Middle Rio Grande
Endangered Species Collaborative Program

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

January 2011

Parametrix
Mussetter Engineering, Inc.
Tetra Tech, Surface Water Group
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Prepared for

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Endangered Species Collaborative Program
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10 January 2008

DECISION PAPER TO COLLABORATIVE PROGRAM EXECUTIVE COMMITTEE

PROPOSED DISCLAIMER LANGUAGE TO BE INCLUDED IN ALL PROGRAM-FUNDED DELIVERABLES

Reports and other deliverables from Program-funded grants and contracts are intended to address requirements specific to the funded project. Projects that have been funded address a wide variety of technical, scientific, and policy issues – many of which are controversial in nature. The Bureau of Reclamation as the fiscal agent and Program signatories or their designees, as stakeholders, may review and comment on deliverables. A review process that sets a schedule and ground rules for the reviews is almost completed and will be presented to the Executive Committee in early 2008.

Neither the deliverables nor the reviews of such deliverables necessarily reflect the views, opinions or decisions of the diverse array of stakeholders that are signatories to the Program. Nor is any one study or report expected necessarily to provide a definite answer or result on the project subject matter. As such, the Coordination Committee and the technical workgroups have recommended that a short disclaimer note be attached to all deliverables once they have been finalized (i.e., fulfilled contractual obligations and had a Program review). The information in the reports can then be available for the Program and public without concern that it be misinterpreted that the Program necessarily endorses all the conclusions or recommendations in each report.

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

ACEC	Area of Critical Environmental Concern

B

BLM	Bureau of Land Management
BOR	Bureau of Reclamation

C

C	Celcius
cfs	cubic feet per second

E

ESA	Endangered Species Act

F

flycatcher	Southwestern willow flycatcher
FWS	U.S. Fish and Wildlife Service

G

GIS	Geographic Information System

H

HSI	Habitat Suitability Index

M

m	meters
MEI	Mussetter Engineering, Inc
mm	millimeters
MRG	Middle Rio Grande

N

NHNM	Natural Heritage New Mexico
NMED	New Mexico Environment Department
NMGF	New Mexico Game and Fish
NWI	National Wetland Inventory

O

OVRA	Orilla Verde Recreation Area

P

Program	Middle Rio Grande Endangered Species Collaborative Program

R

RGIS	New Mexico Resource Geographic Information System Program
RGSM	Rio Grande silvery minnow

S

SHAs	Safe Harbor Agreements
silvery minnow	Rio Grande silvery minnow
SJC	San Juan Chama
SL	standard length
SWFL	southwestern willow flycatcher

T

TES	Terrestrial Ecosystem Survey

U

URGWOP	Upper Rio Grande Water Operations Program
USACE DEIS	U.S. Army Corps of Engineers Draft Environmental Impact Statement
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service

W

WRAB	Water Rights Abstract Bureau

Chapter 1 Introduction

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

Parametrix was funded by the Middle Rio Grande Endangered Species Act Collaborative Program (Program) in Fiscal Year 2007 to assess the potential for restoring habitat in segments of the Rio Grande watershed in northern New Mexico for two federally endangered species: the Rio Grande silvery minnow (*Hybognathus amarus*) and the Southwestern willow flycatcher (*Empidonax traillii extimus*). The study area for this report includes the Rio Grande from Taos Junction Bridge downstream to the northern boundary of Ohkay Owingeh Pueblo, and the Rio Chama from Christ in the Desert Monastery downstream to the western boundary of Ohkay Owingeh Pueblo (excluding Abiquiu Lake; see Exhibit 1-1). This upper portion of the Rio Grande watershed in New Mexico has been generically referred to by the Program as the *Velarde Reach*.

The "Velarde" Project Reach

The Middle Rio Grande Endangered Species Act Collaborative Program has referred to the Rio Grande watershed upstream of Cochiti Reservoir as the "Velarde Reach". While the project area covered in this report includes the Rio Grande through Velarde, NM, it also covers segments of the Rio Grande upstream and downstream of the town, as well as 43 miles of the Rio Chama upstream of Okay Owingeh Pueblo (see Exhibit 1-1).

The primary objectives of this project included:

- Gathering existing data, reports, and Geographic Information System (GIS) layers relevant to the project reach.
- Evaluating current conditions in the project reach through review, analysis, and synthesis of existing data, reports, and other pertinent information.
- Performing site visits and landowner meetings to better understand habitat restoration opportunities and land management issues in the project area.

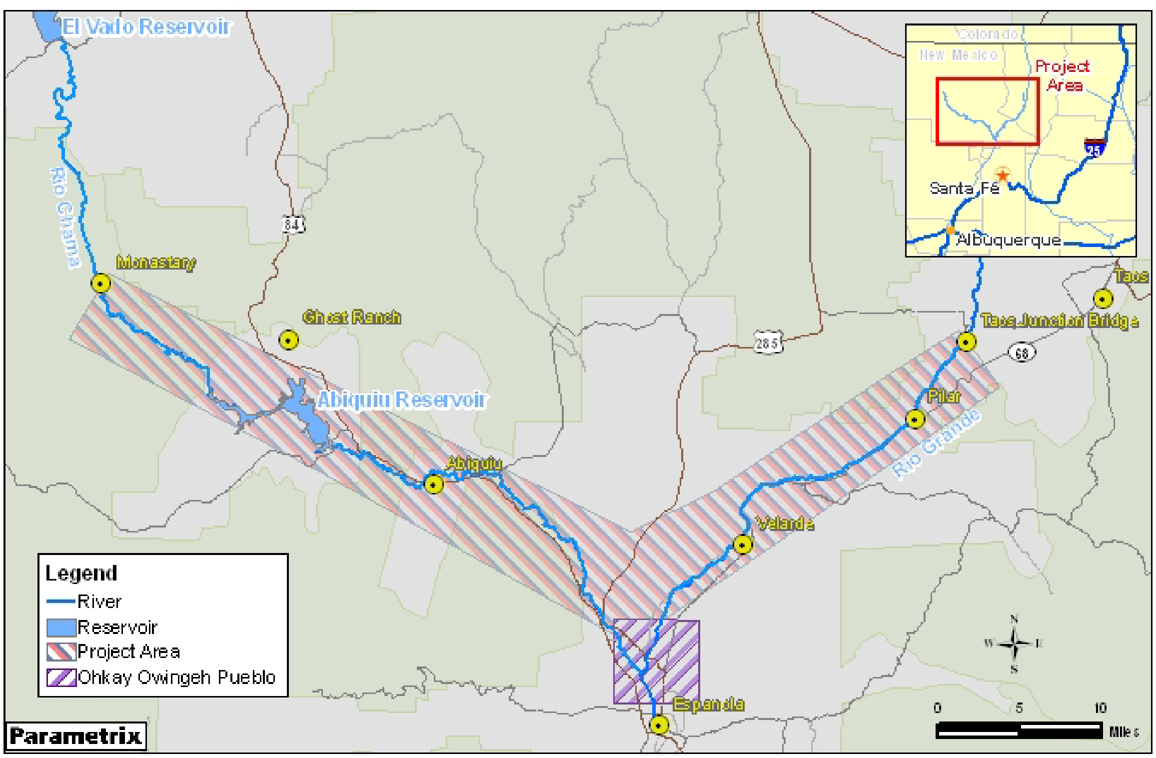
- Identifying physical, biological, jurisdictional, and managerial constraints to habitat conditions and restoration potential in various segments of the project reach.
- Utilizing this information to recommend restoration approaches and identify potential project locations where habitat restoration may be most attainable.
- Developing conceptual-level restoration recommendations, including both active and passive restoration approaches.
- For active restoration approaches, developing conceptual level project designs and cost estimates.
- Developing monitoring criteria and adaptive management recommendations for proposed restoration projects.
- Identifying data gaps and research and monitoring needs.
- Organizing existing and new GIS data into a consolidated Geo-Database for use by the Program.

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

GIS technology was an essential tool for performing analyses used in the development of this report. Datasets were compiled into a thematically organized database, which has been 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 Program's FTP site.

Exhibit 1-1

Project Area Location Map



2 What is the Middle Rio Grande Endangered Species Act Collaborative 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 Rio Grande silvery minnow (silvery minnow) and the Southwestern willow flycatcher (flycatcher). The signatories to the Program include:

- 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."

Program Area

The Middle Rio Grande, as defined by the Program, includes the headwaters of the Rio Chama watershed and the Rio Grande, including tributaries, from the New Mexico-Colorado state line downstream to the elevation of the spillway crest to Elephant Butte Reservoir at 4,450 feet above mean sea level, excluding the land area reserved for the full pool of the Elephant Butte Reservoir. Indian Pueblo and Tribal lands and resources within the Program area are not included in the Program without the express written consent of the affected Indian Pueblo or Tribe.
(Middle Rio Grande Endangered Species Act Collaborative Program, 2006).

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 Why is the Velarde Reach important for meeting the Program's goals?

The Middle Rio Grande, as defined by the Program, includes the headwaters of the Rio Chama watershed and the Rio Grande, including tributaries, from the New Mexico-Colorado state line downstream to the elevation of the spillway crest to Elephant Butte Reservoir at 4,450 feet above mean sea level (Middle Rio Grande Endangered Species Act Collaborative Program, 2006). In order to attain species recovery goals, the Program is interested in evaluating opportunities for restoring habitat for both the flycatcher and the silvery minnow to all segments of the Program Area, including those that fall within the Velarde Reach.

For several reasons the Velarde Reach may be particularly important for flycatcher recovery. First, the segment of the Rio Grande between Taos Junction Bridge and the upstream boundary of Ohkay Owingeh Pueblo is designated critical habitat for the flycatcher (U.S. Fish and Wildlife Service [FWS], 2002). There is particular interest by management agencies, therefore, to explore habitat restoration opportunities in this reach segment.

Southwestern willow flycatcher. Photo Credit: USGS http://sbsc.wr.usgs.gov/cprs/research/projects/swwf/wifllook.asp.

