the use of riparian cuttings or potted material with well established root systems. While determining the sheer stress tolerance of first and second year riparian seedlings is of great importance to developing managed flow prescriptions, there is currently no published data available on this topic (G. Auble, USGS personal communication, 2007; J. Bair, personal communication, 2007; J. Stromberg, Arizona State University, personal communication, 2007; A. Wilcox, University of Montana, personal communication, 2007).

We strongly advocate the need for performing research on the Middle Rio Grande to evaluate the sheer stress thresholds for first and second year riparian seedlings on various bar substrates. Bair (2003) describes a successful restoration effort on the Trinity River (California) that combined initial mechanical vegetation removal with subsequent managed flows to restore the active channel width for improving aquatic habitat for salmon. We believe that this combined “active” (mechanical vegetation removal) and “passive” approach (managed flows to prevent seedling encroachment) to restoration has potential on the Middle Rio Grande.

Without a strategy to encourage the river to perform this restoration work, the only other viable means of managing channel vegetation is through implementing on-going mechanical treatments (i.e., bulldozers or other heavy equipment).

Issues and Opportunities: Increasing the Availability of Silvery Minnow Nursery Habitat

8 What restoration options exist for improving nursery habitat availability in the Isleta Reach?

Vegetated Island/Bar Habitat Manipulations

As stated previously, inundated floodplains are considered important nursery habitat for a number of reasons (Pease et al., 2006). Recent observations (May 2008) at Isleta Pueblo, for example, estimated tens of thousands of silvery minnow eggs adrift within the inundated floodplain (C. Walker, Pueblo of Isleta, personal communication). An important management issue, however, is that many silvery minnow become trapped in the floodplain after flood flows recede (Thompson et al., 2006). As such, it may be difficult to design restoration projects that encourage inundating floodplain habitat outside the active river channel without inadvertently facilitating silvery minnow entrapment.

However, the New Mexico Interstate Stream commission has developed and implemented several projects in the Albuquerque Reach that aim to improve nursery habitat within vegetated bars and islands located in the active river channel (SWCA, 2006a, 2006b and 2006c). The NMISC is also planning to implement similar projects in portions of the Isleta Reach (NMISC, 2007). These projects involve using heavy equipment to manipulate the topography of vegetated channel bars by excavating flow through channels, lowering banks, and creating variable terraces to promote inundation under a range of flows. Such restoration techniques targeting vegetated bars within the active channel are appealing for a variety of reasons, including the fact that silvery minnow entrapment is far less likely than if these projects were implemented in the floodplain outside the active river channel.

Unlike the island destabilization technique described previously in this chapter that specifically concentrates on accreted islands that are infrequently inundated, the bar and island habitat manipulation techniques described here could theoretically target any vegetated island within the active channel. We suggest that these island habitat manipulation techniques, especially in combination with the island destabilization treatments described earlier, could greatly improve nursery habitat availability and diversity throughout the Isleta Reach.

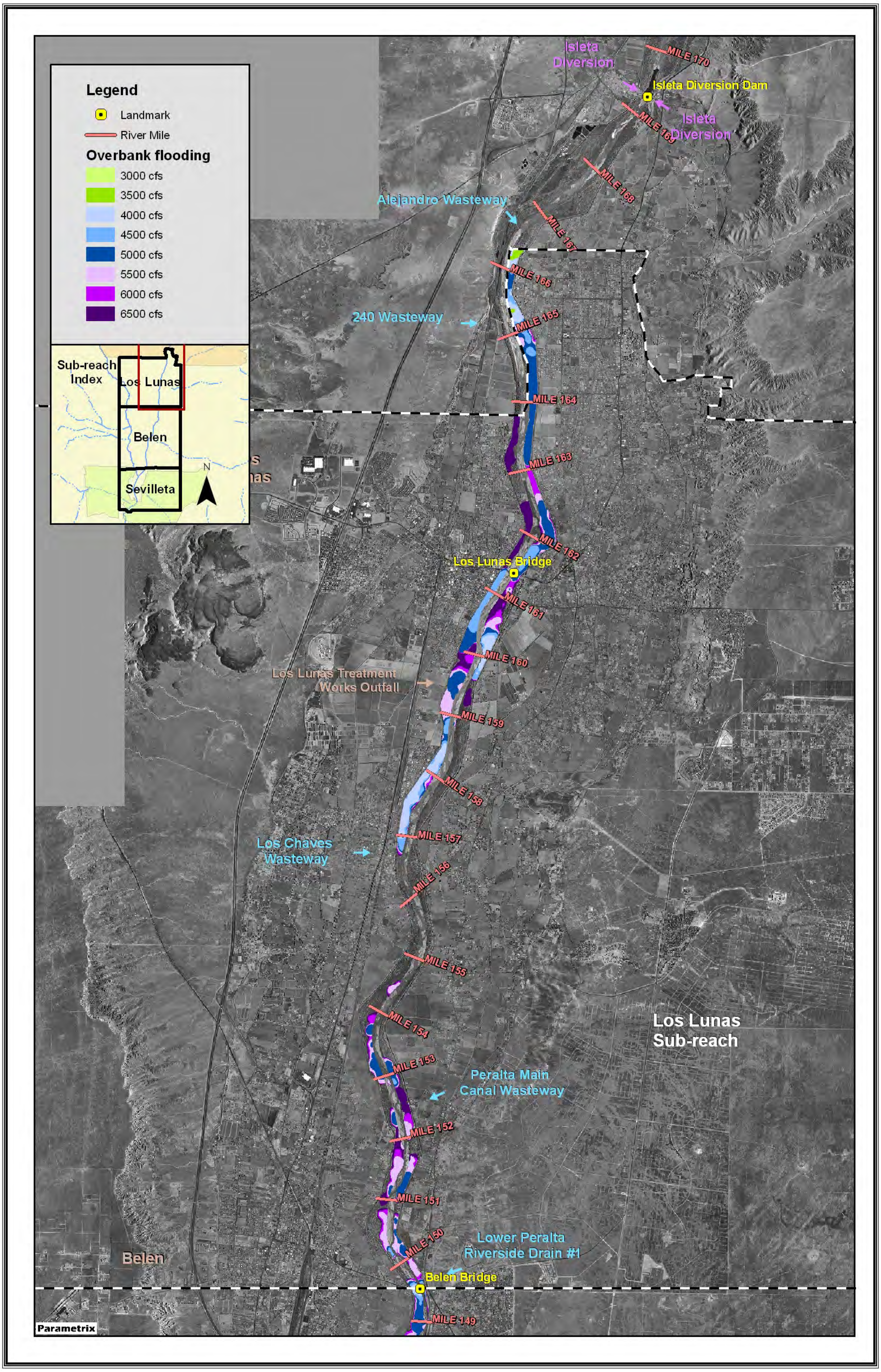
Backwater Channels

The Isleta Reach has some important features that distinguish it from other reaches of the Middle Rio Grande. For one thing, large portions of floodplain become inundated at flows less than 6,000 cfs (Exhibits 4-5 through 4-7; also see Chapter 2). As cited previously, these inundated floodplains are thought to provide important nursery habitats for native fish, including the silvery minnow. The Isleta Reach also has twelve irrigation return canals (i.e., wasteways) that, according to FLO2D analysis, function as backwater habitats at both moderate and high flows (Exhibits 4-5 through 4-7). Cowley et al. (2007) found numerous silvery minnows in the Peralta Drain return canal, and field observations by others (M. Porter, USACE, personal communication, 2007) indicates that other irrigation wasteways and backwater channels are being used by adult fish and may provide important silvery minnow nursery habitat.

However, these habitat conditions (overbank flooding and extensive backwater habitats) are generally lacking in the Isleta Reach downstream of Abo Arroyo. For example, the 23-mile river segment downstream of Abo Arroyo (to the San Acacia Diversion Dam) experiences almost no overbank flooding, even at flows above 6,000 cfs. Furthermore, most of the irrigation returns that function as backwaters during high flow conditions are concentrated upstream of the Abo Arroyo confluence (RM 139). There are no irrigation wasteways or return canals in the 10-mile segment between RM 137 and RM 127 (Exhibits 4-5 through 4-7).

Exhibit 4-5

Floodplain Inundation and Irrigation Return Canals in the Los Lunas Sub-reach



Background Photo: June 2006.

The boundary of Isleta Pueblo depicted on this map is an older depiction of the boundary; however, the Pueblo of Isleta currently recognizes the eastern boundary between RM 163.7 and RM 166.3 along the Rio Grande as being the MRGCD right-of-way adjacent to the Peralta Drain (J. Sorrell, personal communication).

Exhibit 4-6
Floodplain Inundation and Irrigation Return Canals in the Belen Sub-reach

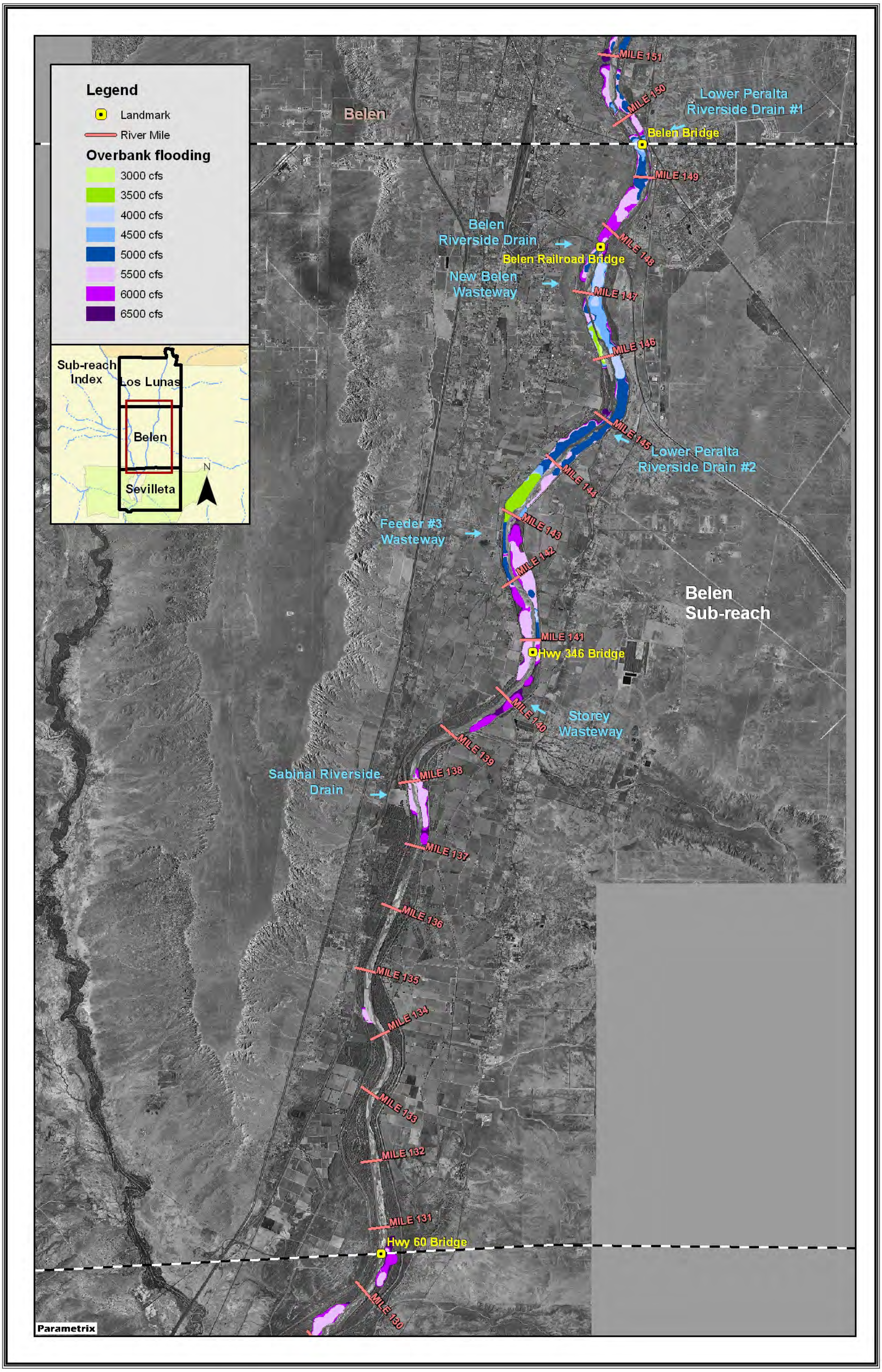
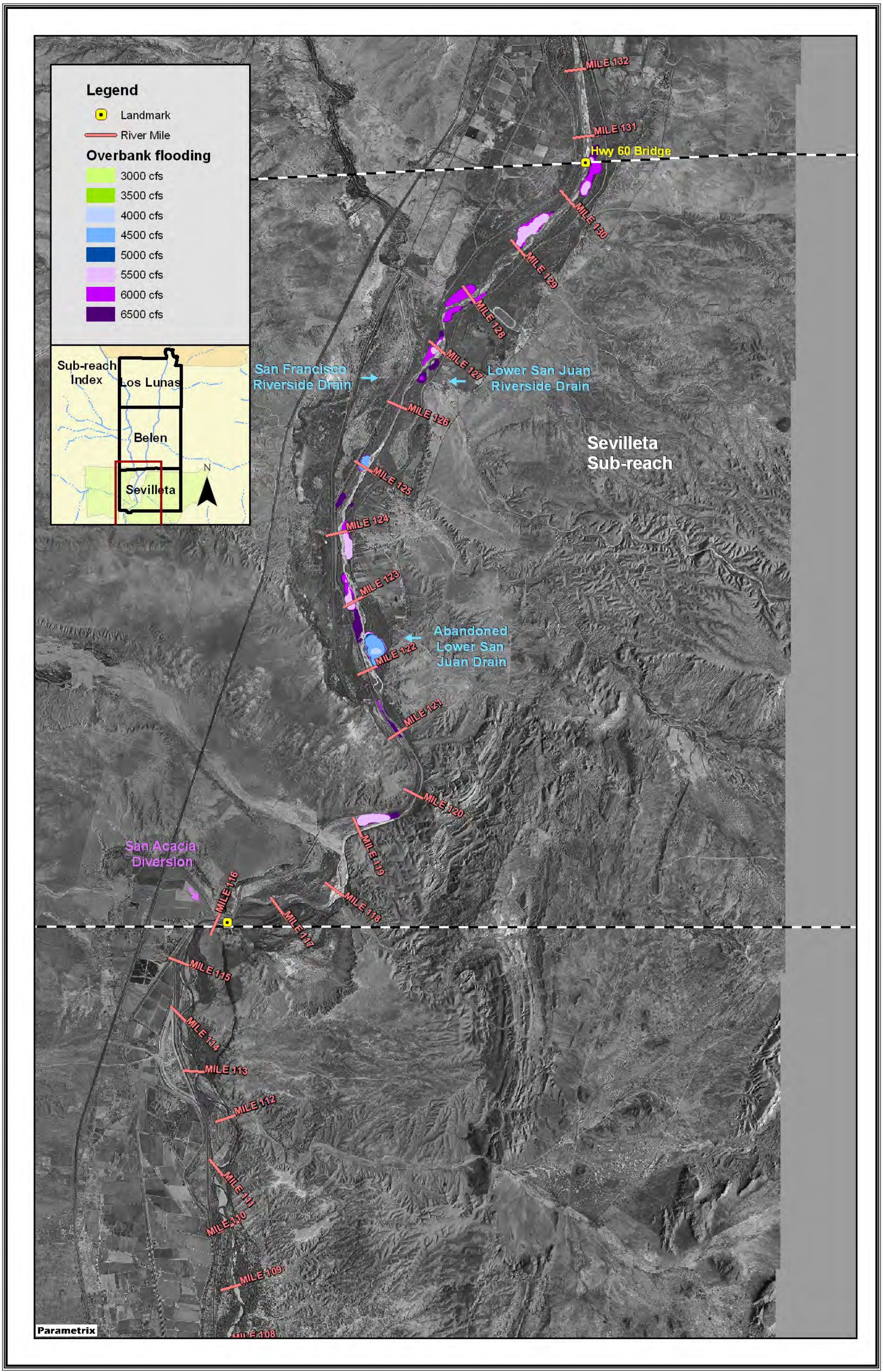


Exhibit 4-7

Floodplain Inundation and Irrigation Return Canals in the Sevilleta Sub-reach



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Downstream of Abo Arroyo, efforts to improve backwater nursery habitat availability may be more successful in the 10-mile river segment upstream of the Rio Puerco. In the channelized reach downstream of the Rio Puerco, physical restoration projects (e.g., bank destabilization, backwater channels, flow training structures, etc.) would probably be at high risk due to the potential for large summer flash flood events from both the Rio Puerco and Rio Salado.

For example, USGS (Bovee et al., in preparation) documented significant changes in the channel geometry below the Rio Salado confluence following several summer 2006 storm events (Exhibit 4-8). These storms uprooted large (>30 feet tall) cottonwood and saltcedar trees and shifted the entire meander bend nearly 50 meters to the south (K. Bovee, USGS, personal communication, 2007). While these natural disturbance events are desirable for improving aquatic and riparian habitat diversity, reaches like this that are prone to intense and unpredictable thunderstorm flood events make the outcome of restoration construction projects highly unpredictable.

Another limitation of constructing backwater restoration treatments in the channel segment between the Rio Puerco confluence and the San Acacia Diversion Dam is that the MRGCD and BOR are currently exploring the potential for constructing a siphon under the channel to provide water from the San Juan Drain outfall (eastside floodplain just below the Rio Puerco confluence, see Exhibit 4-7) to the Unit 7 Drain on the west side of the floodplain. It may be prudent, therefore, to wait until the BOR has completed their analysis of this project and the fate of the siphon project has been determined.

Exhibit 4-8

Channel Migration Downstream from Rio Salado Confluence with the Rio Grande (Bovee et al., in preparation)

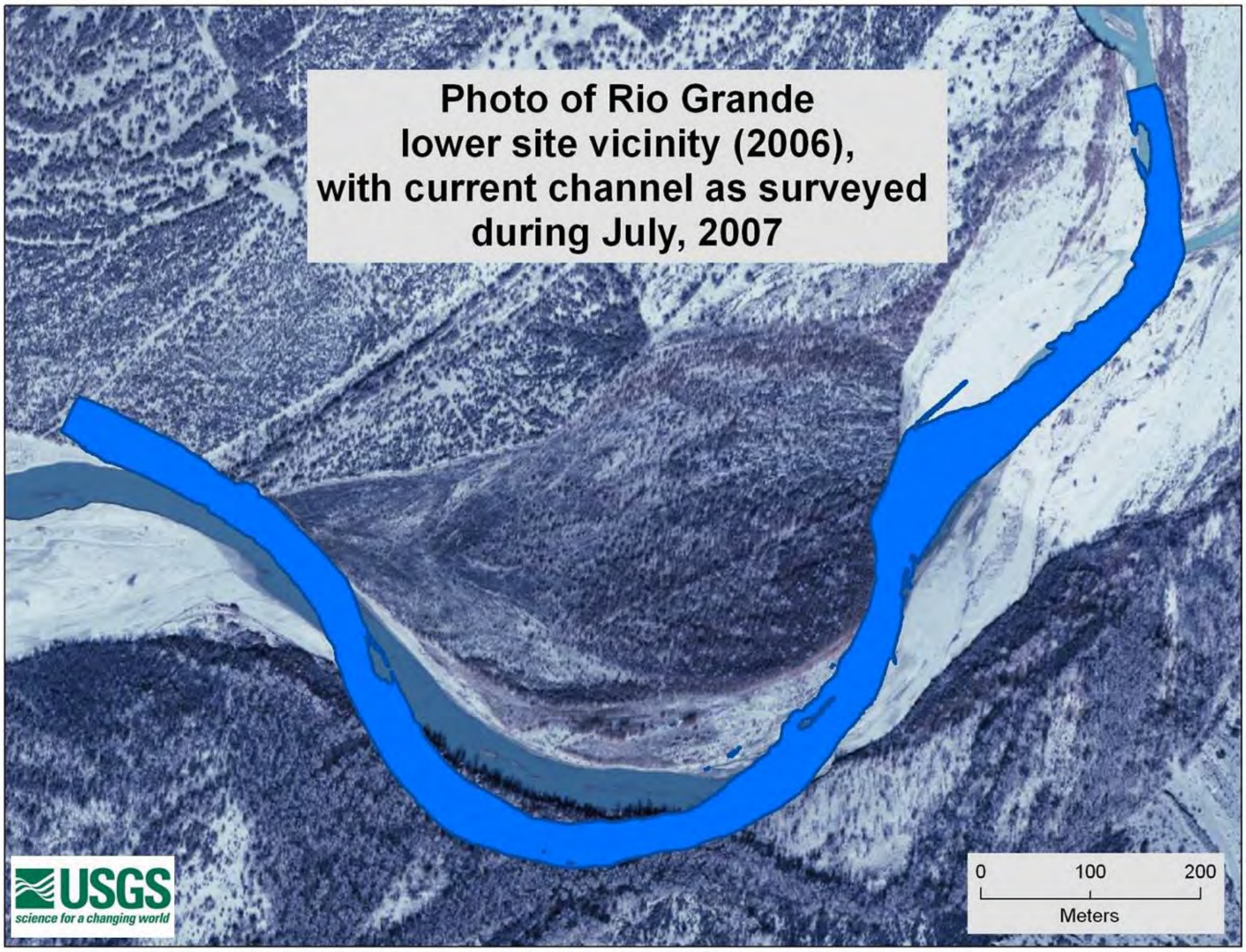


Photo courtesy of Dr. Ken Bovee, USGS, Ft. Collins, CO.

9 What nursery habitat restoration options exist along the river between Abo Arroyo and the Rio Puerco?

Upstream of the Rio Puerco confluence, one way to potentially improve silvery minnow nursery habitat would be to create backwater channel habitat. Backwater channels may be ideal nursery habitat features because flow velocities are extremely low and can effectively retain silvery minnow eggs and larvae. These channels also provide areas for adult fish seeking refuge from the high flow velocities in the river channel during high flow events.

As mentioned above, there are no irrigation wasteways, drain outfalls, or tributary channels providing backwater habitat between RM 137 and RM 127. We suggest that this 10-mile river segment is probably the most appropriate area to construct backwater channels for the benefit of silvery minnow nursery habitat. As with any recommended project presented in this report, the species benefits are proposed as hypotheses and monitoring would be required to validate that the silvery minnow are using these constructed backwaters. In Chapter 5, we identify two potential locations for these backwater channels, along with planning level cost and net depletion estimates. Monitoring and adaptive management criteria associated with these projects are described in Chapter 6.

Restoration Issues and Opportunities: Channel Drying and Silvery Minnow Refugia

10 What opportunities exist to increase silvery minnow refugia during low-flow or dry channel conditions?

“Off-Channel” Refugia Habitat

In addition to potentially providing important backwater nursery habitat during high-flow conditions, irrigation return channels may also be important sites for creating refuge habitat during periods of channel drying. Silvery minnow have been found in several studies to use irrigation drains in the Isleta Reach during times of channel drying (BOR, 2007). Given the large number of irrigation wasteways and drain returns, the Isleta Reach includes unique opportunities, relative to the other two major reaches of the MRG, to development restoration projects with significant potential to mitigate effects of channel drying on silvery minnows.

This is not a new concept. For example, the Collaborative Program’s Silvery Minnow In-channel Wetted Habitat Workgroup (2005) developed a concept paper addressing developing drains and wasteways as refuge habitat for silvery minnow during periods of channel drying. That paper stated, “Establishing such wetted habitats during periods of channel drying are viewed by the Program's technical sub-committees as viable habitat enhancements that have high potential for decreasing the threat of RGSM [sic.] extinction and increasing their recovery potentials in the MRG." That document identified eight drains and wasteways within the Isleta Reach upstream from Bernardo: Alejandro, 240, San Fernandez, Harlan, Peralta Main Canal, Lower Peralta Drain No. 1, Lower Peralta Drain No. 2, and Jarales. Of these, some regularly carry water to the river and some could be rehabilitated to allow for regular discharge to the river. Water from such discharges, working in conjunction with appropriate habitat restoration measures, could serve to create in-channel and off-channel habitats that could be maintained in a wetted condition using diversions from the irrigation system.

The water used for such projects would presumably be dedicated water purchased for this purpose. At the time of the Program concept paper, the MRGCD estimated flow requirements to maintain partial wetted conditions in the river channel using all eight of the identified drains and wasteways. They estimated discharge would equal a maximum of 54 cfs across all eight wasteways; which, if required for 100 days in a given dry year, would be about 11,000 acre-feet.

Considerably less water, however, may be required for alternative implementations of this concept. For example, instead of managing the irrigation wasteway discharges to maintain wetted areas in the river channel, an alternative approach may be to simply discharge enough water to keep the irrigation return or wasteway channels wet. Conceptually, this would involve releasing some minimal amount of water into some of the wasteways and/or return canals as the river channel begins to dry and maintain the minimal wetted condition until the river channel is re-wetted by natural flows. Program rescue and salvage personnel have observed silvery minnow to be among the first to leave a drying reach, as well as the first to enter a re-wetted reach (M. Hatch, FWS, personal communication, 2007). Thus as the river channel dries, the silvery minnow would be able to enter this wet "off-channel" refugia, and still have the ability to re-enter the channel when flows resume.

The required seepage into the drain outfalls would vary for each drain and would need to be evaluated, although the MRGCD stated that 1 to 3 cfs may be sufficient to keep them wetted (D. Gensler, MRGCD, personal communication, 2007). We are unaware of any existing channel geometry (width, depth, length) information for any of the wasteways, but this type of information would be important for determining the flow volume requirements and to design additional habitat features for enhancing refugia habitat, including protection from predators (e.g., piscivorous fish and wading birds).

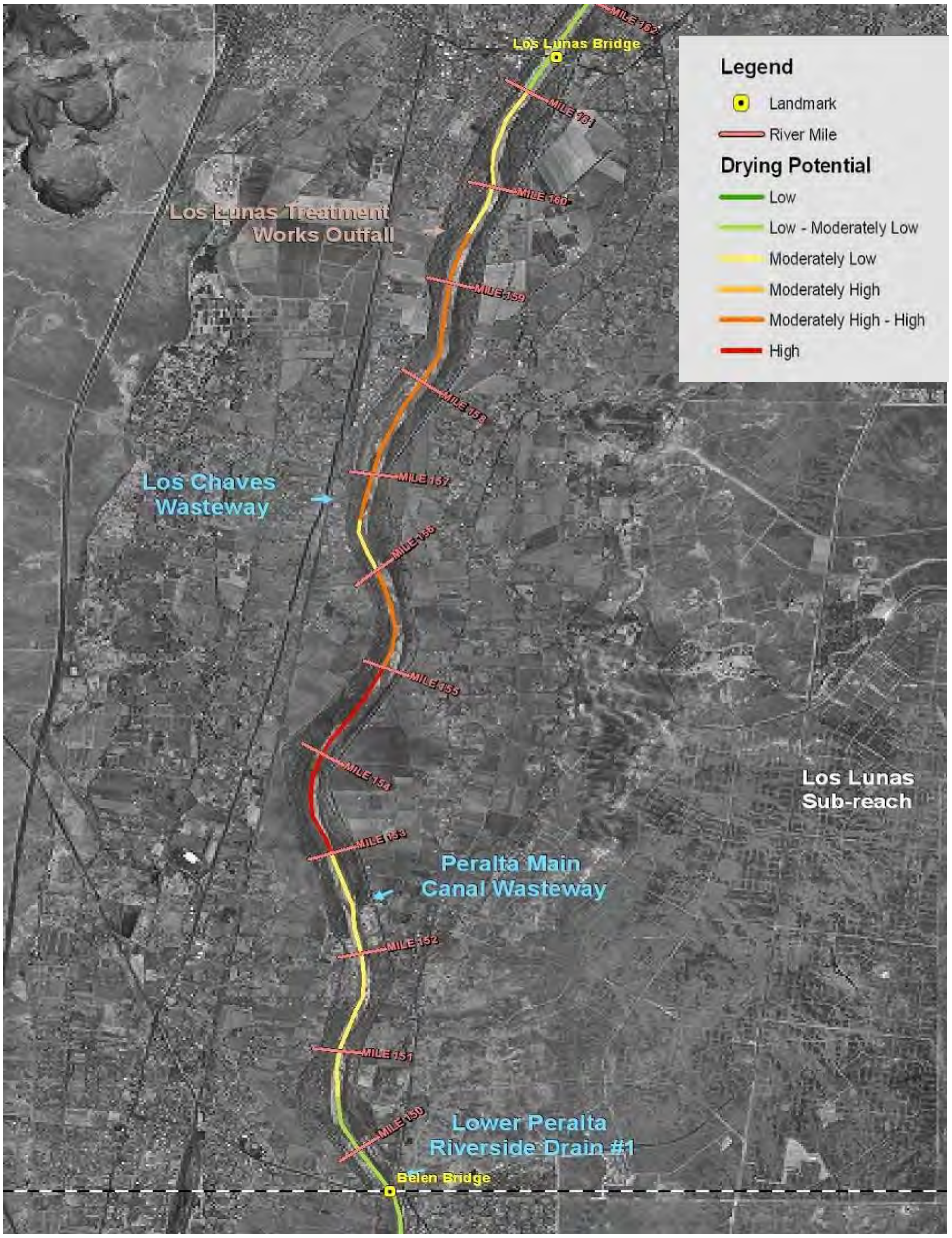
"In-Channel" Refugia

Under dry channel conditions, there are few options for creating "in-channel" refugia. One creative approach is currently being tested by MRGCD and Habitech, Inc. Their "perennial pool" projects involve anchoring large cottonwood snags to the river bank and extending them into the channel immediately upstream and downstream of a drain outfall. The intent is to create deep scour holes on the downstream side of the debris pile during high river flows. During low flows or dry periods, these scour holes kept wet by providing minimal flows (e.g., 1 to 3 cfs) from the adjacent drain outfall (BOR, 2006a).

Habitech and MRGCD are currently in the process of constructing "perennial pool" projects at three wasteway outfalls in the Isleta Reach: Los Chavez Wasteway (≈ RM 157), Peralta Wasteway (≈ RM 152.5), and the Lower Peralta Riverside Drain No. 1 (≈ RM 150). In addition, there is another perennial pool project at the 240 Wasteway on the Isleta Pueblo. The Los Chavez Wasteway is a particularly strategic location because it is within the river segment described previously that most frequently dries (Exhibit 4-9). There is currently no monitoring data available to determine if these projects function as intended.

Exhibit 4-9

Perennial Pool Project Locations in the Isleta Reach



The perennial pool projects are currently being implemented in the Los Lunas Sub-reach at the Los Chavez, Peralta Main Canal, and Lower Peralta Riverside drain outfalls shown here.

Another derivation of this approach could involve the placement of large, log flow deflectors along the channel edges, especially in channel segments with a well-defined thalweg along the bank. This technique differs slightly from the perennial pool technique described above in that it does not necessarily have to be constructed immediately downstream of an irrigation outfall. Placement would focus on reach segments that do not typically go completely dry, or that only intermittently run dry. Some existing locations that may be suitable for this treatment include RM 128 to RM 138.5, RM 150 to RM 152.5, and RM 155 to RM 160.5. In these reach segments, intermittent flows occur but the flows tend to be less severe and of short duration than others. In reach segments that tend to dry more severely and more often, silvery minnows entering scour pools may be more likely to become trapped and require rescue.

For example, when the channel dries during the day, deeper pools can serve as temporary refuge habitat for silvery minnows and other fish species. Then, as the channel re-wets overnight due to reduced evaporation rates by riparian vegetation, these temporary pools can reconnect and allow the fish to move back into and through the channel, potentially swimming to reaches with more dependable flows.

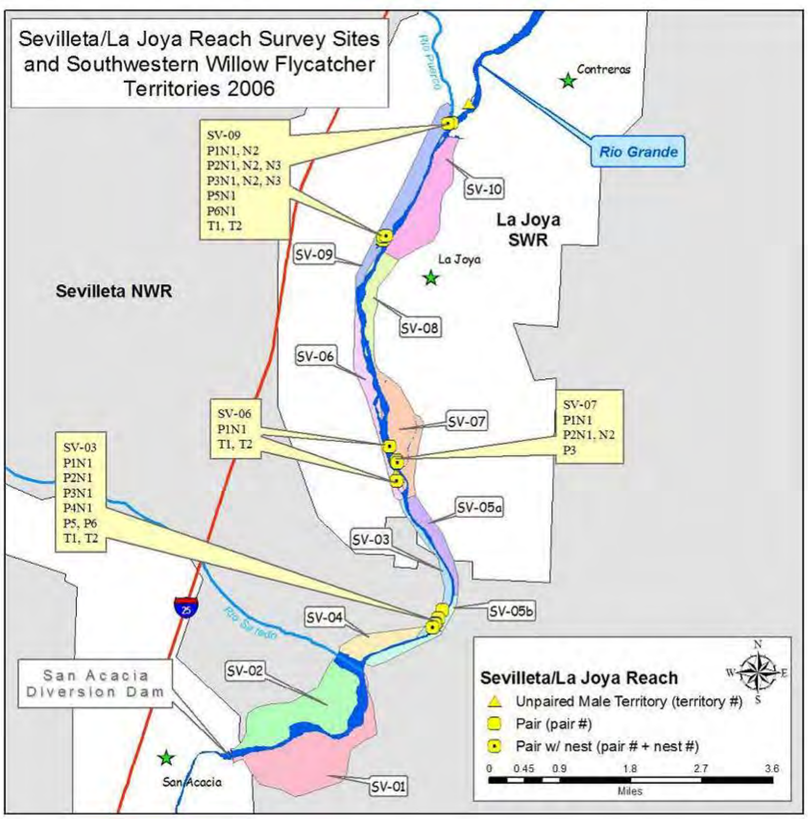
As with most other restoration techniques presented in this report, however, the utility of scour pools formed by large logs has not been fully evaluated as to their actual benefits in aiding the recovery of silvery minnows. As such, implementation of these projects should include a rigorous monitoring component to document the actual utility, and results should be used to guide adaptive management to improve future designs.

Restoration Issues and Opportunities for the Flycatcher

11 How can existing data be used to select flycatcher restoration sites in the Isleta Reach?

There are very few active flycatcher territories in the Isleta Reach. The existing territories are generally concentrated in four clusters in the Sevilleta Sub-reach between the Rio Grande confluence with the Rio Puerco and Rio Salado (Exhibit 4-10). This is somewhat perplexing because several of the key physical habitat characteristics generally associated with suitable flycatcher habitat (e.g., dense, multi-story riparian vegetation, periodic flood inundation) exists over extensive acreages of the Los Lunas and Upper Belen Sub-reaches.

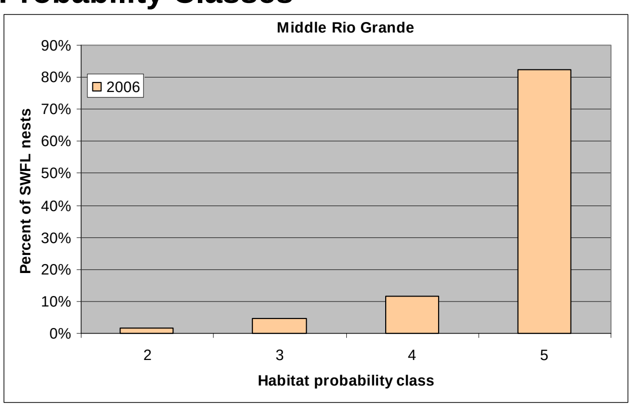
Exhibit 4-10
Flycatcher Nest Sites in the Isleta Reach (Moore and Ahlers, 2006b)



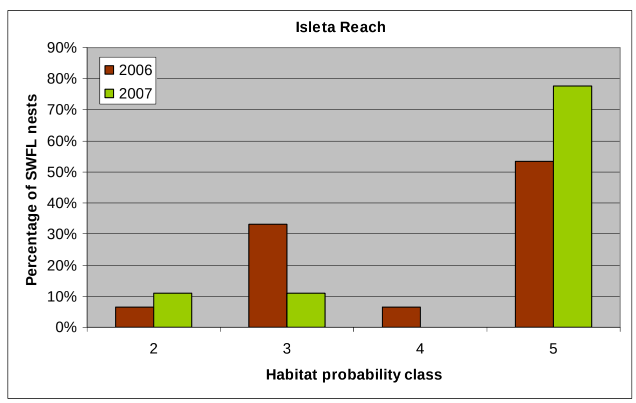
While flycatcher biologists have been working to identify and quantify critical physical habitat attributes associated with flycatcher nest sites (e.g., Smith and Johnson, 2007), there are few quantitative tools available for predicting suitable flycatcher breeding habitat over large geographic areas. One recent model, however, was developed by Hatten and Sogge (2007). They developed a GIS-based model to predict suitable breeding habitat for the flycatcher in the MRG based upon a similar model developed and tested in Arizona (Hatten and Paradzick, 2003). The models use a logistic regression equation to divide riparian vegetation into five probability classes based upon characteristics of riparian vegetation and floodplain size. Sites assigned to the highest probability class (Class 5) were predicted to support the highest density of flycatcher breeding territories. Both models, including the MRG model, performed as expected (Hatten and Sogge, 2007). The MRG model worked particularly well over the total project area, but its predictive power was variable between 2006 and 2007 for flycatcher breeding locations in the Isleta Reach (Exhibit 4-11).