Second, flycatchers have for several years been actively nesting in riparian habitats immediately downstream of the project area on lands owned by Ohkay Owingeh Pueblo (near the Rio Chama/Rio Grande confluence; see Exhibit 1-1). In fact, the habitat at Ohkay Owingeh supports the largest concentration of nesting flycatchers along the Rio Grande north of Elephant Butte Reservoir. Researchers in Arizona banded and tracked movements of breeding flycatchers over a ten year period and found that the majority of adult birds nested less than 8.5 miles from the previous year's nest location. Young birds establishing their first territory typically did so within 13 miles from their natal sites (Paxton et al., 2007). While dispersal distance is largely influenced by the proximity of suitable habitat, these data support the notion that flycatcher habitat restoration in the Velarde Reach could facilitate territorial expansion upstream of the existing Ohkay Owingeh flycatcher population.

The Velarde Reach is also important for the Program to facilitate down-listing (and eventually de-listing) the flycatcher from the federal endangered species list. The Velarde Reach falls within the *Upper Rio Grande Management Unit* – one of five Management Units within the *Rio Grande Recovery Unit*. Restoration of stable flycatcher populations across these Management Units is not only important for preventing jeopardy from federal or state management actions, but down-listing and de-listing ultimately requires meeting population recovery goals set for each individual Management Unit (FWS, 2002; G. Beatty, FWS, personal communication). In other words, regardless of how many nesting pairs occur further downstream near the Elephant Butte Reservoir delta (which falls within the Middle Rio Grande Management Unit), the flycatcher will remain a federally listed species until all other Management Units also attain their recovery goals.

Rio Grande silvery minnow.
Photo Credit: FWS.

The relative importance of the Velarde Reach for silvery minnow recovery is less apparent. The recovery plan (FWS, 1999) states that habitat restoration priority for silvery minnow in the Rio Grande watershed upstream of Cochiti Lake is lower than for other segments of the Rio Grande (e.g., Rio Grande through Big Bend National Park, TX) and the Rio Pecos (e.g., Sumner Dam to Brantley Reservoir, NM). A more recent report by the FWS (Buntjer and Remshardt, 2005) suggested that the Rio Grande upstream of Cochiti Lake and the Rio Chama below Abiquiu Dam were generally too swift, water temperatures too cold, and the habitat too uniform to support sustainable silvery minnow populations. In that report, however, the FWS did suggest that experimental stocking above Cochiti Lake could be considered when a surplus of silvery minnow is available (Buntjer & Remshardt, 2005). The Program has expressed interest in exploring further the potential for silvery minnow habitat restoration within various segments of the Velarde Reach project area. This report, therefore, applies equal weight to examining habitat restoration potential for both the flycatcher and the silvery minnow.

5 What organizations and individuals participated in this project?

Parametrix and our subcontractors (Mussetter Engineering, Inc [MEI], Tetra Tech, 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 project area. We would like to specifically acknowledge the support received by the following individuals and entities:

- The Program's Habitat Restoration Workgroup.
- Mr. Charles Fischer; Bureau of Reclamation, Albuquerque, NM.

- Ms. Mary Orr, U.S. Forest Service, Santa Fe National Forest, Espanola Ranger District, Espanola, NM.
- Ms. Valerie Williams and Mr. Sam DesGeorges, Bureau of Land Management, Taos Field Office, Taos, NM.
- Ms. Nancy Baczek; U.S. Fish and Wildlife Service, Albuquerque, NM.
- Mr. Robert Findling; The Nature Conservancy, Santa Fe, NM.
- Mr. Gilbert Ferran; Abiquiu Land Grant, Abiquiu, NM.
- Mr. Patrick Salazar; Los Luceros Property, Velarde, NM.
- Ms. Ermalinda Crim, Abiquiu, NM.
- Ms. Marcia Mason, Double M Ranch, Abiquiu, NM.
- Mr. Gilbert Vigil, Chili, NM.
- Mr. Arturo Archuleta; Mexicano Land Education Conservation Trust, Albuquerque, NM.
- Mr. Ernie Atencio; Taos Land Trust, Taos, NM.
- Deborah Callahan and Darrell Ahlers; Bureau of Reclamation, Technical Service Center, Denver, CO.

Chapter 2 Reach Description

Project Location, Land Ownership, and Infrastructure

1 Where is the Velarde Reach?

The Velarde Reach (herein referred to as the "project area") includes segments of the Rio Grande and Rio Chama within Rio Arriba and Taos Counties of northern New Mexico. The Rio Grande segment extends downstream approximately 29.5 miles from Taos Junction Bridge within the Orilla Verde Recreation Area (OVRA) to the northern boundary of Ohkay Owingeh Pueblo. The Rio Chama segment extends 13.6 miles from the Christ in the Desert Monastery to the ordinary high-water mark of Abiquiu Lake, and then another 29.4 miles from Abiquiu Dam to the western boundary of Ohkay Owingeh Pueblo. The project area does not include Abiquiu Lake or any lands owned by, or held in trust for, Ohkay Owingeh Pueblo or other sovereign tribal governments.

2 Who owns and manages property within the project area and what are the various land uses?

For analytical and descriptive purposes we have divided the project area into five sub-reaches: the Upper and Lower Chama Sub-Reaches of the Rio Chama; and the Orilla Verde, Pilar, and Velarde Sub-Reaches of the Rio Grande. River miles associated with each sub-reach is shown in the adjacent sidebar, and a general sub-reach location map is displayed in Exhibit 2-1.

Sub-Reaches of the Velarde Reach Project Area:

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

Rio Chama

- *Upper Chama Sub-Reach* extends 13.6 miles from Christ in the Desert Monastery (RM 55.5) downstream to the ordinary high water mark of Abiquiu Reservoir (RM 41.9).
- *Lower Chama Sub-Reach* extends approximately 29.4 miles from Abiquiu Dam downstream to the western boundary of Ohkay Owingeh Pueblo (RM 3.9).

Rio Grande

- *Orilla Verde Sub-Reach* extends downstream approximately 5 miles from Taos Junction Bridge (RM 305) to Pilar, NM (RM 300).
- *Pilar Sub-Reach* extends downstream approximately 15 miles from Pilar (RM 300) to the Velarde Diversion Dam near RM 285.
- *Velarde Sub-Reach:* Extends 9.5 miles from Velarde Diversion Dam (RM 285) to the northern boundary of Ohkay Owingeh Pueblo (RM 275.5).

Geographic information regarding land ownership within the project area was obtained from the New Mexico Resource Geographic Information System Program (RGIS) and the U.S. Forest Service (USFS). Land ownership maps are displayed by sub-reach in Exhibit 2-2 through Exhibit 2-6.

Exhibit 2-1

Sub-Reach Location Map

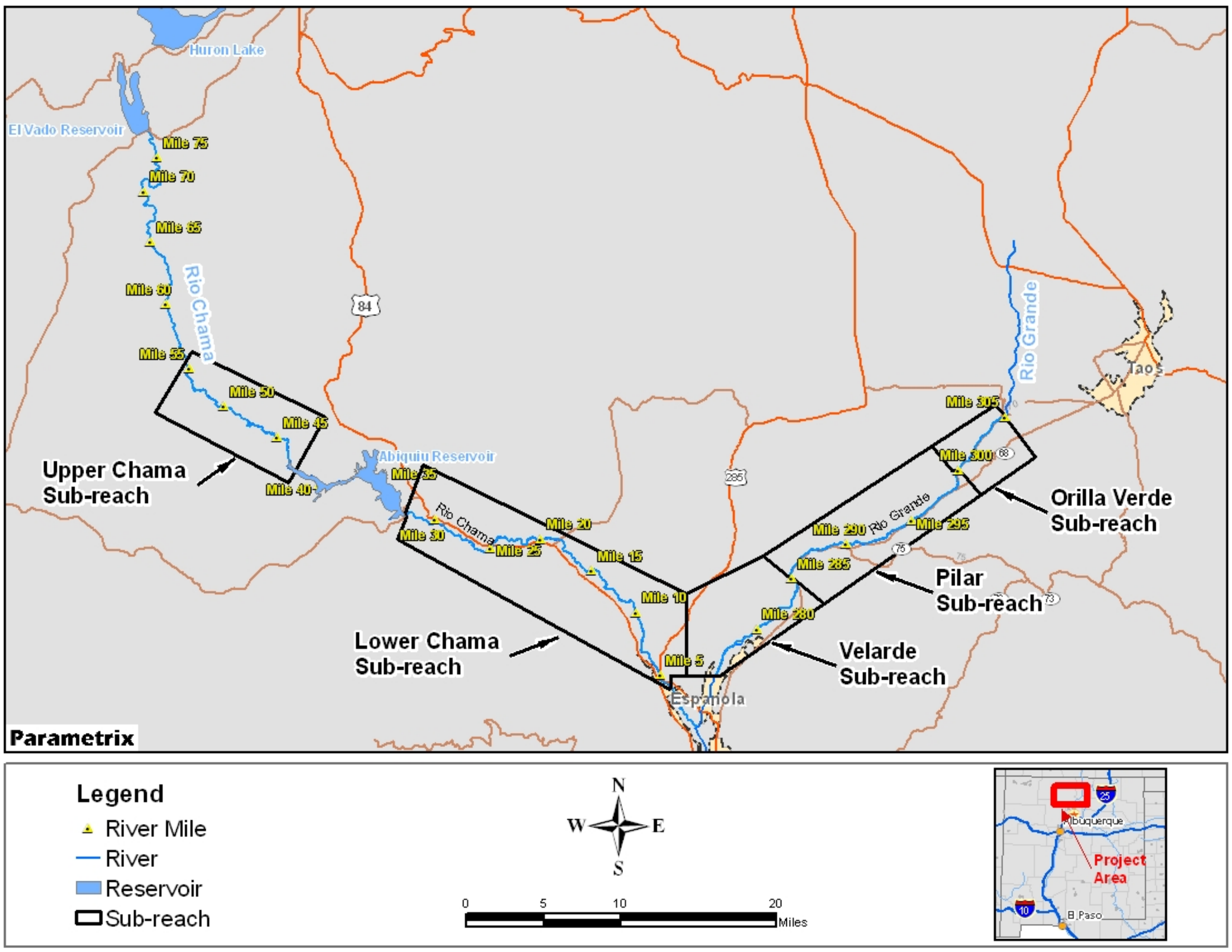
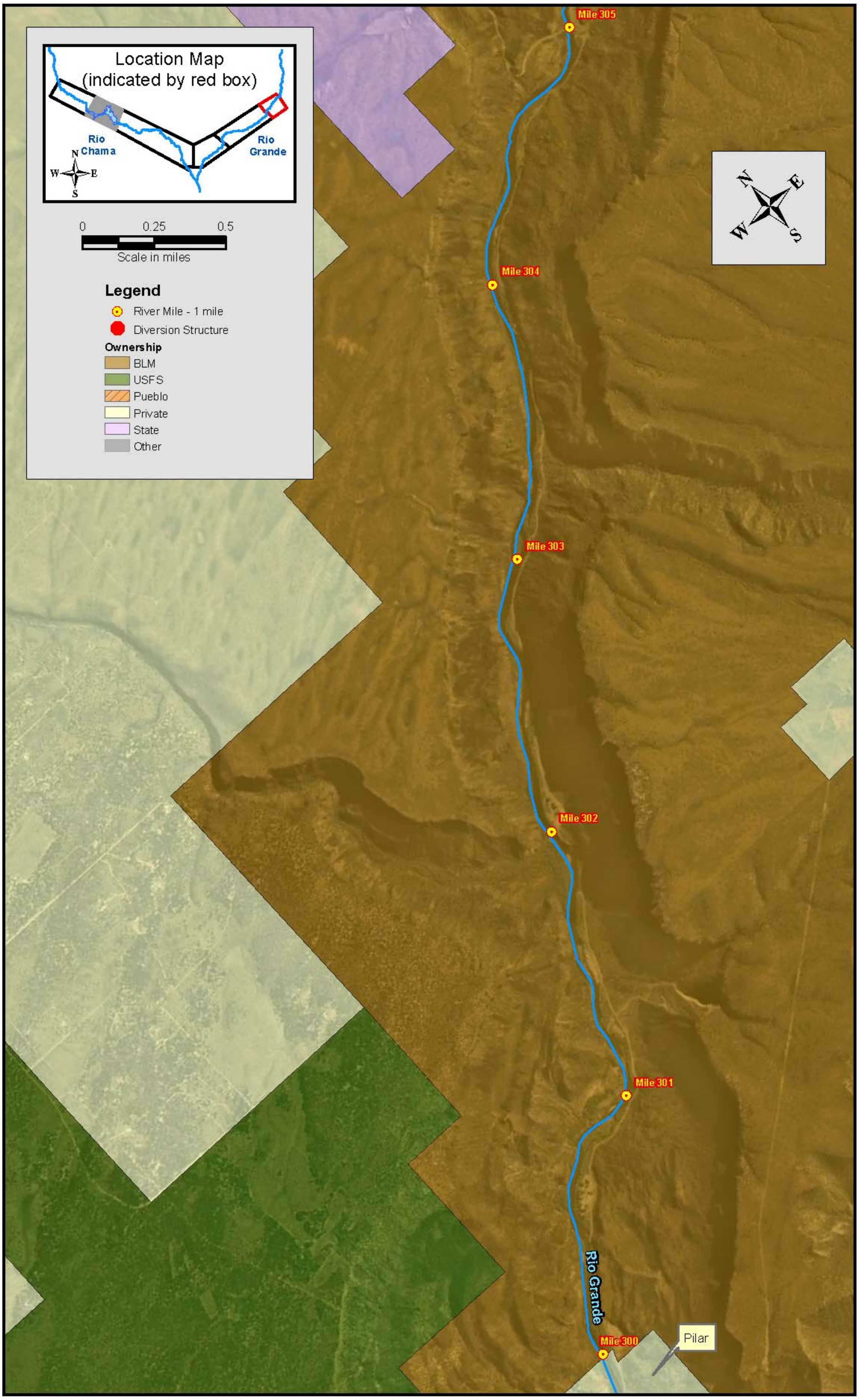
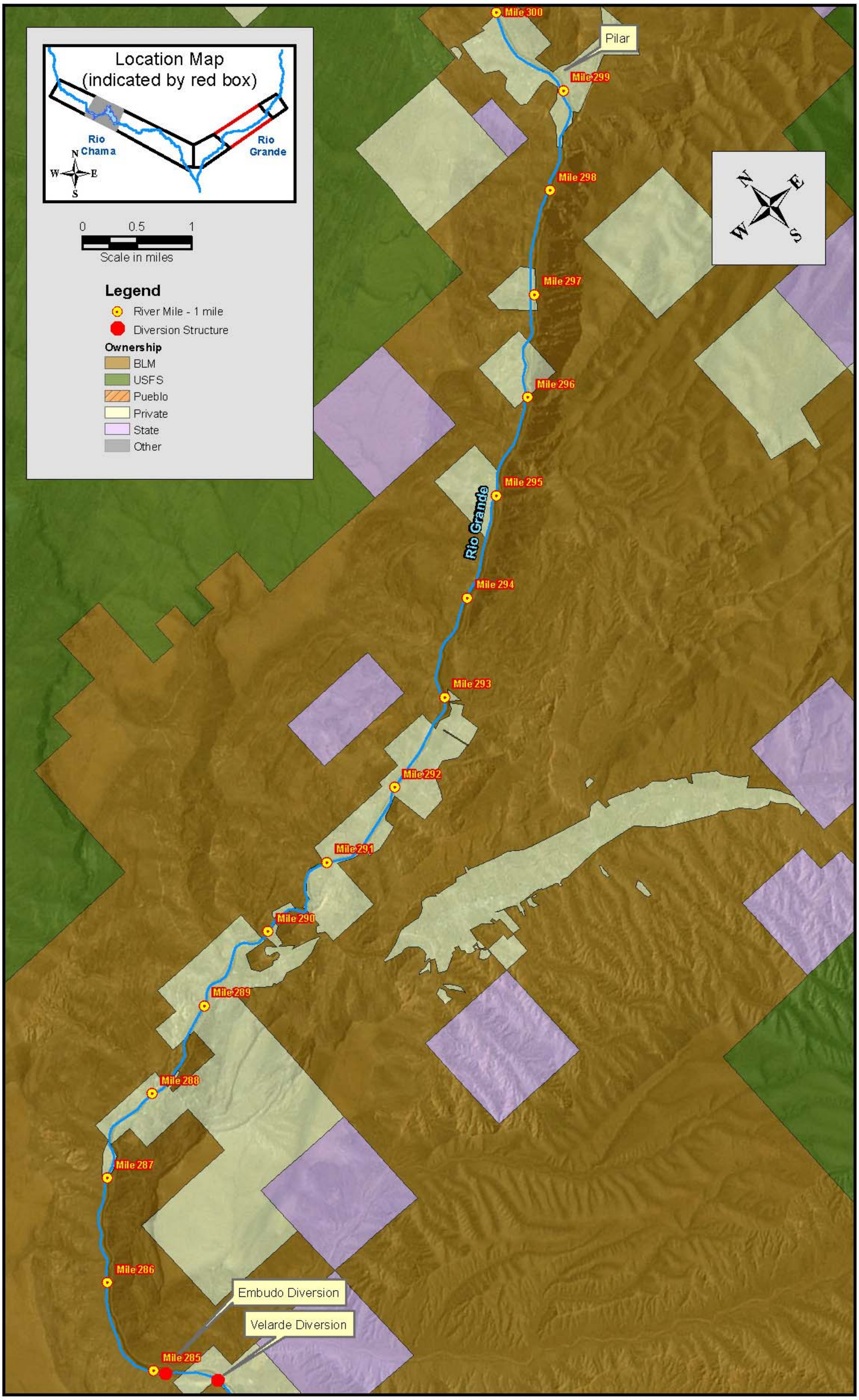


Exhibit 2-2
Land Ownership – Orilla Verde Sub-Reach



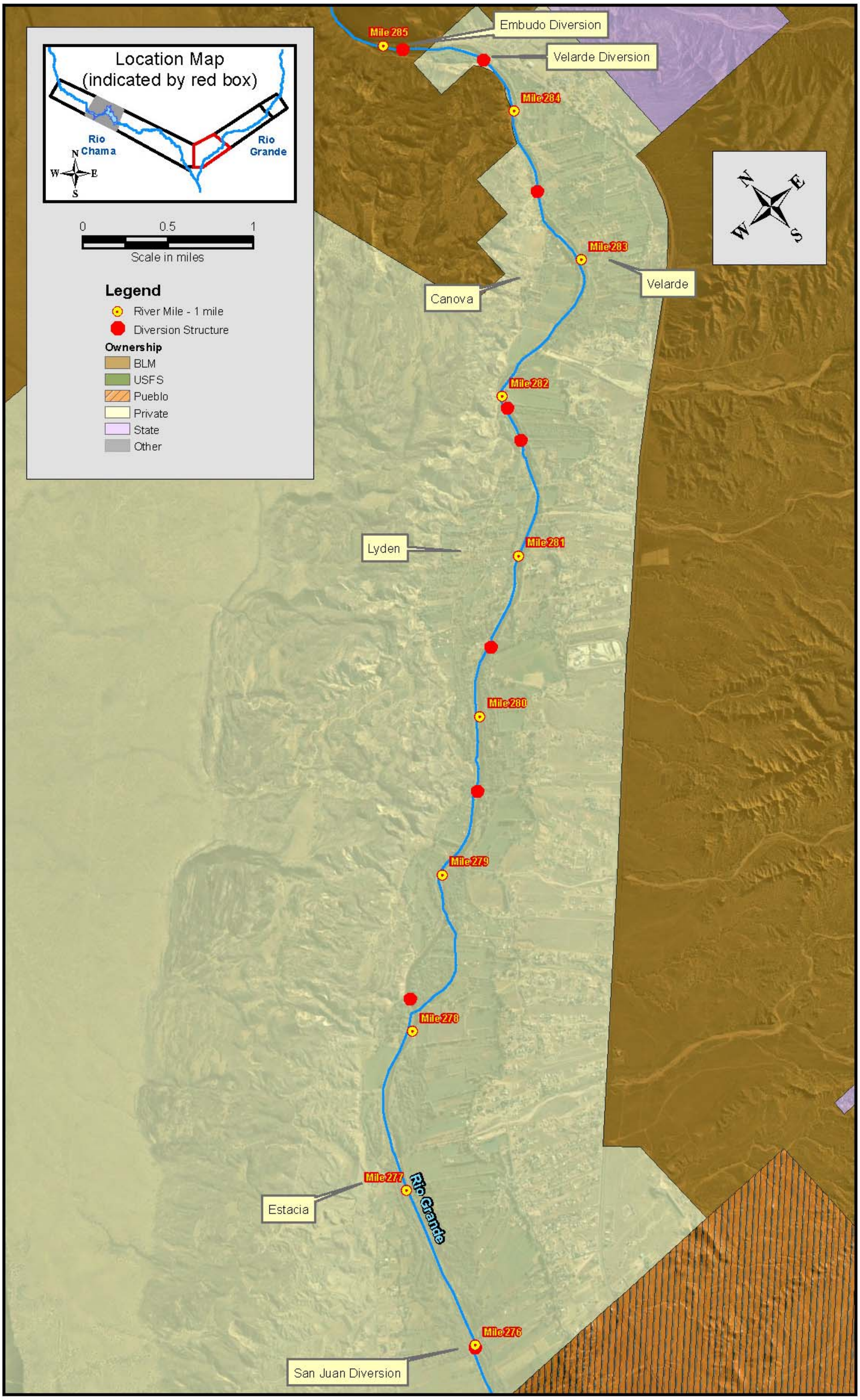
Background image source: 2005 DOQQ images