Exhibit 4-11

Proportion of Flycatcher Nest Sites Occurring in Different Breeding Habitat Probability Classes



This bar chart was generated by Parametrix by comparing MRG nest locations in 2006 (data provided by R. Doster, BOR) with habitat modeling data provided by M. Sogge (USGS). The results show that >80 percent of the 2006 breeding locations were within the highest probability class.



This bar chart was generated by Parametrix by comparing 2006 and 2007 nest locations in the Isleta Reach (data provided by R. Doster, BOR) with habitat modeling data provided by M. Sogge (USGS). The results show a higher proportion of nests in 2006 occurred in areas the model considered lower probability breeding habitat (Probability Class 3). It also shows that nest numbers declined in the "less suitable" sites (Probability Class 3) and increased in the "more suitable sites" (Probability Class 5) in 2007.

The Hatten and Sogge (2007) model indicates 1,944 acres (23.7 percent of the total floodplain area) of high probability breeding habitat (Probability Class 5) exists in the Isleta Reach (Exhibit 4-12). It is important to note, however, that most of the areas designated as high probability flycatcher breeding habitats in the Isleta Reach contain no active flycatcher territories. In particular, there are extensive areas in the Los Lunas and upper Belen Sub-reaches assigned to Probability Class 5 that do not currently contain known breeding territories (Exhibits 4-14 through 4-16). This should not be surprising because the model is intentionally coarse and does not consider other important breeding site attributes like plant species composition and flood inundation potential. As such, we suspect that it may grossly over-estimate the extent of "highly-suitable" flycatcher habitat in the Isleta Reach. Their model would be considerably more powerful if it also incorporated other key attributes, particularly metrics that quantify surface water inundation, inundation frequency, and groundwater depth, particularly during the nest establishment period (May/June).

Exhibit 4-12

Acreage of Flycatcher Habitat Probability Class (Hatten and Sogge 2007)

Probability Class (5 is the highest probability)	Total Area (acres)	Percent of Total Floodplain Area (minus active channel)
5	1,944	23.7%
4	1,147	14.0%
3	1,057	12.9%
2	1,001	12.2%
1	3,058	37.3%

To get some sense of how much the Hatten and Sogge (2007) acreage estimates might change if flood inundation potential were considered, we used GIS outputs from the 2008 FLO-2D model to evaluate the flow volumes required to inundate sites in Probability Classes 4 and 5. The results indicate that the acreage of Probability Class 5 dropped by 40 percent from 1,944 acres (see Exhibit 4-12) to 1,166 acres (see bottom half of Exhibit 4-13). Similar results were found for Probability Class 4 (see top half of Exhibit 4-13). This relationship between the Hatten and Sogge (2007) model and flood inundation should be considered cursory, and more work is needed to get a better understanding of the hydrologic attributes of these sites. While this cursory exploration may help to narrow down the areas of high probability breeding habitat in the reach, there is still a large discrepancy between predicted versus actual breeding territories in the Isleta reach.

Exhibit 4-13

Estimates of Acreage Inundation for Hatten and Sogge (2007) Probability Classes 4 and 5

Probability Class 4

Flow (cfs)	Los Lunas (ac)	Belen (ac)	Sevilleta (ac)	Grand Total (ac)
less than 5,000	46.6	61.8	11.8	120.2
5,000	55.5	63.6	1.1	120.3
5,500	45.3	73.0	18.1	136.4
6,000	21.4	39.1	21.0	81.6
6,500	48.6	11.8	14.1	74.5
Total Acreage	**217.5**	**249.3**	**66.2**	**533.0**

Probability Class 5

Flow (cfs)	Los Lunas (ac)	Belen (ac)	Sevilleta (ac)	Grand Total (ac)
less than 5,000	98.9	169.0	36.1	304.0
5,000	80.6	161.4	7.1	249.1
5,500	68.3	207.7	45.0	321.0
6,000	33.1	99.2	51.8	184.1
6,500	54.2	18.9	34.7	107.7
Total Acreage	**335.2**	**656.1**	**174.7**	**1,166.0**

Table outputs were generated by overlaying FLO-2D model results with GIS data from Hatten and Sogge (2007). Both data-sets are included in the geo-database that accompanies this report.

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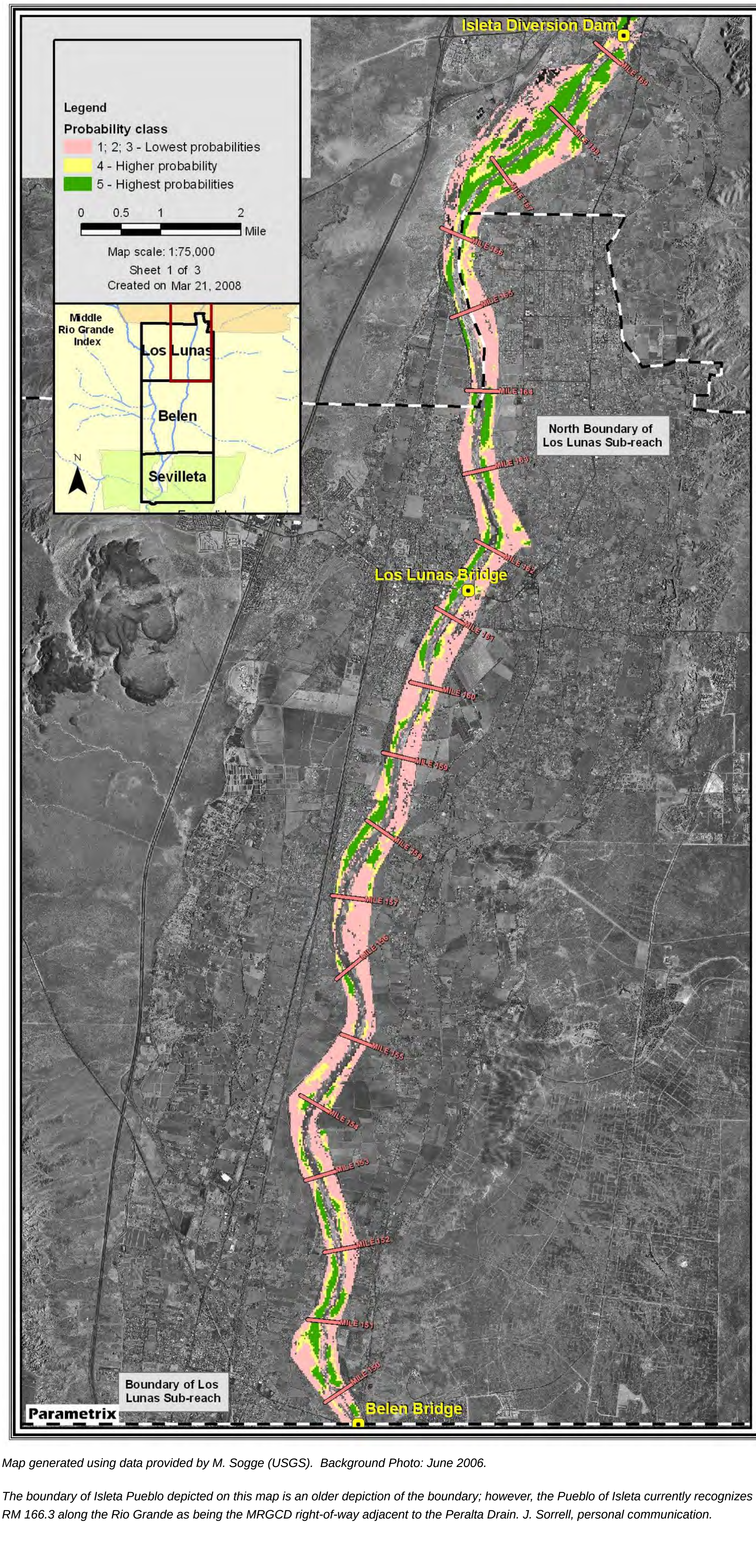
Exhibit 4-14

Flycatcher Breeding Habitat Probability Class Distribution in the Los Lunas Sub-reach (based upon data from Hatten and Sogge [2007])

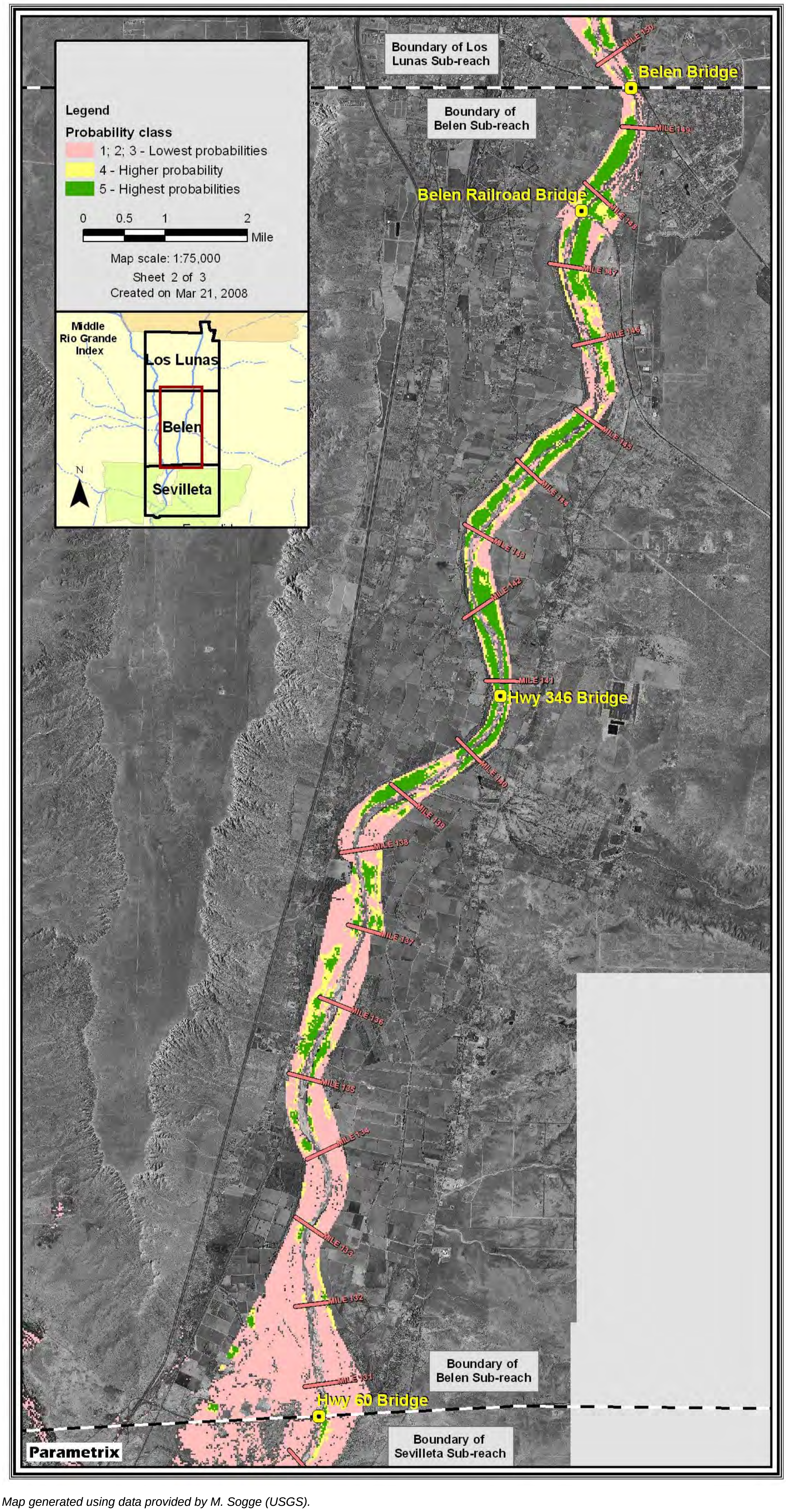


Map generated using data provided by M. Sogge (USGS). Background Photo: June 2006.

The boundary of Isleta Pueblo depicted on this map is an older depiction of the boundary; however, the Pueblo of Isleta currently recognizes the eastern boundary between RM 163.7 and RM 166.3 along the Rio Grande as being the MRGCD right-of-way adjacent to the Peralta Drain. J. Sorrell, personal communication.

Exhibit 4-15

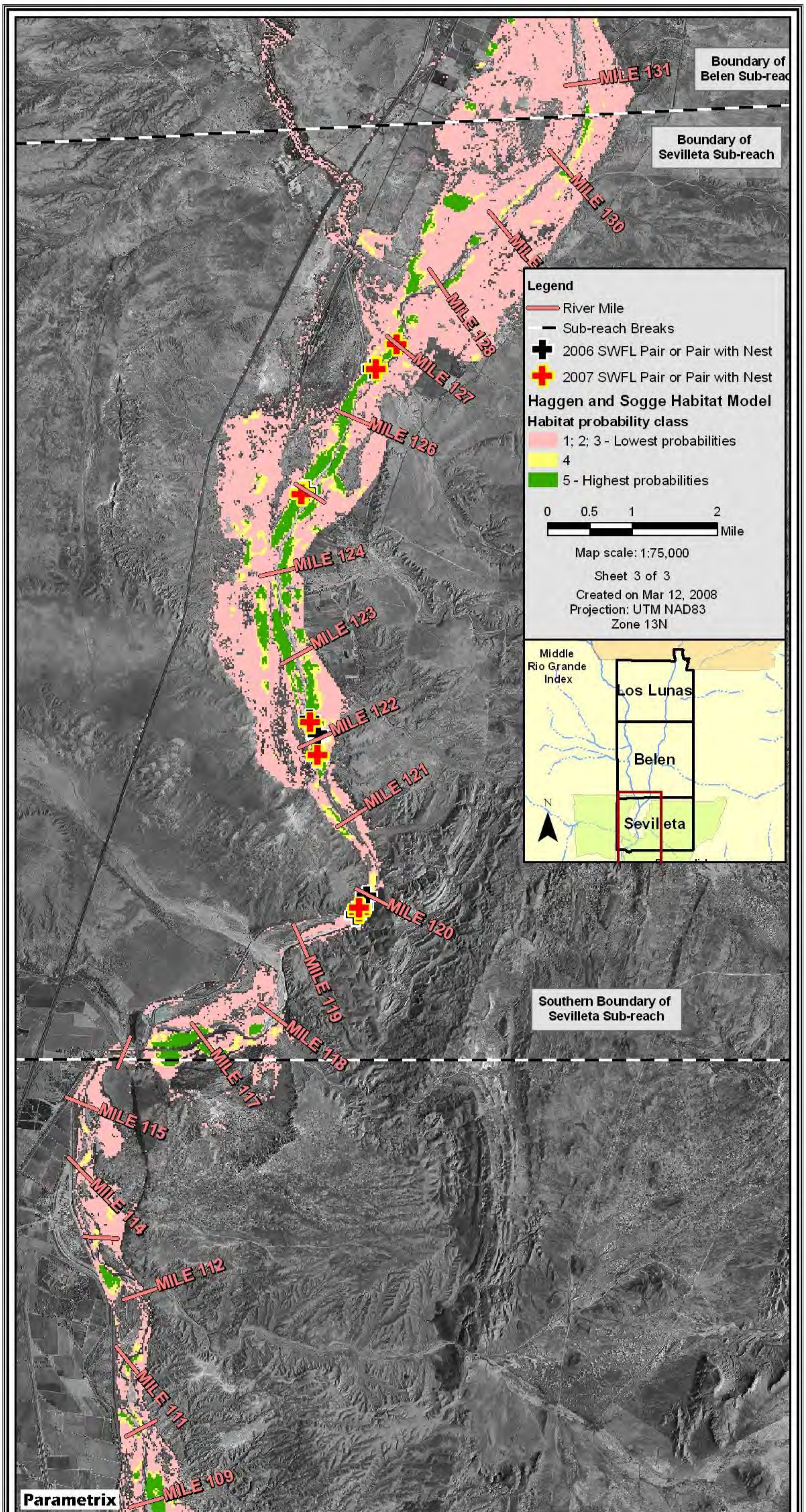
Flycatcher Breeding Habitat Probability Class Distribution in the Belen Sub-reach (based upon data from Hatten and Sogge [2007])



Map generated using data provided by M. Sogge (USGS).

Exhibit 4-16

Flycatcher Breeding Habitat Probability Class Distribution in the Sevilleta Sub-reach (based upon data from Hatten and Sogge [2007])



Map generated using data provided by M. Sogge (USGS).

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12 Why aren't flycatchers nesting in potential breeding habitat in the Los Lunas and Belen Sub-reaches?

We can only surmise why flycatchers are not breeding in the upper and middle Isleta Sub-reaches. One hypothesis is that, even though the sub-reaches support appropriate vegetation densities and structure, soils may not be saturated or inundated frequently enough to be highly desirable by territorial flycatchers. While it is true that extensive acreages in these sub-reaches become inundated at flows greater than 5,000 cfs, these flows have only been achieved twice in the past decade (2005 and 2008).

Smith and Johnson (2007), for example, found that breeding flycatchers at Isleta Pueblo abandoned their historic nest sites once the sites became too dry. The flycatchers instead opted to nest in adjacent vegetation patches with saturated or inundated soil conditions. The nesting territories at Isleta Pueblo are commonly wetted, both through overbank inundation and through drain water released from the Alejandro wasteway (J. Sorrell, Pueblo of Isleta, personal communication, 2007).

The seasonally saturated soil conditions at the Isleta Pueblo breeding territories have created dense stands of coyote willow with a discontinuous overstory canopy containing both cottonwood and Goodding's willow (Smith and Johnson, 2007). This vegetation type is relatively uncommon in the floodplain in the Isleta Reach. For example, the vegetation data presented in Chapter 2 showed an approximate 50 percent decline in coyote willow in the Isleta Reach between 1984 and 2002. There are also very few sites with Goodding's willow (tree willow) as a dominant component of the vegetation community (see Chapter 2, Exhibit 2-27). These species are indicators of frequent flooding and relatively shallow groundwater tables (Parametrix 2008). Since more than 80 percent of MRG breeding flycatchers nest in willow-dominated habitats (see Chapter 3), the importance of restoring hydrologic conditions that foster establishment and growth of dense willow habitat appears critical for expanding flycatcher-breeding habitat in the Isleta Reach.

It is hard to imagine, however, that there are not at least a few patches of habitat within the Los Lunas and/or Belen Sub-reaches with both these vegetation characteristics and hydrologic conditions. Assuming this to be the case, another possible reason that flycatchers are not using patches of suitable breeding habitat in the Los Lunas and Belen Sub-reaches is that these sites may be too far from existing flycatcher territories. For example, flycatchers tend to return to the same general nesting locations each year (i.e., strong nest-site fidelity). Also, flycatchers tend to be gregarious breeders; that is, where flycatchers already nest, more flycatchers will tend to nest (D. Ahlers, BOR, personal communication, 2007). Thus, flycatchers may be more likely to expand relatively short distances from existing territories, rather than establish nests in habitats deemed "highly suitable" several miles away.

This has important implications for selecting flycatcher restoration sites. We believe it indicates that restoration success potential may be far greater if projects focus on improving breeding habitat characteristics to sites in relatively close proximity to existing territories. We hypothesize that flycatcher habitat restoration projects implemented in relatively close proximity to existing territories have a greater probability of success than similar projects constructed several miles away from existing territories. Any such restoration projects should focus on developing conditions that promote formation and sustenance of dense willow stands with seasonally saturated soils and close proximity to low velocity, open water.

Issues and Opportunities: Using Managed Flows to Maximize Biological Benefits for the Silvery Minnow and Willow Flycatcher

13 In years when the snowmelt runoff is sufficient, how can the available science be used to help water managers maximize the biological benefits of a managed hydrograph?

Given the climate forecasts of reduced average mountain snow pack over time, it becomes especially important to maximize the biological benefits of managed hydrographs when adequate snowmelt runoff is available. Current pressing demands on water use and the continuing alteration of watersheds require scientists to help develop management protocols that can accommodate economic uses while protecting ecosystem functions (Poff et al., 1997). This report section is intended to foster dialogue between water management agencies and scientists involved with the Program regarding how alternative hydrograph management could maximize biological benefits using available scientific data. Here we discuss some of the available science relating hydrology to biological needs of the silvery minnow and the creation of native dominated, suitable flycatcher habitat. Later in this section, we also discuss some of the legal and physical issues currently limiting water management flexibility. The purpose of this discussion is not to solve these issues, but to raise the topics and facilitate discussion and operational planning in advance of “good” water years.

14 What are the potential benefits of managed flows for restoring silvery minnow populations?

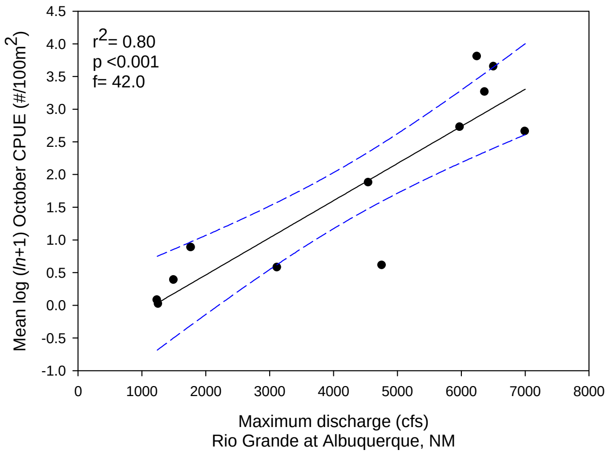
Data recently published by Dudley and Platania (2007c) and Liccione (2007) shows a strong statistical relationship between several hydrologic parameters and silvery minnow population monitoring results. Their studies compared mean October catch rates (catch per unit effort) across all Middle Rio Grande population monitoring sites between Bernalillo and Elephant Butte Reservoir (n = 20) to peak snowmelt discharge recorded at the Albuquerque Gage between 1993 and 2005 (Exhibit 4-17a and b). October catch rates are generally the most appropriate for this comparison because a rapid decline in population is typically observed following silvery minnow spawning and recruitment from May to September (Liccione, 2007).

In addition, the October sampling numbers provide a good estimate of summer survival (particularly important during years of low flows) and indicate the number of silvery minnows likely to overwinter and spawn in the spring. There are generally only modest changes in mean catch per unit effort (CPUE) from October to May of the following year. Moreover, October conditions on the river are characterized by relatively stable flows, which are important for consistent sampling efficiency (Liccione, 2007).

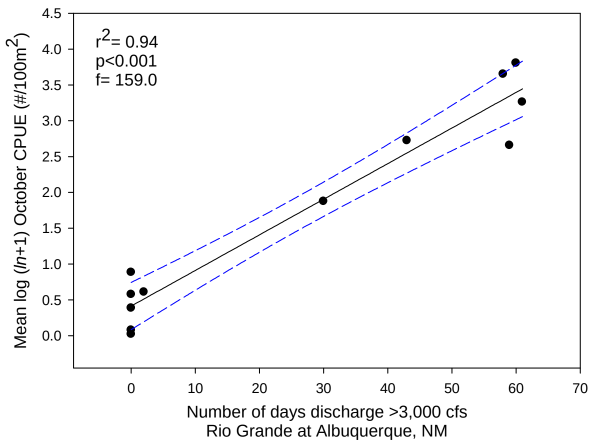
Regression analyses of October catch rates of silvery minnow revealed significant relationships with several hydraulic variables. Dudley and Platania (2007c) and Liccione (2007) both reported that October catch rates increased significantly with maximum discharge (Exhibit 4-17a) and all combinations of number of days with discharge exceeding a threshold value at the Albuquerque Gage. The relationship that explained the most variation (94 percent) in mean catch rate was number of days with discharge greater than 3,000 cfs (Exhibit 4-17b).

Exhibit 4-17a and b

Relationship Between October Silvery Minnow Catch Rates for All MRG Sampling Sites and Hydrologic Variables at the Albuquerque Gage (Liccione, 2007)



a. *From Liccione, 2007. This graph displays annual mean CPUE for silvery minnow from all MRG sampling locations in relation to peak May/June discharge at the Albuquerque Gage (1993–1997, 1999–2005).*



b. *From Liccione, 2007. This graph displays annual mean CPUE for silvery minnow from all MRG sampling locations in relation to number of days discharge exceeded 3,000 cfs at the Albuquerque Gage (1993–1997, 1999–2005).*

Dudley and Platania (2007c) conclude that these data indicate "…the physical conditions produced by prolonged and elevated flows result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline and island backwaters" (p. 48). This conclusion is supported in the scientific literature, as many fish species synchronize their reproduction with flooding, thus allowing the fish to take advantage of low-velocity habitats created through overbank flooding and lateral river expansion (Coutant, 2004; Lytle and Poff, 2004). Nursery habitats for silvery minnow (and other native MRG fishes) include backwaters, isolated pools, flooded vegetation, disconnected side channels, side channel margins, and main channel margins (Pease et al., 2006). As described previously, Pease et al. (2006) cite a few reasons why these flooded habitats are thought to provide important nursery grounds, including:

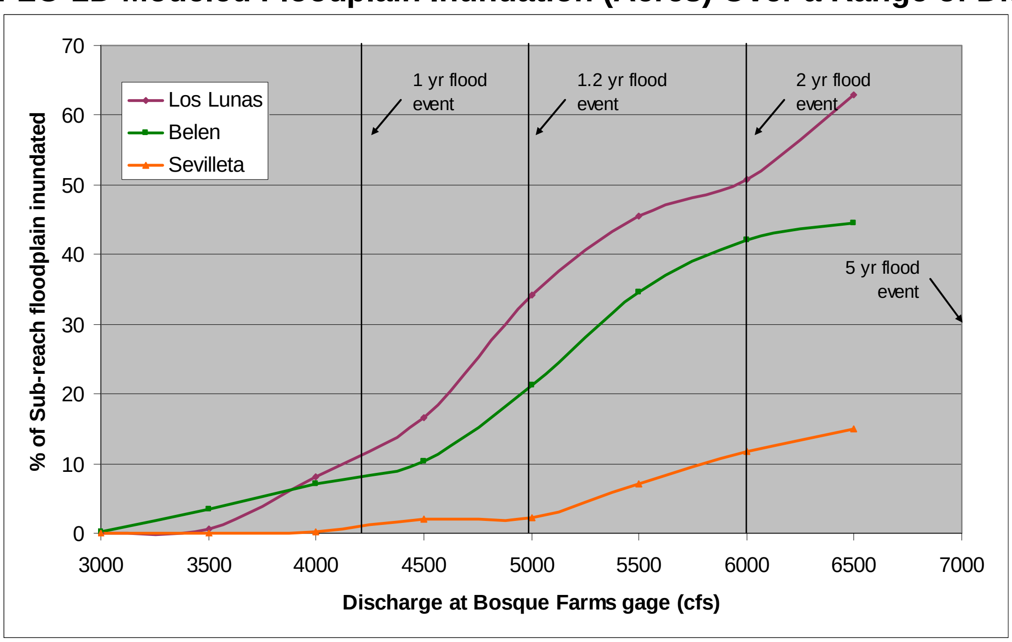
- Water velocities are reduced in these habitats, so eggs, larvae, and juvenile fish may avoid downstream displacement;

- Water temperatures are generally higher and food production is higher in the presence of inundated riparian vegetation and other organic and inorganic material (i.e., invertebrates, detritus, algae, etc.), and;
- Inundated floodplains provide more complex habitat and structural refugia than the main river channel.

As reported in Chapter 2, relatively large portions of the Los Lunas and Belen Sub-reaches are inundated when flows exceed 5,000 cfs (Exhibit 4-18). Conversely, few areas in the Sevilleta Sub-reach achieve floodplain inundation at discharges less than 6,500 cfs. Our FLO-2D model analysis does not include inundated islands or other inundated habitats within the active channel, so it is difficult for us to evaluate nursery habitat availability within the active channel at different flow volumes. Nonetheless, given the statistical relationships shown in Exhibit 4-17a and b, it appears that in years with adequate snowmelt runoff, maximizing the May to June peak discharge at the Albuquerque Gage and extending the number of days peak discharge exceeds 3,000 cfs has potential to increase silvery minnow populations in the Isleta Reach.

Exhibit 4-18

FLO-2D Modeled Floodplain Inundation (Acres) Over a Range of Discharges



15 Could flows that benefit silvery minnow recruitment also prevent seedling vegetation from encroaching into the active channel?

As discussed previously in this chapter, authors of the *Conceptual Restoration Plan for the Active Floodplain of the Rio Grande, San Acacia to San Marcial* (Tetra Tech, 2004b) hypothesize that the 2-year flow should be sufficient to scour first-year, and possibly second-year, woody riparian seedlings from the active channel. They also hypothesize that these flows would need to be sustained for at least 5 to 6 days, and occur at least once in a 3-year period to prevent seedling encroachment and maintain an active channel. Although these hypotheses have not been tested in the field, we believe that defined parameters like these are helpful for designing field experiments to evaluate whether managed flows could effectively address the on-going issue of channel vegetation encroachment.

16 What is the scientific basis for the hypothesis that the 2-year discharge could effectively scour encroaching seedlings and provide "channel maintenance" functions?

Channel forming flows are related to bed material mobility, maximizing sediment transport (effective discharge), or bank-full discharge. Channel forming flow may be defined as the flow at which the bed material is mobilized and the banks begin to erode. Wolman and Miller (1960) emphasized that the channel shape is affected by a range of flows, not just a single peak discharge; and therefore, the importance of destructive large flood events can be overstated. Bank-full discharge is defined as the flow that fills the channel without overtopping the banks and it is often considered as the dominant or channel forming discharge for alluvial rivers (Richards, 1982). The channel forming discharge is assigned a flow frequency that is in the range of the bank-full discharge return period, usually between 2 and 5 years (Richards, 1982).

Channel forming flows in the range of the bank-full discharge vary throughout the Isleta Reach. Bank-full discharge has a higher magnitude and is less frequent in the Sevilleta Sub-reach than the upper sub-reaches. In the upper sub-reaches, bank-full discharge has a return period that is less than 2 years based on post-Cochiti flows. For the post-Cochiti period from 1974 to 2002, the 2-year flood at Albuquerque is approximately 6,000 cfs (USACE, 2006). The peak and annual duration discharges in this range have decreased over the past several years, encouraging channel narrowing.

The authors of the Save our Bosque Task Force (SOBTF) report (Tetra Tech, 2004b) suggest that maintaining an active channel with diverse aquatic habitat requires that flows approach the channel forming flows on a sufficiently frequent basis to promote bank erosion and diverse channel bed-forms, and eliminate vegetation encroachment within the active channel. They generally suggest that channel forming discharge should ideally occur at least once every 3 years to avoid channel narrowing associated with (woody) seedling vegetation encroachment.

17 What are some important hydrograph management considerations for restoring suitable flycatcher habitat dominated by native riparian vegetation?

The Recovery Plan for the Southwestern willow flycatcher advocates for management agencies to restore, whenever possible, key riverine functions and processes as a first step in improving suitable flycatcher habitat (FWS, 2002). The BOR developed a flycatcher habitat suitability model in 1998 that defines *Highly Suitable Native Riparian Habitat* as stands dominated by willow and cottonwood, having adequate structure with a dense understory, and within 100 meters of water (Tetra Tech, 2004a). While aspects of this model are being refined (R. Doster, BOR, personal communication, 2008), data presented in Chapter 3 demonstrates that most (80 percent) of flycatcher nests in the MRG are in habitats

The Program's Long-Term Plan encourages the *adaptive management* of river flows to benefit the listed species (see Appendix A in ESACP, 2006a).

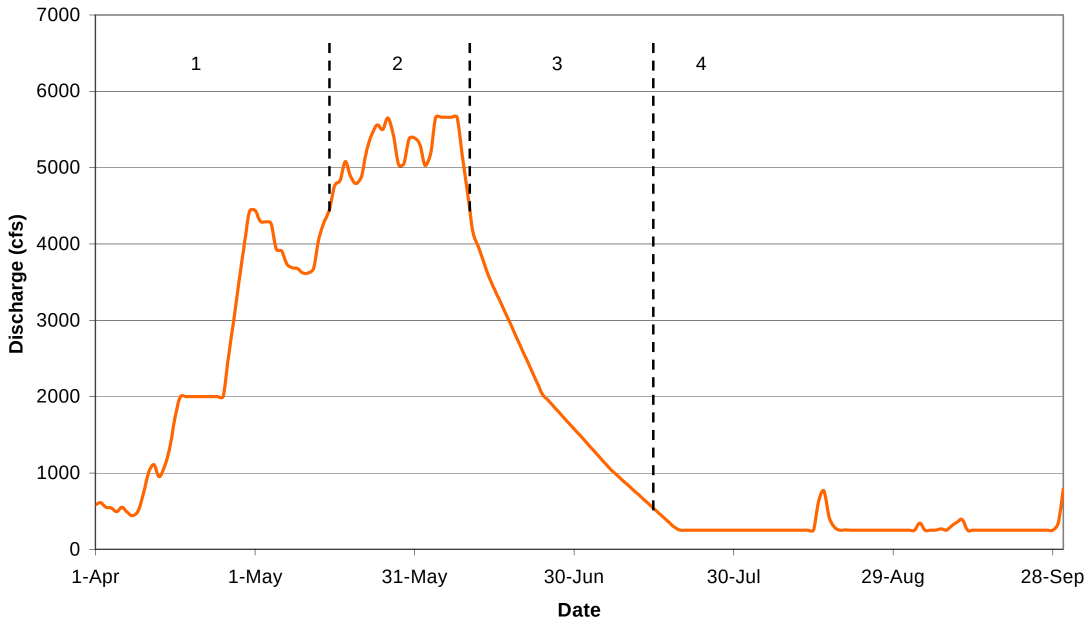
dominated by Goodding's and coyote willow. Unfortunately, these habitats are exceedingly uncommon in the Isleta Reach.

There is an increasingly large body of published information regarding the hydro-ecological processes required for native willow and cottonwood establishment (e.g., Amlin and Rood, 2002; Horton and Clark, 2001; Johnson 2000; Karrenberg et al., 2002; Lite and Stromberg, 2005; Mahoney and Rood, 1998; Scott et al., 1993; Shafroth et al., 1998; Stromberg, 1993; Stella, 2006; Taylor et al., 1998). These and other publications provide useful information that can be used to guide managed flow prescriptions to maximize native riparian species establishment.

Scott et al. (1993), Mahoney and Rood (1998), and Stella (2006) provide particularly useful guidelines for developing snowmelt hydrograph prescriptions for native willow and cottonwood establishment. For example, Scott et al. (1993) divided a conceptual snowmelt hydrograph into distinct segments to highlight the role and relative importance of each segment to riparian seedling establishment and survival (Exhibit 4-19).

Exhibit 4-19

Conceptual Seedling Recruitment Hydrograph



Segment 1 of the conceptual "seedling recruitment hydrograph" represents the rising river stage associated with snowmelt runoff. This segment of the hydrograph plays an insignificant role in the successful regeneration of cottonwood and willow species (Scott et al., 1993). Therefore, there is no preconceived pattern that needs to be followed for seedling recruitment purposes.

Segment 2 of the hydrograph represents the peak flow which must be timed with seed dispersal of desired riparian plant species, which for the MRG is primarily Goodding's and coyote willow. For these species, peak seed dispersal near Albuquerque in most years is probably around mid-May, although we are aware of no published data that evaluates seed dispersal timing in specific MRG reach segments. Segment 2 of the hydrograph is critical for wetting the floodplain surface and recharging the alluvial groundwater table. In natural systems, this peak is also critical for scouring existing vegetation and preparing new seedbeds. Releases from Cochiti Dam are currently constrained to 7,000 cfs by channel capacity and levee conditions. These discharges are below the flow magnitude required to achieve this scouring function for current vegetative conditions, so the floodplain surface needs to be prepared for seedling germination by mechanically clearing vegetation and debris from proposed recruitment sites.

Hydrograph Descending Limb

To survive, these seedlings must maintain contact with moist soil or the seedlings will desiccate and die. Consequently, the river stage must decline at a rate that allows the seedling roots to maintain contact with the capillary fringe. The acceptable stage decline rate for Segment 3 is ultimately dictated by the drainage characteristics of the alluvium at the restoration site.

Segment 3 represents the descending limb of the hydrograph. The shape and slope of this descending limb is critical for seedling establishment and is as important as the timing and magnitude of the flood peak. As river discharge declines and water levels gradually recede, seeds are deposited on moist, freshly exposed alluvium where the seeds germinate rapidly. To survive, these seedlings must maintain contact with moist soil or they will desiccate and die. Consequently, the river stage must decline at a rate that allows the seedling roots to maintain contact with the moist soil zone (i.e., capillary fringe) that follows the receding groundwater table to depths generally associated with surface water base-flow in the channel.