Exhibit 2-3
Land Ownership – Pilar Sub-Reach



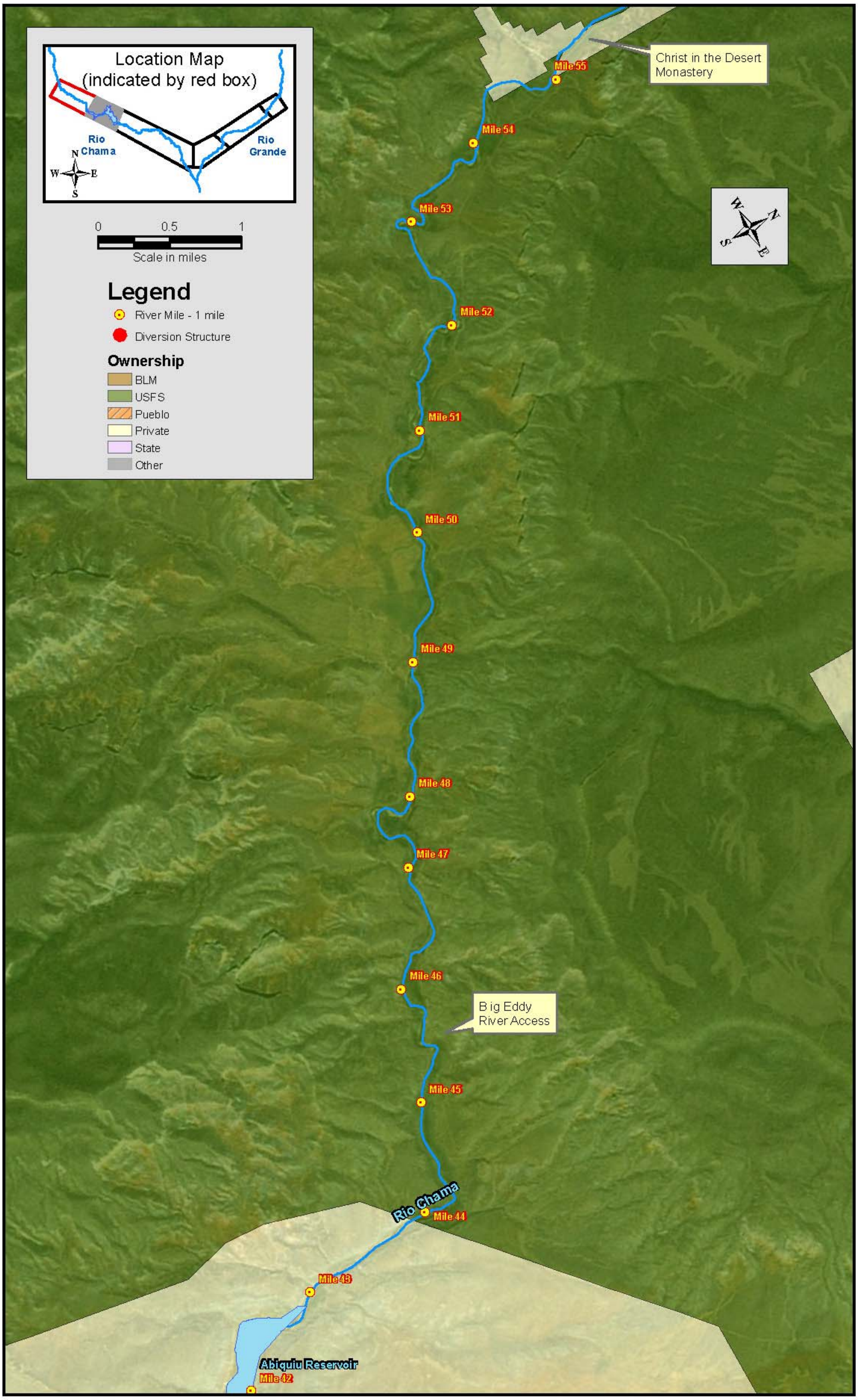
Background image source: 2005 DOQQ images

Exhibit 2-4
Land Ownership – Velarde Sub-Reach



Background image source: 2005 DOQQ images

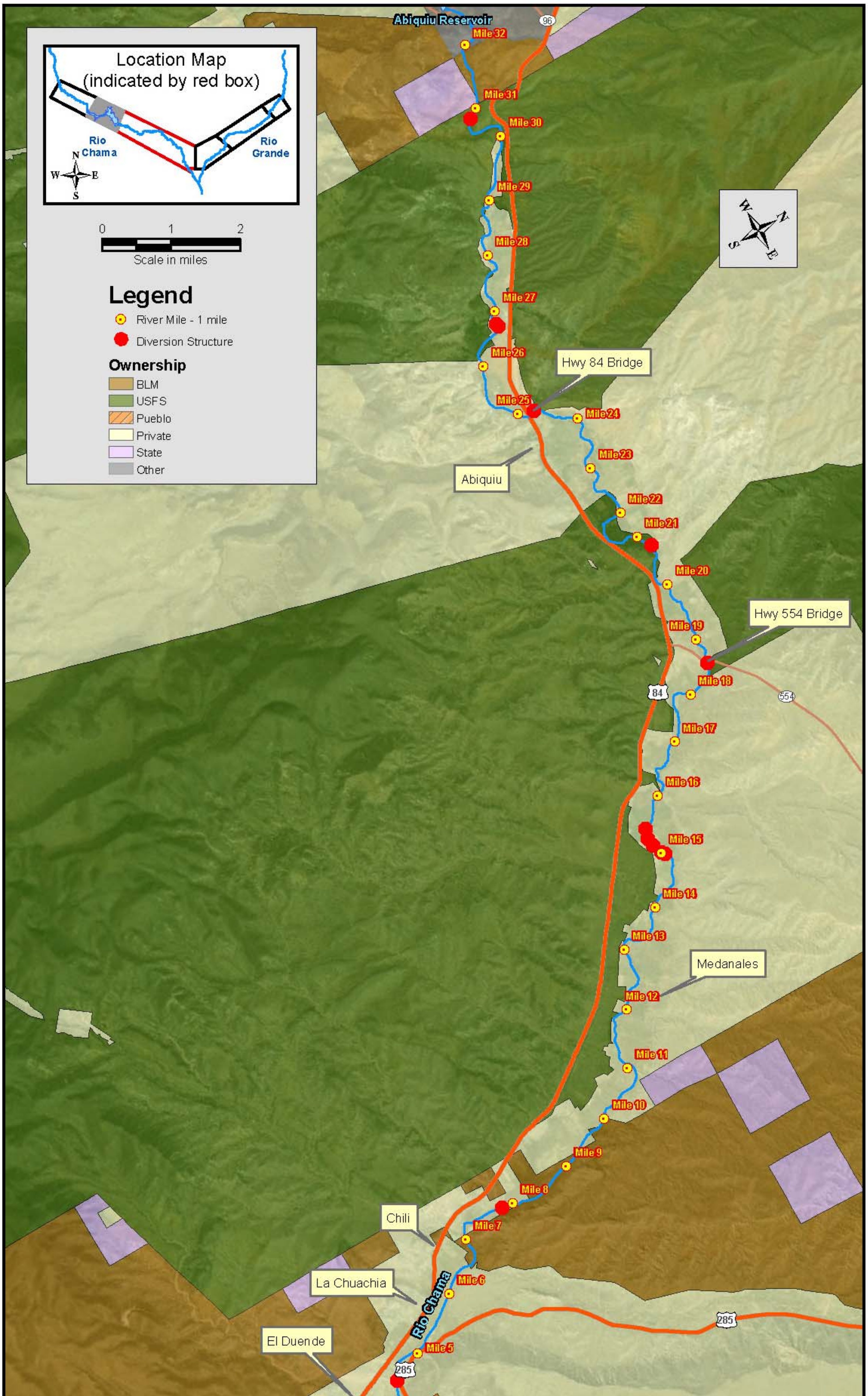
Exhibit 2-5
Land Ownership – Upper Chama Sub-Reach



Background image source: 2005 DOQQ images

Exhibit 2-6

Land Ownership – Lower Chama Sub-Reach



Background image source: 2005 DOQQ images

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The general land ownership and associated land-use descriptions by sub-reach are discussed below.

Rio Grande

Orilla Verde Sub-Reach (5-miles)

The Orilla Verde Sub-Reach extends through the OVRA for five river miles from Taos Junction Bridge to the upstream boundary of the Village of Pilar (Exhibit 2-7). This river segment received *Scenic* status in 1994, when Congress added it to the National Wild and Scenic River system. The land through this sub-reach is owned by the Bureau of Land Management (BLM), Taos Field Office, and is managed primarily for recreation, education and fish and wildlife conservation purposes (BLM, 2000). State Highway 570 parallels the river along the east-side of the river for the entire length of the OVRA, providing access to thousands of visitors each year interested in boating (non-motorized), fishing, hiking, camping, swimming, picnicking, bird watching, and general sightseeing. The west side of the river is undeveloped except for the campground at Taos Junction. The OVRA is managed for its scenic quality, and BLM closely adheres to federal Visual Resource Management guidelines. Further relevant site management details can be found within the BLM's Rio Grande Corridor Final Plan (BLM, 2000).

All river mile designations in this report reference a modified river mile system based upon the Bureau of Reclamation's (BOR) 2002 river mile system for the Rio Grande. Parametrix extended the system from its northern most extent on the Rio Grande to extend through the project area. In addition, a river mile system was developed for the Rio Chama that uses the confluence with the Rio Grande as River Mile 0.

Exhibit 2-7

Photographs of the Orilla Verde Sub-Reach

View of the Orilla Verde Sub-Reach during November 2007 site visit.

The Orilla Verde Sub-Reach is canyon bound, with riparian vegetation mostly restricted to channel bars.
Photo: April 2008.

Another view of the canyon-bound Orilla Verde Sub-Reach. This photo shows some of the only large cottonwood trees in the 5-mile long sub-reach.
Photo: November 2007.

Pilar Sub-Reach (15 miles)

The Pilar Sub-Reach extends 15 miles from the Village of Pilar downstream to the Velarde Diversion Dam. This entire sub-reach falls within a BLM special management area known as the Lower Gorge Area of Critical Environmental Concern (ACEC). This ACEC status recognizes the area's value for recreation, wildlife habitat, and riparian vegetation (BLM, 2000).

The upper segment of the Pilar Sub-Reach includes a river segment known to whitewater boating enthusiasts as *the racecourse*, which extends approximately seven miles through the Lower Gorge from Pilar downstream to the County Line river access along State Highway 68. The racecourse segment of the Rio Grande flows through BLM property and, along with the OVRA, was designated *Scenic River* status in 1994 (BLM, 2000). The BLM estimates nearly 40,000 whitewater boaters visit this river segment each year (BLM, 2000). Camping is not permitted along this river segment, but fishing, picnicking, hiking and other forms of recreation are allowed.

Downstream of the County Line river access, the land on both sides of the river shifts between BLM ownership and private property. Some recreational boaters float this stretch downstream to Embudo, but limited public access, relatively mild stream gradient, and increased private land development may contribute to fewer boaters utilizing this river segment. It is common to see houses along the riverbanks on private lands in this segment of the Pilar Sub-Reach, as well as orchards and other forms of agriculture (Exhibit 2-8). The Embudo Diversion Dam is the only irrigation diversion dam in the Pilar Sub-Reach, and is located approximately 14.2 river miles downstream of Pilar.

Exhibit 2-8

Photographs of the Pilar Sub-Reach

The upstream segment of the Pilar Sub-Reach flows through the "race-course"–a popular spot for whitewater enthusiasts. This river segment is owned and managed by the BLM. Photo taken May 2005 when flows were approximately 5000 cfs..

The Pilar Sub-Reach downstream of the Taos/Rio Arriba County line flows through a mix of private and BLM land. Several private landowners have built houses close to the riverbank. Photo: April 2008.

Riparian vegetation through most of the Pilar Sub-Reach is limited to a relatively narrow band along the bank line, although some extensive cottonwood groves do occur in isolated stands along the reach. Photo: April 2008.

Velarde Sub-Reach (9.5 miles)

The Velarde Sub-Reach extends approximately 9.5 miles from the Velarde Diversion Dam downstream to the northern boundary of Ohkay Owingeh Pueblo (Exhibit 2-9). The geo-spatial data we obtained from RGIS indicates all of the property within this reach is privately owned, and the sub-reach passes through several villages, including Velarde, Cañova, Lyden, and Estacia.

The river in this sub-reach was channelized by Reclamation in the 1950's. Most of the available floodplain in the sub-reach has been developed for agricultural, and irrigation water is delivered to acequias via several (eight) diversion dams constructed by Reclamation and operated and maintained by the Velarde Community Ditch Association (R. Padilla, Reclamation, personal communication, 2008). Public access to the river and floodplain in this sub-reach is extremely limited and requires permission from private landowners.

Exhibit 2-9

Photographs of the Velarde Sub-Reach

One of the eight irrigation diversion dams in the sub-reach. Photo: April 2008.

Orchards and agricultural fields line the floodplain along much of the sub-reach. This photo shows an irrigation ditch near Cañova. Photo: April 2008.

Some riparian vegetation still occurs in the project reach, including a few well developed cottonwood-willow bosques. Photo: July 2008.

Rio Chama

Upper Chama Sub-Reach (13.6 miles)

The Upper Chama Sub-Reach extends 13.6 river miles from Christ in the Desert Monastery to the ordinary-high-water mark of Abiquiu Lake (Exhibit 2-10). This segment of the project area is owned by the U.S. Forest Service (Santa Fe National Forest), but is jointly managed by the Santa Fe National Forest and the Albuquerque District of the Bureau of Land Management (USFS et al., 1990). With the exception of the last two river miles downstream of Big Eddy rest area, this portion of the project area was designated as a *Scenic River* in 1988 under the National Wild and Scenic Rivers Act of 1968 (Public Law 100-633). The river segment downstream of Big Eddy to an elevation of 6283.5 ft is considered a “study section” that is administered by the Santa Fe National Forest (USFS et al., 1990). The Rio Chama Management Plan (USFS et al., 1990) specifies, however, that …*nothing in the Rio Chama Wild and Scenic River Act nor in the original Wild and Scenic Rivers Act specifically authorizes any interference with the Secretary of the Army’s authorized operation and management of Abiquiu Dam and reservoir* (p.3).

Forest Service Road 151 parallels the river from Big Eddy rest area upstream to near the monastery. This road is well maintained and provides access to recreational boaters (e.g., canoes, kayaks, and rafts), fishermen, campers, hikers and wildlife enthusiasts. There are several designated campgrounds, picnic areas and river access points for non-motorized boats. There is no agricultural development, but this sub-reach is within the Chama Grazing Allotment, and livestock grazing (cattle) is permitted between October 1 and April 15 of each year (USFS, 1999). At the time of the most recent grazing management plan (1999) for this area, there were seven current grazing permits for a total of 190 head of cattle. The purpose of removing livestock by April 15 was to minimize impacts to riparian vegetation, reduce conflicts between livestock grazing and recreationists, and to improve habitat suitability for the Southwestern Willow Flycatcher.

Exhibit 2-10

Photographs of the Upper Chama Sub-Reach

View of the Upper Chama Sub-Reach showing the densely vegetated floodplain surfaces. Photo: July 2008.

The Triassic-age Chinle Group geologic formation, shown here, consists of interbedded sandstones, siltstones and shales. This mix of harder and softer rocks provides conditions that are ideal for producing debris flows during high-intensity summer monsoon storms. Photo: April 2008.

The Upper Chama Sub-Reach has deep pools even during low flows. Portions of this pool were "chest-deep", even though flows were less than 100 cfs. Photo: July 2008.

Lower Chama Sub-Reach (29.4 miles)

The Lower Chama Sub-Reach extends approximately 29.4 miles from Abiquiu Dam to the western boundary of Ohkay Owingeh Pueblo. State Highway 84 parallels the sub-reach for most of its length, but only comes within visual distance of the river at a few locations. Land ownership along this sub-reach is primarily private property, but there are a few segments, particularly parcels upstream of the State Highway 84 river crossing, that is owned and managed by the

U.S. Forest Service. The primary land use along most of the Lower Chama Sub-Reach is agriculture and livestock grazing. Irrigated agriculture is supported by a network of acequias fed by multiple (13) diversion dams scattered along the sub-reach. Several homes have also been constructed in close proximity to the river, and with no engineered or extensive spoil bank levees along the reach, houses and farm fields within the floodplain are typically buffered only by relatively narrow bands of riparian vegetation (Exhibit 2-11). Barbed wire fencing is common along the riverbanks, so access from the river to the floodplain (and vice versa) is very limited.

There are several townships along this sub-reach, including the villages of Abiquiu, Medanales, Chili, La Chuachia, and El Duende. The only communal land grant in this sub-reach officially confirmed by the United States is the *Abiquiu Land Grant* (New Mexico Legal Aid, 2008). According to New Mexico Legal Aid (2008), this communal land grant encompasses approximately 16,547 acres, including several contiguous river-front miles upstream of the State Highway 554 Bridge crossing. Upon federal confirmation, the Abiquiu Land Grant was initially a livestock grazing association, however; the land grant is now managed for more diverse purposes, including natural resources enhancements (A. Archuleta, personal communication, December 2008).

Exhibit 2-11

Photographs of the Lower Chama Sub-Reach

Most irrigation diversion dams along the reach are constructed mostly from pieces of concrete and woody debris. Photo: April 2008.

Several houses have been constructed close to the river bank. This is one of the larger homes observed along the sub-reach. Photo: April 2008.

There are several locations, particularly in close proximity to diversion dams, with healthy riparian habitats. Photo: October 2008.

3 What is the primary water use infrastructure in the Velarde reach?

On the Rio Grande within the Velarde reach there are eight diversion structures including the San Juan Diversion at the downstream boundary of the reach and the Velarde Diversion that is located at the boundary between the Pilar and Velarde Sub-Reaches. With the exception of the two named diversions that are concrete structures, the diversions are composed of rock berms that have been placed across the river. On the Rio Chama downstream of Abiquiu Dam, there are thirteen diversion structures between the dam and the Chamita gage, the majority of which are composed of rock berms.