Note in Exhibit 4-17a and b that the descending limb of the conceptual hydrograph may drop rapidly at first, but once discharge approximates bank-full elevations, the decline ideally slows down to a rate of approximately 1 inch/day (2.5 cm/day) (per Mahoney and Rood, 1998). The acceptable stage decline rate for Segment 3 is ultimately dictated by the drainage characteristics of the alluvium and the maximum depth to groundwater at a restoration site. This type of information would need to be collected at any proposed restoration site to calibrate this segment of a managed hydrograph if the management goal is to maximize riparian seedling establishment.

It is important to clarify that we are not proposing that this type of hydrograph management is plausible or even necessary in below average, or even some average, water years. Rather, we are attempting to provide some ecological guidelines to the Program to maximize restoration success of flycatcher habitat restoration in years when the water could be available.

Segment 4 of the seedling recruitment hydrograph represents summer base flow conditions. Management of this segment is critical for maintaining seedling root access to moist soil throughout the growing season. Scott et al. (1993) have suggested the maximum groundwater depth during low-flow conditions should not exceed approximately 5 feet (1.5 meters). This depth, however, is ultimately determined by the rate of seedling root growth and the stratigraphy of the alluvium and its influence on the capillary rise of groundwater into the floodplain soil profile. Sites that commonly flood in the Los Lunas and Belen Sub-reaches may be appropriate sites for implementing experimental flows for facilitating riparian seedling recruitment. Recent burn areas in need of aggressive restoration (e.g., the 2006 “Belen Burn”) may be particularly well suited.

We want the reader to understand that to work at any potential location on the MRG, considerable site-specific data would need to be collected to calibrate the various hydrograph segments to maximize the potential for restoring suitable, native dominated flycatcher habitat. Until such data is collected and analyzed, it is not possible to determine how feasible this might be on the Middle Rio Grande. We also want the reader to understand that we are not advocating that this type of hydrograph is plausible or even necessary in below average, or even some average, water years. Rather, our intention is to provide some ecological guidelines to the Program for

The development of potential flycatcher habitat can be achieved by means other than promoting germination and seedling establishment by manipulating water management of the Rio Grande. This was discussed under question 12 above, but should be reiterated. Physical manipulation of site conditions at restoration project construction sites are yet another mechanism to create flycatcher habitat.

evaluating opportunities, when adequate flows are available, to improve flow management and flycatcher habitat availability in the Isleta Reach.

18 What water year conditions are needed for experimental hydrographs designed to benefit the silvery minnow and/or flycatcher?

The information presented previously indicates that on a "good" water year, silvery minnow and flycatcher restoration efforts might yield greater results by using biological parameters to guide experimental hydrograph management. For these examples, a "good" water year theoretically includes years of average to above average water supply. The operation of Corps of Engineers reservoirs of the Middle Rio Grande Project (Jemez, Abiquiu, and Cochiti) for flood control purposes has altered the peak and shape characteristics of the natural hydrograph. Ideally, these facilities could be utilized to satisfy some of the hydrograph characteristics presented earlier to enhance silvery minnow recruitment; riparian seedling recruitment; and potentially, scouring seedling vegetation encroaching into the active channel.

The best opportunity to implement various restoration hydrographs would probably be during those years when inflow requires the Corps' reservoirs to begin flood control operation. Flood control operations may be anticipated when the runoff forecasts indicate average monthly flow of the Rio Grande at Otowi Bridge in excess of about 5,000 cfs during the months of May or June. We suggest, however, that the more appropriate approach to determining water volume requirements is to first develop hypotheses, then evaluate what the water volume requirements might entail.

For example, the data presented earlier showed a strong statistical relationship between flow attributes and October silvery minnow catch rates. These data can be used to develop hypotheses about biologically beneficial flow management requirements. One hypothesis includes:

> *Managed flows that achieve a peak snowmelt discharge of 5,000 cfs at the Albuquerque Gage, and maintain flows above 3,000 cfs for the next 25 days, will result in significantly higher October silvery minnow catch rates than in comparable water years where these criteria were not met.*

We further hypothesize that this flow prescription would have the added benefit of scouring first year (and possibly second year) woody riparian seedlings from active channel bars. We recommend these hypotheses be used to evaluate water-year requirements and potential operational issues associated with implementing these flows, including impacts on river maintenance requirements. Having this information in advance of water years that can satisfy the flow requirements would give the Program time to develop a statistically rigorous monitoring approach to validating the hypothesis, to address any environmental or Rio Grande Compact compliance issues, and to develop adaptive management procedures to guide next steps.

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Chapter 5 Recommended Restoration Projects

Restoration Approach

The restoration projects presented in this chapter build on the knowledge of the physical conditions and biological needs of the silvery minnow and flycatcher described in previous report chapters. The restoration projects described below should be considered conceptual due to relatively limited site-specific data available at this time. Each proposed project description includes a list of additional site-specific data needed to bring the projects to a more detailed design level. Further project refinement includes fine-tuning project cost estimates and refining net-depletions analyses.

The restoration projects presented below address some of the key issues and opportunities presented in Chapter 4 for enhancing aquatic and riparian habitat for the silvery minnow and the flycatcher. Proposed projects were selected to function under variable hydrologic conditions (i.e., dry, average, and wet years), and all will require varying levels of adaptive management to be sustained over the long term. Projects aimed at enhancing irrigation return channels and wasteways to provide “off-channel” refugia during channel drying are not included in this chapter because there is currently insufficient data available to support preliminary restoration design. These projects, therefore, are addressed in Chapter 6 under the section titled “Data Gaps.”

All of the restoration projects presented in this chapter can be implemented without specialized flow management. However, we believe the Program would benefit from evaluating various flow management scenarios so that passive restoration options could be ready to execute in years with adequate snowmelt runoff. In Chapter 4, we presented biological data and hypotheses that can be used or refined by the Program to design, implement, and test hydrograph modifications to achieve various restoration objectives. Water requirements and operational constraints will have to be evaluated before passive restoration approaches like hydrograph modifications are ready to be implemented. Additional discussion of data gaps and research needs associated with these concepts are discussed in Chapter 6.

1 What restoration techniques are recommended for the Isleta Reach?

Altered hydrology in the Isleta Reach is the primary cause for habitat degradation for the silvery minnow and flycatcher. For example, limited peak flows and frequent channel drying allow vegetation encroachment into the river channel. This trend has increased dramatically over the past decade and is promoting extensive channel narrowing, reduced channel habitat diversity and the availability of low flow velocities across a range of flows. With increasing demands on limited water resources, it is becoming increasingly apparent that combinations of active (i.e., mechanical) and passive (i.e., prescribed flow releases) management techniques will be necessary to reverse this trend. We also suggest that site-specific restoration techniques (e.g., bar/island habitat manipulation) implemented in concert with techniques for affecting reach-wide fluvial processes hold the greatest potential for silvery minnow habitat restoration in the Isleta Reach.

Photo of dry channel near Bosque del Apache. (Photo Credit: Michael Hatch)

There is also an urgent need to develop wetted refugia for silvery minnow when channel sections go dry during the irrigation season (especially July–September). Projects are needed that can provide both “in-channel” and “off-channel” wetted refugia. We believe that opportunities for creating “off-channel” refugia in the Isleta Reach are especially worth exploring. For example, the Isleta Reach is unique in the MRG in that it contains 12 irrigation return channels and wasteways.

We suggest it would be important to evaluate potential for managing these features as “off-channel” refugia by exploring how many of these features could be kept wet with relatively minor water discharges from irrigation canals. Unfortunately, there is no available data on the channel geometry of these irrigation return features to support preliminary restoration analysis or design, although we strongly urge the Program to explore this option as we think it has considerable potential to mitigate impacts of channel drying on the silvery minnow. Since further investigation is needed to explore project potential, there is no further discussion of “off-channel” refugia until Chapter 6.

Flycatcher habitat restoration in the Isleta Reach is needed to expand active breeding territories in the reach. The vast majority of flycatcher breeding territories along the MRG are concentrated downstream of the San Marcial Railroad Bridge. Habitat restoration projects are needed to facilitate expansion of breeding habitat to upstream reach segments. There are several existing territories in the Isleta Reach, but these numbers declined substantially between 2005 and 2007 (see Chapters 3 and 4). Native willow habitats throughout the reach have declined dramatically over the past two decades and floodplain inundation frequency has been extremely limited (see Chapter 2). Restoration techniques are needed that will restore physical habitat conditions in strategic locations that have the greatest potential for promoting breeding territory expansion.

The recommended restoration techniques presented in this chapter focus on active (i.e., construction oriented) restoration techniques for addressing these issues. All of the recommended active restoration techniques were promoted in the *Habitat Restoration Plan for the Middle Rio Grande* (Tetra Tech, 2004a) and/or in *Restoration Analysis and Recommendations for the San Acacia Reach of the Middle Rio Grande* (Parametrix, 2008). Passive restoration techniques involving prescribed flow releases from Cochiti Dam and irrigation return canals are considered “data gaps,” and are discussed in Chapter 6.

The active restoration techniques proposed include:

- Bar and Island Destabilization and Lowering: This restoration technique is a modification of the “island destabilization” technique described in the MRG Habitat Restoration Plan (Tetra Tech, 2004a). The technique involves the use of heavy equipment to remove mature vegetation and roots from accreted bars and islands that no longer inundate, or inundate infrequently. The elevation of the bars and islands are then lowered by expanding the areal extent of the sand feature. The approach aims to facilitate the mobilization of sediment that has been hydrologically inactive during flood events. As discussed in Chapter 4, the mobilization of these islands is intended to improve aquatic habitat for the silvery minnow by reversing channel narrowing processes and reactivating stabilized sand bars. The reactivated sediment will be redistributed within the active channel, thus creating more mesohabitat in the form of mobile sand bars that provide slow velocity aquatic habitat for silvery minnow under a range of flow conditions.
- Bar Habitat Manipulations: These projects involve using heavy equipment to manipulate the topography of vegetated channel bars by excavating flow-through channels, lowering banks, and creating variable terraces to promote inundation under a range of flows. Unlike the bar and island destabilization technique described above that specifically concentrate on accreted islands that are infrequently inundated, the bar and island habitat manipulation techniques could theoretically target any vegetated island within the active channel. We suggest that these island habitat manipulation techniques, especially in combination with the island destabilization treatments described previously, could improve nursery habitat availability and aquatic diversity throughout the Isleta Reach.

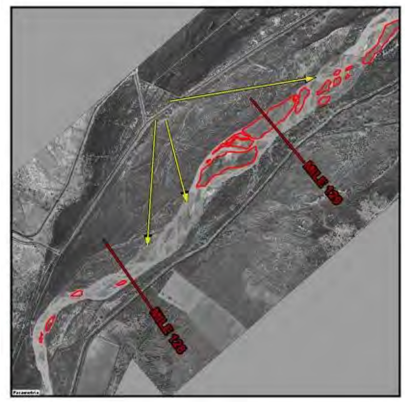
- "In Channel" Refugia using Large Woody Debris: This technique involves placing large, log flow-deflectors along the channel edges, especially in channel segments with a well-defined thalweg along the bank. This technique differs slightly from the perennial pool technique, currently being tested by MRGCD and Habitech, Inc., in that it does not necessarily have to be constructed immediately downstream of an irrigation outfall. Placement would focus on reach segments that do not typically go completely dry, or that only intermittently run dry.
- Terrace Bankline Destabilization: Heavy equipment is used to remove vegetation and root material from the bank lines along elevated terraces. This technique will be applied to areas where the river channel is poised to undercut and erode the paleo-floodplain and is intended to promote channel migration and deposition of large woody debris into the channel. This technique is intended to facilitate channel widening in portions of the project reach.
- Willow Swales with Backwater Habitat: Willow swales are constructed where natural willow establishment is prevented by the infrequency of overbank flooding. Willow swales are recommended as a flycatcher habitat improvement. The primary site characteristics required to successfully create highly suitable flycatcher habitat are a shallow groundwater table (i.e., maximum depth <5 feet), relatively low soil salinity (<3 dS/m), and close proximity (<330 feet) to open water. Backwaters that cut into the swale provide low velocity aquatic habitat for silvery minnow during moderate to high flow events. Backwaters are intended to increase the habitat suitability for both the silvery minnow and the flycatchers.

Looking northeast at RM 128 and RM 129, it is possible to see the large number of vegetated bars and islands. (Photo Credit: Parametrix)

All of these restoration techniques will require varying degrees of follow-up maintenance and require a commitment from the Program and the project sponsors to long-term monitoring and adaptive management. Monitoring results should be applied to adjusting management to maximize project benefits, to control follow-up maintenance costs and to inform design and planning of similar project in the future.

2 What are the recommended projects for improving aquatic habitat diversity in the Isleta Reach?

To enhance aquatic habitat diversity within the Isleta Reach, the restoration recommendations focus on providing shallow, low velocity aquatic habitat under a range of flow conditions. A heterogeneous channel bed provides shallow, low velocity habitat in the form of vegetated and non-vegetated sand bars even at bank-full discharge. The nature of sand movement in a wide, shallow river channel occurs in pulses and large wave forms that continually progress downstream. The presence of these migrating sand features creates low velocity habitat under a range of flow conditions. The reduction in channel width in this reach has been well documented (Chapter 2) and as the river has narrowed, average velocities have increased. These changes correspond to progression from lower regime sediment transport channel bed forms (sand dunes) to upper regime antidune and plane bed at high flows.



Vegetated channel bars and islands at RM 128 in January 2002.

During the past 30 years, the width to depth ratio of the channel has progressively decreased with the channel becoming more uniform in cross section with less aquatic habitat diversity. This narrowing trend resulting from channelization and the decrease in peak discharge and sediment load has been exacerbated by vegetation encroachment (both native and non-native) on the active channel sand bars.

Vegetated channel bars and islands at RM 128 in June 2006.

As vegetation becomes established on the sand bars and is not removed by subsequent high flow events, the velocity through the vegetation and over the sand bars is decreased, resulting in sediment deposition in the vegetation. This deposition increases the sand bar elevation (accretion) and active sand bars become stabilized islands. When this occurs on sand bars along the banks, the islands or inset terraces that are created can gradually become conjoined to the banks, thus reducing the active channel width. Formerly wide reaches have significantly narrowed and show evidence of a series of terraces with varying age groups of vegetation.

The decrease in the active channel width in the Isleta Reach is widespread. Program projects funded to enhance aquatic habitat should strongly consider approaches that expand and sustain the active channel within targeted project segments. The recommended restoration techniques were selected to improve both "reach-wide" fluvial processes and to promote site-specific habitat enhancements. We suggest that this combined restoration approach has greater potential for realizing short-term and long-term habitat benefits than either approach alone. Success of these techniques requires rigorous monitoring and a commitment by the Program for adaptive management (see Chapter 6). Monitoring is critical for evaluating if project objectives have been achieved and to inform follow-up maintenance requirements. Maintenance could be in the form of periodic mechanical treatments or could involve implementing managed flows to maintain the active channel.

Restoration Technique: Bar and Island Destabilization

This technique is designed to destabilize islands and bank-attached bars (Tetra Tech, 2004a) and has been applied in the Albuquerque Reach for the purpose of improving aquatic habitat diversity for the silvery minnow (A. Lundahl, NMISC, personal communication, 2007). This technique was also recommended for broad application to improve aquatic habitat in the San Acacia Reach (Parametrix, 2008; Tetra Tech, 2004b) and to limited segments of the Isleta Reach (NMISC, 2007). For this report, we specifically recommend this technique be applied to vegetated channel bars that have accreted to the point where the bars no longer, or infrequently, become inundated by snowmelt runoff.

> It is important to recognize that vegetated channel bars can provide nursery habitat for the silvery minnow when the bars become inundated or when pocket waters form on the downstream end of the bars. However, once the bars accrete to become islands that no longer inundate, the slow velocity habitat provided by inundation is no longer available. The vegetated bars and islands targeted for this treatment, therefore, should focus primarily on those bars and islands that inundate infrequently.

The restoration technique involves removing vegetation stems and roots followed by lowering the sand bars with heavy equipment. Rooted vegetation on bars within the active river channel is mechanically removed by mowing vegetation and removing roots through root plowing, raking, or other appropriate methods. In the Isleta Reach, we recommend the bar surface should also be lowered by 1 to 2 feet and spread laterally (preferred) and longitudinally into the surrounding channel. The purpose is to return the bar sediment to the channel to promote mobile bed forms and channel activity downstream.

Bar and island destabilization and lowering is designed to mobilize sediments stored within the bars and is intended to create mobile bed features that will enhance geomorphic conditions. By implementing this treatment over long sub-reaches, we hypothesize that the silvery minnow will have more slow velocity habitat under a range of flow conditions. The recommended restoration treatments are intended to enhance aquatic habitat diversity for all life-stages of silvery minnow and other native fish.

Example of constricted channel segment immediately upstream and downstream of the Belen Bridge. Areas like this are excluded from bar destabilization and lowering treatments to avoid negative impacts to the bridges.

Site Selection

We selected project areas that we believe have the highest potential for enhancing channel bed heterogeneity through bar destabilization and lowering. Identification and prioritization of the bar destabilization projects was accomplished by comparing the area of vegetated channel bars to active river channels within numerous project areas. Some narrow river segments were avoided during site selection because these segments were assumed to be inherently stable, or there was concern that this treatment could negatively impact existing structures. We also avoided prescribing projects within the active river channel downstream from the Rio Puerco, because project sustainability is severely constrained by large flood events from the Rio Puerco and Rio Salado.

The recommended bar and island destabilization projects have been screened according to the following various site considerations:

- Located within the active channel as defined through analysis of the 2005 overbank monitoring data (Horner and Sanders, 2007).
- Exposed or nearly exposed vegetated islands or bars during the June 2005 flood event.

Sediment Management Associated with Island Destabilization Treatments

Some have expressed concern that island destabilization treatments should involve physically removing sediment rather than allowing the river to re-incorporate the exposed sediment into the active channel. This was particularly raised by the Pueblo of Isleta and MRGCD, who have had problems with sediment accumulations within, or near, their irrigation infrastructure.

As stated throughout this report, the Isleta Reach is generally experiencing a sediment deficit, and further deliberate sediment removal would exacerbate the negative impacts of a limited sediment supply on channel geomorphic processes (and aquatic habitat). However, we suggest that any future sponsors of island destabilization projects evaluate the potential negative impacts of their proposed projects on irrigation infrastructure or other facilities in the reach.

- Not within 1/4 mile from documented 2006 or 2007 flycatcher nests.
- Avoided sites that are hydraulically inappropriate, such as the inside bends of the active river channel.
- Selected sites where project implementation will not impact existing infrastructure (bridges, non-engineered spoil bank levees, and gas pipelines).
- The river reach near RM 149 was avoided to minimize interfering with current research activities by the BOR (P. Makar, BOR, personal communication, 2007).

A total of 246 acres of vegetated islands and attached bars have been identified as high-priority treatment sites in four different project areas. The locations of these sites are concentrated between approximately RM 153 in the Los Lunas Sub-reach to RM 128 in the Sevilleta Sub-reach. These proposed treatment locations are displayed in Exhibits 5-1 through 5-4 (for more details see Appendix C, Exhibits C.5-1 through C.5-9). We recommend that multiple project sites be selected so that the treatment can be replicated. This will allow for more statistically rigorous monitoring to evaluate the effectiveness of this treatment.

Project Benefits

The benefits to aquatic habitat derived from the restoration techniques are presented as hypotheses that need to be validated in the field. The hypothesized benefits to the silvery minnow following bar destabilization and lowering include:

- Increased channel bedform heterogeneity, which will be characterized by:
  - An active river channel with mobile sand bars.
  - Increased average width-to-depth ratio.
  - Decreased average channel velocities.

  - Increased areal extent of low velocity habitat (0 to 1 ft/s) at moderate and high flows.
  - Increased propensity for lower regime bed forms (i.e., dunes rather than plane bed).
- Decreased vegetation encroachment, which will be characterized by:
  - Lower sand bar elevations.
  - Less dense, smaller diameter vegetation on the sand bars.

Exhibit 5-1

Accreted Bar Destabilization and Lowering Projects: RM 126–130 (For more details see Appendix C, Exhibits C.5-1 through C.5-9.)

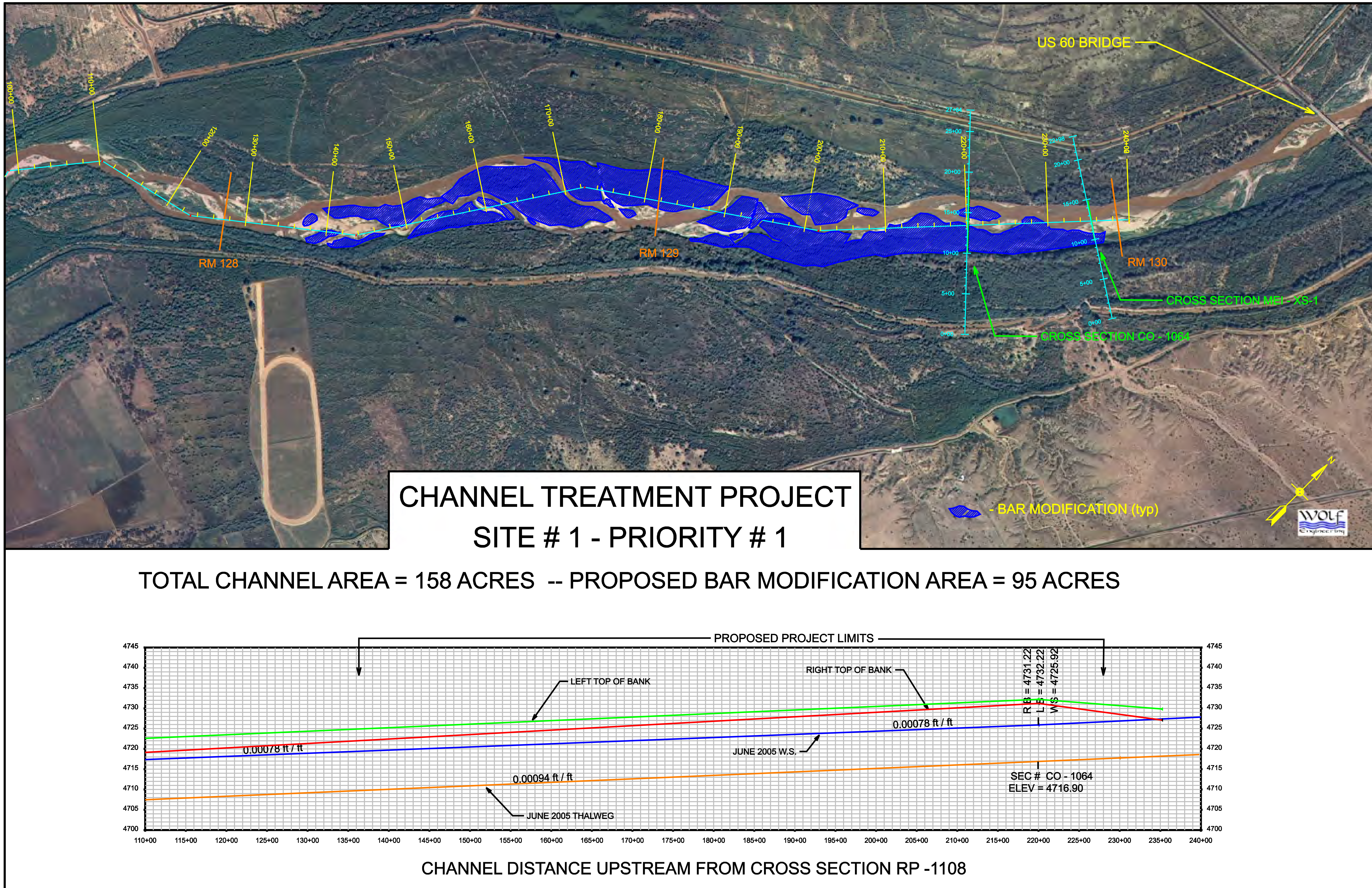


Exhibit 5-2

Accreted Bar Destabilization and Lowering Projects: RM 138–140 (For more details see Appendix C, Exhibits C.5-1 through C.5-9.)

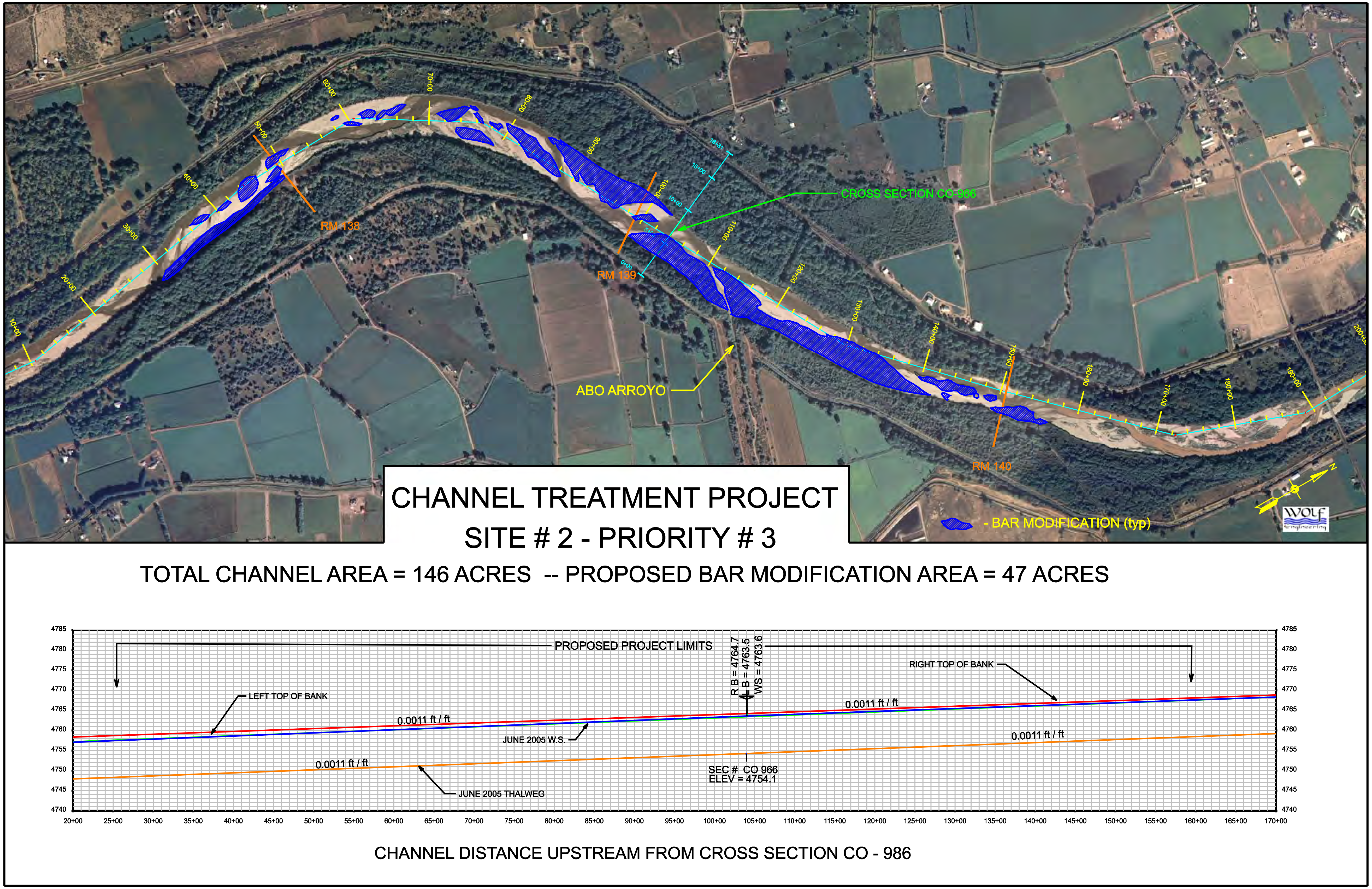
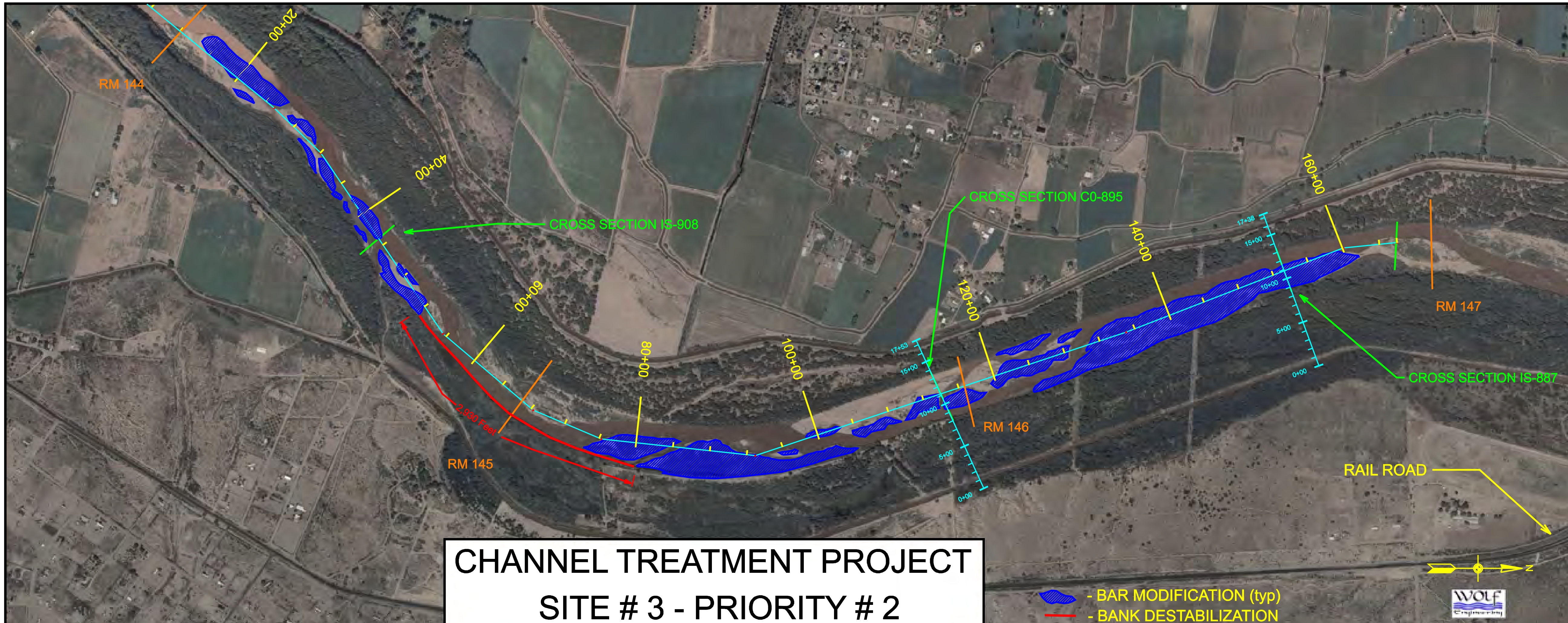


Exhibit 5-3

Accreted Bar Destabilization and Lowering Projects: RM 144-147 (For more details see Appendix C, Exhibits C.5-1 through C.5-9.)



TOTAL CHANNEL AREA = 154 ACRES -- PROPOSED BAR MODIFICATION AREA = 55 ACRES

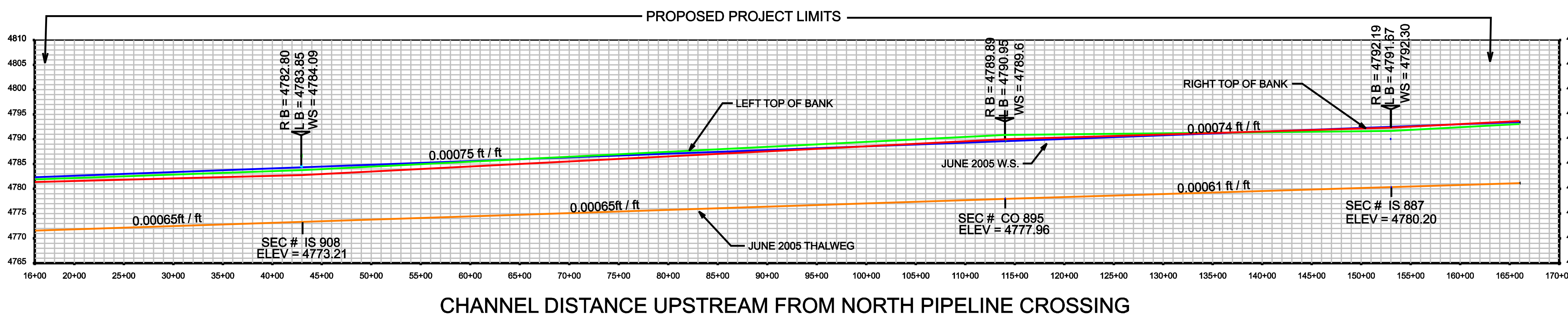
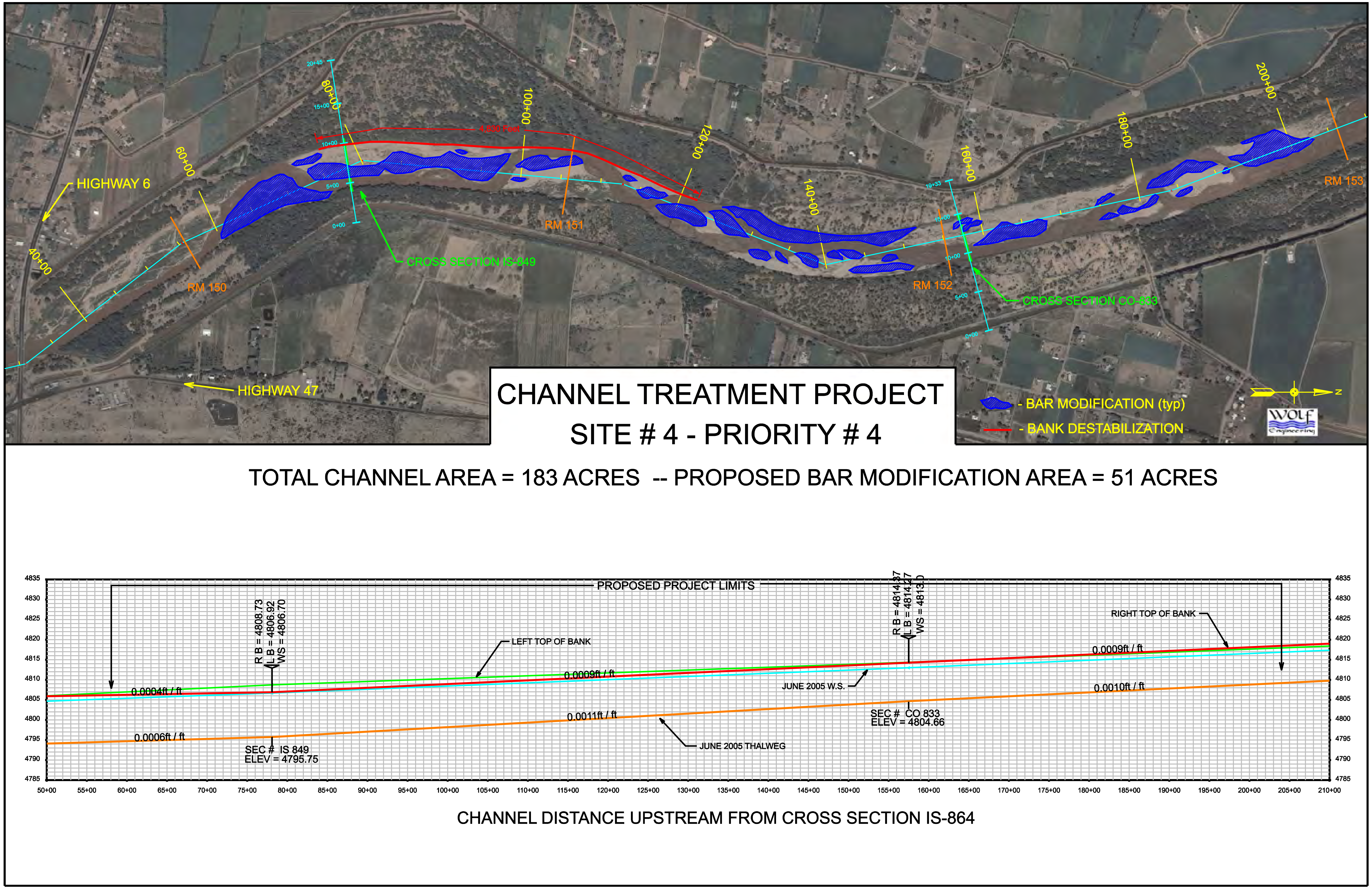


Exhibit 5-4

Accreted Bar Destabilization and Lowering Projects: RM 150-153 (For more details see Appendix C, Exhibits C.5-1 through C.5-9.)



Restoration Technique: Destabilize Terrace Banks

This restoration technique is designed to facilitate channel migration so that more natural channel meander wavelengths can be established, thus improving the channel-floodplain hydrologic connectivity. In addition, bank destabilization is intended to increase the sediment supply to the channel, increase channel bed heterogeneity, and promote deposition of large woody-debris into the river channel.

Bank-line destabilization treatments involve the use of mechanical equipment to uproot vegetation from selected banks to an appropriate distance from the edge of the river channel. The appropriate distance will vary according to site conditions, access, and cost. For the purpose of cost estimation, we assumed an arbitrary distance of 25 feet. The uprooted vegetation would remain on site and would provide large woody debris to the river if bank erosion progressed.

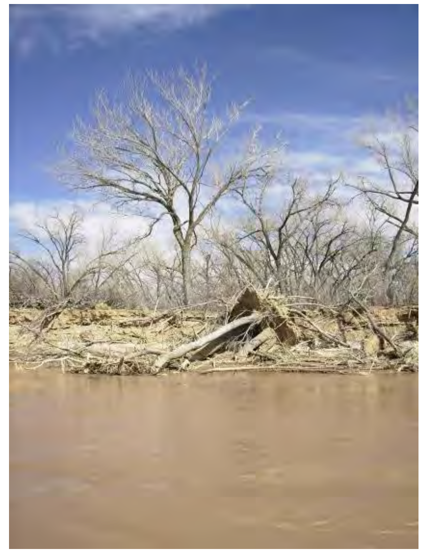


Photo showing bank erosion and cottonwood trees falling into the river near RM 102 in the San Acacia Reach. Bank-line destabilization treatments are recommended to achieve this result in select locations within the Isleta Reach (Photo Credit: Parametrix)

Site Selection

Bank-line destabilization sites were identified using aerial photography and were selected where channel widening would provide the greatest benefit when combined with bar destabilization treatments. Bank-line destabilization is intended to encourage channel widening and migration, which will enhance the channel width-to-depth ratio, increase the channel sinuosity, decrease the slope, enhance channel habitat diversity, and enhance slow velocity habitat through deposition of large woody debris into the channel.

The narrow active floodplain between the levees restricts the opportunities for extensive channel migration. Bank destabilization is prescribed for selected outside bends of the active river channel. Bars and islands on the inside of the bend do not have to be reworked in these locations. This combination mimics the natural process of migration with sediment deposition on the inside of the bend and erosion on the outside of the bend. The extent of proposed terrace bank-line destabilization treatments vary by site, but range between 2,980 feet and 4,830 feet. The total acreage of recommended bank-line destabilization treatments is approximately 4.5 acres (Exhibits 5-3 and 5-4).

Project Benefits

The benefits to aquatic habitat derived from the restoration techniques are presented as hypotheses that need to be validated in the field. Bank-line destabilization is hypothesized to enhance channel migration, which will achieve the following benefits for the silvery minnow:

- Increase local erosion rates after high flow events.
- Reactivate sediment stored in the channel banks, thus increasing the available sediment supply within the active channel and increasing channel bed heterogeneity (see additional project benefits of bar destabilization and lowering).
- Increase the amount of large, woody debris within the channel.

Restoration Technique: Bar/Island Habitat Manipulations

Bar and island habitat manipulation techniques have been implemented in both the Albuquerque Reach (e.g., SWCA, 2006a–c) and the Isleta Reach (USACE and BOR, 2002). These techniques generally involve using heavy equipment to manipulate the shape and topography of vegetated bars and islands within the active channel. The techniques are primarily intended to improve aquatic habitat for various life-stages of the silvery minnow. It is important, however, to distinguish these techniques from the bar and island destabilization technique listed earlier in this chapter. The primary difference is that island and bar **destabilization** techniques are intended to facilitate reach-wide improvements in fluvial processes and aquatic habitat diversity. Bar and island habitat **manipulation** techniques, on the other hand, are intended to improve local aquatic habitat conditions, but are not intended to improve reach-wide fluvial processes. We believe that aquatic habitat restoration in the Isleta Reach would benefit most by employing both restoration approaches (reach-wide and site-specific) concurrently, and has great potential for providing immediate aquatic habitat improvements through the project reach.

Ephemeral Channels

Ephemeral channels are intended to function as low-velocity, flow-through channels excavated into islands or bars within the river channel. As their name implies, these constructed channels are only intended to convey water through the island/bar during part of the year, usually during moderate and/or high flows. Proponents of this habitat restoration technique suggest that constructed ephemeral channels provide excellent habitat for larval development and provide refuge habitat for young silvery minnows (SWCA, 2006a). An illustration of this technique is provided in Exhibit 5-5.

Bank-line Lowering and Terracing

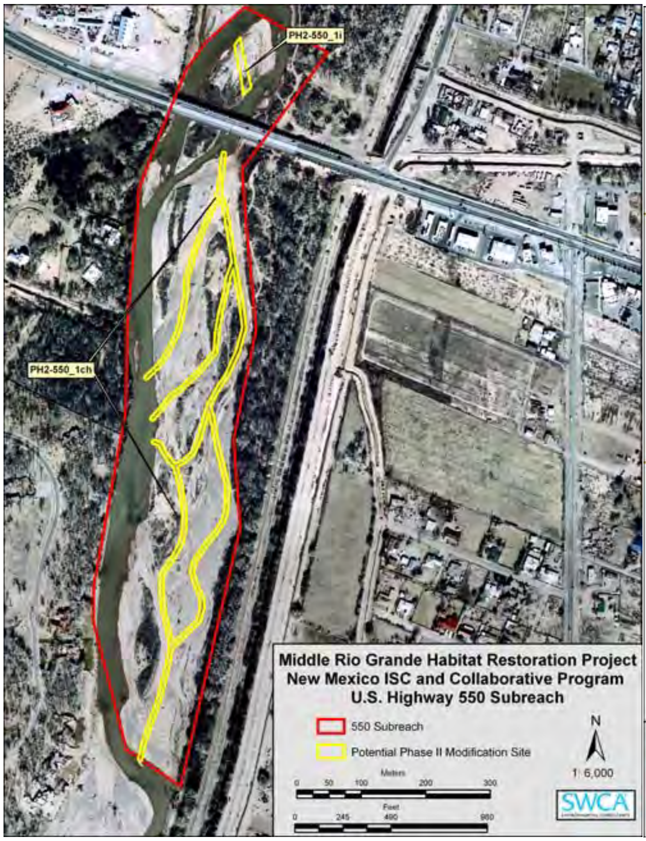
Bank-line lowering and terracing involves removing bank-line vegetation from an island, bank-attached bar, or floodplain bank-line and then lowering the bank-line elevation to increase the potential for flooding over a range of flows. Terracing involves creating a “stair-step” affect by lowering the bank-line different elevations to allow variable flow depths and velocities for greater aquatic habitat variability. The target elevations will vary depending upon the height of the bank and the specific project objectives. This technique is intended to create ephemeral nursery habitat for retention of silvery minnow eggs and larvae. An example conceptual diagram of bank-line lowering and terracing is provided in Exhibit 5-5.

Site Selection

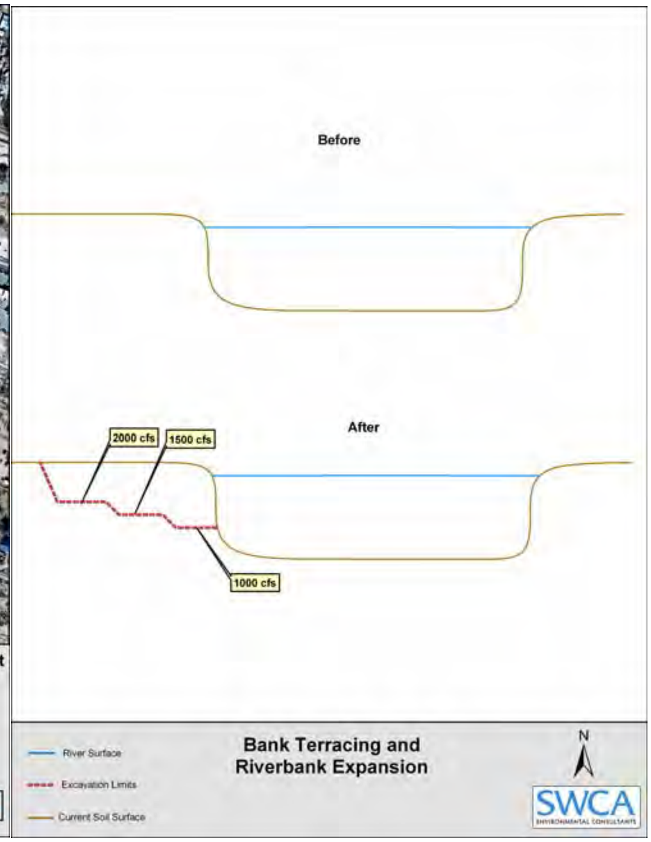
These bar and island habitat manipulation techniques could theoretically be applied to any island or bank-attached bar in the Isleta Reach, particularly where the topographic features are relatively homogenous. Bank-line lowering and terracing techniques may provide the greatest benefits in locations that rarely inundate under current conditions. Since these techniques could theoretically be applied at numerous locations through the Isleta Reach, we leave selection of site-specific treatment locations to future project sponsors.

Exhibit 5-5

Conceptual Drawings of Ephemeral Channels and Bank-line Terracing (from SWCA, 2006a)



Conceptual drawing of multiple ephemeral channels proposed for a channel bar downstream of the U.S. Highway 550 Bridge. This image is reproduced with permission from NMISC.



Conceptual drawing of bank terracing showing "stair-step" technique. This image is reproduced with permission from NMISC.

Project Benefits

The benefits to aquatic habitat derived from bar and island destabilization and habitat manipulation techniques are presented as hypotheses that need to be validated in the field. The hypothesized benefits to the silvery minnow following bar and island habitat manipulations include:

- Increasing frequency and duration of flood inundation at treatment sites;
- Increased flow depth and velocity heterogeneity at treatment sites;
- Increased habitat availability for silvery minnow under moderate and high flow conditions, and;
- Increased retention of silvery minnow eggs.

Supplemental Information Needs and Data Requirements for Bar and Island Destabilization and Habitat Manipulation Techniques

- Multiple river cross-sections at each proposed site. These cross-sections would be used to refine extent of necessary bar lowering and would be used to evaluate pre- and post-treatment conditions.
- Evaluate vegetation size class and density at proposed sites to refine clearing methods and cost estimates.
- Establish additional population monitoring transects within the proposed project sites to evaluate pre- and post-treatment differences in silvery minnow populations.
- Sediment transport models to further explore potential impacts to infrastructure and sediment inputs from tributary sources.
- Coordination with the Corps of Engineers regarding Clean Water Act Sections 404 and 401. This will be especially important for determining how bar lowering, ephemeral channel excavation, and sediment management activities can be legally implemented.
- Coordination with the Fish and Wildlife Service regarding limiting impacts of project activities on silvery minnow and flycatchers.
- Coordinating with the BOR regarding impacts of this activity on their River Maintenance Program, and to validate costs for their Socorro Field Division to implement these projects.

Exhibit 5-6

Project Summary Table – Channel Treatments

Project Description	
Restoration Technique(s)	Destabilize accreted bars and lower the surface elevation, Destabilize Bank-lines.
Functional Limitations Addressed	☒ Channel Narrowing ☐ Channel Drying ☐ Groundwater
Species Focus	☒ Silvery Minnow ☐ Willow Flycatcher ☐ Both
Location (River Mile)	RM 116.2–RM 163.7
Potential Number of Acres Benefited	**Destabilization and Lowering Bars** 50 Acres (RM 150–RM 153) 55 Acres (RM 144–RM 147) 47 Acres (RM 137.5–RM 140) 94 Acres (RM 128–RM 130) **246 Acres – Total Destabilization and Lowering**
	Bank-line Destabilization 2.7 Acres (RM 150–RM153) → (4,830 linear feet x 25 feet wide) 1.8 Acres (RM 144–147) → (2,930 linear feet x 25 feet wide) **4.5 Acres – Total Bank-line Destablilization**
	250.5 Acres – Total Project
Land Ownership/Management Agency	Bureau of Reclamation
Project Description	Mechanical methods will be used to destabilize terrace banklines and accreted, vegetated islands within the active channel. Proposed locations for these treatments are shown in Exhibits 5-1 through 5-4. It is recommended that Island destabilization treatments be implemented as a carefully designed experiment to validate hypothesized project benefits. This requires that multiple sites be selected per site screening criteria, and that statistically rigorous monitoring be performed before and after treatment. Conceptual monitoring approaches are presented in Chapter 6, but a detailed monitoring plan is needed once the specific treatment sites have been selected. Monitoring should also be used to guide adaptive management, and to determine if project maintenance could benefit from managed flow prescriptions.
Construction Elements	a. Mechanical vegetation removal from accreted islands and bank-attached bars. b. Mechanical vegetation removal along terrace bank lines.
General Estimate of Construction Costs	Conservative planning level cost estimates indicates per acre costs of approximately $7,940 (see Appendix C; Exhibit C.5-16).
Operation and Maintenance Issues	Costs associated with follow-up mechanical clearing of vegetation. No estimates have been generated for this anticipated cost.
Adaptive Management/Monitoring	Requires pre- and post-implementation monitoring to validate project hypotheses and to guide adaptive management. Adaptive management would predictably involve treatments aimed at maintaining active channel in the vicinity of island destabilization treatments. This may require periodic, follow-up mechanical treatments to prevent further seedling encroachment. Monitoring criteria, data gaps, and further research needs are described in Chapter 6, Monitoring Criteria section.
Potential Water Salvage/Depletion	Depletion estimates and methods are presented in the Net Depletions section in chapter 5.
Site Preparation and Access	To be determined following final site selection by project sponsor.
Environmental Compliance Requirements	Appropriate level of NEPA associated with the BOR's annual channel maintenance program; ESA consultation regarding construction impacts on silvery minnows; and 404/401 permit consultation with the Corps of Engineers.
Additional Data Requirements	Multiple channel cross-sections at specific treatment sites; quantitatively rigorous monitoring design; qualitative evaluations of vegetation density and height at each bar location needed to support final mechanical clearing cost, extent of bar lowering, and refining net depletions analysis. Additional silvery minnow population monitoring transects to evaluate pre- and post-restoration treatment impacts on minnow populations.
Other Implementation Issues	Coordinate with the BOR's River Maintenance Program regarding costs and interest in implementing these projects.

FLO-2D[1] Analysis of Island and Bank-line Destabilization Projects

3 What are the FLO-2D model modifications to represent the restoration projects?

The FLO-2D model was initially run to establish baseline hydraulic conditions in the Isleta Reach for the May to June 2005 overbank monitoring project for Cochiti releases exceeding 6,800 cfs and the 100-year flood hydrograph at Isleta Lakes. The baseline model was then revised to simulate the proposed restoration project conditions outlined in this chapter. The proposed restoration project sites constitute approximately 10.5 miles of the 48-mile Isleta Reach. The model changes that were implemented to reflect the restoration projects include the following:

- Removal of sand bar vegetation and reworking of the channel sand bars to create a wider, more active cross section. Reworking those channel bars that have become encroached with vegetation and attached to the banks is a restoration priority. In channel treatment Sites No. 2 and No. 3 downstream, there are a high proportion of bars that are attached to the banks which have decreased the active channel. The average cross-section width in these two sites is approximately 100 feet narrower than Sites No. 1 and No. 4. The restored reaches after reworking were designed to hae a cross section that would be about 600 feet wide. To simulate this width increase, a new (non-trapezoidal) cross section was

[1] FLO-2D is a two-dimensional, flood routing model that predicts the flow exchange between channel and floodplain. It has a number of components that add detail to the Rio Grande flood simulation including levees, hydraulic structures, spatially variable infiltration and roughness, and evaporation. The MRG FLO-2D model consists of 167,000 grid elements (250 feet square) from Cochiti Dam to Elephant Butte Reservoir. The Isleta Reach (48 miles) constitutes a portion of this model roughly in the middle of the grid system. The development of the FLO-2D model was initially supported by the Albuquerque District of the Corps of Engineers for operational applications throughout the Middle Rio Grande. FLO-2D was applied to the Isleta Reach with the concurrence of the Habitat Restoration Subcommittee of the ESA program. For a complete description of the FLO-2D model development and calibration, refer to Parametrix (2008).

substituted for the first and last cross section in each of four of the restoration sub-reaches, and all of the channel element cross sections were interpolated between the cross sections. The result was a uniform-wide cross section with a larger flow area to reflect the restored channel shape with the lower sand bars (Exhibit 5-7). The average flow areas vary according to whether it was necessary to raise or lower the lowest top of bank to match the existing floodplain elevation using the new cross section. In general, the channel flow area increased because the restored channel is wider and lower. The modeled project area was limited to the confined floodplain between the non-engineered spoil bank levees. The remobilized sand bars will increase the sand movement through the system to enhance the active channel.

Exhibit 5-7

Comparison of Existing and Proposed Channel Geometry Conditions

Project Areas Listed From Upstream to Downstream	Baseline	Project
Channel Treatment Site No. 1		
Flow Area[a] (sq ft)	1,947	2,294
Top Width (ft)	607	616
Wetted Perimeter (ft)	609	622
Hydraulic Radius (ft)	3.2	3.7
Channel Treatment Site No. 2		
Flow Area[a] (sq ft)	1,881	1,732
Top Width (ft)	504	623
Wetted Perimeter (ft)	507	627
Hydraulic Radius (ft)	3.7	2.8
Channel Treatment Site No. 3		
Flow Area[a] (sq ft)	1,677	2,363
Top Width (ft)	474	626
Wetted Perimeter (ft)	477	632
Hydraulic Radius (ft)	3.6	3.7
Channel Treatment Site No. 4		
Flow Area[a] (sq ft)	2,035	2,593
Top Width (ft)	601	619
Wetted Perimeter (ft)	604	627
Hydraulic Radius (ft)	3.4	4.1

[a] Flow area is based on the bank-full area to the lowest top of bank.

- Channel widening in two locations on the outside of bends in the project sub-reaches was simulated by a top-of-bank set-back of 30 feet. This was accomplished by adding stations in the channel cross section between the thalweg and the top of the bank station. The intent of this top-of-bank set-back is to simulate destabilizing the bank and allowing the excess bank material to be removed by the river.
- The infiltration hydraulic conductivity for the various restoration project simulations was not revised for the project conditions. There is insufficient groundwater data to support modifying the channel hydraulic connectivity. It was also assumed that restoration projects would not appreciably affect the channel roughness (Manning's n-values). The channel n-values currently reflect a reach-wide bed form of dunes at high flow. As the channel narrows, an increasingly larger portion of the thalweg area is becoming upper regime plane bed with lower n-values. This reduces the average channel roughness. The restoration projects should limit or eliminate this change in the channel bed form. Therefore, the channel roughness for the restoration projects was not modified.

Infiltration losses from the channel and floodplain represent water that enters the groundwater system. This seepage water would either increase groundwater storage or be lost to evapotranspiration (ET). The FLO-2D model does not differentiate between the water allocated to groundwater storage or ET. It should be noted that increased groundwater storage should not necessarily be considered depletion from the surface water system. Groundwater may return to the channel downstream. FLO-2D also computes open water evaporation that represents depletions or losses to the system.

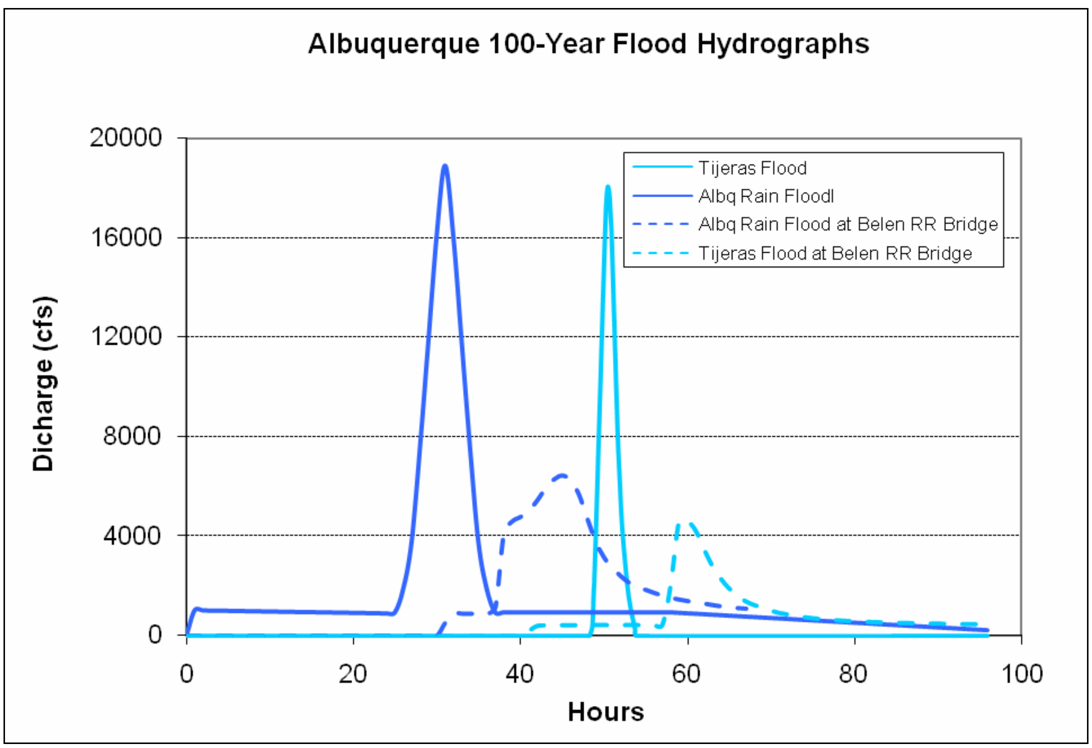
4 How were the restoration projects tested for high flows and flooding conditions?

There were three hydrologic/hydraulic tests of the proposed restoration projects:

1. *May-June 2005 Overbank Flood Monitoring Project Hydrograph.* The FLO-2D model was originally calibrated to this Cochiti Dam release hydrograph that approached 7,000 cfs. The model was calibrated through the MRG with surveyed water surface elevations, the June 1 area of inundation aerial photographs, and measured gaging station discharges. By running the May–June 2005 hydrograph through the Isleta Reach, the difference in area of inundation and water surface elevations can be determined, as well as changes in the channel hydraulic conditions.

2. *The 100-year Flood Hydrograph through the Isleta Reach.* The Corps of Engineers has recently re-analyzed the 100-year hydrograph at Isleta Lakes (USACE, 2006). There are three potential sources of flooding to define the 100-year hydrograph: 1) Snow-pack runoff in the upstream Rio Grande watershed. 2) The rainfall runoff hydrograph in the Albuquerque area. 3) The Tijeras Arroyo 100-year flood hydrograph with a baseflow of 500 cfs in the Rio Grande. It was necessary to review and test three flood hydrographs for the worst-case scenario at Isleta Lakes. The snow-pack hydrograph represents an essentially constant release of 7,000 cfs from Cochiti Dam. The rainfall hydrograph and the Tijeras flood inflow had similar peak discharges, but the rainfall runoff in the Albuquerque area had much more volume, which results in a larger flood event in the Isleta Reach (Exhibit 5-8). This hydrograph constitutes the 100-year flood for the restoration projects.

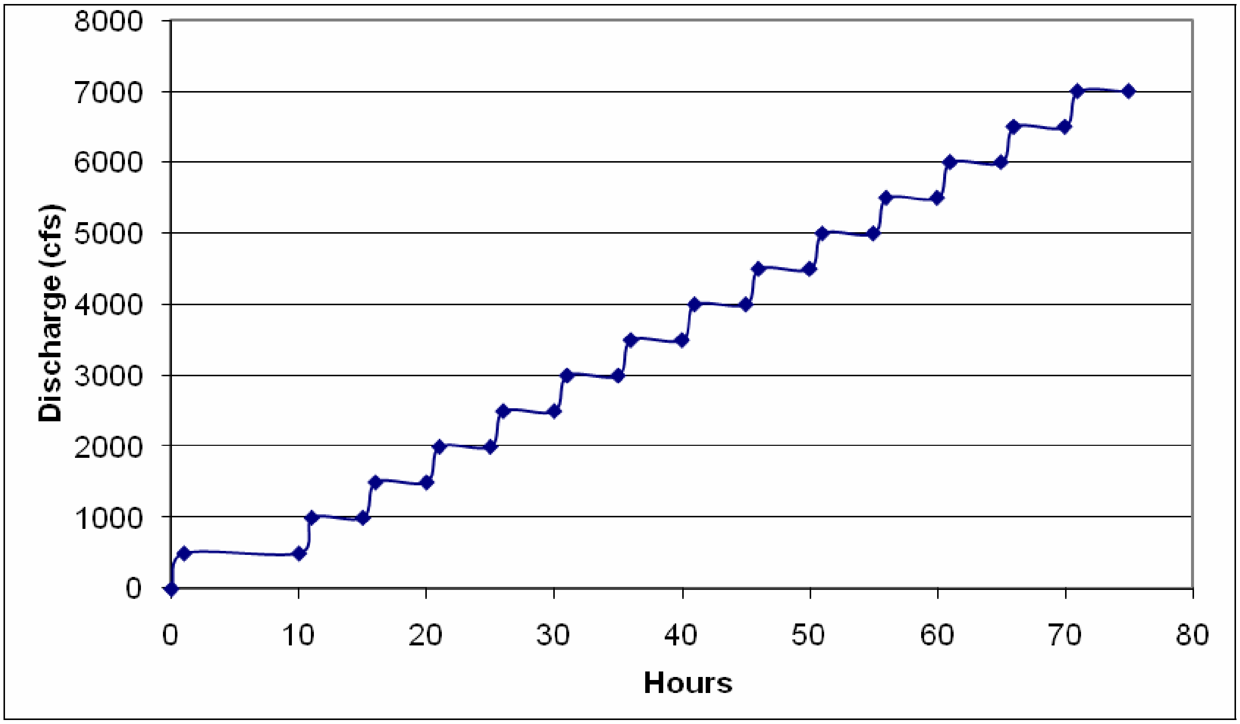
Exhibit 5-8
Estimated 100-Year Flood Hydrographs for Isleta Lakes



3. The third test involved a comparison of the channel hydraulics with and without the restoration projects. A series of step increases in the inflow hydrograph ranging from 500 cfs to 5,000 cfs (roughly bank-full) in 500 cfs increments were input to the model (Exhibit 5-9). The change in the channel hydraulics, as a result of the restoration projects, is reported in the discussion below.

Exhibit 5-9

The Step Inflow Hydrograph to Test the Variation in the Channel Hydraulic Conditions



5 What are the modeling results?

The May-June 2005 high flow was simulated until the peak discharge passed San Acacia. The three-day inflow hydrograph to the Isleta Reach for the May–June 2005 overbank monitoring simulation has a volume of almost 19,000 af. Approximately 3 percent of the inflow is lost to infiltration and evaporation. This is a relatively accurate assessment based upon the calibration of the FLO-2D model at Isleta Lakes. A summary of the flood routing results are presented in Exhibit 5-10. Some observations based on these results are:

- The wider channel and the removal of the sand bars are modeled to result in more channel conveyance.
- Infiltration and evaporation losses are modeled to decrease with the restoration project because there is less overbank flooding.
- The model predicts a 12.4 percent reduction in infiltration and evaporation losses for the 100-year flood and 19.6 percent savings in infiltration and evaporation losses for the 100-year flood.

Exhibit 5-10

Comparison of Existing and Proposed Restoration Project Hydrologic Conditions for the Channel Treatments

	May–June 2005		100-Year Flood	
	Baseline	Project	Baseline	Project
Inflow Hydrograph (acre-feet)	18,790	18,790	8,170	8,170
Infiltration Loss (acre-feet)	487	378	253	217
Evaporation Loss (acre-feet)	121	111	53	51
Maximum Floodplain Area of Inundation (acres)	1,103	713	1,031	751
Maximum Channel Wetted Surface Area (acres)	2,277	2,358	2,041	2,147
Maximum Area of Inundation (acres)	3,380	3,071	3,072	2,898

The impacts of the restoration projects on infiltration volumes, evaporation, and area of inundation are analyzed on the basis that all of the proposed restoration projects are in place. The net change in surface water losses and the area of inundation represents the maximum cumulative effect of all potential restoration projects.

The changes in the hydraulic conditions in response to the restoration projects are presented in Exhibits 5-11 through 5-14 (pages 5-28 through 5-31). Overall, the restoration projects increased the channel flow area, resulting in a decrease in the average flow depth and velocity in each of the four channel treatment locations. The most significant changes occur in Channel Treatment Project No. 3 where the velocity reduction ranges from 17 percent to 21 percent with comparable decreases in flow depth. There is some variability in the hydraulic response to the restoration project throughout each of the four channel treatment projects, but in general there is an increase in average channel width, wetted perimeter, width-to-depth ratio, and surface area of the channel. There is a reduction in average velocity, depth, and hydraulic radius. The reworking and remobilization of channel sand bars will have greater impact in reaches where the bars are more significant in areal extent and where there is bar attachment to the bank.

Exhibit 5-11

Comparison of Existing and Proposed Project Average Channel Hydraulic Conditions as a Function of Discharge for Channel Treatment Site No. 1

Discharge (cfs)	Thalweg Depth (ft)		Velocity (fps)		Flow Area (ft^2)		Wetted Perimeter (ft)		Hydraulic Radius (ft)		Top Width (ft)		Width/Depth Ratio		Surface Area (ft^2)	
	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project
500	1.64	2.53	1.01	1.28	391	340	233	216	1.67	1.57	233	214	114.6	71.9	75,103	68,713
1,000	2.74	3.79	1.51	1.6	638	613	433	424	1.47	1.53	432	421	154.8	106.7	139,796	135,061
1,500	3.41	4.51	1.79	1.73	850	867	524	556	1.62	1.56	523	553	155.2	122.8	168,778	177,313
2,000	3.74	4.84	1.98	1.89	1,021	1,059	550	610	1.85	1.74	549	606	148.5	125.4	177,144	194,242
2,500	4.01	5.09	2.16	2.08	1,170	1,207	566	615	2.06	1.96	565	611	142.2	120.4	182,170	195,883
3,000	4.24	5.3	2.32	2.25	1,301	1,338	574	616	2.26	2.17	573	612	136.1	115.6	184,758	196,010
3,500	4.45	5.5	2.48	2.4	1,421	1,457	578	617	2.46	2.36	576	612	130.5	111.5	185,973	196,073
4,000	4.65	5.68	2.63	2.55	1,533	1,570	585	617	2.62	2.54	583	612	126.5	107.9	188,180	196,130
4,500	4.84	5.85	2.75	2.69	1,648	1,675	595	617	2.77	2.71	593	612	123.5	104.8	191,344	196,208
5,000	5.02	6.02	2.87	2.82	1,755	1,777	603	618	2.91	2.88	599	613	120.4	101.9	193,399	196,286

Exhibit 5-12

Comparison of Existing and Proposed Project Average Channel Hydraulic Conditions as a Function of Discharge for Channel Treatment Site No. 2

Discharge (cfs)	Thalweg Depth (ft)		Velocity (fps)		Flow Area (ft^2)		Wetted Perimeter (ft)		Hydraulic Radius (ft)		Top Width (ft)		Width/Depth Ratio		Surface Area (ft^2)	
	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project
500	2.15	2.19	0.86	0.96	341	318	293	257	0.75	0.77	292	256	88.4	74.9	86,359	71,133
1,000	2.93	3.1	1.29	1.3	581	587	375	397	1.21	1.13	373	395	99.8	99.5	109,483	109,773
1,500	3.54	3.78	1.65	1.6	782	815	423	492	1.62	1.44	421	490	104.1	113.6	122,851	135,799
2,000	4.04	4.31	1.94	1.83	958	1,025	456	577	1.98	1.67	454	573	105.4	125	131,668	158,709
2,500	4.45	4.7	2.2	2.06	1,112	1,190	478	606	2.29	1.92	475	602	104.7	125.7	137,415	166,434
3,000	4.76	4.98	2.41	2.26	1,245	1,329	490	619	2.55	2.14	487	615	102.2	123.4	140,595	169,722
3,500	5.01	5.18	2.58	2.42	1,360	1,450	494	622	2.77	2.33	492	618	98.4	119.3	141,788	170,522
4,000	5.22	5.36	2.73	2.57	1,467	1,563	498	624	2.96	2.5	495	620	94.9	115.7	142,661	171,078
4,500	5.43	5.54	2.87	2.69	1,570	1,676	503	630	3.13	2.66	499	622	92.1	112.2	143,914	171,558
5,000	5.64	5.72	2.99	2.8	1,673	1,788	509	635	3.29	2.81	502	630	89.2	110.14	144,603	171,878

Exhibit 5-13

Comparison of Existing and Proposed Project Average Channel Hydraulic Conditions as a Function of Discharge for Channel Treatment Site No. 3

Discharge (cfs)	Thalweg Depth (ft)		Velocity (fps)		Flow Area (ft^2)		Wetted Perimeter (ft)		Hydraulic Radius (ft)		Top Width (ft)		Width/Depth Ratio		Surface Area (ft^2)	
	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project
500	2.53	1.96	0.76	0.6	296	367	142	245	1.04	0.69	141	244	28	61.9	38,862	66,488
1,000	3.72	2.94	1.17	0.94	545	668	250	369	1.43	1.15	249	366	45	81.7	68,918	99,653
1,500	4.64	3.74	1.45	1.19	790	949	348	475	1.82	1.52	346	472	59.4	97.4	96,006	128,352
2,000	5.34	4.37	1.74	1.43	986	1,187	400	532	2.19	1.89	397	527	65.9	103.4	110,437	143,500
2,500	5.94	4.9	2	1.64	1,156	1,401	429	573	2.54	2.23	427	567	67.9	106.4	119,159	154,614
3,000	6.44	5.34	2.23	1.83	1,308	1,593	451	601	2.85	2.53	448	595	68.4	107.2	125,709	162,589
3,500	6.85	5.71	2.43	1.98	1,442	1,768	467	620	3.1	2.81	462	613	68	106.1	130,215	167,733
4,000	7.17	6.01	2.6	2.1	1,564	1,933	477	629	3.33	3.06	470	622	66.8	103.8	132,576	170,428
4,500	7.4	6.22	2.73	2.23	1,675	2,057	482	632	3.52	3.26	472	624	64.9	100.8	133,120	170,951
5,000	7.63	6.41	2.84	2.34	1,786	2,174	489	633	3.69	3.44	473	624	63.1	97.9	133,377	170,997

Exhibit 5-14

Comparison of Existing and Proposed Project Average Channel Hydraulic Conditions as a Function of Discharge for Channel Treatment Site No. 4

Discharge (cfs)	Thalweg Depth (ft)		Velocity (fps)		Flow Area (ft^2)		Wetted Perimeter (ft)		Hydraulic Radius (ft)		Top Width (ft)		Width/Depth Ratio		Surface Area (ft^2)	
	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project	Base	Project
500	1.97	2.19	0.59	0.55	297	312	162	200	0.7	0.6	161	198	33.7	36.2	42,767	52,908
1,000	3.07	3.31	0.97	0.92	552	579	273	316	1.14	1.02	272	314	53.6	54.3	72,359	83,749
1,500	3.97	4.19	1.29	1.22	783	824	363	411	1.51	1.39	361	408	67.2	68	95,923	108,680
2,000	4.76	4.89	1.56	1.48	995	1,051	435	487	1.82	1.71	432	483	75.7	78.4	115,003	128,747
2,500	5.43	5.46	1.81	1.72	1,187	1,246	487	533	2.12	2.02	484	528	80.3	83.9	129,057	140,853
3,000	6	5.93	2.02	1.93	1,362	1,424	529	566	2.38	2.31	525	562	83.2	87.3	140,104	149,793
3,500	6.46	6.31	2.21	2.11	1,522	1,585	564	590	2.59	2.57	560	585	85.3	89.1	149,400	156,125
4,000	6.81	6.63	2.37	2.27	1,664	1,731	587	607	2.8	2.8	582	601	86.1	89.5	155,323	160,436
4,500	7.08	6.89	2.52	2.41	1,792	1,862	601	616	2.98	3.01	594	610	85.6	88.8	158,624	162,992
5,000	7.28	7.09	2.63	2.53	1,910	1,978	608	619	3.15	3.2	599	613	84	87	159,919	163,853

There is a net decrease in restored floodplain area of inundation because the proposed reworking of the river sand bars increases the channel conveyance, thereby reducing the overbank flooding. One of the objectives of restoration is to enhance the active channel dynamics, increase sand bar mobility, and at the same time reduce high flow average channel velocity. As a result, there is less hydrologic connectivity with the floodplain in the four channel treatment project locations. Outside of these four project areas, overbank flooding is modeled to continue unabated.