By about 1890, the flows in the Rio Grande upstream of the Velarde reach had been reduced by 40 to 60 percent due to irrigation withdrawals in the San Luis Basin in Colorado (National Resource Commission, 1938), and between 1875 and 1925, the mean annual discharge of the Rio Grande at the Del Norte gage in Colorado had decreased by between 60 and 70 percent (Jones and Harper, 1998). With the exception of the Closed Basin Project that was completed in the 1990s to provide about 25,000 ac-ft of water to the Rio Grande to meet Rio Grande Compact delivery requirements there has been little hydrologic alteration in the Velarde reach as a result of emplacement of additional water use infrastructure.

In contrast, on the Rio Chama there has been extensive addition of water-use infrastructure since the construction of El Vado Dam in 1935. El Vado Dam, with a storage capacity of about 195,400 ac-ft, was constructed for the purposes of storing water for irrigation, recreation, incidental flood control, and sedimentation control, including prior and paramount Native American water rights. The dam has been operated by the Bureau of Reclamation (Reclamation) since 1956. Water for downstream irrigation, primarily for the MRGCD, is released from April to October. The outlet capacity of the dam is 6,850 cfs and the downstream channel capacity is about 4,000 cfs. Target flow releases for fishery purposes are between 150 and 185 cfs from November to March, and rafting flows of between 400 and 700 cfs are released during weekends in July, August, and September (U.S. Fish and Wildlife Service [FWS], 2008).

Abiquiu Dam was constructed on the Rio Chama by the Corps of Engineers in 1963 to provide flood control, sediment control and water storage. The storage capacity of the reservoir is 1,192,800 ac-ft at a crest elevation of 6,350 feet; San Juan Chama (SJC) water can be stored up to an elevation of 6,220 feet. All native water inflow is bypassed up to the downstream channel capacity of 1,800 cfs. If storage space is needed for large snowmelt runoff or flood events, the Corps of Engineers can release SJC water in storage.

Heron Dam and Reservoir was built on Willow Creek, a tributary to the Rio Chama upstream of El Vado reservoir, by Reclamation in 1971 as part of the SJC transmountain diversion project. The primary purpose of the dam is storage and downstream delivery of SJC water (96,200 ac-ft) to the MRGCD, the City of Albuquerque, the City of Santa Fe, other municipalities and the Jicarilla Apache Nation and Ohkay Owingeh Pueblo, and it also provides up to 5,000 ac-ft of SJC water annually to maintain a recreation pool at Cochiti Lake. The reservoir capacity is 399,980 ac-ft at a crest elevation of 7,192 feet.

The coordinated operation of Heron, El Vado and Abiquiu Dams on the Rio Chama and the importation of the SJC water have altered stream flows on the Rio Chama and on the Rio Grande downstream of the Rio Chama confluence. The coordinated retention of stream flow in the three reservoirs has increased median stream flows, decreased extreme flows and decreased periods of low stream flow, and the addition of the SJC water has increased the overall stream flow in the Rio Chama (Langman and Anderholm, 2004).

Climate and Geology

4 What is the climate in the project area?

The climate in the Velarde project reach is semi-arid with substantial variation in precipitation from the lower to the higher elevations that results in highly variable stream flow. In the headwaters of the Rio Grande, annual precipitation can exceed 50 inches; whereas, in the lower elevation areas it can be as little as 6 inches (Ellis et al., 1993). Historical climate data at Española (Exhibit 2-12) indicate that the average annual rainfall is 9.84 inches and that about 50 percent occurs between July and October as a result of intense, short duration, monsoonal thunderstorms. Frontal, winter, and fall precipitation occurs as either snow or rainfall. Highest temperatures occur between June and August, and the lowest temperatures occur between November and March. The effects of elevation on the climate within the project reach are shown in Exhibit 2-13. In the Rio Chama Basin, there is a precipitation gradient between the Town of Chama (20.95 inches) and Española (9.84 inches) and in the Rio Grande Basin there is a gradient between Taos (12.3 inches) and Española (9.84 inches). Elevational gradients for both annual average maximum and minimum temperatures indicate that the highest temperatures are found at the lowest elevations and vice versa for the lowest temperatures (Exhibit 2-13).

Exhibit 2-12

Historical Climate Data, Española, New Mexico (1914–2005)

Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max Temperature (ºF)	46.5	52.4	60.3	69.2	78.4	88.2	90.5	87.5	81.6	71.5	57.8	47.1	69.2
Average Minimum Temperature (ºF)	15.0	20.4	26.0	33.2	41.4	50.0	56.6	54.7	46.1	34.0	22.7	15.2	34.6
Average Total Precipitation (in.)	0.44	0.42	0.58	0.71	0.88	0.70	1.35	1.78	1.01	0.99	0.53	0.46	9.84

(*Source: Western Regional Climate Center: wrcc@dri.edu*)

Exhibit 2-13
Average Annual Climatic Data for Rio Chama and Rio Grande Watersheds

Climatic Variable	Chama (291664) (1914–2005)	El Vado Dam (292837) (1923–2005)	Abiquiu Dam (290041) (1957–2005)	Espanola (293031) (1914–2005)	Taos (298668) (1914–2005)
Annual Average Maximum Temperature (ºF)	58.6	62.5	64.8	69.2	63.4
Annual Average Minimum Temperature (ºF)	26.0	27.2	37.0	34.6	30.8
Annual Average Total Precipitation (in.)	20.95	14.25	9.74	9.84	12.3

(*Source: Western Regional Climate Center: wrcc@dri.edu*)

In both the Rio Grande and Rio Chama, most surface water occurs as snowmelt runoff from March through June, but short duration summer monsoon flood events occur between July and September (Langman and Anderholm, 2004). There is considerable variability in the annual flows related to El Nino cycles and extended droughts and wet periods (U.S. Army Corps of Engineers Draft Environmental Impact State [USACE DEIS] Water Ops, 2006). The annual variability on the Rio Grande is shown on Exhibit 2-14. The peak flow in a dry year (1902) was about 1,600 cfs; whereas, in normal (1927) and wet (1920) years, the peak flows were 8,400 and 12,500 cfs, respectively at the Rio Grande at Embudo gage (USGS Gage No. 08279500). Similarly, at the Rio Chama near Chamita gage (USGS Gage No. 08290000) in the pre-dams period, the peak flow in a dry year (1931) was about 2,000 cfs, in a normal year (1928), it was about 5,000 cfs, and in a wet year (1932), it was about 5,800 cfs (Exhibit 2-15).

Currently, the highest flows on the relatively uncontrolled Rio Grande in the Velarde project reach still occur as a result of snowmelt (Exhibit 2-14). As shown on Exhibit 2-14, short duration monsoonal precipitation-related events occur in the July to September period. However, on the Rio Chama, because of the dams the snowmelt floods are now controlled, but significant flooding as a result of monsoonal storms can still occur downstream of Abiquiu Dam in the Lower Chama reach due to runoff from the uncontrolled area downstream of the dam (Massong and Beach, 2008).

Exhibit 2-14

Annual Hydrographs for Representative Dry, Normal, and Wet Years at the USGS Rio Grande at Embudo, NM Gage

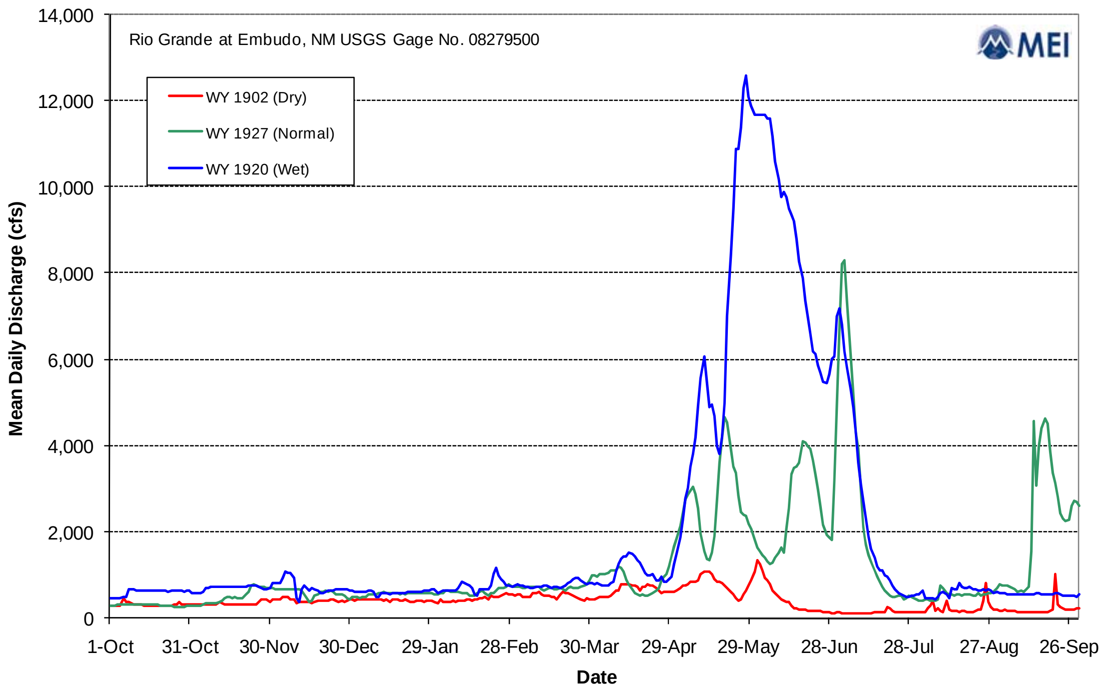
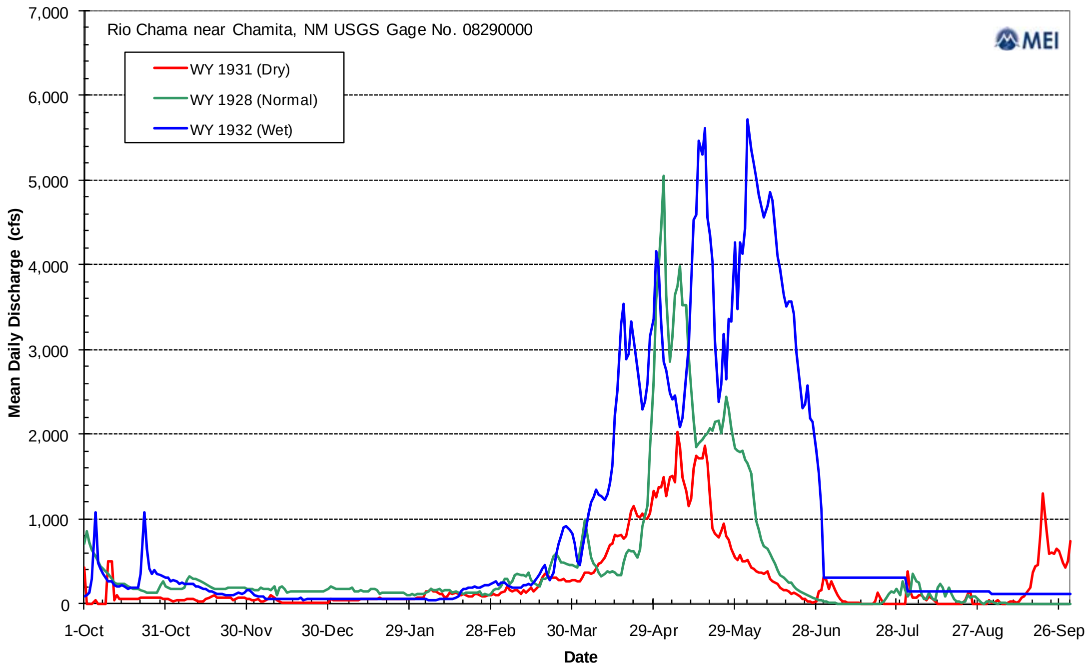