The flooding generally decreases in response to the restoration projects because there is more channel conveyance. In reaches where flooding occurs without the restoration projects, more water volume is flushed downstream in response to the restoration projects that would have been stored in the overbank areas. To identify where the flooding may be increased due to the restoration projects, the difference in water surface elevation between the 100-year baseline condition and the channel treatment condition were assessed and plotted as increased water surface elevations. The increase in water surface is less than 1 foot except in one location downstream of the Highway 60 Bridge and upstream of the Rio Puerco confluence.

In summary, the primary impact on channel hydraulics and morphology of the proposed restoration treatments for the Isleta Reach is an increased active channel with lower flow depths and velocities at high flow conditions. The flow depth and velocity reduction is on the order of about 10 to 20 percent for the bank-full conditions. This will provide enhanced low velocity habitat at high flow conditions. A greater portion of the channel will have shallow flows with a more mobile bed. The channel will be slightly wider with the reworking and elimination of vegetated bars attached to the channel banks and there will be increased channel conveyance resulting in reduced overbank flooding in the project sub-reaches. With the redistribution of the high flow volume, some increased overbank flooding will occur in areas outside of the project sub-reaches. There will also be a marginal reduction in infiltration and evaporation losses associated with the increased channel conveyance.

Restoration Technique: In-Channel Refugia Using Large Woody Debris

Under drying channel conditions, there are few options for creating "in-channel" refugia. One creative approach is currently being tested by MRGCD and Habitech, Inc. Their "perennial pool" projects involve anchoring large cottonwood snags to the river bank and extending the snags into the channel immediately upstream and downstream of a drain outfall. The intent is to create deep scour holes on the downstream side of the debris pile during high river flows. During low flows or dry periods, these scour holes are kept wet by providing minimal flows (e.g., 1 to 3 cfs) from the adjacent drain outfall (BOR, 2006a).

Habitech and MRGCD are currently in the process of constructing "perennial pool" projects at three wasteway outfalls in the Isleta Reach: Los Chavez Wasteway (≈ RM 157), Peralta Wasteway (≈ RM 152.5), and the Lower Peralta Riverside Drain No. 1 (≈ RM 150). In addition, there is another perennial pool project at the 240 Wasteway on the Isleta Pueblo. The Los Chavez Wasteway is a particularly strategic location because it is within the river segment described previously that most frequently dries (see Chapter 4, Exhibit 4-9). There is currently no monitoring data available to determine if these projects function as intended.

Another derivation of this approach could involve installing large, log flow-deflectors along the channel edges, especially in channel segments with a well-defined thalweg along the bank (Exhibit 5-15). This technique differs slightly from the perennial pool technique described above in that it does not necessarily have to be constructed immediately downstream of an irrigation outfall. Site selection would focus on reach segments that do not typically go completely dry, or that only intermittently run dry. Some existing locations that may be suitable for this treatment include RM 128 to RM 138.5, RM 150 to RM 152.5, and RM 155 to RM 160.5. In these reach segments, intermittent flows occur but tend to be less severe and of shorter duration than others. In reach segments that tend to dry more severely and frequently, silvery minnows entering scour pools may be more likely to become trapped and require rescue.

For example, when the channel dries during the day, deeper pools can serve as temporary refuge habitat for silvery minnows and other fish species. Then, as the channel re-wets overnight due to reduced evaporation rates by riparian vegetation, these temporary pools may reconnect and allow the fish to move back into the channel, potentially swimming to reaches with more dependable flows.

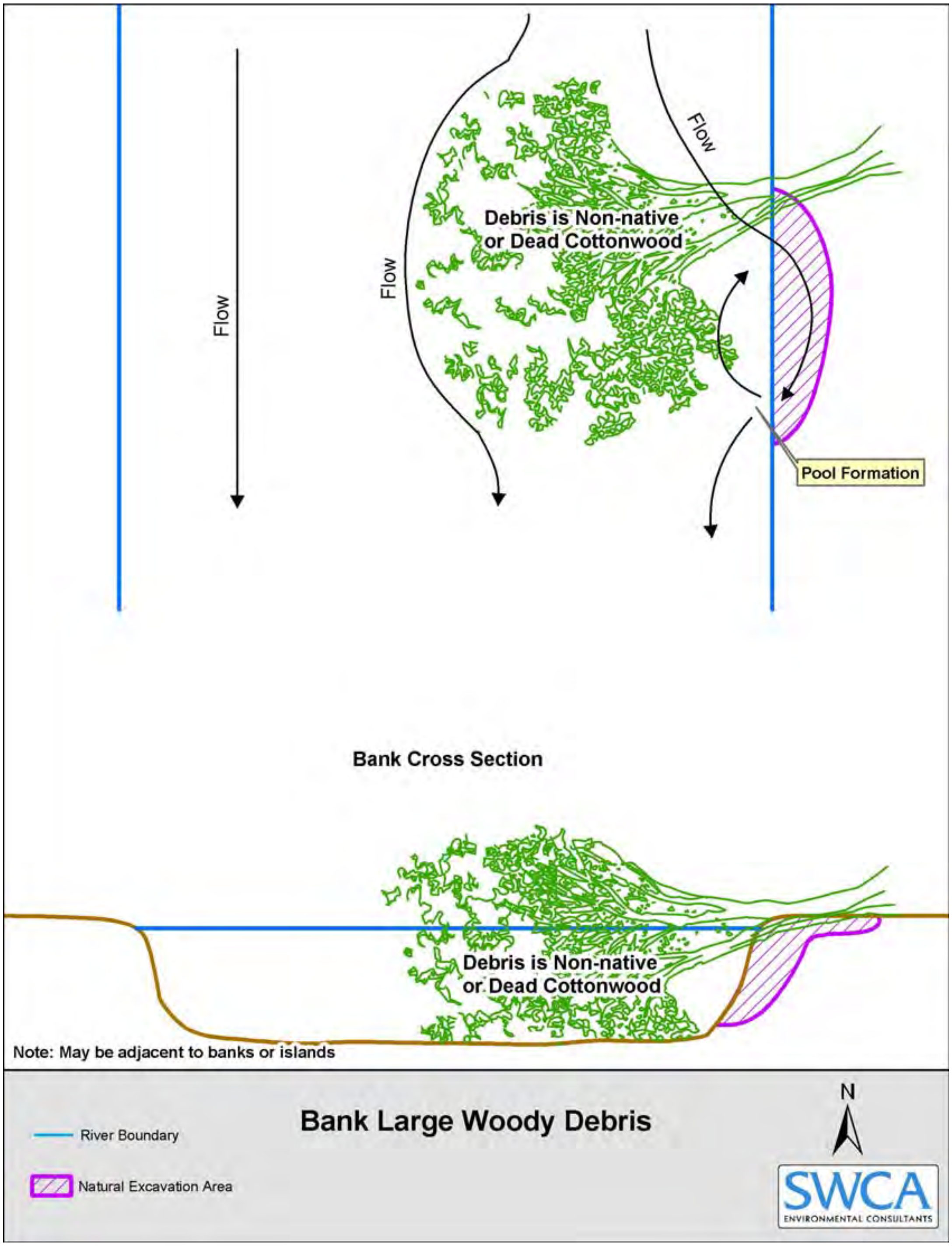
- As with most other restoration techniques presented in this report, however, the utility of scour pools formed by large, woody debris has not been fully evaluated to assess the actual benefits in aiding the recovery of silvery minnows. As such, implementation of these projects should include a rigorous monitoring component and results should be used to guide adaptive management to improve future designs.

Site Selection

Installation of large, woody debris would focus on reach segments that do not typically go completely dry, or that only intermittently run dry. Some existing locations that may be suitable for this treatment include RM 128 to RM 138.5; RM 150 to RM 152.5; and RM 155 to RM 160.5. In these reach segments, intermittent flows occur but tend to be less severe and of shorter duration than others. In reach segments that tend to dry more severely and frequently, silvery minnows entering scour pools may be more likely to become trapped and require rescue.

Exhibit 5-15

Conceptual Drawing of In-Channel Refugia Using Large, Woody Debris (from SWCA, 2006a).



Graphic reproduced with permission from NMISC.

Project Benefits

The benefits to aquatic habitat derived from the restoration techniques are presented as hypotheses that need to be validated in the field. The hypothesized benefits to the silvery minnow following installation of large, woody debris along channel banks include:

- Creates scour holes and slow-water habitats for all life-stages of silvery minnow;
- Provides refugia for silvery minnow during low-flow and/or drying channel conditions;
- Provides shelter for silvery minnow from predators;
- Provides over-winter habitat for silvery minnow, and;
- Provides structure for periphyton growth to improve food supplies for developing silvery minnow larvae.

6 What is the recommended restoration approach for facilitating flycatcher territory expansion in the Isleta Reach?

Facilitating flycatcher territory expansion through habitat restoration is a difficult challenge, especially when there are relatively few existing territories in the 48-mile Isleta Reach. All of the existing territories in this reach are concentrated in the Sevilleta Sub-reach between Rio Puerco and Rio Salado (the downstream end of the project reach). There are no documented nesting territories in the Belen or Los Lunas Sub-reaches, but there are active territories immediately upstream of the project reach on lands owned by the Pueblo of Isleta (Smith and Johnson, 2007).

Information presented from Hatten and Sogge (2007) in Chapter 4 indicates that vegetation density and structure may provide suitable breeding habitat in large segments of the Isleta Reach. As discussed in Chapter 4, however, we suspect that the extent of the high probability of breeding habitat estimated by Hatten & Sogge (2007) is probably grossly overestimated because hydrologic parameters are not factored into their analysis. Although extensive acreage in both the Los Lunas and upper Belen Sub-reaches are inundated when river flows exceed 5,000 cfs (see Chapter 2), flood flows of this magnitude have occurred only twice in the past decade (2005 and 2008). Since flycatchers in the MRG typically establish breeding territories in close proximity to lentic (slow moving) water bodies and/or seasonally saturated soil conditions (White, 2006; Smith and Johnson, 2007), we hypothesize that infrequent flooding may be an important limiting factor for territorial expansion into these upper sub-reaches.

Restoration efforts aimed at increasing flood frequency on an annual basis to sites with adequate vegetation characteristics might be one way to encourage flycatchers to expand their territories in the Isleta Reach. Given the extensive acreages across the project reach that may already have adequate vegetation structure (see Chapter 4, Restoration Issues and Opportunities for the Flycatcher), we suggest site selection for restoration treatments should initially focus on areas in close proximity to existing flycatcher territories. This is predicated on the understanding that flycatchers tend to be "gregarious breeders;" that is, where flycatchers already nest, more flycatchers will tend to nest (D. Ahlers, BOR, personal communication, 2007).

In addition to enhancing site hydrologic characteristics, flycatcher habitat restoration projects may also benefit from increasing cover and density of native riparian species, especially of Goodding's and coyote willow. This is based on the fact that at least 80 percent of the nesting flycatchers in the MRG are found in habitats dominated by these species (Moore and Ahlers, 2006a, 2006b). Analyses presented in Chapter 2 indicate that coyote willow cover in the Isleta Reach has declined by approximately 50 percent since 1984, and that few sites are currently dominated by Goodding's willow. We hypothesize that restoration projects that create frequently flooded, dense willow habitats have significant potential for attracting breeding flycatchers, especially when these projects are constructed in close proximity to existing flycatcher territories.

We hypothesize that restoration projects that create frequently flooded, dense willow habitats have significant potential for attracting breeding flycatchers, especially when these projects are constructed in close proximity to existing flycatcher territories.

Dense stands of native willow habitat can be potentially created through a variety of methods. For example, Bosque del Apache NWR has implemented mechanical site manipulations in the active floodplain followed by managed flow releases to establish native cottonwoods and willows (Taylor et al., 2006). Reclamation is currently implementing pilot restoration projects on abandoned floodplain terraces along the Colorado River. Their on-going research project uses irrigation infrastructure to flood fields followed by broadcast seeding willow and cottonwoods (GeoSystems Analysis, Inc, 2007). This approach has considerable potential on private lands and wildlife refuges along the MRG that already have existing irrigation infrastructure and parcels in close proximity to the active river channel.

Along the MRG, the most commonly applied revegetation method has involved planting dormant cottonwood and willow stems into the groundwater table. A modified version of this planting approach involves construction of “willow swales” that can create exceptionally dense willow thickets. This approach has been used successfully by the Pueblos of Santa Ana and Cochiti, and is being evaluated for extensive application in the Albuquerque Reach by the Corps of Engineers for their MRG Bosque Ecosystem Restoration Project.

To maximize the potential for attracting breeding flycatchers, restoration of dense native riparian habitat should include features that promote presence of slow moving water. This may be especially important during the nest establishment period from approximately mid-May through June (D. Ahlers, BOR, personal communication, 2007). Once a mechanism exists that allows leasing water for conservation purposes, some sites could be inundated with water provided via existing irrigation infrastructure or through pumping groundwater. In the meantime, the only feasible technique involves constructing backwater channels through the willow restoration sites.

Coyote willow plants were harvested from the Low Flow Conveyance Channel for previous willow-swale restoration projects at the Pueblos of Santa Ana and Cochiti. These willow “cuttings” were harvested and planted during winter months when the plants were dormant.
(Photo Credit: Parametrix)

Restoration Technique: Willow Swale Construction

Willow swale construction was listed as a recommended restoration technique in the report titled *Restoration Analysis and Recommendations for the San Acacia Reach of the Middle Rio Grande* (Parametrix, 2008). This technique was originally performed at the Pueblo of Santa Ana and was recently performed by the Corps in several burned areas in the Albuquerque bosque. The concept behind constructing willow swales is that they provide opportunities to create relatively large acreages of dense willow dominated habitat without the need for supplemental irrigation water. Where these features are constructed in place of existing stands of exotic vegetation, willow swales have the added benefit of reducing exotic root-sprouts because most or all of the undesirable roots are removed when the swale trenches are excavated.

Swale construction in the Albuquerque bosque in 2005.
(Photo Credit: Parametrix).

Constructing a willow swale involves the following basic steps:

- Removing existing non-native vegetation from the site. This can be accomplished using mowing tractors.
- Creating the swale by lowering the floodplain grade. This serves the dual purpose of removing unwanted plant roots and bringing the ground surface closer to the water table. The soil and root spoil will be spread on-site to avoid excessive hauling costs.
- Excavating parallel, linear trenches within the swale until groundwater begins flowing into the trenches.
- Purchasing and/or collecting willow material. Previous projects requiring large quantities of coyote willow (e.g., Santa Ana and Cochiti Pueblos) have coordinated with the BOR to collect coyote willow cuttings along the LFCC. Bosque del Apache has collected large numbers of Goodding's willow tree poles from the Elephant Butte delta, although it may be more cost effective in some situations to coordinate with a qualified local plant nursery to grow and deliver the tree poles.

Willow installation at a swale constructed at Cochiti Pueblo.
(Photo Credit: Parametrix)

- While the plants are dormant (December–February), cuttings are installed vertically in the exposed trenches with their butt-ends in standing water. The coyote willow cuttings are spaced approximately 3 to 5 feet apart. Goodding's willow and cottonwood tree poles should be added to the trenches to add structural diversity to the restoration project. Bosque del Apache has planted Goodding's willow poles as close as 10 feet apart at some of their restoration sites (G. Dello Russo, Bosque del Apache NWR, personal communication, 2007). Although, wider planting distances may be more appropriate if planted in combination with coyote willow shrubs because coyote willows tend to be more robust when the overstory tree canopy is relatively open. To reduce potential beaver damage to tree poles, it may be desirable to install devices to minimize beaver damage to the poles.
- Backfilling the trenches.

If conditions are suitable, willow canopy cover can exceed 100 percent after only two growing seasons. This photo was taken at the Albuquerque bosque site shown in the photo above. (Photo Credit: Parametrix)

Restoration Technique: Backwater Channels

Backwater channels are described here because these channel features are very compatible with willow swales and other willow planting techniques. As their name implies, backwater channels allow river water to "back-up" into a restoration site from the downstream end of a secondary channel. Backwater channels can be excavated adjacent to a willow swale and incorporated as part of the construction design of the swale. In the development of design-build construction plans, specific consideration should be given to backwater to channel connectivity to avoid stranding silver minnows.

Backwater channels enhance willow swales by improving hydraulic conditions that favor willow growth and by providing a low-velocity water source commonly associated with MRG nest sites. These backwater channels are also important because they have potential to provide low-velocity nursery habitat for silvery minnow during periods of high river flow. The Program's Habitat Restoration Workgroup expressed strong interest in habitat features, like backwater channels, designed to benefit both the flycatcher and the silvery minnow.

The Program's Habitat Restoration Workgroup expressed strong interest in restoration projects, like backwater channels, designed to benefit both the flycatcher and the silvery minnow.

Site Selection

The primary site selection criteria for constructing willow swale and backwater projects included sites that:

- Are within 1 mile from recent (2006 or 2007) flycatcher territories.
- No closer than 1/4 mile to existing territories.
- Are adjacent to the active river channel.
- Are dominated by non-native vegetation.
- Have shallow estimated depths to groundwater.
- Have low exposure to high-velocity flows.
- Have relatively wide buffer zones between the restoration feature and the levee.
- Are located away from developed recreation areas (e.g., picnic areas).
- Support a minimum swale size of 5 acres.
- Are compatible with bar destabilization and lowering projects.

Existing GIS data was used in concert with field reconnaissance to evaluate which sites met these site selection criteria. This analysis was concentrated in areas near existing flycatcher territories in the Sevilleta Sub-reach and in the upper Los Lunas Sub-Reach, immediately downstream of breeding territories near the south boundary of Isleta Pueblo (Exhibits 5-16 through 5-21).

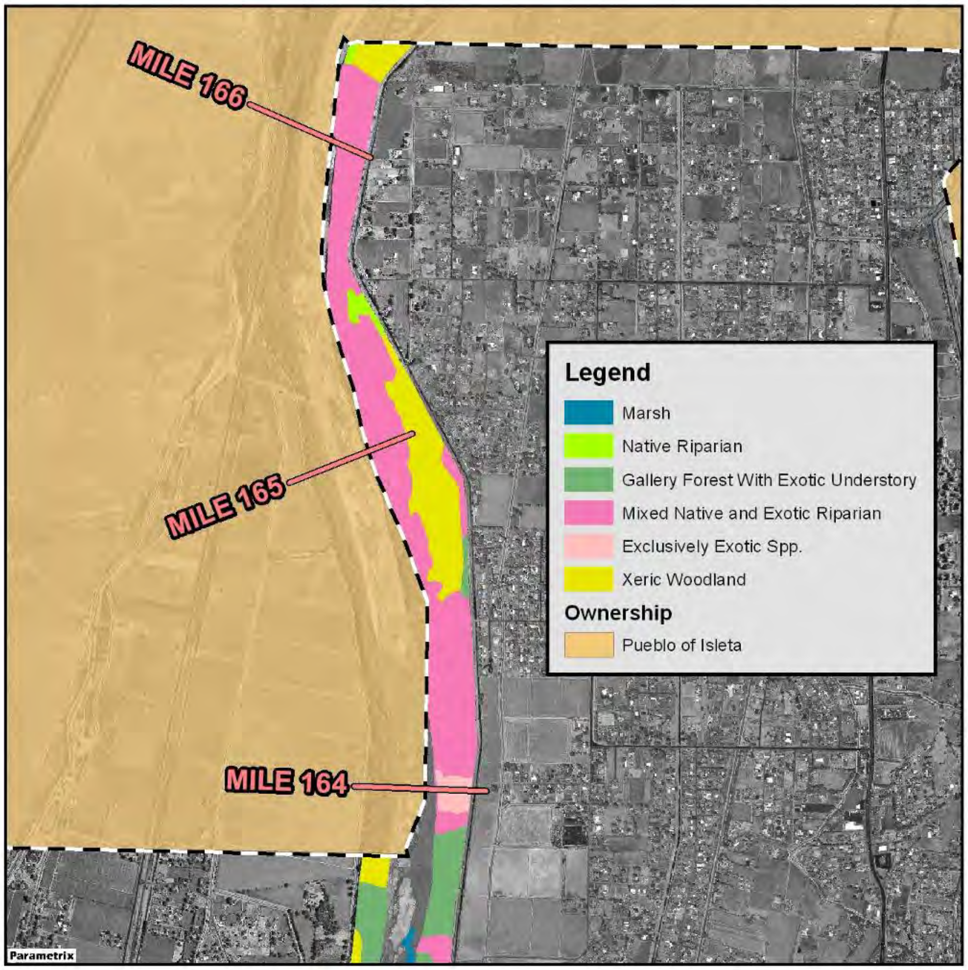
Only two project sites met the site-selection criteria, and both were located immediately upstream of the Rio Puerco confluence (Exhibit 5-17). The Rio Puerco sites corresponded to the river segment that we identified in Chapter 4 as being important for establishing backwater habitat for the silvery minnow. We identified two sites in this location, one on either side of the river, with high potential for successful willow swale and backwater habitats.

Exhibit 5-16

Potential Flycatcher Restoration Site Near the South Boundary of Isleta Pueblo

<u>Selection Criteria</u>

- √ Distance
- X Vegetation
- √ Depth to GW
- √ Surface Water
- X Constructibility



The east-side floodplain across from the Isleta Pueblo boundary has a relatively shallow groundwater table and can be inundated by flood flows greater than 4,000 cfs. The vegetation is dominated by a cottonwood gallery forest with a dense exotic understory. Constructing willow swales and backwater channels through this site would not be feasible without killing the cottonwoods. For these reasons, this site is not recommended for willow swale and backwater channel construction treatments.

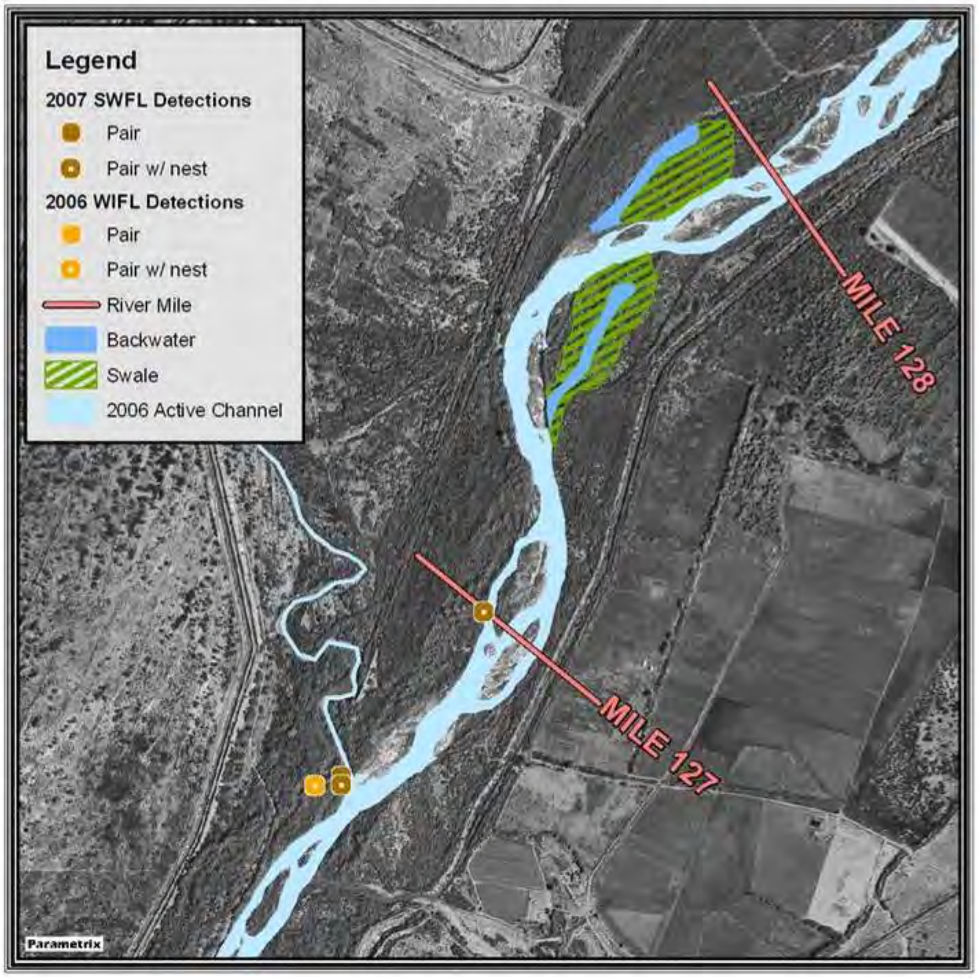
The boundary of Isleta Pueblo depicted on this map is an older depiction of the boundary; however, the Pueblo of Isleta currently recognizes the eastern boundary between RM 163.7 and RM 166.3 along the Rio Grande as being the MRGCD right-of-way adjacent to the Peralta Drain.

Exhibit 5-17

Potential Flycatcher Restoration Site Upstream of the Rio Puerco Confluence

<u>Selection Criteria</u>

√ Distance
√ Vegetation
√ Depth to GW
√ Surface Water
√ Constructibility



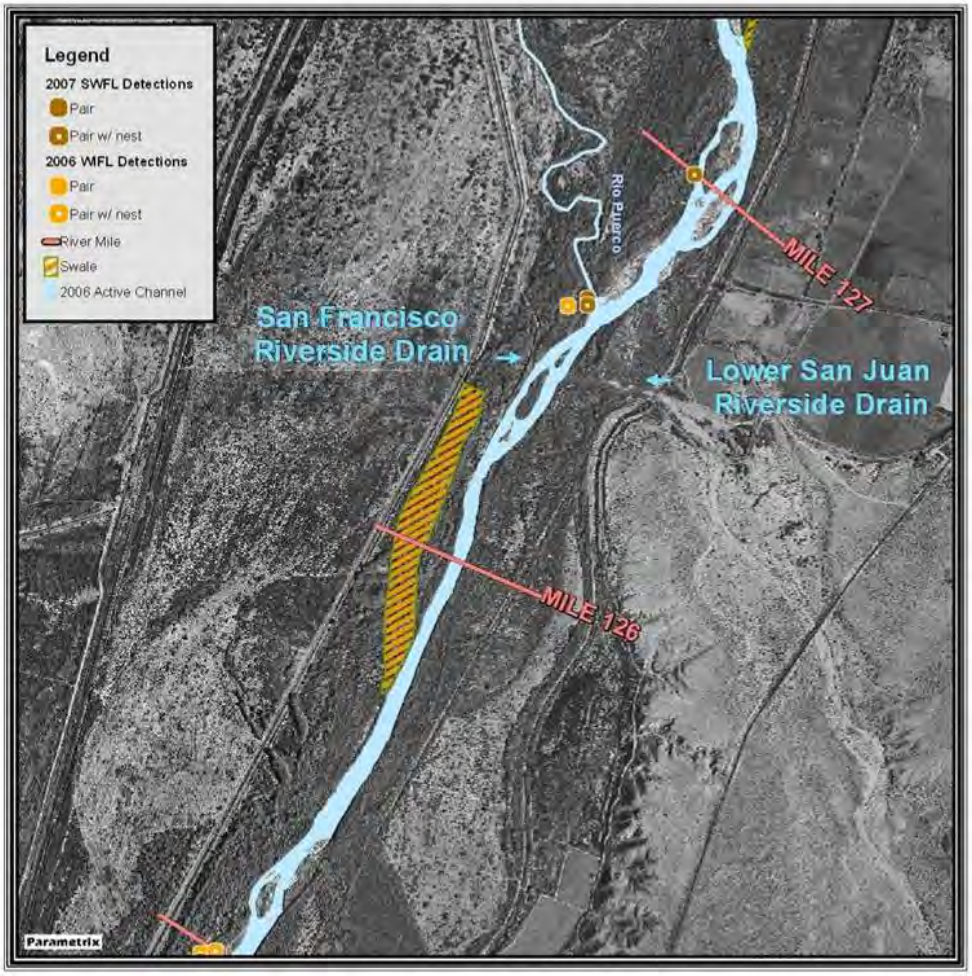
The proposed backwater channel locations were selected because hydrologic data (FLO-2D analysis and data from Horner and Sanders, 2007) indicated that these locations currently function as backwater channels when flows exceed 5,000 cfs. Relatively minor excavation would be required to increase inundation potential of these existing backwaters at moderate flows (i.e., 2,500 cfs).

Exhibit 5-18

Potential Flycatcher Restoration Site Downstream of the Rio Puerco Confluence

Selection Criteria
- √ Distance
- √ Vegetation
- √ Depth to GW
- √ Surface Water

Constructibility
- Siphon project
- High soil clay content in potential backwater channel location
- Close proximity to levee



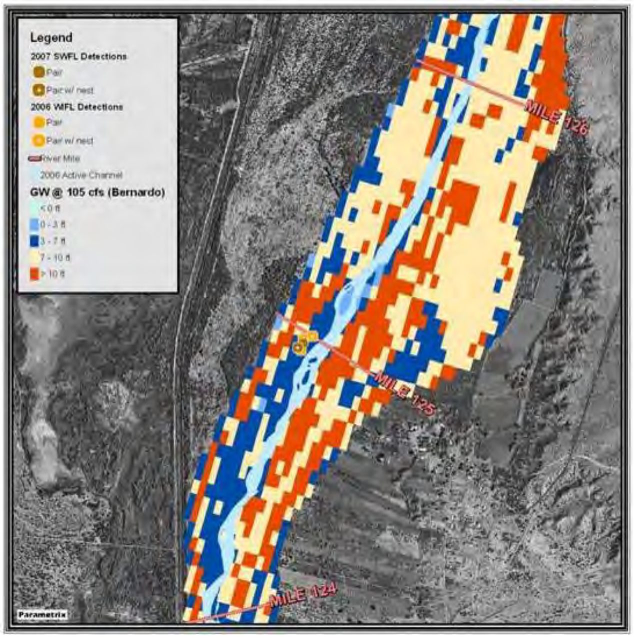
The backwater channel location depicted in the photo above was selected using terrace elevation maps provided by the BOR. Field reconnaissance of this potential backwater channel location revealed thick clay lenses deposited over time by the Rio Puerco. This condition, coupled with the proposed San Juan Drain Siphon project and the close proximity to the west-side levee, rendered this site undesirable for a swale/backwater restoration project.

Exhibit 5-19

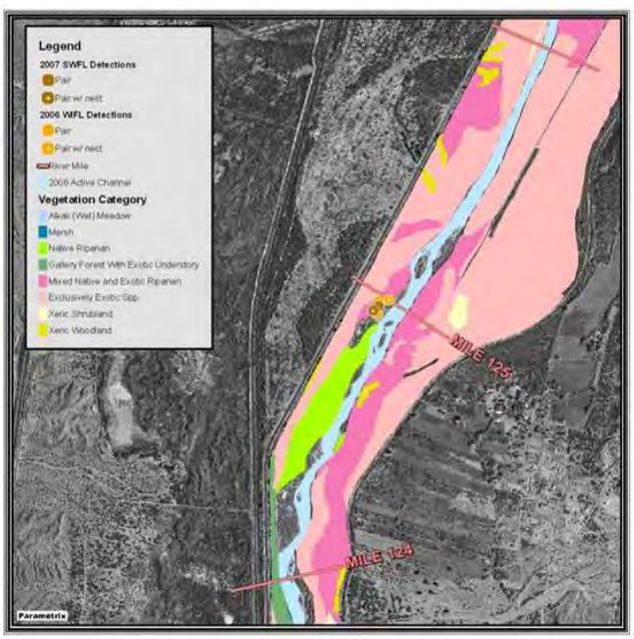
Potential Flycatcher Restoration Site Near the La Joya Fish and Game Refuge

<u>Selection Criteria</u>

√ Distance
X Vegetation
X Depth to GW
√ Surface Water
√ Constructibility



Data from the existing riparian groundwater model (NMISC, 2007) indicates that groundwater depths exceed 7 feet in areas greater than 1/4 mile from the existing flycatcher nest sites (shown in "yellow" in the above map).



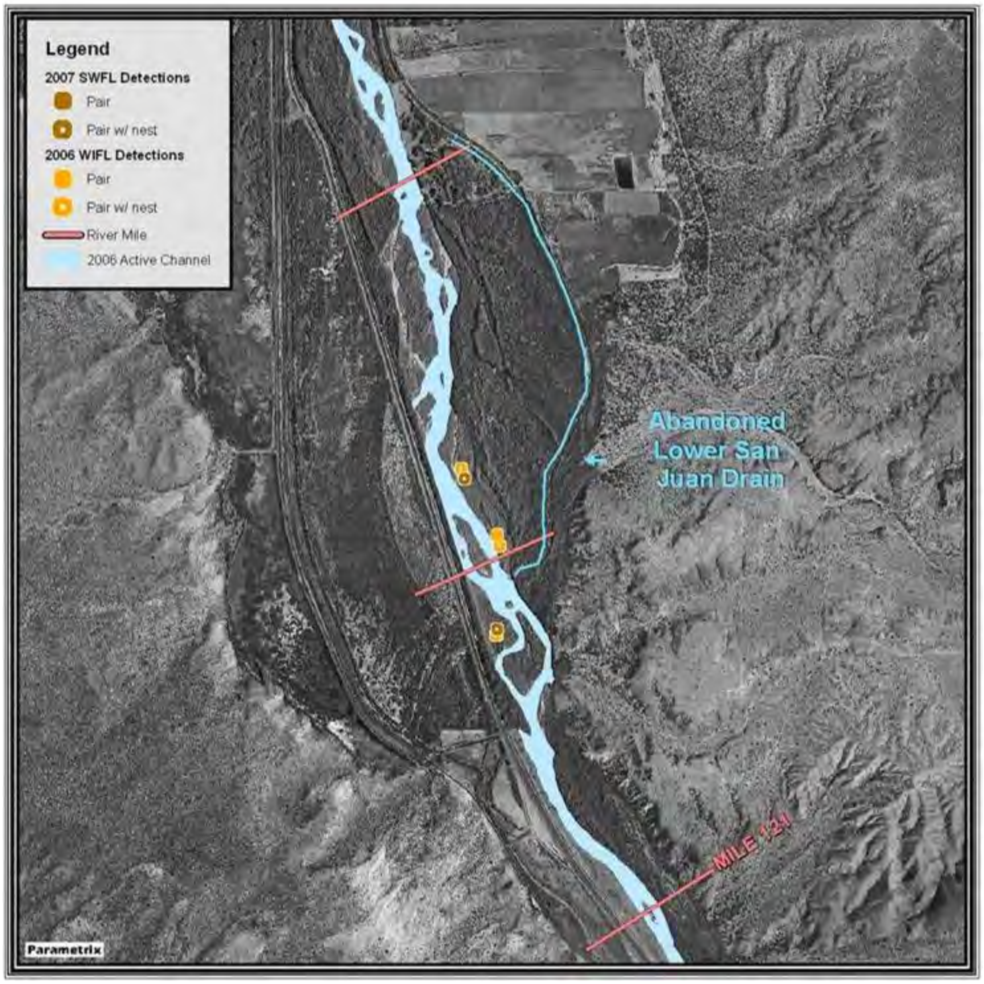
Vegetation data provided by BOR indicates that existing vegetation at least 1/4 mile from existing flycatcher nests are co-dominated by native riparian vegetation.

Exhibit 5-20

Potential Flycatcher Restoration Site Near the Lower San Juan Drain Outfall

Selection Criteria

- X Distance
- √ Vegetation
- √ Depth to GW
- √ Surface Water
- √ Constructibility



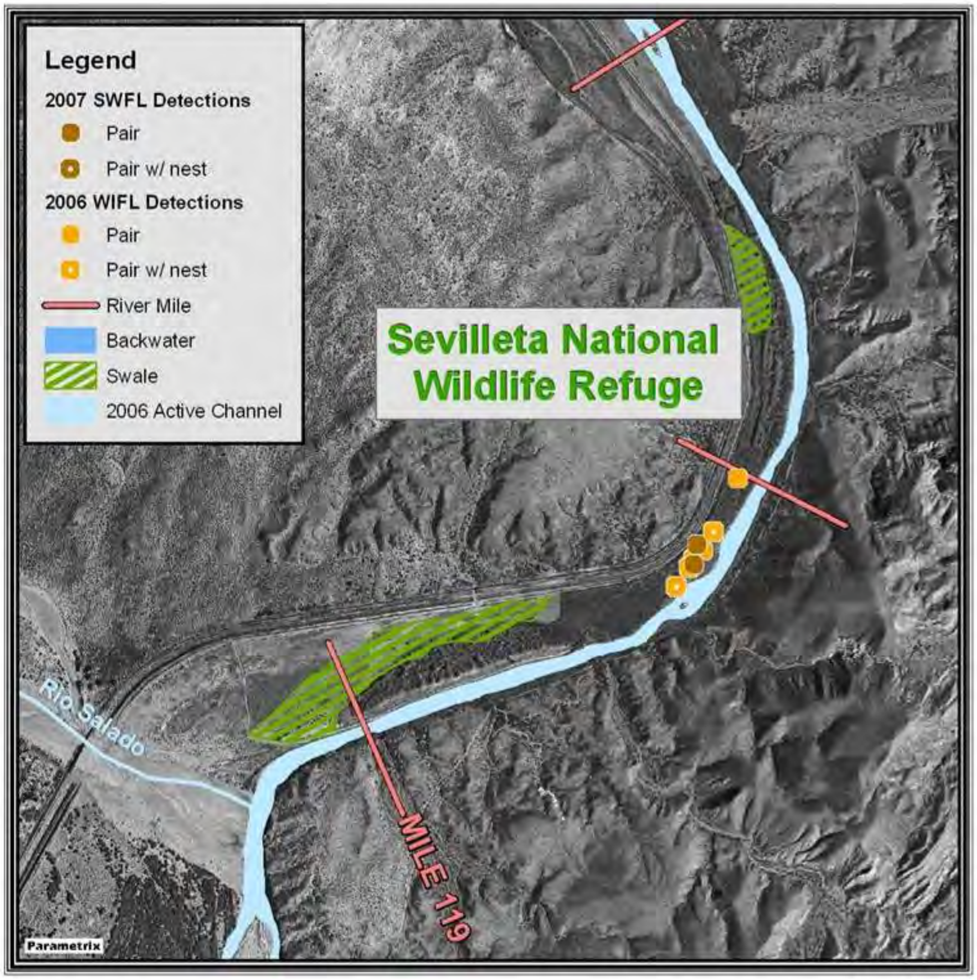
Portions of this area that met the majority of site selection criteria were within 1/4 mile of existing nest sites. This was considered too close to existing territories to be selected as a recommended project.

Exhibit 5-21

Potential Flycatcher Restoration Site Within the Sevilleta National Wildlife Refuge

Selection Criteria

√ Distance
√ Vegetation
√ Depth to GW
X Surface Water
X Constructibility



Two locations were identified upstream and downstream of existing flycatcher nest sites. This area is referred to as "Unit B" on the Sevilleta NWR. The upstream location highlighted in green could support a willow swale, but a backwater channel would not be feasible because the floodplain terrace is too elevated. The downstream location highlighted in green near RM 119 has thick clay lenses that would need to be removed in order to construct a willow swale. This site is, however, situated next to an irrigation turnout from the Unit 7 drain. The Refuge has cleared saltcedar vegetation from this site, and is interested in seeding willows and irrigating the site, but they currently lack the ability to lease water that would enable them to apply irrigation water during the plant growing season.

Another advantage of these locations is that both proposed project sites already have existing backwater channels (Exhibits 5-22 and 5-23). FLO-2D analysis and data from Horner and Sanders (2007) indicate that flood waters back into these sites at flows of approximately 5,000 cfs. Relatively minor excavation would be required to lower these backwater channels to promote inundation at relatively moderate flows (i.e., 2,500 cfs). Project summary tables are provided in Exhibit 5-24 and Exhibit 5-25. Estimated excavation quantities and costs are provided in a project cost summary table in Appendix C (Exhibit C.5-16). FLO-2D analysis of these proposed projects are described below.

Project Benefits

The construction of willow swales and backwater channels that restore historic riparian habitat are hypothesized to achieve the following benefits for the silvery minnow and flycatcher:

- Willow swale construction techniques have a high potential for creating dense riparian habitats in a relatively short period of time (i.e., less than 3 years).
- The proposed projects will create suitable habitat for flycatchers close enough to existing nesting territories to serve as potential expansion territories for territorial males and nesting pairs.
- Backwater channels will provide open water habitat within close proximity to willow swales during the flycatcher-nest establishment period (May through June).
- Backwater channels will provide new low-velocity nursery habitat for silvery minnow under a range of flow conditions.

Backwater channels may fill with sediment over time, particularly near the contact point with the river channel. Project monitoring should be used to guide adaptive management and future design improvements of these projects.

Supplemental Data Requirements

There was no existing detailed site information for these project sites. Supplemental site data should include:

- Establishing cross-sections through the proposed project sites.
- Verifying groundwater depths, particularly during low-flow conditions at each project site.
- Verifying that soil salinity does not exceed published tolerance ranges for Goodding's or coyote willow.
- Re-calculating excavation quantities and verifying that excavation spoils can be spread on-site.

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Exhibit 5-22

Planning Level Construction Plan for Willow Swales and Backwaters Upstream of the Rio Puerco

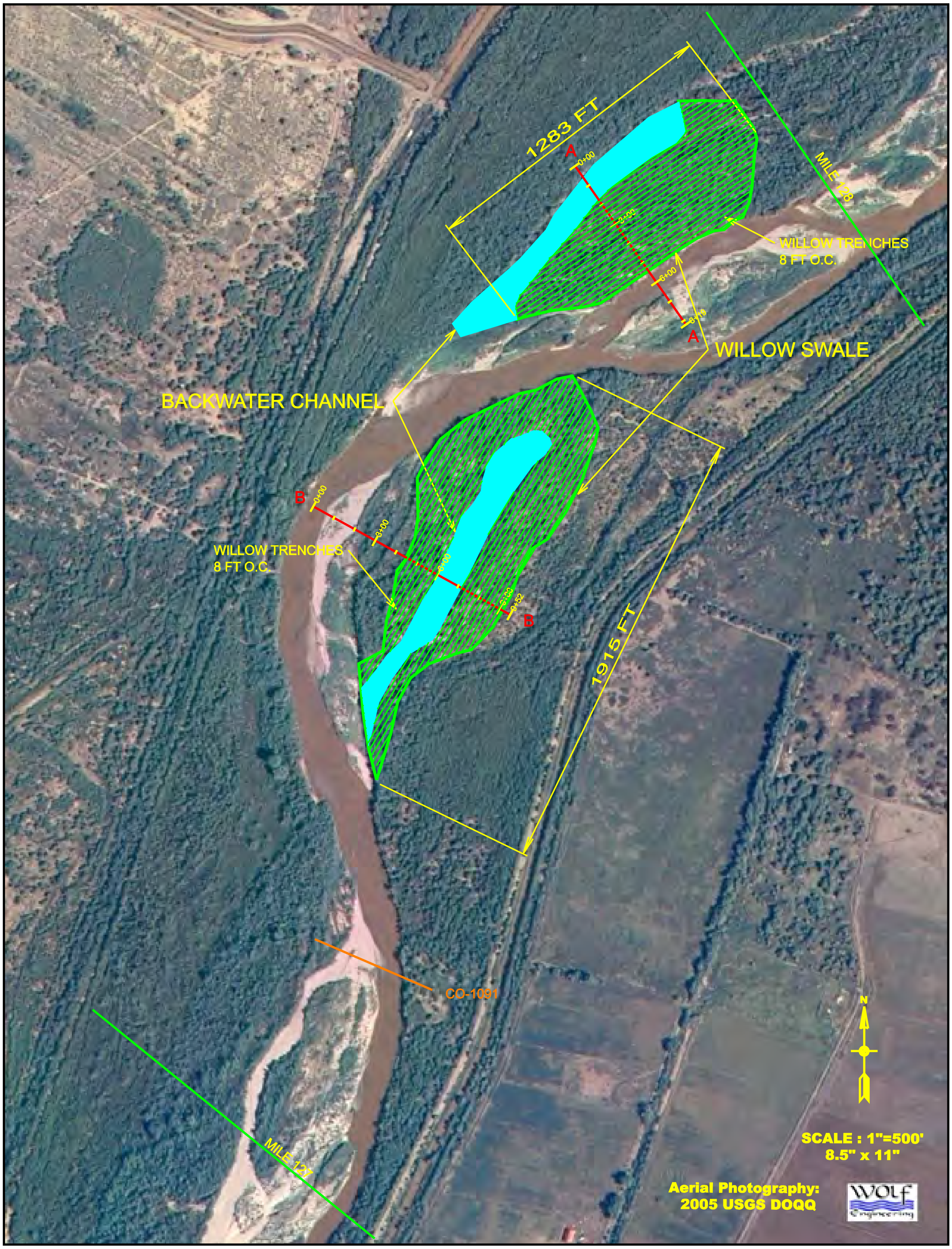

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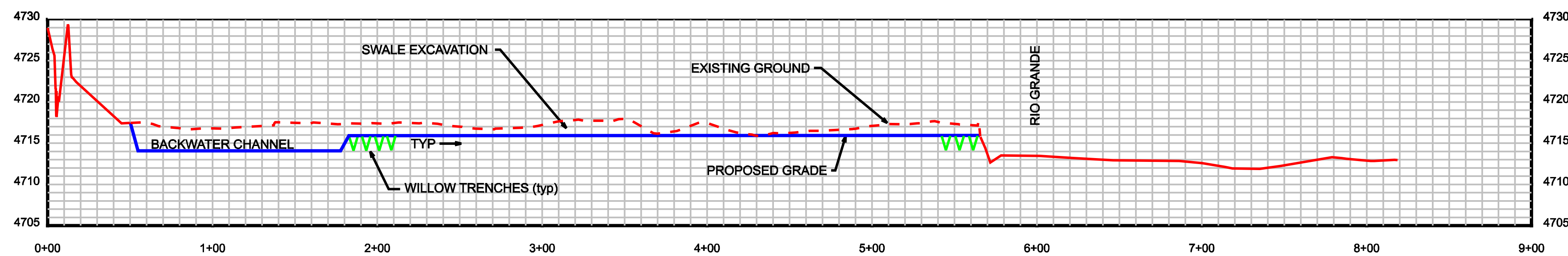
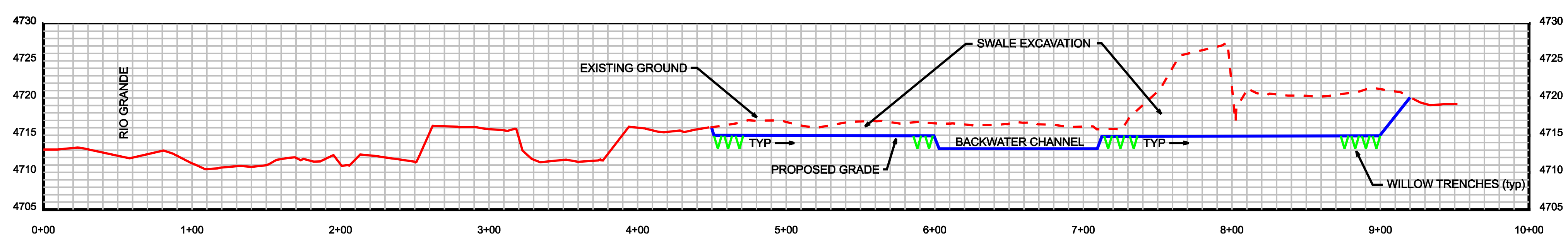
Exhibit 5-23

Planning Level Construction Cross-Sections of Willow Swales and Backwaters Upstream of the Rio Puerco

CROSS SECTION A-A : WILLOW SWALE RM 127.8



CROSS SECTION B-B : WILLOW SWALE RM 127.6



* EXISTING GROUND FROM 1998 LIDAR DTM DATA

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Exhibit 5-24

Project Summary Table – Willow Swale and Backwater (East Side Near RM 127.6)

Project Description			
Restoration Technique(s)	Willow Swale, Backwater Channel		
Functional Limitations Addressed	☐ Channel Narrowing	☐ Channel Drying	☒ Groundwater
Species Focus	☐ Silvery Minnow	☐ Willow Flycatcher	☒ Both
Location (River Mile)	RM 127.4 – RM 127.7		
Potential Number of Acres Benefited	12.0 acres (willow swale) 3.3 acres (backwater channel) **15.3 Acres Total Project**		
Land Ownership/Management Agency	Bureau of Reclamation		
Project Description	This project would construct a willow swale on the east side of the existing river channel. Existing vegetation at the site location would be mowed to ground level using mechanized equipment. The swale area would be lowered approximately 18 inches below grade and spoil would be either spread on-site or hauled to a nearby deposition area. Goodding's willow tree poles and Coyote willow stem cuttings would be planted in linear trenches excavated to expose groundwater. Trenches are excavated parallel to one another at spacings no greater than 10 feet apart. Spacing of Goodding's willow poles within individual trenches is no greater than 30 feet apart. Coyote willow stems are planted no greater than 3 feet apart. Trenches are backfilled after willows are installed. A backwater channel would be excavated to a depth of approximately 3 feet below grade. Side slopes should be no greater than 3:1. Channel should be constructed to supply low-velocity surface water during flows greater than 3,500 cfs and provide moist soil throughout the flycatcher breeding season.		
Construction Elements	a. Mow existing vegetation. b. Lower bar approximately 18 inches. c. Excavate backwater channels. d. Excavate swale planting trenches. e. Install plant material. d. Backfill trenches.		
General Estimate of Construction Costs	Preliminary cost estimates indicates approximately $617,000 (see Appendix C; Exhibit C.5-16).		
Operation and Maintenance Issues	Periodic sediment removal from downstream end of backwater channels.		
Adaptive Management/Monitoring	Annual monitoring of willow growth characteristics, moist soil conditions, and seasonal groundwater table conditions. Annual flycatcher monitoring and evaluations of backwater channels used by silvery minnow. Likely outcomes should be developed so the effects on river maintenance programs can be evaluated. Monitoring criteria and data gaps are described in Chapter 6, Monitoring Criteria section.		
Potential Water Salvage/Depletion	Depletions analyses were performed on all willow swale/backwater projects combined, rather than on individual projects. Analyses are presented in the Net Depletions section below.		
Environmental Compliance Requirements	Possible 404/401 Clean Water Act compliance issues associated with swale construction and backwater channel excavation.		
Additional Data Requirements	Site-specific detail on topography, groundwater depth, soil salinity levels, and existing vegetation characteristics is needed to finalize design, plant material amounts/sizes, and to fine-tune project cost estimates.		
Other Implementation Issues	Land ownership boundaries need to be confirmed.		

Exhibit 5-25

Project Summary Table – Willow Swale and Backwater (West Side Near RM 127.8)

Project Description			
Restoration Technique(s)	Willow Swale, Backwater Channel		
Functional Limitations Addressed	☐ Channel Narrowing	☐ Channel Drying	☒ Groundwater
Species Focus	☐ Silvery minnow	☐ Willow flycatcher	☒ Both
Location (River Mile)	RM 127.7.8 – RM 128		
Potential Number of Acres Benefited	10.0 acres (willow swale) 3.4 acres (backwater channel) **13.4 Acres Total Project**		
Land Ownership/Management Agency	Bureau of Reclamation		
Project Description	This project would construct a willow swale on the west side of the existing river channel. Existing vegetation at the site location would be mowed to ground level using mechanized equipment. The swale area would be lowered approximately 18 inches below grade and spoil would be either spread on-site or hauled to a nearby deposition area. Goodding's willow tree poles and Coyote willow stem cuttings would be planted in linear trenches excavated to expose groundwater. Trenches are excavated parallel to one another at spacings no greater than 10 feet apart. Spacing of Goodding's willow poles within individual trenches is no greater than 30 feet apart. Coyote willow stems are planted no greater than 3 feet apart. Trenches are backfilled after willows are installed. A backwater channel would be excavated to a depth of approximately 3 feet below grade. Side slopes should be no greater than 3:1. Channel should be constructed to supply low-velocity surface water during flows greater than 3500 cfs and provide moist soil throughout the flycatcher breeding season.		
Construction Elements	a. Mow existing vegetation b. Lower bar approximately 18 inches c. Excavate backwater channels d. Excavate swale planting trenches e. Install plant material f. Backfill trenches		
General Estimate of Construction Costs	Preliminary cost estimates indicates approximately $532,000 (see Appendix C; Exhibit C.5-16)		
Operation and Maintenance Issues	Periodic sediment removal from downstream end of backwater channels.		
Adaptive Management/Monitoring	Annual monitoring of willow growth characteristics, moist soil conditions, and seasonal groundwater table conditions. Annual flycatcher monitoring and evaluations of backwater channel use by silvery minnow. Likely outcomes should be developed so the effects on river maintenance programs can be evaluated. Monitoring criteria and data gaps are described in Chapter 6, Monitoring Criteria section.		
Potential Water Salvage/Depletion	Depletions analysis was performed on all willow swale/backwater projects combined, rather than on individual projects. Analyses are presented in the Net Depletions section below.		
Environmental Compliance Requirements	Possible 404/401 Clean Water Act compliance issues associated with swale construction and backwater channel excavation.		
Additional Data Requirements	Site-specific detail on topography, groundwater depth, soil salinity levels, and existing vegetation characteristics is needed to finalize design, plant material amounts/sizes, and to fine-tune project cost estimates.		
Other Implementation Issues	Land ownership boundaries need to be confirmed.		

Flycatcher Restoration Projects at Sevilleta NWR

The Sevilleta NWR has indicated a strong interest in utilizing existing infrastructure to enhance flycatcher habitat near existing nest sites on the refuge. Parametrix staff worked with them to identify two locations upstream and downstream of existing flycatcher nest sites with potential for enhancing flycatcher habitat (see Exhibit 5-26).

The potential restoration site is situated next to an irrigation turnout from the Unit 7 drain. The refuge has cleared saltcedar vegetation from this site and has lowered the area so that it can be effectively flooded, however; they currently lack the ability to lease irrigation water during the plant growing season. Anticipating that there may be a mechanism for leasing water at some point in the near future (e.g., through the NM Strategic Water Reserve or some other conservation water bank), we have provided a project description for the Program's future consideration.

MRGCD Concerns

It is important to state that MRGCD has expressed concerns about utilizing their irrigation infrastructure to supply water for this project. Therefore, in addition to developing a mechanism for obtaining the water, MRGCD should be involved in discussions regarding the use of their irrigation facilities to deliver water to the proposed project.

The proposed project would involve constructing two habitat features: a willow swale (upstream of the existing flycatcher nests) and a willow wetland downstream of the flycatcher nests near RM 119 (see Exhibit 5-26). The willow swale would be constructed as previously described, but the willow wetland would instead be seeded with willow and cottonwood seed similar to the technique currently being used by the BOR along the Colorado River (GeoSystems Analysis, Inc, 2007).

To succeed, the site would need to be flooded using irrigation water delivered via an existing turnout from the adjacent Unit 7 drain. This technique is recommended near RM 119 because the site contains an extensive clay lens that serves as an impermeable layer that could hold irrigation water and maintain a wet condition for a prolonged period. Additional earthwork would be required to maximize project function, and an existing outflow control structure would be utilized to control ponding levels and drainage.

Once adequately prepared, the site would be flooded and seeded with coyote willow, Goodding's willow, and cottonwood seeds. After seeding, the soil moisture will need to be monitored to provide proper soil conditions for seedling establishment, growth, and survival. The site would require irrigation water for seedling establishment and maintenance of the established trees. The USFWS would need to develop a water budget to determine the precise amounts of water needed for initial establishment and on-going maintenance. Project summary tables are provided in Exhibit 5-27 and Exhibit 5-28.

Project Benefits

The willow swale and willow wetland projects are recommended because there are very few existing breeding territories in the Isleta Reach. We suggest the following benefits of this project:

- Project will create suitable habitat for flycatchers in close proximity to existing nesting territories. We hypothesize that such projects have considerable potential to facilitate breeding habitat expansion in the reach.
- The willow wetland project will create saturated soil conditions within the willow restoration site.
- The irrigation infrastructure provides greater flexibility for controlling the amount, timing, and duration of flood water than relying on flows from the river.
- High water surface elevations in the drain during the irrigation season, and the availability of water during the non-irrigation season, will help to minimize groundwater depths to help maintain the site.

Supplemental Information Needs and Data Requirements

Detailed site information for the Sevilleta project sites did not exist. Supplemental site data should include:

- Developing a water budget to determine irrigation water requirements for both establishment and maintenance of willow vegetation.
- Identifying a mechanism for leasing conservation water for this project.
- Evaluate soil conditions including texture, permeability, salinity, and depth to groundwater. Use these data in combination with water budget to refine the project design.
- Work with MRGCD regarding their concerns about using their irrigation infrastructure to provide water to the willow wetland site.

Exhibit 5-26

Sevilleta "Unit B" Willow Wetland and Swale Project – Overview

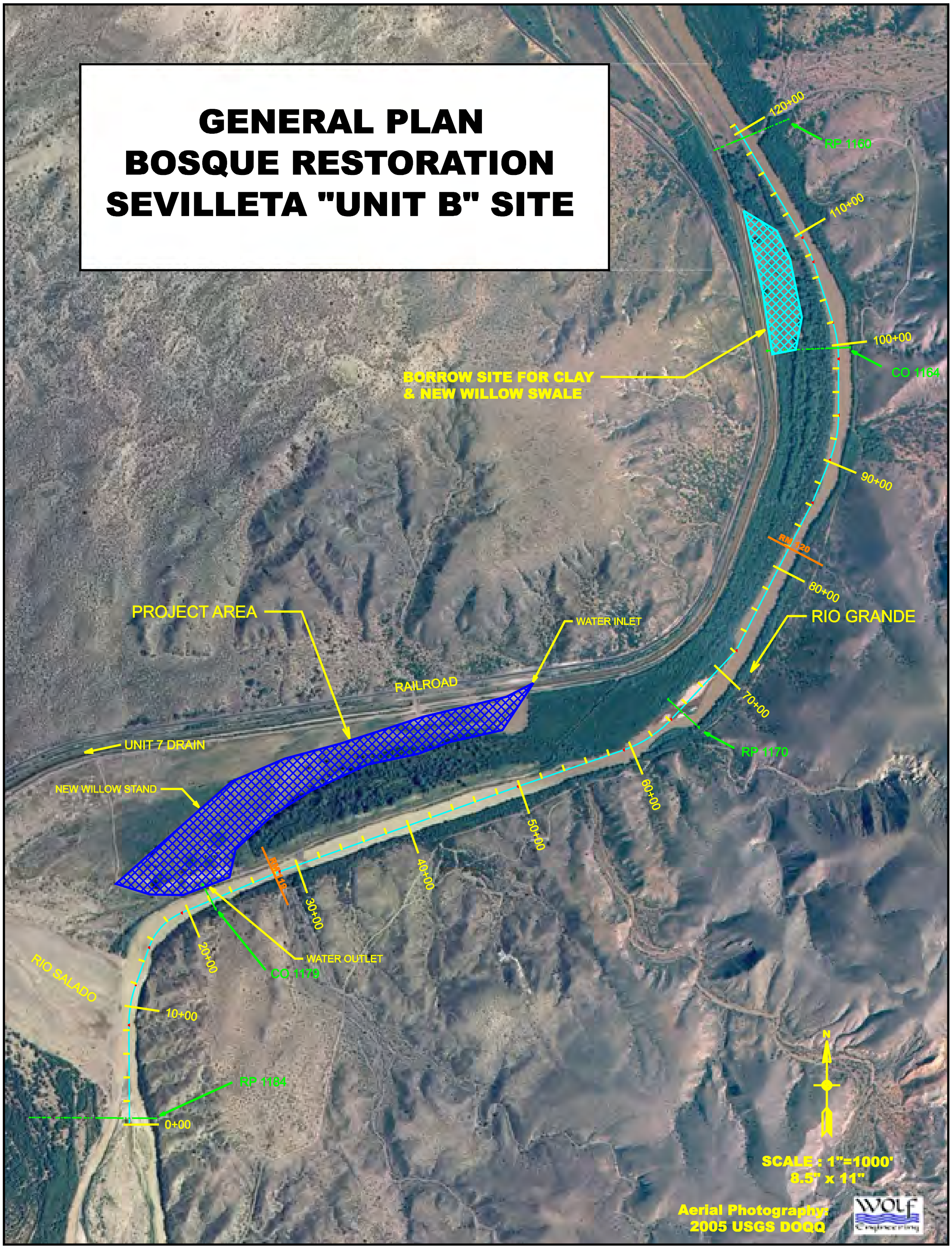

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Exhibit 5-27

Project Summary Table – Willow Swale (RM 120.5)

Project Description			
Restoration Technique(s)	Willow Swale		
Functional Limitations Addressed	☐ Channel Narrowing	☐ Channel Drying	☒ Groundwater
Species Focus	☐ Silvery minnow	☒ Willow flycatcher	☐ Both
Location (River Mile)	RM 120.4-120.6		
Potential Number of Acres Benefited	7.0 acres – Willow swale		
Land Ownership/Management Agency	Sevilleta National Wildlife Refuge		
Project Description	This project would construct a willow swale on the west side of the existing river channel. Existing vegetation at the site location would be mowed to ground level using mechanized equipment. Goodding's willow tree poles and Coyote willow stem cuttings would be planted in linear trenches excavated to expose groundwater. Trenches are excavated parallel to one another at spacings no greater than 10 feet apart. Spacing of Goodding's willow poles within individual trenches is no greater than 30 feet apart. Coyote willow stems are planted no greater than 3 feet apart. Trenches are backfilled after willows are installed.		
Construction Elements	a. Mow existing vegetation b. Lower site approximately 3.8 ft c. Excavate trenches d. Install plant material e. Backfill trenches		
General Estimate of Construction Costs	Preliminary cost estimates indicates approximately $311,000 (see Appendix C; Exhibit C.5-16).		
Operation and Maintenance Issues	Detailed construction plans will need to be developed.		
Adaptive Management/Monitoring	Annual monitoring of willow growth characteristics, moist soil conditions, and seasonal groundwater table conditions. Annual flycatcher monitoring. Likely outcomes should be developed so the effects on river maintenance programs can be evaluated. Monitoring criteria and data gaps are described in Chapter 6, Monitoring Criteria section.		
Potential Water Salvage/Depletion	Depletions analyses were performed on all willow swale/backwater projects combined, rather than on individual projects. Analyses are presented in the Net Depletions section below.		
Environmental Compliance Requirements	Possible 404/401 Clean Water Act compliance issues associated with swale construction.		
Additional Data Requirements	Site-specific detail on topography, groundwater depth, soil salinity levels, and existing vegetation characteristics is needed to finalize design, plant material amounts/sizes, and to fine-tune project cost estimates.		

Exhibit 5-28
Project Summary Table – Willow Wetland (RM 119)

Project Description			
Restoration Technique(s)	Apply irrigation water and broadcast seed willow and cottonwood seeds		
Functional Limitations Addressed	☐ Channel Narrowing	☐ Channel Drying	☒ Groundwater
Species Focus	☐ Silvery Minnow	☒ Willow Flycatcher	☐ Both
Location (River Mile)	RM 119		
Potential Number of Acres Benefited	29.8 acres – Willow wetland		
Land Ownership/Management Agency	Sevilleta National Wildlife Refuge		
Project Description	This project would create a willow wetland on the west side of the existing river channel on the Sevilleta NWR through a combination of managed flooding and seeding native willows and cottonwoods. The willow swale would be constructed as previously described, but the willow wetland would instead be seeding with willow and cottonwood seed similar to the technique currently being used by the BOR along the Colorado River (GeoSystems Analysis, Inc, 2007). Willow and cottonwood seed would be broadcast to the site along with irrigation water supplied by the Unit 7 drain. To succeed, the site would need to be flooded using irrigation water delivered via an existing turnout from the adjacent Unit 7 drain. This technique is recommended near RM 119 because the site contains an extensive clay lens that serves as an impermeable layer that could hold irrigation water and maintain a wet condition for a prolonged period. Additional earthwork would be required to maximize project function, and an existing outflow control structure would be utilized to control ponding levels and drainage. A water budget developed by the USFWS would be used to determine how much water would be needed initially for establishment, and subsequently for maintenance, of willow vegetation.		
Construction Elements	a. Excavate trench for clay deposition. b. Spread sand over project area where clay is at the surface. c. Flood site and seed with Gooding's and coyote willow seeds. d. Maintain proper soil moisture conditions during establishment period.		
General Estimate of Construction Costs	Preliminary cost estimates indicates approximately $919,000 (see Appendix C; Exhibit C.5-16).		
Operation and Maintenance Issues	A mechanism needs to be identified for leasing conservation water for this project. In addition, site conditions need to be evaluated and used in combination with the water budget to refine the project design. The site evaluation should include soil conditions (texture, permeability, and salinity) and depth to groundwater.		
Adaptive Management/Monitoring	Annual monitoring of willow growth characteristics, soil moisture, and seasonal groundwater table conditions. Annual flycatcher monitoring.		
Potential Water Salvage/Depletion	Depletions analyses were performed on the willow swale/backwater projects, combined with the willow wetland project rather than on individual projects. Analyses are presented in the Net Depletions section below.		
Environmental Compliance Requirements	Possible 404/401 Clean Water Act compliance issues associated with swale construction.		
Additional Data Requirements	Site-specific detail on topography, groundwater depth, soil salinity levels, and existing vegetation characteristics is needed to finalize design, plant material amounts/sizes, and to fine-tune project cost estimates.		
Other Implementation Issues	Water would need to be leased from the NM Strategic Water Reserve or some other source in order for this project to be implemented. A water budget developed by the USFWS would be used to determine how much water would be needed initially for establishment, and subsequently for maintenance, of willow vegetation.		

FLO-2D Analysis of Willow Swale and Backwater Projects

7 What are the FLO-2D model modifications to represent the restoration projects?

The new willow swales and backwater channels associated with projects near RM 127 were simulated in the model by lowering the active floodplain elevation by 1 to 2 feet and adjusting topography along the channel banks to ensure hydrologic connectivity. Backwater habitat in two of the swale areas was simulated by further adjusting the floodplain topography by an addition 1 to 2 feet. This simulates a backwater area next to the channel. The swales and backwaters were combined in a single FLO-2D model and simulated separately from the other restoration projects.

The infiltration hydraulic conductivity for the various restoration project simulations was not revised for the project conditions. There is insufficient groundwater data to support modifying the channel hydraulic connectivity. It was also assumed that restoration projects would not appreciably affect the channel roughness (Manning's n-values). The channel n-values currently reflect a reach-wide bed form of dunes at high flow. As the channel narrows, an increasingly larger portion of the thalweg area is becoming upper regime plane bed with lower n-values. This reduces the average channel roughness. The restoration projects should limit or eliminate this change in the channel bed form. Therefore, the channel roughness for the restoration projects was not modified.

8 How were the restoration projects tested for high flows and flooding conditions?

The same three hydrologic/hydraulic tests were performed for the proposed willow swale and backwater projects as for the channel treatment projects described previously in this chapter.

9 What are the modeling results?

Model results predict that the swale and backwater projects near RM 127 will have very little effect on the water surface elevation. There is only one small reach in the entire Isleta Reach where the water surface is predicted to increase slightly (less than 1 foot) as a result of the proposed projects. This variation is primarily due to the redistribution of water in the channel cross section due to the swale project. The increase does not extend to the floodplain (Exhibit 5-29).

The impact of swales and backwater on overall channel morphology and overbank flooding is limited to the actual project footprint. There is no appreciable depletion or gain in surface water and the increased flooded swale and backwater areas do not affect the floodplain area of inundation. These projects can be expanded in extent or number without any significant impacts.

The proposed swale and backwater treatments have a negligible effect on the infiltration and evaporation losses. The slight increase in the floodplain in the maximum area of inundation is essentially the result of the swale or backwater project footprint (Exhibit 5-30).

Exhibit 5-29

Predicted Increase in Water Surface Elevation for the 100-Year Flood as a Result of the Swale-Backwater Projects

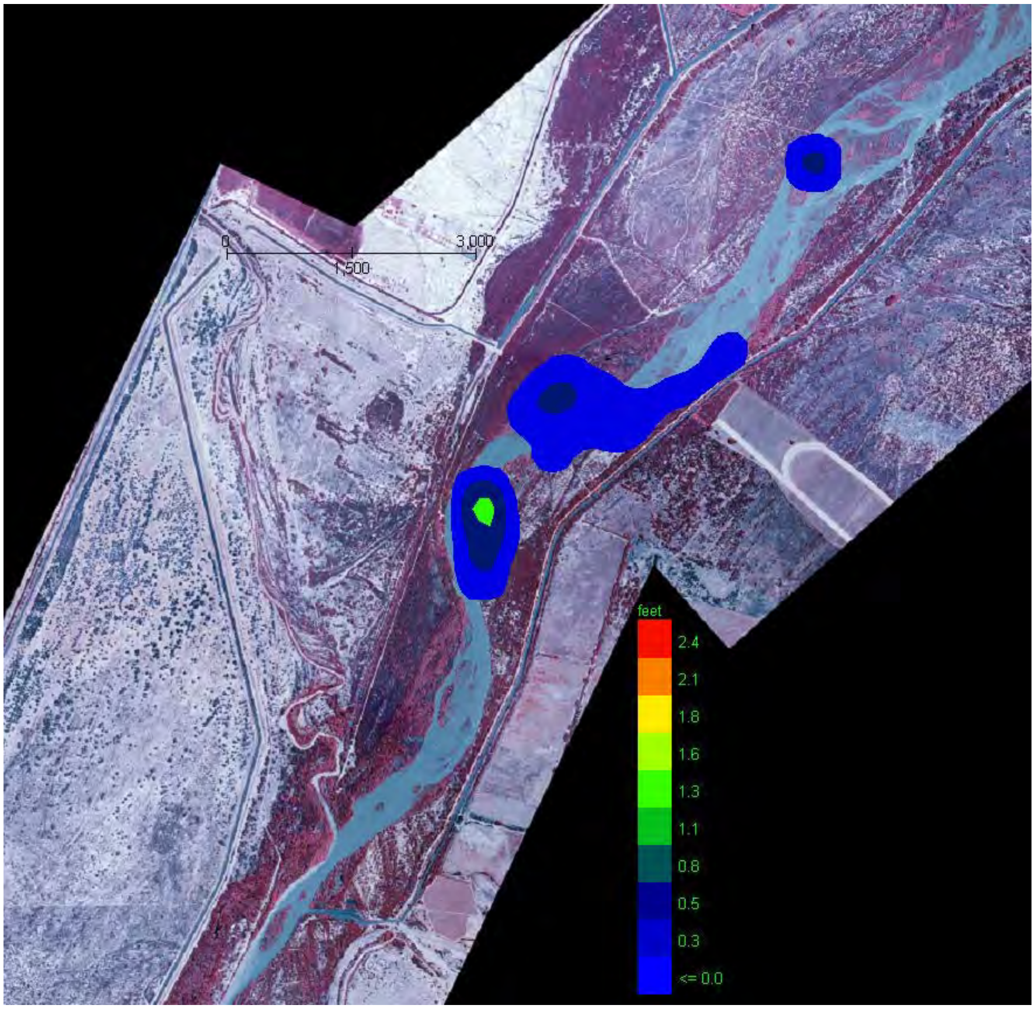


Exhibit 5-30

Comparison of Existing and Proposed Restoration Project Hydrologic Conditions for the Willow Swale, Wetland, and Backwater Treatments

	May–June 2005		100-Year Flood	
	Baseline	**Project**	**Baseline**	**Project**
Inflow Hydrograph (acre-feet)	18,790	18,790	8,170	8,170
Infiltration Loss (acre-feet)	487	498	253	256
Evaporation Loss (acre-feet)	121	121	53	53
Maximum Floodplain Area of Inundation (acres)	1,103	1,123	1,031	1,029
Maximum Channel Wetted Surface Area (acres)	2,277	2,287	2,041	2,049
Maximum Area of Inundation (acres)	3,380	3,410	3,072	3,078

Net Depletions Analysis

10 How were rates of consumptive use for the Isleta Reach determined?

Consumptive use estimates used herein to determine riparian vegetation evapotranspiration and open water surface evaporation loss are based on three sources: the Final Environmental Assessment for the Rio Grande Habitat Restoration Project, Los Lunas, NM (March, 2002); historic data from the Bureau of Reclamation's Agricultural Water Resources Decision Support system (AWARDS)/ET Toolbox; and the criteria outlined in the New Mexico Interstate Stream Commission's October 3, 2007, Memorandum entitled, "New Mexico Interstate Stream Commission comments to MRG ESACP Coordination Committee on Quantifying Depletions Associated with Habitat Restoration Projects in the Middle Rio Grande." In addition, the NMISC recently proposed a 600-foot-wide river corridor within which net depletions would not be counted against restoration projects, but we have no further details about the status of this concept.

Monthly consumptive use data for cottonwood, willow, grassland, and combined saltcedar/Russian olive were obtained from the Los Lunas Final EA. In the case of cottonwood, grassland, and saltcedar/Russian olive, the Los Lunas Environmental Assessment (EA) lists a range (high and low) of consumptive use values. In the analysis used herein, the higher consumptive use value is used and is assumed to be representative of high-density, mature vegetation. Exhibit 5-31 lists the consumptive use rates for these species as found in the Los Lunas Final EA.