Exhibit 2-15

Annual Hydrographs for Representative Dry, Normal, and Wet Years at the USGS Rio Chama near Chamita, NM Gage



Base flows in the Rio Grande within the Velarde Project reach have not changed significantly since the upstream water resource development projects in Colorado were completed in the late 1800s. In contrast, the coordinated reservoir storage and addition of SJC water have significantly increased the base flows in the Rio Chama (Langman and Anderholm, 2004). A more detailed discussion of the hydrologic effects of the Rio Chama dams and their significance to channel morphology, dynamics, overbank flooding, and ecology is provided in later sections of this chapter (see River Geomorphology, Surface Water Hydrology and Vegetation sections below).

5 How does the local geology affect the rivers in the project reach?

The Velarde project reach is located within two physiographic provinces, the Rio Grande Rift and the Colorado Plateau (Fenneman and Johnson, 1946). The Rio Grande and the Lower Rio Chama within the Velarde project reach are entirely contained within the Rio Grande Rift physiographic province, whereas the upper Rio

Chama is located within the Colorado Plateau physiographic province. The contrasting geologic settings within the two provinces are shown Exhibit 2-16 and Exhibit 2-17.

The Orilla Verde Sub-Reach is bounded by Tertiary-age basaltic to andesitic lava flows that overlay and are interspersed with sediments of the Santa Fe formation (Exhibit 2-16). The width of the Rio Grande Valley within the reach is constrained by the erosion-resistant volcanic rocks, but there has been sufficient historic fluvial erosion of the more erodible Santa Fe formation to permit the accumulation of an alluvial fill within the valley. Ephemeral flow tributaries within the reach, such as Petaca Canyon, form coarse-grained sediment constrictions that create upstream backwater conditions in the river and formation of mid-channel bars (Exhibit 2-18) (Harvey et al., 1993), as well as downstream flow expansion zones where mid-channel bars also develop (Harvey et al., 2003). Springs that originate in the volcanic rocks are a secondary source of flows to the reach and sustain localized wetlands (Bauer et al., 2007) (Exhibit 2-19). The average slope of the river in the sub-reach is about 7 feet per mile.

The Pilar Sub-Reach of the Rio Grande is located in a narrow valley that is dominated by landslide deposits where underlying Santa Fe formation sediments have failed due to undercutting by the Rio Grande and loading by the overlying Tertiary-age volcanic rocks (Exhibit 2-16). Paleoproterozoic meta-sedimentary rocks are located on the east side of the river for a portion of the sub-reach. The Rio Grande within the sub-reach is laterally constrained by the armored landslide deposits, colluvial deposits and bedrock outcrop, and there are a number of rapids within the sub-reach (Exhibit 2-20). The average slope of the river in the sub-reach is 31 feet per mile.

The Velarde Sub-Reach is bounded by landslide deposits and outcrop of the Santa Fe Formation on the west and by Quaternary-age piedmont deposits consisting of alluvial deposits of higher gradient tributaries that drain the eastern side of the valley that are underlain by the Santa Fe formation (Exhibit 2-16). Historically, the river had a wandering planform (Desloges and Church, 1989; Mussetter and Harvey, 2001)

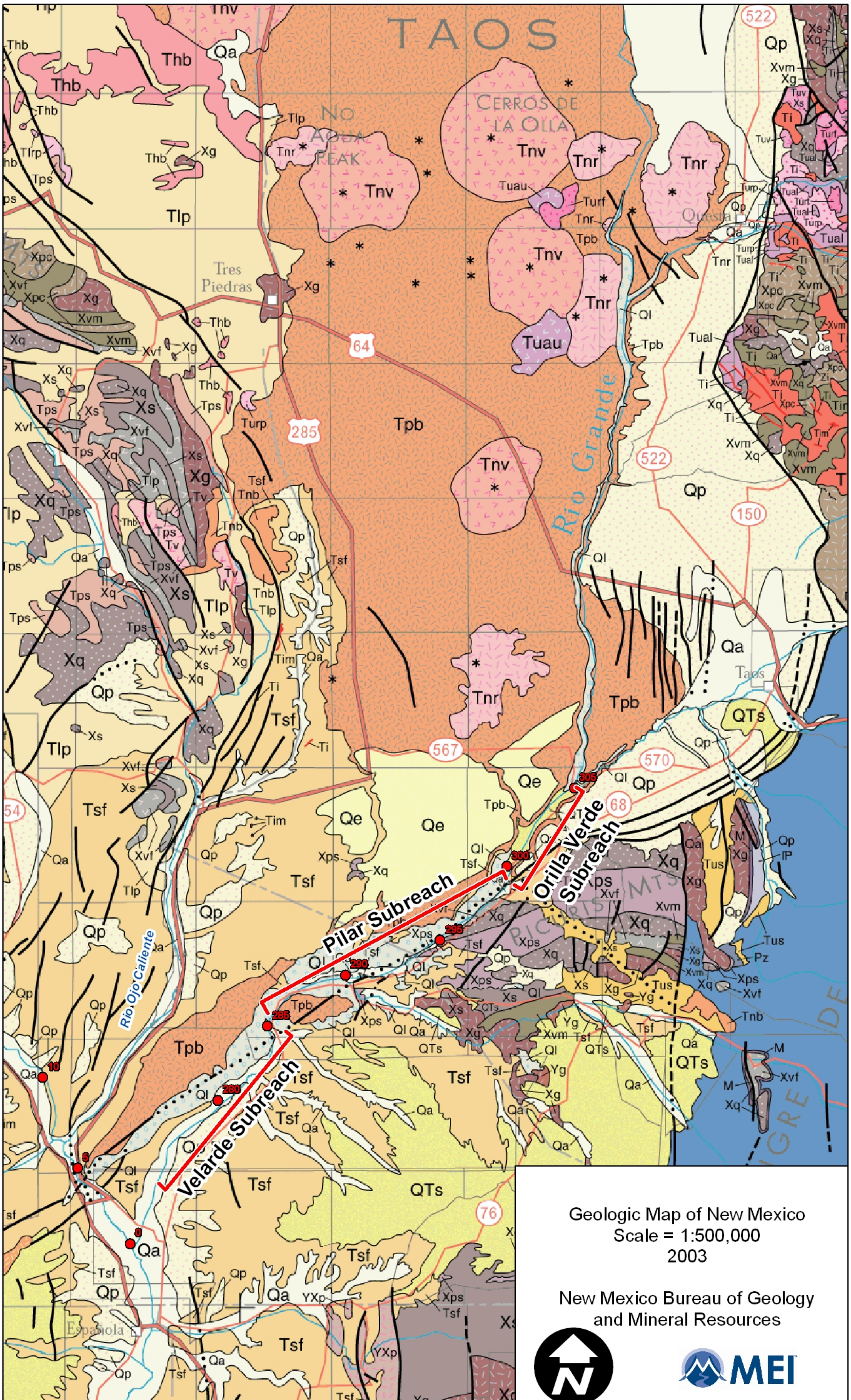
(Exhibit 2-21), but it was channelized and leveed in the 1950s by the Corps of Engineers and the Bureau of Reclamation (Exhibit 2-22). Vertical control of the channel in the sub-reach is provided by the diversion structures. The reach-average slope is about 11 feet per mile.

The upper reach of the Rio Chama between Abiquiu Reservoir and the Rio Gallinas confluence is bounded by Jurassic - and Triassic-age sedimentary rocks (Exhibit 2-17). The Triassic-age Chinle Group consisting of interbedded sandstones, siltstones and shales crop out closest to the river and the mix of harder and softer rocks provides conditions that are ideal for producing debris flows during high-intensity summer monsoon storms (Exhibit 2-23). Coarse-grained debris flow deposits at tributary confluences, bedrock outcrop and landslide deposits (Exhibit 2-24) control the planform of the river and the spatial distribution of the alluvial reaches (Exhibit 2-25) within the sub-reach (Swanson et al., 2008).