Exhibit 5-31

Tabulation of Riparian Vegetation Consumptive Use Rates Near Los Lunas, NM

Month	Consumptive Use Rates (ft) by Vegetative Type			
	Cottonwood	Willow	Grassland (Salt grass)	Saltcedar/ Russian Olive
January	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00
March	0.00	0.00	0.00	0.00
April	0.69	0.60	0.28	0.70
May	0.8	0.70	0.33	0.82
June	0.88	0.77	0.36	0.90
July	0.78	0.68	0.32	0.79
August	0.7	0.61	0.39	0.71
September	0.55	0.48	0.23	0.56
October	0.41	0.36	0.17	0.42
November	0.00	0.00	0.00	0.00
December	0.00	0.00	0.00	0.00
Total:	**4.81**	**4.2**	**2.08**	**4.9**

Loss from open water surface areas was determined in accordance with the procedures outlined in NMISC's October 3, 2007, criteria. The criteria provide that evaporation water loss is to be derived directly from Soil Conservation Service Map 4-R-33582 (Gross Annual Lake Evaporation, New Mexico, 1972). The scale of Map 4-R-33582 is 1:1,500,000 and the map shows lines of equal annual gross evaporation in 5-inch increments. For the purposes of this analysis, monthly evaporation losses are determined by applying a monthly percentage of annual evaporation to the gross annual evaporation loss determined from Map 4-R-33582. The monthly percentages of annual evaporation are taken from Table 26 of Blaney's 1965 Technical Report (TR) 32, *Consumptive Use and Water Requirements in New Mexico*. Exhibit 5-32 lists the monthly percentage of the annual evaporation rate from TR-32.

The evapotranspiration rate is normally expressed in the units of depth per unit time. The rate expresses the amount of water lost through the combined processes of evaporation (from soil and plant surfaces) and plant transpiration in units of water depth. This allows a user to determine the amount of water taken up by a certain vegetative type based upon the amount of area it covers. Utilizing Exhibit 5-29, cottonwoods are estimated to use 4.81 feet of water annually. If a cottonwood stand covers one acre of land, that stand would use 4.81 acre-feet of water annually. This is much greater than an individual tree that covers 200 feet^2, which would use 962 feet^3 (4.81 feet x 200 feet^2) of water annually.

Exhibit 5-32

Monthly Percentage of Annual Evaporation

Month	Percent of Annual Evaporation
January	3
February	4
March	8
April	11
May	13
June	14
July	13
August	11
September	9
October	7
November	4
December	3
Total:	**100**

Certain land treatment and restoration projects are located as much as 40 miles downstream of the site of the restoration projects described in the Los Lunas EA. Therefore, the evapotranspiration rates (consumptive use) rates must be adjusted (increased) to account for the fact that some of these projects are located downstream of Los Lunas. This adjustment for riparian vegetation depletion is based on data collected and analyzed by the Bureau of Reclamation's AWARDS/ET Toolbox. The AWARDS/ET Toolbox computes evapotranspiration loss from riparian vegetation based on hourly weather data collected from stations along the Middle Rio Grande, including the area of the proposed projects, the Penman reference ET calculation, and vegetation growth curves for cottonwood, saltcedar, and an average of saltcedar and cottonwood. The ET Toolbox riparian evapotranspiration for the Isleta to Bernardo Reach (Los Lunas) and the Bernardo to San Acacia Reach (project area) for the years 2000 through 2007 are summarized in Exhibit 5-33. These values represent Rio Grande water use (i.e., daily consumptive use less rainfall).

Exhibit 5-33

AWARDS/ET Toolbox Riparian Evapotranspiration Rates

Year	Isleta to Bernardo Riparian ET (ft)	Bernardo to San Acacia Riparian ET (ft)
2000	2.80	3.06
2001	3.04	3.35
2002	2.53	3.02
2003	2.65	3.04
2004	2.90	3.20
2005	2.70	3.41
2006	2.74	3.08
2007	3.25	2.85
Average:	**2.83**	**3.13**

The ratio of the riparian ET loss between the two reaches is 1.11 (3.13/2.83 = 1.11); therefore, the riparian ET rates used in the Los Lunas Final EA are increased by 11 percent for application to riparian vegetation in the project area.

Water surface evaporation loss at the two proposed backwater areas at RM 127.6 and RM 127.8 was determined from Map 4-R-33582 by interpolation to be 72.13 inches (6.01 feet). After applying the monthly percentages found in TR 32, the open water surface evaporation loss rates used in the analysis of the backwater projects are shown in Exhibit 5-34.

Exhibit 5-34

Project Water Surface Loss Rates

Month	Evaporation (inches)
January	2.16
February	2.89
March	5.77
April	7.93
May	9.38
June	10.10
July	9.38
August	7.93
September	6.49
October	5.05
November	2.89
December	2.16
Annual (inches)	**72.13**
Annual (feet)	**6.01**

11 What methods and assumptions were used to calculate site-specific water depletions?

The water depletions at the locations of the proposed restoration projects are evaluated under the existing conditions and under the post-project condition. The existing conditions at the proposed project sites have been identified through vegetation and land use surveys. The surveys identified the overstory species and their height, understory species, and the total vegetative cover as a percent of the total area (density). For each project area, the data on existing vegetation were categorized as cottonwood, willow, or saltcedar/Russian olive combined for the purpose of estimating evapotranspiration loss. Maximum vegetative cover as the percent of total project area is 75 percent. The consumptive use computation used herein is applied to 100 percent of the project area, as evapotranspiration loss includes evaporation from the ground surface as well as vegetation transpiration.

Existing Conditions

Exhibit 5-35 summarizes the vegetation found at the site of each project location and categorized for computation of depletion.

Exhibit 5-35

Existing Vegetation/Land Use Area at Project Sites

Type	Location (River Mile)	Vegetative/Land Use (acres)				Open Water	Total
		Cottonwood	Willow	Grassland (Salt grass)	Saltcedar/ Russian Olive		
Swale	119	0.7	6.2	15.7	7.2	0.0	29.8
	120.4	1.4	0.0	0.0	5.6	0.0	7.0
	127.3	3.6	0.0	0.0	8.5	0.0	12.1
	127.8	2.9	0.0	0.0	7.0	0.0	9.9
Backwater	127.3	1.6	0.0	0.0	1.7	0.0	3.3
	127.8	1.4	0.0	0.0	2.1	0.0	3.5
Bank Destabilization	144–147	0.4	0.5	0.0	0.9	0.0	1.9
	150–153	0.5	0.6	0.0	1.3	0.3	2.1
Total Acreages:		**12.5**	**7.3**	**15.7**	**34.3**	**0.3**	**70.1**

The NMISC's October 3, 2007, criteria are generally concerned with the increased depletion associated with increases in open water areas, as the NMISC recognizes that the magnitude of changes in the water budget resulting from removal or modification of vegetation is uncertain and cannot be reliably quantified. For the purpose of illustrating the relative magnitude of water depletions associated with implementation of the proposed projects, the estimated water depletions associated with the existing conditions at the sites of the proposed projects were computed and are tabulated in Exhibit 5-36 through Exhibit 5-38.

Exhibit 5-36

Swale Project Locations Existing Conditions Estimated Depletions (acre-feet)

Month	Cottonwood	Willow	Grassland (Salt grass)	Salt cedar/ Russian Olive	Total
January	0.0	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0	0.0
April	6.5	4.1	4.8	21.8	37.2
May	7.6	4.8	5.7	25.5	43.6
June	8.3	5.3	6.2	28.0	47.8
July	7.4	4.6	5.5	24.6	42.1
August	6.6	4.2	6.7	22.1	39.6
September	5.2	3.3	4.0	17.4	29.9
October	3.9	2.5	2.9	13.1	22.3
November	0.0	0.0	0.0	0.0	0.0
December	0.0	0.0	0.0	0.0	0.0
Annual:	**45.5**	**28.6**	**35.9**	**152.5**	**262.6**

Exhibit 5-37

Backwater Project Locations Existing Conditions Estimated Depletions (acre-feet)

Month	Cottonwood	Saltcedar/Russian Olive	Total
January	0.0	0.0	0.0
February	0.0	0.0	0.0
March	0.0	0.0	0.0
April	2.3	2.9	5.2
May	2.6	3.4	6.1
June	2.9	3.8	6.7
July	2.6	3.3	5.9
August	2.3	3.0	5.3
September	1.8	2.3	4.2
October	1.4	1.8	3.1
November	0.0	0.0	0.0
December	0.0	0.0	0.0
Annual:	**15.9**	**20.5**	**36.4**

Exhibit 5-38

Bankline Destabilization Project Locations Existing Conditions Estimated Depletions (acre-feet)

Month	Cottonwood	Willow	Saltcedar/ Russian Olive	Total
January	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0
April	0.7	0.7	1.7	3.1
May	0.8	0.8	2.0	3.6
June	0.9	0.9	2.2	4.0
July	0.8	0.8	1.9	3.5
August	0.7	0.7	1.7	3.1
September	0.5	0.6	1.4	2.5
October	0.4	0.4	1.0	1.9
November	0.0	0.0	0.0	0.0
December	0.0	0.0	0.0	0.0
Annual:	**4.8**	**5.1**	**11.9**	**21.7**

The depletions associated with the proposed bar destabilization and lowering projects (246.3 acres) are not included in this analysis. The locations of these projects are within the active river channel, and water loss from open water, wetted sands, and vegetation is variable and difficult to reliably quantify. In addition, existing vegetation and groundwater level data at the sites of the proposed projects are not available for the active channel areas. Based upon the NMISC criteria (dated October 3, 2007), these projects will not result in the increase in open water surface area or any increase in water depletions, and therefore, would not jeopardize the State's Rio Grande Compact deliveries. In addition, a recent proposal by the NMISC recently proposed identifying a 600-foot-wide river corridor within which net depletions would not be counted against restoration projects. At this time, we have not seen details about the proposed 600-foot-wide river corridor, but this would be further justification that the bar destabilization and lower projects would not contribute to Net Depletions.

Future (with Project) Conditions

Generally, the proposed swale projects will involve the removal of existing vegetation, and the area will be revegetated with coyote willow, Goodding's willow, and cottonwood. The ground elevation of the sites would be lowered to allow seasonal overbank flooding. Specifically, the willow swale at RM 120 has no potential for overbank flooding. The willow wetland at RM 119 will be leveled by the addition of fill, will be flooded during the November 1 through March 31 period, and will be revegetated with coyote willow and Gooding's willow.

The with-project depletion computation conditions assume that the swale areas will be revegetated with an equal mixture of willow and cottonwood, except for the RM 119 location, which will be entirely revegetated with willow. Depletions at RM 119 include evaporation loss during the period of November 1 through March 31. Exhibit 5-39 summarizes the estimated depletions associated with the development of willow swales.

Exhibit 5-39

Willow Swales and Wetland Projects Estimated Depletions (acre-feet)

	Depletions – Willow Swale Projects RM 120.5, 127.3 and 127.8 (Area = 29 acres)			Depletions – Willow Wetland Project RM 119 (Area = 29.8 acres)		
Month	**Cottonwood**	**Willow**	**Total**	**Willow**	**Open Water**	**Total**
January	0.0	0.0	0.0	0.00	5.36	5.36
February	0.0	0.0	0.0	0.00	7.18	7.18
March	0.0	0.0	0.0	0.00	14.33	14.33
April	11.0	9.6	20.6	19.67	–	19.67
May	12.8	11.2	23.9	22.95	–	22.95
June	14.0	12.3	26.3	25.24	–	25.24
July	12.4	10.8	23.3	22.29	–	22.29
August	11.2	9.7	20.9	20.00	–	20.00
September	8.8	7.7	16.4	15.73	–	15.73
October	6.5	5.7	12.3	11.8	–	11.80
November	0.0	0.0	0.0	0.00	7.18	7.18
December	0.0	0.0	0.0	0.00	5.36	5.36
Annual:	**76.7**	**67.0**	**143.7**	**137.68**	**39.41**	**177.09**

Construction of the backwater area projects involves the removal of vegetation and lowering the elevation of the area to allow flooding at moderate flows. Implementation of these projects would result in an increase in the open water area of approximately 6.78 acres during the months of May and June during those years when the snowmelt runoff would result in flow levels in excess of 2,500 cfs in the Isleta Reach. During the remainder of the period, the sites may experience water loss through evaporation from wetted sands. Water loss from wetted sands is partially a function of site specific data on depth to groundwater, which are not available for these specific locations. For the purposes of this analysis, it will be conservatively assumed that water loss at this site may be based on using the open water surface loss rate. Exhibit 5-40 summarizes the loss rates for the backwater project areas.

The future or with-project depletion associated with the bank destabilization projects is uncertain, as the ultimate development land use conditions under this project are unknown. Solely for the purposes of quantifying an approximate depletion value, it is assumed that those areas of bank destabilization will revegetate naturally with willow. Exhibit 5-41 tabulates the bank stabilization (with-project) depletion estimate. The location of these projects is closer to the site of the restoration work accomplished under the Los Lunas EA and the depletion values used in that document are used, without adjustment.

Exhibit 5-40

Backwater Project Estimated Water Depletion (RM 127.6 and 127.8)

Month	Backwater Projects Depletion (acre-feet)
January	1.22
February	1.63
March	3.26
April	4.48
May	5.30
June	5.71
July	5.30
August	4.48
September	3.67
October	2.85
November	1.63
December	1.22
Annual:	**40.75**

Exhibit 5-41

Bank Destabilization Project Estimated Depletions

Month	Bank Destabilization Depletion (acre-feet)
January	0.00
February	0.00
March	0.00
April	2.70
May	3.15
June	3.47
July	3.06
August	2.75
September	2.16
October	1.62
November	0.00
December	0.00
Annual:	**18.90**

Net Depletions Summary

Exhibit 5-42 summarizes the findings of the preliminary net depletions analyses. The Backwater project areas are projected to increase net depletions by 4.35 acre-feet annually. The Bank Destabilization projects are estimated to decrease net depletions by 2.8 acre-feet. The willow swales and willow wetland projects combined are estimated to have a net increase in depletions by 58.19 acre-feet, while the bar destabilization and lowering projects were not included in the analyses for the reasons specified above and are anticipated to have no impact on net depletions based upon criteria published by the NMISC. Overall, the projects recommended in this analysis are estimated to increase net depletions by approximately 59.74 acre-feet annually. The project sponsors would be required to mitigate for project-related net depletions, which would need to be refined after developing design-build project restoration plans for each site as opposed to the planning level estimates provided in this report.

Exhibit 5-42

Willow Swales and Wetland Projects Estimated Depletions (acre-feet)

	Total Estimated Project Area Depletions Summary (acre-feet)			
	Bank Destabilization	**Willow Swales and Willow Wetland**	**Backwater**	**Total**
Pre-project	36.40	21.7	262.60	320.70
Post-project	40.75	18.9	320.79	380.44
Difference	4.35	-2.8	58.19	**59.74**

Chapter 6 Adaptive Management, Monitoring, and Data Gaps

Habitat restoration is essentially an exercise in applied science—it is fundamentally based on a set of hypotheses on what is needed, how it can be best implemented, and what benefits will be produced by the project. Adaptive Management provides established processes to link project implementation, monitoring, and assessment to provide key information and knowledge on which to base future resource management decisions. Correctly implemented, monitoring linked to management helps to reduce future uncertainty and risk associated with implementing habitat restoration projects.

The following sections discuss the processes of Adaptive Management, its linkages to monitoring, and the steps involved in defining appropriate criteria for developing habitat restoration monitoring efforts for the Middle Rio Grande. In the final section of this chapter, we offer general monitoring approaches for the conceptual projects and discuss data gaps and research needs related to restoration planning and implementation in the Isleta Reach.

Adaptive Management

1 What is Adaptive Management?

Adaptive Management is a science and performance-based approach to ecosystem management that involves integrating planning and design with ongoing monitoring, assessment, and evaluation. The overall purpose of Adaptive Management is to substantially improve the chance of success in achieving ecosystem management goals when there is significant uncertainty about how this is to be accomplished (USACE, 2006).

Adaptive Management embraces a "learning by doing" philosophy that tests hypotheses through carefully designed monitoring and research activities. Hypotheses are formulated before implementation, and monitoring data collected before (baseline) and after the restoration treatment are used to test the hypotheses. The ensuing results are used to inform managers and decision makers about whether management is meeting its intended objectives, if objectives could be met through additional management intervention, or if the overall restoration approach should be rejected. Thus, Adaptive Management is specifically designed to improve management and accommodate change by learning from the outcomes of a set of environmental management policies and practices (Gregory et al., 2006). To be effective, Adaptive Management involves participation by and coordination between decision makers, managers, project teams, scientists, technical experts, and stakeholders.

Adaptive Management

Adaptive Management embraces a "learning by doing" philosophy that tests hypotheses through carefully designed monitoring and research activities. The ensuing results are used to inform managers and decision makers about whether management is meeting its intended objectives, or if management adjustments will be required.

2 What is the relationship between monitoring and Adaptive Management?

Adaptive Management and monitoring are inseparable. Monitoring (and research) provides the data that allows scientists to inform managers and decision makers about whether ecosystem management objectives are being met or if management changes are necessary. Monitoring and research are the means by which hypotheses about specific restoration treatments can be tested, evaluated, and adjusted.

For this report, monitoring is defined as "the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress towards meeting a management objective" (Elzinga et al., 1998). This definition was chosen because it is directly tied to the evaluation of specific restoration project objectives. Defined in this manner,

Monitoring

For this report, monitoring is defined as "the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress towards meeting a management objective" (Elzinga et al., 1998).

monitoring is specifically intended to inform managers about the progress towards or success in meeting a resource management objective and provides the evidence for management change or continuation (Holling, 1978). Monitoring restoration projects on the Middle Rio Grande should also inform about adverse effects on infrastructure, water delivery, and river maintenance programs.

3 What is the Program's position regarding Adaptive Management and monitoring?

In its recently adopted *Long-Term Plan* (ESACP, 2006a), the Program has expressed a strong commitment to following an Adaptive Management approach to achieving its goals and objectives. The *Long-Term Plan* explicitly states:

> Because science is still evolving on the listed species, adaptive management will be an important tool for Program success *(p. 6), and* …the Program will use an adaptive management process to monitor and evaluate our activities and serve as the vehicle to make changes in activities as the life of the Program progresses *(p. 8).*

Precisely how the Program intends to implement Adaptive Management continues to be refined. For example, how monitoring results would ultimately be translated to changes in management has not yet been clearly described or referenced in their *Long-Term Plan*. In short, while there is a commitment from the Program to using Adaptive Management principles, no formal Adaptive Management Plan has been developed that outlines the specific procedures for affecting monitoring guided changes in management.

For an example of an Adaptive Management Plan developed for the Florida Everglades Restoration Program, see http://www.conference.ifas.ufl.edu/GEER2006/AM_Strategy.pdf

4 How does monitoring inform Adaptive Management?

To be effective, monitoring should be driven by objectives that describe an expected outcome. For example, one of the expected outcomes of destabilizing accreted islands within the active channel is to reduce flow velocities during moderate and high flow conditions. Monitoring should be designed to evaluate whether success in meeting this expected outcome has been achieved.

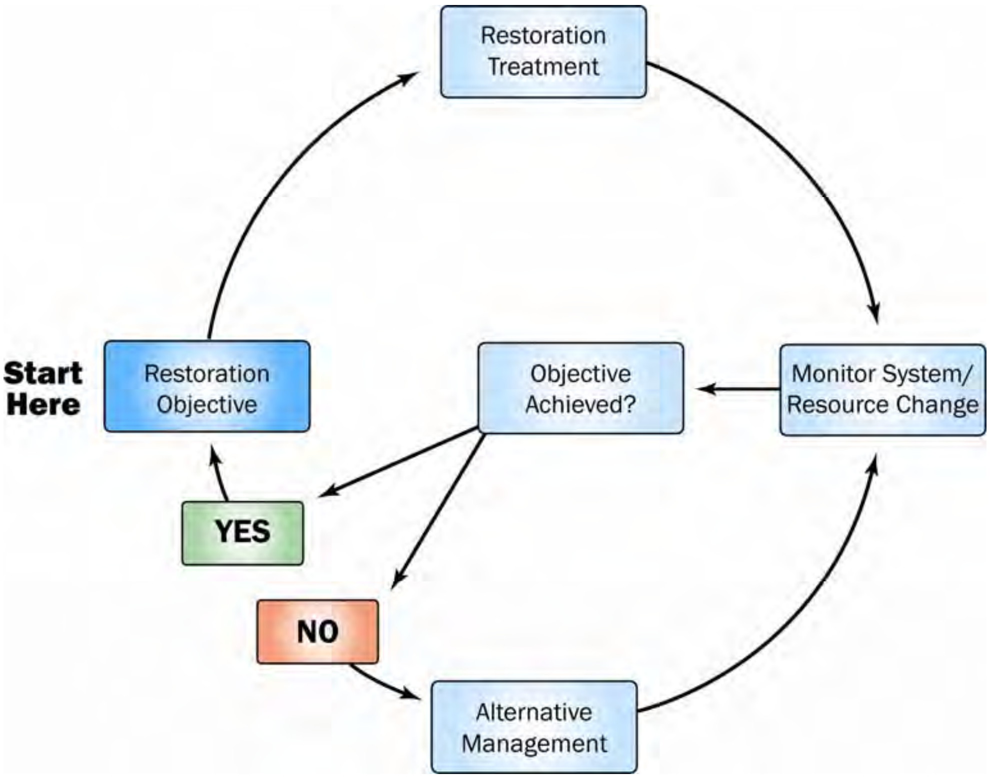
The Adaptive Management process as it pertains to ecological restoration can generally be broken down into the following steps:

- Restoration management objectives and hypotheses are developed to describe a desired condition.
- Assumptions related to the management objectives and hypotheses are identified.
- Restoration treatments are prescribed to achieve the stated objectives.
- Site parameters at proposed treatment sites are measured to document baseline conditions and provide a basis of comparison to post-treatment conditions.
- Restoration treatments are implemented and post-treatment conditions are monitored.
- A determination is made as to whether the objectives are being met.
- Conclusions are shared with the Program’s Adaptive Management Group.
- Restoration management is continued as planned or is modified, depending upon the monitoring results.
- Similar or modified restoration treatments are applied to other suitable locations following similar steps as above.

These steps are illustrated in Exhibit 6-1.

Exhibit 6-1

Adaptive Management Cycle (modified from Elzinga et al., 1998)



5 What is the difference between monitoring and research?

The fundamental difference between monitoring and research is that monitoring cannot statistically validate a cause-and-effect relationship (Elzinga et al., 1998). For example, monitoring can statistically evaluate changes in the channel width-to-depth ratio before and after a restoration treatment by gathering data at multiple sites. If monitoring reveals that the width-to-depth ratio is statistically different after restoration, the results support the hypothesis that the prescribed restoration contributes to the difference in width. To determine cause-and-effect, however, a statistically significant change has to be found at several areas that received the restoration treatment and **not** found at several untreated (control) areas.

In reality, even when determining causal relationships between a specific restoration treatment and an expected outcome is preferred, a research approach may not be feasible. Some typical problems encountered are: 1) the complexity of the system being studied (e.g., lots of potentially confounding variables); 2) the non-linear response of organisms to causal mechanisms, and 3) the lack of available replicates because of issues associated with temporal or spatial scale (Beeby, 1993; Chapin et al., 2002; Elzinga et al., 1998; ESACP, 2006b).

The difference between validating resource change through monitoring and demonstrating cause-and-effect are important. The Program and project sponsors should be careful not to set unrealistic expectations as to what monitoring can or cannot produce in support of restoration planning and Adaptive Management. Gregory et al. (2006) cite the tendency among many scientists to overstate their capability to measure complex functional relationships through experimentation as one of the most common reasons for failed Adaptive Management programs.

Gregory et al. (2006) cite the tendency among many scientists to overstate their capability to measure complex functional relationships through experimentation as one of the most common reasons for failed Adaptive Management programs.

6 What are the key elements of an Adaptive Management oriented monitoring program?

Elements of the Monitoring Program

Monitoring may be uniquely designed for each restoration project considering monitoring frequency, seasonal monitoring, and funding. It is recognized that monitoring complexity and cost may limit the extent of monitoring some ecological or geomorphological variables.

An important aspect of a successful monitoring program is to establish the monitoring parameters for a particular restoration project that will identify whether treatment objectives have been accomplished, and when additional restoration maintenance activity is required. The key monitoring variables as well as the procedures to monitor restoration success can be adjusted over time as restoration knowledge is assimilated. The necessary steps to creating the monitoring program are:

1. Establish consensus on goals and objectives for the restoration projects. What constitutes successful restoration for a particular project?

2. Establish restoration parameters that will monitor the project response.

3. Determine pre-treatment and post-treatment baseline conditions that will enable future survey and sampling methods to measure the response of the restoration projects.

4. Create a sampling plan that will track the restoration response.

5. Establish a monitoring Program Adaptive Management Team that has authority to implement restoration maintenance activities (such as high flow releases or further mechanical restoration) with a set agenda and schedule (e.g., fall and spring meetings).

6. Establish Adaptive Management criteria which will either recognize success and terminate the monitoring program (such as meeting species population goals or habitat utilization) or allow for modifications to the restoration treatment program intended to achieve success.

Designing Monitoring Methods

The importance of a well-designed monitoring plan cannot be overstated. Walters (1997) noted that of 25 major planning exercises for Adaptive Management that he has participated in, only seven resulted in monitoring efforts of an appropriate scale, and only two could be considered well planned in terms of statistical design. This provides a strong argument for a monitoring design based upon well-defined management and sampling objectives.

Walters (1997) noted that of 25 major planning exercises for Adaptive Management that he has participated in, only seven resulted in monitoring efforts of an appropriate scale and only two could be considered well planned in terms of statistical design.

Once the management and corresponding sampling objectives have been defined, monitoring methods that are most likely to provide the necessary data must be identified. There are commonly a variety of methods that may ultimately satisfy the data requirements for a given sampling objective, but the method selected should be based upon a balance of precision (i.e., sampling objectivity), efficiency, and cost.

The *Conceptual Restoration Plan for the Active Floodplain, of the Middle Rio Grande: San Acacia to San Marcial* (Tetra Tech, 2004b) includes tables listing examples of different monitoring objectives and associated field methods that may (or may not) apply to a specific sampling objective. The Program is also in the process of developing a Draft Interim Monitoring Plan (ESACP, 2006b) that, in its present form, describes a variety of restoration sampling techniques. Techniques from both sources should be included (but not exclusively relied upon) as part of an exhaustive investigation of applicable and appropriate monitoring methodologies. To choose from a pre-defined list of sampling techniques, however, is less important (and possibly detrimental) than carefully selecting data collection techniques that directly address the stated management and sampling objectives.

It is important to state that, regardless of which monitoring approach is selected, sampling objectives should be realistic and based upon existing knowledge of the ecosystem attribute of interest. Elzinga et al. (1998) recommends consulting with scientists or other stakeholders interested in the monitoring results to be sure that they are comfortable with the targeted levels of precision, power, etc. specified in the sampling objective before moving forward with the monitoring design. The Program accounts for this by assigning a Technical Team to assist project proponents (i.e., project sponsors) with reviewing monitoring criteria and developing monitoring and statistical methods (ESACP, 2006a).

Reporting Results and Recommending Alternative Management

For Adaptive Management to work, the monitoring results must be reported and presented to decision makers. If monitoring indicates that site maintenance or other Adaptive Management treatments are required, the decision makers (i.e., an Adaptive Management Team) would theoretically work with the project sponsor and Program Technical Team to determine what Adaptive Management procedures (and funding) would be required. The specific process defining how these management steps will be implemented should be clearly defined in a Program-wide Adaptive Management Plan.

7 Who is ultimately responsible for developing and implementing project-monitoring activities?

The Program's current *Draft Interim Monitoring Plan* (ESACP, 2006b) distinguishes between three primary types of monitoring that would be implemented through the Program. On one end of the spectrum is **implementation monitoring**, which addresses whether restoration projects were completed as designed and have important implications for contractual obligations of funding agencies. This type of monitoring is unrelated to Adaptive Management in that it is not implemented to evaluate if a restoration driven outcome has been achieved. The *Draft Interim Monitoring Plan* specifies that this type of monitoring would be implemented by the project sponsor.

On the other end of the spectrum is **validation monitoring**, which addresses the correctness of the cause-effect assumptions used in the restoration design, planning, and execution. Findings from validation monitoring could point to incorrect assumptions regarding ecological relationships or to the use of inappropriate monitoring indicators. The *Draft Interim Monitoring Plan* states that validation monitoring will be a Program responsibility and will be used to improve overall Program effectiveness.

Somewhere in the middle between these types of monitoring is **effectiveness monitoring**. This is most parallel to the monitoring approach addressed in this chapter because it is specifically implemented to assess whether the restoration project goals are achieved. The *Draft Interim Monitoring Plan* indicates that monitoring performance criteria would be developed by the project proponent and that the Program would assign a Technical Team to work with the proponent to finalize the monitoring design. Effectiveness monitoring would then be implemented by the Program. There is no mention of the project sponsor's role in effectiveness monitoring. Although, at a minimum, it makes sense that the project sponsor participates in developing the monitoring design.

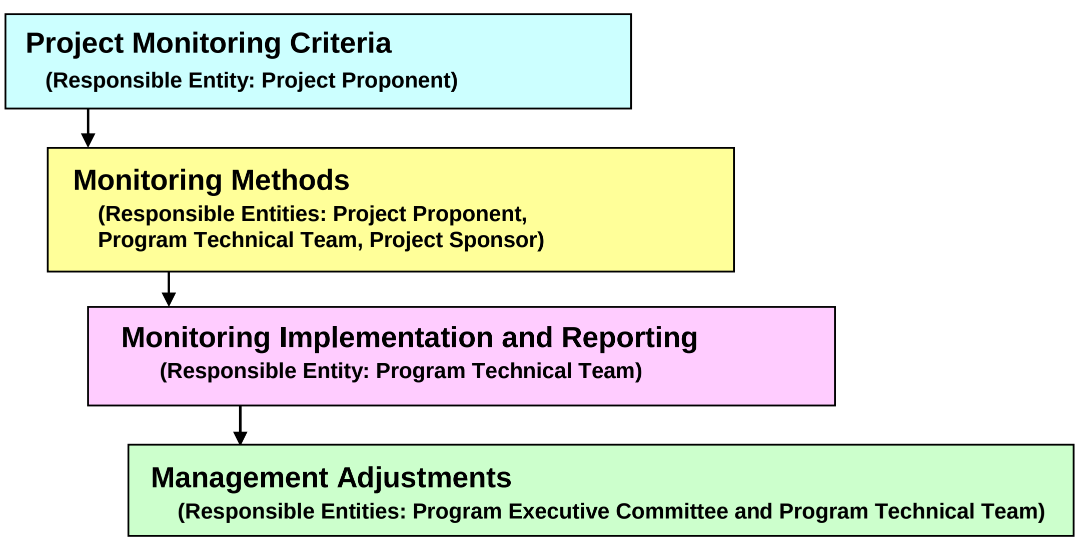
The Program's current *Draft Interim Monitoring Plan* (ESACP, 2006b) indicates that monitoring performance criteria would be developed by the project proponent and that the Program would assign a Technical Team to work with the proponent to develop the monitoring design. Effectiveness monitoring would then be implemented by the Program.

8 How would the monitoring results translate to management action?

There is no point to effectiveness monitoring unless a mechanism exists that allows the results to effect adjustments in restoration management. Neither the Program's *Long-Term Plan* (ESACP, 2006a) nor the *Draft Interim Monitoring Plan* (ESACP, 2006b) clearly articulates the process by which this would happen. In lieu of a Program sponsored *Adaptive Management Plan* that outlines this process, it is suggested that the monitoring results must ultimately be presented and discussed with a decision making body (i.e., the Program's Executive Committee). This is where the need for management adjustments will be determined and a course of action would be developed.

A process by which monitoring would be implemented and translated to management action is illustrated in Exhibit 6-2.

Exhibit 6-2
Monitoring Process



We want to emphasize that the nexus between monitoring and Adaptive Management (steps three and four in Exhibit 6-2) is critical to restoration project sustainability in the Isleta Reach (and the MRG). The success of the proposed restoration projects is dependent on the management response to identified changes in the physical system. For example, the Isleta Reach has narrowed more uniformly in response to the water and sediment deficit, channel training, and vegetation encroachment than other MRG reaches. This channel narrowing trend will persist even if the proposed restoration projects are implemented, unless Adaptive Management tools are in place with the authority to apply them.

An effective Adaptive Management Plan is the core of the Isleta Reach Restoration Plan because there is future uncertainty over the availability of spring high flows that would limit the narrowing trends. There are also management questions and funding constraints regarding when and where to implement restoration. The specific process defining how these management steps will be implemented should be clearly defined in a Program-wide Adaptive Management Plan. As previously stated, an Adaptive Management Plan should include funding priorities, a decision making work group, monitoring requirements, restoration target goals, and methods of conflict resolution. The Adaptive Management Plan will evolve over time, but the intent of this report is to provide a framework to proceed with monitoring.

The critical elements of a successful Monitoring and Adaptive Management Plan are displayed in Exhibits 6-1 and 6-2. The failure to follow through with any one these steps could result in the long-term failure of the restoration projects. In the case of proposed island destabilization projects, for example, this could translate to the river reverting back to the process of the vegetation encroachment and channel narrowing. The failure of restoration projects could occur in a relatively short time frame of three to five years depending on the spring flows and lack of monitoring or Adaptive Management response.

The June 2001 Biological Opinion stated that “adaptive management principles will be used, if necessary, to obtain successful restoration of the silvery minnow and flycatcher habitats.” (p. 109)

The key to a successful Adaptive Management Plan is to have an efficient and flexible application of resources from year to year and to be able to marshal the available resources through agency cooperation (see sidebar). The intent of the Adaptive Management Plan is to abate and reverse any adverse trends that are identified through monitoring after restoration implementation.

Monitoring Projects in the Isleta Reach

9 What is the recommended monitoring approach for the restoration projects?

Chapter 5 outlines several restoration conceptual designs and techniques that are hypothesized to improve habitat conditions for the silvery minnow and flycatcher in the Isleta Reach. The proposed restoration techniques are:

- Reworking stable, accreted islands and vegetated bars to enhance the active channel and improve hydraulic conditions for silvery minnow habitat at moderate and high flows.
- Destabilizing channel banklines to stimulate channel migration and facilitate the deposition of large woody debris into the channel. By increasing channel bank erosion and encouraging the introduction of large woody debris into the channel, more low-velocity, deep pool habitat for the silvery minnow may be created during low-flow conditions in proximity to the woody debris piles.
- Constructing Goodding's and coyote willow habitat and backwater channels in areas near existing flycatcher breeding sites. These projects are intended to facilitate expansion of breeding territories in the project reach. The backwater channels are also intended to provide low-velocity refuge habitat for the silvery minnow during moderate and high flows.

If these projects are funded, the Program will assign a Technical Team to review the project management and sampling objectives and work with the project sponsors to develop the sampling and analytical methods (ESACP, 2006b).

The following sections provide a synopsis of each project and recommended measurement parameters and general monitoring approaches. The project sponsor and the Program Technical Team can use these recommendations to develop statistically rigorous monitoring methods for each project (ESACP, 2006b).

Restoration Treatment: Bar Destabilization and Lowering Combined with Terrace Bank Destabilization

Management Need and Restoration Objectives

Sand bar stabilization with established vegetation has accelerated over the past 15 years primarily in response to reduced spring peak flows and sediment loads. Previously active sandbars have evolved into permanent islands. As these islands accrete and become attached to banks, they contribute to channel narrowing and adversely impact the aquatic habitat by confining flows and increasing the overall channel velocity. The restoration technique is intended to rework these bars and enhance the active channel dynamics.

Looking northeast at RM 128 and RM 129 (Photo Credit: Parametrix)

Without high flow conditions, the opportunities for future vegetation encroachment in the active channel will persist in the presence of reduced sediment loads. The monitoring objective is to measure the response of the restoration projects and ultimately support Adaptive Management decisions regarding future maintenance requirements to maintain, or cease, the restoration program.

Recommended Restoration Treatment(s)

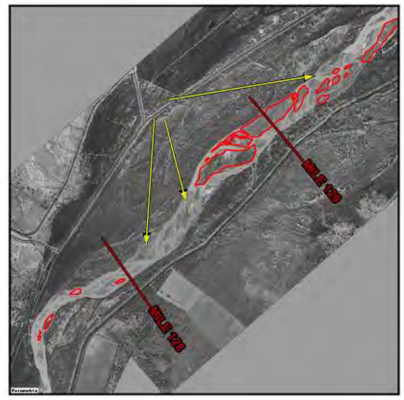
Restoration treatments to promote an active channel and enhance aquatic habitat diversity are proposed as experimental treatments to be tested between RM 128 and RM 153. The proposed restoration treatments are designed to improve aquatic habitat by restoring channel dynamics associated with an active channel and a highly mobile bed condition. The proposed treatments include:

- Destabilizing accreted bars by removing vegetation and mechanically reworking bar alluvium so that it can become re-mobilized during subsequent snowmelt runoff.
- Mechanically uprooting vegetation from the edge of channel banks and reworking the bankline to initiate some channel widening and migration, and facilitate deposition of large woody debris into the channel.

Expected Result(s)

Projected future channel conditions following restoration include:

- Increase channel habitat diversity, which will be characterized by:
  1. Increased average width-to-depth ratio.
  2. Increased areal extent of low velocity habitat (less than 1 ft/s) over a range of flows.
  3. Increased probability of observing lower regime bed forms (i.e., dunes) compared to higher regime bed forms (i.e., plane bed) at high flows.
  4. Increase the amount of large woody debris within the channel.
- Enhanced fluvial geomorphic activity as characterized by:
  1. Increased sand bar mobility.
  2. Enhanced bankline erosion and localized channel migration.



Vegetated channel bars and islands at RM 128 in January 2002.

Monitoring Approach

This section describes general monitoring approaches for measuring and monitoring attributes deemed to be important indicators of successful implementation of the channel treatment restoration projects. We suggest that in order to evaluate treatment response, the monitoring techniques described below should be performed at specified treatment locations before and after restoration, and in some cases, also measured at representative locations that do not receive the restoration treatment (i.e., control sites).

Vegetated channel bars and islands at RM 128 in June 2006.

Baseline conditions for the restoration projects can be two-tiered, including:

1. Pre-treatment baseline conditions immediately prior to restoration. The pre-treatment baseline data documents the site conditions prior to restoration activities.

2. Post-treatment baseline conditions. The post-treatment data collection documents the baseline condition to which future monitoring of trends and changes will be compared. Long-term monitoring may not begin immediately following restoration, but establishing post-treatment baseline conditions is critical to support any future monitoring.

Control sites can theoretically be established in any location along the Isleta Reach with the caveat that there is no major compounding influence on the site that renders comparison to treated sites unreasonable (e.g., influence of major tributaries, river maintenance activities, etc.). It is recognized that there are inherent limitations to selecting control sites due to the complexity and variety of site-specific hydraulic influences and geomorphic conditions at different locations. Nonetheless, attempts should be made at identifying "representative" locations that can be compared to treatment sites. In addition, monitoring sites should include locations of high river maintenance concern with potential impacts due to the implementation of restoration projects.

We recommend that, in addition to collecting data from existing cross sections listed in Exhibit 6-4, new cross sections also be established in restoration treatment sites to more thoroughly characterize conditions in these locations. Monitoring cross sections should also include areas of high river maintenance concern with potential impacts due to the implementation of restoration projects.

Data collection efforts should be similar at each specified restoration treatment site (and at control locations, when appropriate). Much of the information needed for evaluating island and bankline destabilization treatments can be collected during surveys of existing and/or new cross sections at these sites. Cross-section surveys constitute a key element of the monitoring program and are critical to the Adaptive Management Program. Cross sections should be surveyed during (ideally) and after spring runoff. If there are no significant peak flows, then no post-runoff surveys are required. It may not be necessary to resurvey every cross section in a given sub-reach (this is an Adaptive Management decision).

The channel monitoring database associated with cross-section monitoring should consider including several parameters listed below. Some of these parameters link directly to monitoring and the expected restoration treatment results specified above, while others provide important supplemental information that may be valuable to understanding broader trends. Example parameters include:

- USGS gage record.
- Observations of the location where the river goes dry.
- Cross-section survey data.
- A set of four photos, upstream and downstream about mid-cross section and one from each bank toward the opposite bank.
- Bed material size samples at one cross section per restoration project (at three samples per cross section that can be combined into one composite sample).
- Bank-full discharge measurement (at one or more cross sections).
- Velocity profiles and review of cross-section stations with low velocity.
- Observations of the bed forms.
- Observation of the bank and overbank vegetation.
- Water surface elevations at bank-full discharge.
- Bankline locations and heights documented in GIS.

High water surface elevation surveys can be accomplished with the cross-section surveys, but they should also be coordinated with aerial photography (and possibly videos) of the flooded areas. In conjunction with water surface elevation surveys, discharge data should be retrieved from the nearest gage. At low flows, it is important to monitor river flows in the Isleta Reach to determine if and where the river is going dry in relationship to the discharge at the Bosque Farms gaging station.

The cross sections in Exhibit 6-3 have a long history and should be considered for long-term monitoring of baseline conditions of control (untreated) sites in the Isleta Reach.

Exhibit 6-3

Baseline Cross Sections for Long-Term Monitoring of Potential Control Sites in the Isleta Reach

Cross Section ID	RM	First Survey
CO-765	158.8	1982
CO-787	156.6	1982
CO-833	152.1	1983
CO-877	147.7	1982
CO-895	145.9	1982
CC-936	142	1990
CO-986	137.1	1992
CO-1026	133.2	1992
CO-1064	129.7	1992
CO-1104	126	1992

The cross sections identified in Exhibit 6-4 should be considered for long-term monitoring of the channel treatment project areas. By analyzing data gathered during cross-section surveys, the expected results of the channel treatment projects can be evaluated. We recommend that additional cross sections also be established in restoration treatment sites to more thoroughly characterize conditions in these locations.

Exhibit 6-4

Selected Restoration Project Cross Sections

Cross Section ID	RM	First Survey
Channel Treatment Site No. 1		
CO-1064	129.7	1992
CO-1091	127.3	1992
Channel Treatment Site No. 2		
CO-966	139.1	1992
CO-986	137.1	1992
Channel Treatment Site No. 3		
CO-895	145.9	1982
IS-908	144.6	1998
Channel Treatment Site No. 4		
CO-833	152.1	1983
IS-849	150.5	1998

Measurement Parameters

We recommend that the following monitoring parameters be measured by the Program to evaluate restoration treatment success. Precise measurement methods and statistical parameters should be more fully developed by project sponsors and the Program Technical Team and documented in a detailed Project Monitoring Plan. The monitoring parameters outlined below are considered important metrics of project success, both in terms of specific habitat benefits for silvery minnow and overall benefits to channel geomorphic processes.

Silvery Minnow Habitat Benefits

Changes in Width-to-Depth Ratio

One of the hypothesized channel habitat benefits is that destabilizing accreted islands and bank-attached bars will locally increase the channel width-to-depth ratio. The management objective can be stated as follows:

> *Compared to baseline conditions, the prescribed restoration treatment will achieve a statistically significant increase in the average width-to-depth ratio at each project site in the first year following bank-full discharge.*

The results can be analyzed by comparing changes in the width-to-depth ratios of the surveyed cross sections within the project areas over time, and by comparing changes at treatment sites with those at control sites.

> We recommend that, in addition to collecting data from existing cross sections listed in Exhibit 6-4, new cross sections also be established in restoration treatment sites to more thoroughly characterize conditions in these locations.

Areal Extent of Low Velocity Habitat (less than 1 ft/s) Over a Range of Flows

A second hypothesis is that destabilizing accreted islands and bank-attached bars will locally increase the areal extent of low-velocity habitat over a range of flow conditions. The associated management objective can be stated as follows:

> *Compared to baseline conditions, the prescribed restoration treatment will achieve a statistically significant increase in the spatial extent of low velocity habitat (e.g., <1 ft/s.), under a range of flows, at each project site in the first year following bank-full discharge.*

To estimate the amount of low velocity habitat available to fish, it will be necessary to take a limited number of measurements and extrapolate over the treatment area. To do this, it is recommended that the methods be duplicated in treated and untreated sites.

The amount of low velocity habitat can be estimated within the project area at a specific discharge by monitoring the velocity profile across multiple cross sections within a project site. The average velocity profile within a segment of the project reach can provide an estimated proportion of the active channel area that has low velocity habitat at the specific discharge that the cross sections were monitored. Using the total area of the active channel and the estimated proportion of low velocity habitat within the active channel, a rough estimate of the amount of low velocity habitat present within the project reach can be calculated. Homogenous project reaches will provide more accurate estimates of the area of low velocity habitat available in that reach. If channel morphology is not similar throughout the project reach, it can be broken into segments that have similar channel morphology to assess the amount of low velocity habitat present in each segment.

The specific monitoring approach and the desired level of detail will need to be developed further by the project sponsor prior to the implementation of any of the recommended projects.

Increase the Amount of Large Woody-Debris within the Channel

An important objective associated with bankline destabilization treatments is to increase the amount of large woody debris (LWD) available in the channel for silvery minnow habitat. The management objective can be stated as follows:

> *Compared to baseline conditions, project sites that receive bankline destabilization treatments will experience a localized increase in the amount of LWD eroded into the river channel.*

The establishment of photopoints associated with each bankline destabilization project may provide a sufficient account of the amount and persistence of woody vegetation deposited into the channel at the bankline destabilization sites. If this approach is selected, we suggest that four photopoints be established for each bankline destabilization project (facing upstream and downstream of each of the two surveyed cross sections established at the bankline destabilization sites). Comparing the photo sequence will qualitatively assess how much LWD is eroded into the channel and how long the LWD persists in the treatment locations. In addition, LWD locations should be monitored to determine whether beneficial habitat conditions are created in association with LWD and whether the presence of LWD in the channel impacts river maintenance activities or creates the need for further river maintenance.

Channel Geomorphic Benefits

Sand Bar Mobility

We hypothesize that bar destabilization and lowering projects, followed by sufficient snowmelt runoff, will reduce the potential for vegetation to persist, and thereby allow sand bars to be more mobile than prior to treatment. A management objective associated with this hypothesis can be stated as:

> *Compared to untreated areas, sand bars within treated reach segments will tend to be more mobile and are predicted to have greater variation in their locations over time.*

The specific monitoring approach and the desired level of detail will need to be developed further by the project sponsor prior to the implementation of any of the recommended projects.

This is a critically important parameter to monitor since sand bar stabilization through vegetation encroachment is hypothesized to be a principal driver of progressive channel narrowing in the Isleta Reach. Islands and bars targeted for destabilization treatments should be identified on aerial photographs, and changes should be tracked with subsequent aerial photographs and cross-section monitoring. We also recommend that direct field measurements of seedling vegetation establishment and growth be documented on at least a sub-set of the treated bars. This information will be important for comparing with post-treatment hydrologic conditions. For example, if seedling riparian vegetation recruitment occurs on a treated bar following runoff in Year 1, but the vegetation is gone in Year 2, then we might start to gain some insight into the flows needed to scour seedlings from these bars. The converse is also true—if the vegetation continues to persist and grow, we would gain insight into what flows appear incapable of scouring seedlings from the bars. As importantly, if monitoring indicates that vegetation is once again stabilizing the bars, then the results could be used to develop a follow-up mechanical maintenance treatment with the Program's Adaptive Management Team.

Enhanced Bankline Erosion and Localized Channel Migration

Another hypothesis associated with the channel restoration treatments is that the local erosion rates at bankline destabilization treatment sites will increase after high flow events. The associated management objective can be stated as follows:

> *The prescribed restoration treatment will achieve a statistically significant increase in the local erosion rates following high flow events compared to the erosion rates at control sites.*

The specific monitoring approach and the desired level of detail will need to be developed further by the project sponsor prior to the implementation of any of the recommended projects.

Two cross sections should be established with each bankline destabilization project so that local erosion rates can be monitored. Each cross section should be surveyed annually after the spring runoff peak flows. The distance from the top of the bank to any given station can be measured to monitor changes in local erosional rates following high flow events compared to the erosion rates at control sites outside of the project areas. Bankline location and height should also be documented with GPS data and compared in GIS after all high flow events to help understand processes associated with changes in the bankline. Bed material size changes should also be monitored.

Restoration Treatment: Constructing Willow Swales and Backwater Channels

Management Needs and Restoration Objectives

There are few breeding flycatcher territories in the Isleta Reach. All existing territories are concentrated in a relatively short reach segment between the main channel confluences with the Rio Puerco and Rio Salado. The majority of flycatcher nests in the MRG are established in vegetation communities dominated by Goodding's and coyote willow, and most are in close proximity (within 50 m) of lentic water bodies and/or seasonally saturated soils (see Chapter 3).

Restoration projects are needed that facilitate expansion of existing breeding territories. We hypothesize that this may be best achieved by implementing projects that create dense stands of Goodding's and coyote willow in combination with backwater channels that remain inundated through the nest establishment period (May through June). Given that flycatchers tend to be "gregarious breeders," we recommend that these restoration projects should be constructed in relative close proximity to existing breeding territories.

Willow swale construction near Albuquerque.
(Photo Credit: Parametrix)

Recommended Restoration Treatment(s)

The most reliable way to create these habitat conditions is to construct willow swales and backwater channels. In Chapter 5, we describe two project sites to implement this experimental restoration treatment. Both are located immediately upstream of the Rio Puerco confluence near RM 127.6 and RM 127.8.

Expected Result(s)

Constructing willow habitat and associated backwater channel features are hypothesized to benefit flycatchers by creating Goodding's and coyote willow stands characterized by:

Same location as above 18 months after construction.
(Photo Credit: Parametrix)

- Aerial canopy cover by coyote willow shrubs of at least 75 percent, with total overstory canopy by Goodding's willow and cottonwood of approximately 25 to 50 percent.[1]
- Swale is within 50 meters of open water or saturated soil conditions in most years through the months of May and June.
- Presence of territorial male flycatcher(s) and/or breeding pair(s) within 5 years following project construction.
- The backwaters are also hypothesized to benefit silvery minnow by creating backwater habitat that:
  - Create low-velocity (less than 0.5 ft/s) habitat for the silvery minnow in most years during the months of May and June.
  - Documented use of silvery minnow in the project feature(s).

[1] Field observations indicate that coyote willow growth and canopy cover is less vigorous when overstory canopy cover is closed. As such, we recommend that overstory canopy cover should ideally be between approximately 25 and 50 percent.

Measurement Parameters and General Monitoring Approach

The monitoring approach should focus on validating the benefits of the proposed restoration treatment as follows:

Willow Canopy Cover

Dense willow stands with high cover are considered important attributes of suitable flycatcher habitat. The following management objective can be used to evaluate if the habitat creation goal has been achieved:

> *Willow swales will achieve at least 75 percent total aerial canopy cover by the end of third growing seasons following project construction.*

Estimating canopy cover can be implemented by using quantitative and/or qualitative methods.

<u>Quantitative Methods:</u> This could involve establishing multiple, permanent transects through the willow swale. The precise transect orientation and length should be specified in a detailed monitoring plan developed by the project sponsor. If stem density measurements are also recorded, we suggest the transect width should probably not exceed one meter wide. This will enable accurate plant stem counts along the length of the continuous belt transects. Monitoring should also consider recording whether each stem is live or dead, as this information can be used to determine if initial planting densities were too high (i.e., over planting could result in higher plant mortality). This would be useful information to guide future projects.

Unlike stem density counts, which are done continuously along the belt transect, canopy cover measurements can be recorded at even intervals along each transect (e.g., every 5 meters). Canopy cover can be estimated by a variety of methods, including using a densitometer (i.e., “rhino horn”) or a spherical densiometer. Regardless of which method is used, cover estimates should include percent cover of vegetation in both understory (e.g., coyote willow shrubs) and overstory (Goodding’s willow and cottonwood trees) canopy layers at each measurement point. Height estimates of plant species in each canopy layer should also be documented at each measurement point.

If quantitative methods are implemented, we recommend that they be performed twice over a 5-year project period; towards the end (August or September) of the second and fifth growing season, respectively. Late summer monitoring is preferred because measurements will account for additional growth and/or mortality by the end of the season, and will allow the surveys to be performed during a time of year when they will not have the potential to disturb flycatchers during breeding season.

Qualitative Methods: Qualitative methods involve considerably less time and cost to implement, but are less precise (subject to observer bias). Qualitative methods could involve walking through each willow swale and completing a "modified Hink & Ohmart" survey form developed by Reclamation's Denver Technical Service Center (Exhibit 6-5). This form was used by field personnel during field verification of the 2002 bosque vegetation maps produced for the FEIS.

Implementing this monitoring approach generally involves making ocular estimates of canopy cover of different plant species in different height classes. Other important site information, including ocular estimates percent dead vegetation and site hydrologic attributes, is also captured using this method. If this monitoring approach is selected, we suggest the timing and frequency of this monitoring could mirror those described for quantitative methods.

In addition to measuring plant cover, we recommend also establishing at least two permanent photo monitoring stations at each swale site. Photographs taken from the same location and same angle over time are an easy way to document changes in site condition and are useful for presentations and reporting. We recommend that photo monitoring stations be established regardless of whether the project sponsor implements quantitative or qualitative plant cover estimates. Ideally, photo documentation would occur annually over a 5-year project life.

Exhibit 6-5

Modified Hink and Ohmart Vegetation Classification Form

H&O Classification Form

Date		**Update Polygon Y or N**		Rev. 01/09/2006
Recorder			**Phone Number**	
Polygon ID			**Photo Number**	
State Plane NAD83, NM	**X**		**Declination**	
Central Coordinates	**Y**			
GPS File Name		**Time**		
2002 Classification				
Updated Hink and Ohmart Classification (2006)				

Riparian Vegetation

A = False Indigobush
ATX= Fourwing Saltbush
B = Baccharis (Seep Willow)
C = Rio Grande Cottonwood
CW - Coyote Willow
J = Juniper
LY = Wolfberry
MB= Mulberry
MES = Mesquite
NMO – New Mexico Olive
RO = Russian Olive
SB = Silver Buffaloberry
SBM=Screwbean Mesquite
SC = Salt cedar
SE = Siberian Elm
TW = Tree Willow
TH = Tree of Heaven

End Qualifiers

f=dense understory >75%
s=sparce understory 25-50%

Canopy

Height and Cover				
Canopy Cover	>40 Ft	1-25%	25-75%	75-100%
	20-40 Ft	1-25%	25-75%	75-100%
%Dead	1-25%	25-50%	50-75%	75-100%
Species (Relative species cover)				
(Circle One for each species present)				
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*

Understory

Height and Cover				
Height	5-15 Ft	1-25%	25-75%	75-100%
	<5 Ft	1-25%	25-75%	75-100%
%Dead	1-25%	25-50%	50-75%	75-100%
Understory Species (Relative species cover)				
(Circle One for each species present)				
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*
	1-25%	25-50%	50-75%	*75-100%*

Wetland

MH- Cattail Marsh		OW-Open Water		WM - Wet Meadow		

Other

OP - Open Area	SM=Salt Grass Meadow	Road	Burn	Cleared	Ag-Agricultural

Hydrology Indicators (circle all that apply)

Surface water present	Debris in vegetation	Watermarks on vegetation	None
Sediment deposits	Drainage patterns	Back channel	Overbank flooding

Notes

This form was developed by Reclamation's Denver Technical Service Center.

Proximity to Open Water and/or Saturated Soils

The restoration objective is that surface water and/or saturated soil conditions be present within, or at least 50 m from the willow swale, particularly during the months of May and June. The corresponding management objective may be stated as follows:

> *Willow swales will have, or be within, 50 m of seasonally inundated or saturated soil conditions during the months of May and June in most years during the 5-year project period.*

Since this timing (May/June) corresponds to flycatcher nest establishment, we suggest that these hydrologic parameters be assessed by flycatcher biologists during annual surveys of the restoration project sites. Hydrologic parameters can be either quantitatively or qualitatively estimated.

Quantitative approaches should consider soil moisture measurement methods similar to those implemented by Smith and Johnson (2007). At flycatcher breeding sites at the Pueblo of Isleta, they installed soil temperature loggers at 50 m intervals on a pre-determined grid covering the study area. These data loggers were installed in early May before the breeding season and programmed to record soil temperature data every 30 minutes. Data was downloaded from the soil loggers at the end of the breeding season and compared to daily observations of soil moisture conditions. These data were then used to create soil moisture maps of the habitat on the first and fifteenth of each month throughout the breeding season (Smith and Johnson, 2007).

An alternative (or complimentary) approach would be to record qualitative observations of site inundation or soil moisture conditions during annual flycatcher surveys. For example, when performing annual flycatcher surveys, Reclamation biologists document visual observations of hydrologic attributes on the standard flycatcher survey form. The specific questions on the form are:

- Was surface water or saturated soil present at or adjacent to site? Yes / No (circle one)
- Distance from the site to surface water or saturated soil: _____________ (specify units)
- Did hydrological conditions change significantly among visits (did the site flood or dry out)? Yes / No (circle one)
- If yes, describe in comments section below.

Southwest Willow Flycatcher Survey Forms can be found at: http://sbsc.wr.usgs.gov/cprs/research/projects/swwf/cprsmain.asp)

Backwater Channels

Backwater channel features are intended to serve two primary habitat functions:

- Provide a lentic water source in close proximity to willow swales to enhance flycatcher habitat, particularly during the nest establishment period (May through June).
- Provide low-velocity refuge and nursery habitat for the silvery minnow during moderate and high flow conditions in the river channel.

Low Velocity, Lentic Habitat

The physical characteristics of a backwater virtually guarantees that water within the constructed backwater area will provide a low-velocity, lentic environment any time water is present (except during the most extreme flood events). To assess when water is present within the backwater area, it is recommended that two data loggers be placed within each backwater area. The data loggers could be placed within the deepest portion of the backwater area and within the mouth of the backwater. The purpose would be to document timing, duration, and water surface elevation when water is present within the backwater. The data loggers could be accessed via telemetry and monitored as frequently as necessary. The data can be compared to USGS gaging station data to evaluate relationships between river discharge and surface water elevations in the backwater channels.

Groundwater seepage may inundate the data logger before surface water flows into the backwater. In addition, the discharge that river water flows into the backwater channel (rather than groundwater seepage) could be monitored by using the data collected at the mouth of the backwater in conjunction with USGS gaging station data.

Data loggers should be surveyed in and tied into the benchmark used for topographic surveys of the project site. This set-up will provide the ability to determine the water surface elevation within the backwater channel at any given time. If an absolute pressure data logger is used, it will be necessary to install a barometric pressure logger at the site as well. This arrangement allows users to compensate for changes in barometric pressure. The alternative would be to use a vented cable system, which has more maintenance issues and requires attention more frequently (Solinst, Inc., 2007). Either arrangement should limit the liability that would be faced if the dataloggers are vandalized by using simple security measures, such as the use of a locking cap to access the dataloggers.

Refuge and Nursery Habitat for Silvery Minnow

It is also recommended that the constructed backwaters be monitored for silvery minnow eggs, larvae, and juvenile and adult fish during and following periods that surface water inundates the backwater area. It may be necessary to rescue silvery minnow from the backwater area if the mouth of the backwater aggrades following moderate to high flow events. Data from the data loggers could be analyzed to determine when water is present within the backwater channel, but the mouth of the backwater channel is dry.

Data Gaps and Research Needs

10 What are some important data gaps for planning and designing restoration projects in the Isleta Reach?

Groundwater Data

There are few groundwater wells in any of the project locations proposed in this report. Details of shallow groundwater response to river hydrology are needed to finalize all project designs associated with willow flycatcher habitat restoration recommended in this report. Following are some recommendations pertaining to groundwater data needs associated with proposed restoration projects:

- At least one instrumented groundwater piezometer is recommended to be established in each proposed willow swale construction project location. These data will be important to determine the ultimate excavation depths and the length requirements for coyote and Goodding's willow cuttings.
- It is also recommended that the NMISC riparian groundwater model (Belen and Bernardo models) be calibrated to existing well data in the reach (see Chapter 2).

Soils Data

There is no detailed mapping of floodplain soils in the Isleta Reach. The existing NRCS soil surveys of Valencia and Socorro Counties were conducted in 1983 (although maps were digitized in 2004) when the top priority for mapping was agricultural areas. The floodplain area was considered to be of lower priority at that time, and the soils were only briefly and generally described in the published report.

Detailed floodplain soils mapping would greatly assist restoration-planning projects, particularly for gaining a better understanding of alluvium stratigraphy, estimating the upper limits of the soil capillary fringe, and for evaluating soil salinity. This information is needed at all the proposed restoration project locations. These data would specifically be used to:

- Evaluate if soil salinity is, or could become, a limiting factor to establishing desired plant communities.
- Evaluate the soil textures and associated permeability rates between the soil surface and permanent groundwater table. This will assist with calibrating a seedling recruitment hydrograph and evaluating other surface water irrigation opportunities associated with constructed willow swale projects.
- Evaluate the extent of the groundwater capillary rise. This is critical information both for calibrating a seedling recruitment hydrograph and for finalizing willow swale designs.

Sediment Transport Relationships

MEI (2007) developed a sediment transport model of the Rio Grande between Angostura Diversion Dam and the Isleta Diversion Dam. This model is recommended to be expanded to include the rest of the MRG, including the Isleta Reach. Sediment transport analyses would contribute to defining baseline conditions and would assist in better understanding the fluvial geomorphic conditions and the complex relationships that exist.

Silvery Minnow Population Monitoring

Ultimately, the success of restoration projects along the MRG will depend on their success in contributing to increasing the number of silvery minnows in the MRG. Section 4(f)(1)(b)(ii) and (iii) of the ESA, states that recovery plans must include "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list; and estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal." The Program (2003) also has established the monitoring goal "to track population trends on an annual basis" for the RGSM. Finally, the FWS Consultation Handbook requires that monitoring programs be established when incidental take is anticipated to determine the project effects “on populations of listed species, effects on habitat (critical or not) of a listed species, or effect on both” (FWS 1998, page 9-1).

Unfortunately, to date, an accurate estimate of the size of the silvery minnow population in the MRG has not been accomplished. Successful population size estimates of any small-bodied fish in large rivers with high sediment loads and limited visibility is a very difficult task. Typically, population estimation techniques for populations in any environment depend on implementation of mark-recapture techniques or techniques that can be used in support of various closed or open population models, including depletion sampling (e.g., Ricker, 1975; Seber, 1982). To date, assessments of the silvery minnow populations in the MRG have primarily depended on catch frequency estimates and trends of change in these catch rates. Most of these studies have been conducted using habitat-based sampling at a series of about 20 fixed, or index, sites along the MRG from Angostura Dam to upstream of Elephant Butte Reservoir (Bestgen and Platania, 1991; Dudley and Platania, 2002; Dudley et al., 2004b, 2004c, et seq.). Such statistics do not provide population estimates and has been demonstrated to be highly variable (Cowx, 1991; R. Valdez personal communication, SWCA Environmental Consultants, Logan, UT, 2004), and unreliable for assessing species status and trends, benefits of management actions, and progress to species recovery.

There are very few silvery minnow population monitoring transects within the Isleta project reach. Only five transects are being monitored over a 48-mile reach of river. The basis and representativeness of these sites relative to conditions in the reach, if known, are not clearly documented. Increasing the number of monitoring transects and stratification of the monitoring efforts among reaches with geomorphologic and hydrologic differences and similarities would provide better monitoring results of silvery minnow populations.

Standardizing the sampling methods to allow an application of the accepted fisheries population techniques would increase the value of sampling relative to assessing the goals of the Program, assessing total benefits for implemented habitat restoration projects, and evaluating progress toward recovery of the silvery minnow population. Overall, a comprehensive monitoring strategy would advance the understanding of silvery minnow habitat needs throughout the MRG.

Recent funding by the Program has attempted to produce better metrics to assessment population numbers of silvery minnows based on silvery minnow capture rates and distributions associated with habitat types. Unfortunately, use of methods employing open sampling or blocking distinct habitat types (e.g., runs, riffles, plunges, pools, debris piles, etc.) have previously been found to disturb the fish in these small units and usually moved the fish away from the unit before the area could be sampled (R. Valdez, SWCA Environmental Consultants, Logan, UT,). Program efforts are continuing to assess and refine definitions for appropriate sampling techniques for silvery minnows to allow for a better understanding about the status and trend of the population, to assess benefits of restoration actions, and to determine progress of the species toward recovery.

11 What are some important research needs for long-term restoration of the Isleta Reach?

In addition to the active restoration techniques recommended in Chapter 5, we recommend the Program explore feasibility and opportunities for passive restoration techniques involving implementing experimental flow prescriptions to facilitate sustainable habitat restoration in the Isleta Reach.

Flow Requirements for Scouring Seedlings from Channel Bars

To reduce the potential for ongoing vegetation encroachment and subsequent channel narrowing, it is prudent to evaluate opportunities to implement managed flows, rather than rely solely on repeated mechanical treatments to achieve this objective. There is considerable effort on other regulated rivers (e.g., Trinity River CA; Lower San Joaquin River, CA; Lower Tuolumne River, CA; Bill Williams River, AZ) to evaluate the potential for prescribing managed flows to scour seedlings from the active channel (Bair, 2003; Stella et al., 2002; Wilcox et al., 2006).

Riparian seedlings have flexible stems and are able to withstand flow sheer stresses up to a certain threshold beyond which they are physically dislodged from the bar substrate. Once their root systems are well established, however, it becomes increasingly difficult to provide managed flows sufficient to scour these woody plants from the bar substrate. The cohesive properties of the bar substrate (i.e., gravel, sand, silt) also plays a central role in the ability of flows to scour these seedlings. Thus, determining the ability of managed flows to perform this scouring function is site specific, and results from investigations in other river basins should be applied carefully to the Middle Rio Grande.

Authors of the *Conceptual Restoration Plan for the Active Floodplain of the Rio Grande, San Acacia to San Marcial* (Tetra Tech, 2004b) hypothesize that the 2-year flow (≈ 5,600 cfs) should be sufficient to scour first-year, and possibly second-year, woody riparian seedlings from the active channel. Unfortunately no field data has been collected to validate this hypothesis. MEI (2006) used a HEC-RAS hydraulic model to compute bed sheer stress for a range of flows on the Middle Rio Grande, including for cross sections in the Isleta Reach. Maximum calculated sheer stresses associated with cross sections between Lemitar and San Marcial ranged between 0.1 lb/ft² and 0.3 lbs/ft². MEI (2006) suggests that these sheer stresses would be insufficient to scour bar vegetation, citing bioengineering literature that reports plant material on its own can tolerate sheer stresses up to 1.0 lbs/ft².

It should be pointed out, however, that the bioengineering literature cited by MEI (2006) does not address sheer stress thresholds of riparian seedlings. Rather, the field of bioengineering focuses on the use of riparian cuttings or potted material with well established root systems. While determining the sheer stress tolerance of first- and second-year riparian seedlings is of great importance to developing managed flow prescriptions, there is currently no published data available on this topic (G. Auble, USGS personal communication, 2007; J. Bair, McBain & Trush, Inc., personal communication, 2007; J. Stromberg, Arizona State University, personal communication, 2007; A. Wilcox, University of Montana, personal communication, 2007). We recommend the Program fund research on the Middle Rio Grande to evaluate the sheer stress thresholds for first- and second-year riparian seedlings on various bar substrates. This would require gaining an understanding of the rooting structure of riparian seedlings on different alluvial substrates and elevations above perennial groundwater.

McBain and Trush, Inc. (1997) researched this issue on the Trinity River (CA), and their study may serve as a useful model for similar research on the Middle Rio Grande. As a precursor for evaluating flows required to scour first-year and second-year riparian seedlings from channel bars, they developed several hypotheses that may serve as a useful guide to performing similar research in the Isleta Reach:

- Critical rooting depth is a function of seedling age.
- Mobilization of the channel bed surface during snowmelt runoff would remove seedlings established the previous summer.
- Flows sufficient to produce channel bed scour would remove 1- and 2-year-old seedlings.

It is recommended that the Program fund research aimed at testing these and other relevant hypotheses in order to evaluate the potential for designing and implementing managed flows to retard continual seedling encroachment into the active channel.

Analyzing and Developing Operational Criteria for Implementing Managed Flows that Maximize Biological Benefits for the Silvery Minnow and Flycatcher

Given the climate forecasts of reduced average mountain snowpack over time, it is especially important to be prepared in years with adequate snowmelt runoff to manage flows to maximize the biological benefits for silvery minnows and flycatchers. The Program would be likely to benefit from evaluating various flow management scenarios now, so that the experimental flow prescriptions are ready to execute in years with appropriate snowmelt hydrology. Considerable work beyond the scope of this report is needed to evaluate water-year requirements and operational issues so that benefits of specific flow-management prescriptions can be realized.

The existing operating criteria for Jemez Canyon Reservoir, Abiquiu Reservoir, and Cochiti Lake are designed to provide flood protection through the middle valley without impairing water rights or Compact deliveries. The operation of Cochiti Reservoir to provide a hydrograph with multiple ecological benefits would require the development of operating criteria that will provide flows suitable for habitat restoration purposes without impairing the delivery of water to downstream users and that will minimize adverse impacts of this operation, if any, in the reservoir area. Flood control operations can generally be predicted in advance based on snowmelt runoff forecasts. The runoff forecasts can also be used to establish a trigger to implement criteria for the operation of the reservoirs to produce appropriate hydrograph modifications.

Chapter 4 presents data showing the relationship between river flow attributes and silvery minnow population monitoring along the MRG. Data is also provided showing the relationships between hydrograph attributes and recruitment of native riparian vegetation known to provide important habitat for the flycatcher. These data serve as useful biological guides and starting points for developing hypotheses and experimental flow management criteria for restoration in the Isleta Reach.

For example, data presented in Chapter 4 shows the strong relationship between October silvery minnow catch rates and peak discharges at the Central Bridge Gage in Albuquerque. The data showed a similarly strong relationship between these catch rates and number of days discharge exceeded 3,000 cfs. These data could be used to formulate the following hypothesis:

> *Managed flows that achieve a peak snowmelt discharge of at least 5,000 cfs at the Central Gage and maintain flows above 3,000 cfs for the next 25 days will result in significantly higher October silvery minnow catch rates than in comparable water-years where these criteria were not met.*

This hypothesis (or others like it) could then be used as a guide to evaluate the specific runoff requirements (i.e., April snowpack forecast) to achieve this experimental flow prescription. Such evaluation might reveal that this hypothesis could be tested on any "average" water-year, without impairing irrigation or Compact delivery requirements. Knowing this in advance would allow the Program to develop statistically rigorous monitoring plans to test this hypothesis. If monitoring validates this and other hypotheses, then the results can be used to supplement or modify the BiOp or other relevant operational documents. The Adaptive Management of flows to achieve restoration and other water management objectives holds greater potential for improving the population of silvery minnows and flycatchers in the Isleta Reach than through construction projects alone.

Irrigation Drains and Wasteways as Off-Channel Refugia for Silvery Minnow

There are few options for mitigating channel drying in the Isleta Reach. The Isleta Reach, however, has twelve irrigation drain returns and wasteway channels that could be enhanced to provide important off-channel silvery minnow refugia during conditions of channel drying. The concept was discussed in Chapters 4 and 5, and we suggested that a relatively minor amount of water released into these irrigation returns when the

Silvery minnow kill found within a dried pool (Photo Credit: M. Hatch) river channel begins to dry might provide important refuge for silvery minnow. Similarly, strategically placed wells could be used for the same purpose (Hatch et al., 2008). Use of wells would provide greater assurance of water delivery to meet time and space dependant needs for silvery minnows.

Three irrigation water return sites having characteristics that include attributes most favorable to the success for such restoration project goals selected as pilot projects for creating “in-channel” refugia (BOR, 2007). These sites are located at the outfalls of Los Chavez Drain Wasteway, Peralta Wasteway, and the Lower Peralta Drain No. 1. These sites are all located upstream of the Highway 309 bridge near Belen, New Mexico. Additional information is required to evaluate the suitability of these and the other remaining irrigation outfall channels to produce “off-channel” refugia and to generate projections on how much water would be needed to achieve the restoration objective.

The quantity of water necessary to provide cover for the silvery minnow depends on several factors and may vary for each project. The factors include, but are not limited to:

- Geometry of the wasteway channel (depth, length, and width).
- Seepage losses within the wasteway channel.
- Groundwater seepage and groundwater depth.
- Drain leakage into the wasteway.

Another important data gap associated with this restoration concept is the extent that the silvery minnow utilize specific drain wasteways during channel drying episodes. This is expected to vary for each wasteway depending on its location within the reach and whether the adjacent channel has a propensity for drying. It is hypothesized that the silvery minnow would seek refuge in wasteways, if adequate water was provided to them, as the adjacent river channel begins to dry.

To be implemented, the Program would need to acquire supplemental water for release into the drain wasteways via the MRGCD's irrigation infrastructure. An exploratory evaluation of the off-channel habitat concept could be performed to determine the amount of water required. These data could then be used by the Program to pursue options for obtaining the supplemental water. The NM Strategic Water Reserve is one possible mechanism though which water for these projects may be obtained.

Additionally, Hatch et al. (2008) recently suggested future research needs required to better understand the benefits of these habitat projects for the silvery minnow in the MRG. They suggest, first, that an improved knowledge is needed of the habitat conditions under which the silvery minnow could be reasonably expected to maintain viable populations. Such information is vital to efforts to manage for a functioning condition for the species. They also suggest that these refugia projects should focus on implementing a variety of habitat designs comprising several spatial configurations to allow an assessment of design and operation criteria most benefiting silvery minnows.

Lastly, and perhaps most importantly, the Program would need to explore options to ensure that MRGCD would be protected from potential "take" of silvery minnow resulting from utilizing these irrigation wasteways as off-channel refugia. For example, creating habitat inside wasteways and drains implies a commitment from the MRGCD to provide water to those facilities and conduct operations and maintenance in a manner that would prevent harm to silvery minnow. Since MRGCD cannot guarantee either one, the take policy and its current constraints needs to be addressed before MRGCD could agree to habitat projects within their facilities (Y. Najmi, MRGCD, personal communication, 2008).

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