The relatively wide Rio Chama Valley between Abiquiu Dam and Chamita is primarily bounded by poorly consolidated and highly erodible sediments of the Santa Fe Formation (Exhibit 2-17). The Rio Chama in the lower sub-reach is a low to moderate sinuosity meandering river flowing through an alluvial valley floor with local base-level controls provided by coarse-grained fans at the tributary arroyo confluences and by diversion structures. The larger size sediments that control the local gradient of the Rio Chama are delivered by mudflows and debris flows in the tributary arroyos that transport the larger rocks primarily from the south side drainages where volcanic rocks overlie the Santa Fe formation sediments. Upstream of valley floor contractions caused by tributary arroyo fans, the sinuosity of the river tends to be higher because of the lowered slope, and in steeper sections of the channel downstream of the constrictions the sinuosity is lower (Exhibit 2-26). Channel slopes vary from about 10 to 15 feet per mile. The high frequency of tributary arroyos that drain the erodible Santa Fe Formation accounts for the Rio Chama being the major supplier of sediments to the Rio Grande upstream of Cochiti Reservoir (Rittenhouse, 1944; Happ, 1948).

Exhibit 2-16

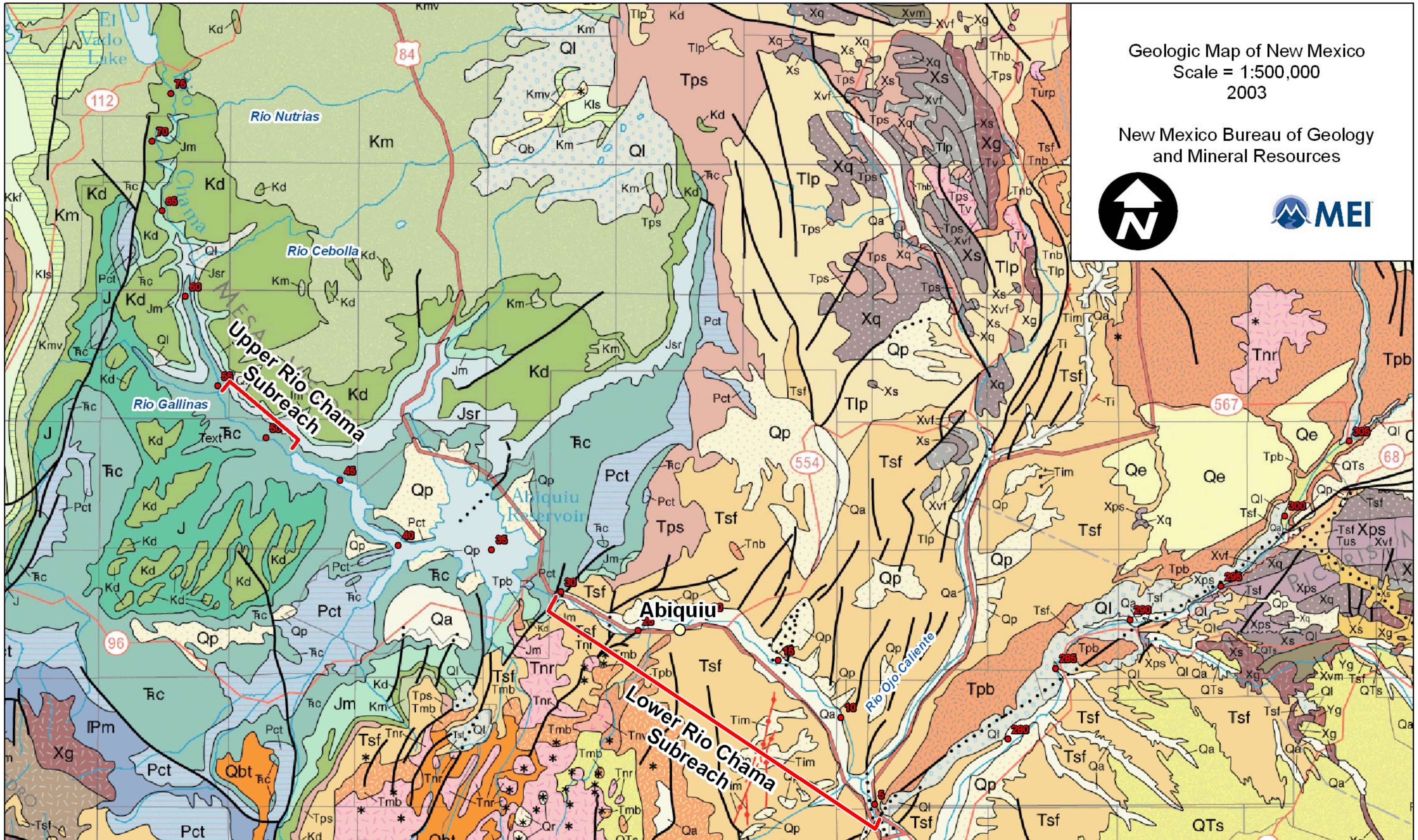
Geologic Map of the Rio Grande Portion of the Velarde Project Reach



(Source: Geologic Map of New Mexico, 1:500,000 Scale, 2003. New Mexico Bureau of Geology and Mineral Resources and USGS)

Exhibit 2-17

Geologic Map of the Rio Chama Portion of the Velarde Project Reach



(Source: Geologic Map of New Mexico, 1:500,000 scale, 2003. New Mexico Bureau of Geology and Mineral Resources and USGS)

Exhibit 2-18

Upstream View of Mid-Channel Bar Formed Upstream of Channel Constriction at the Petaca Canyon Alluvial Fan

Note the slope armoring by basaltic boulders that overlie the Santa Fe formation. Photo: April 2008.

Exhibit 2-19

Eastward View of a Wetland on the Floodplain of the Rio Grande that is Sustained by Spring Flows Emanating from the Volcanic Rocks that Form the Valley Walls

Photo: April 2008.

Exhibit 2-20

Large Rapid Caused by a Landslide on the West Side of the Rio Grande Within the Pilar Sub-Reach

Note colluvial basaltic boulders overlying Santa Fe formation outcrop that maintain the constriction of the river.

Exhibit 2-21

1935 Aerial Photographs of the Rio Grande and the Rio Chama Within the Velarde Project Reach

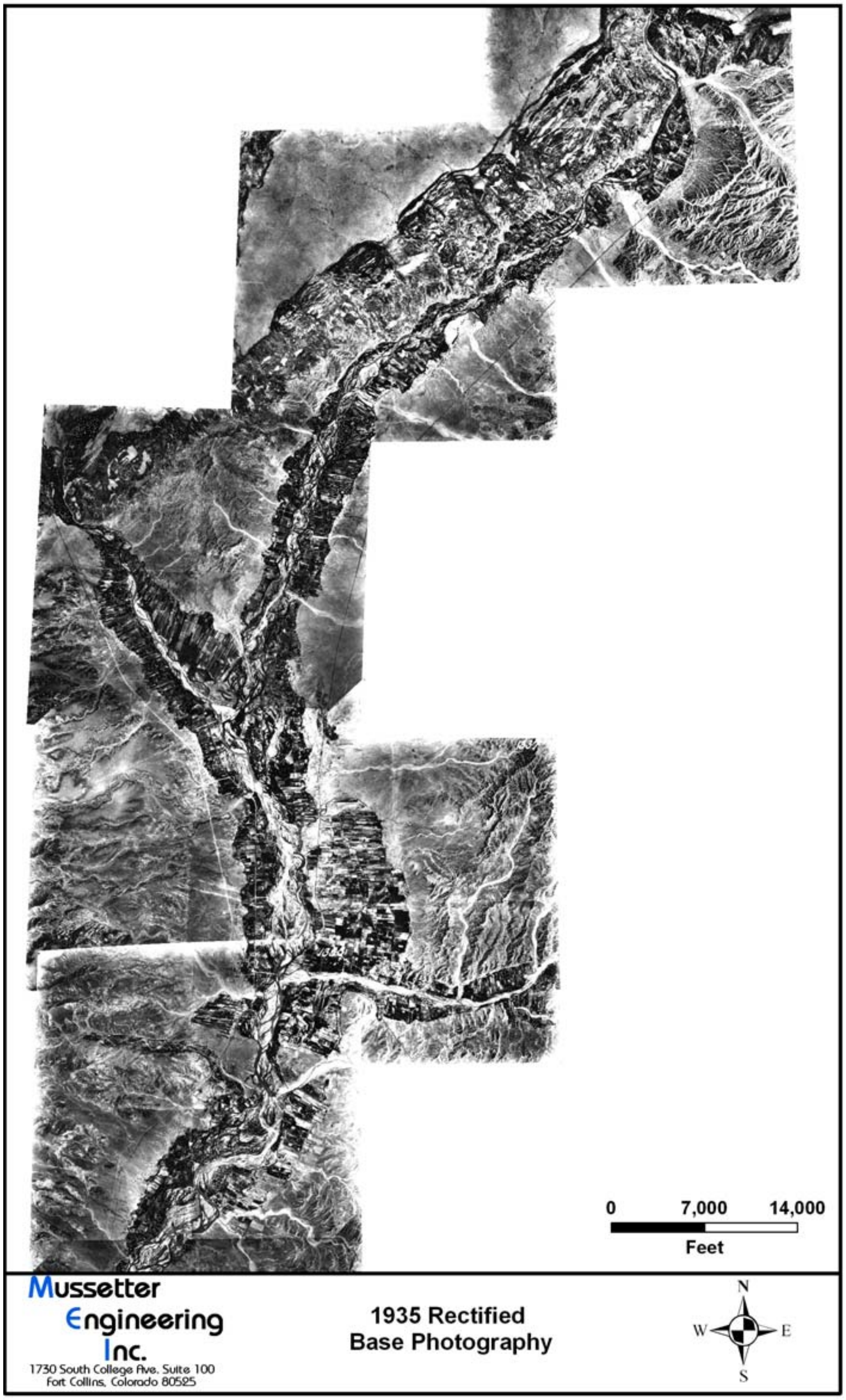


Exhibit 2-22

Aerial View Downstream of Channelization of the Rio Grande from about Los Luceros to the Rio Chama Confluence in 1956

(Bureau of Reclamation photo by Herman E. Carter courtesy of La Calandria Associates, Inc., 2007)

Exhibit 2-23

Highly Dissected Chinle Group Sedimentary Rocks in the Upper Chama Sub-Reach

Photo: April 2008.

Exhibit 2-24
Active Landslide on the West Bank of the Rio Chama Upstream of Abiquiu Reservoir

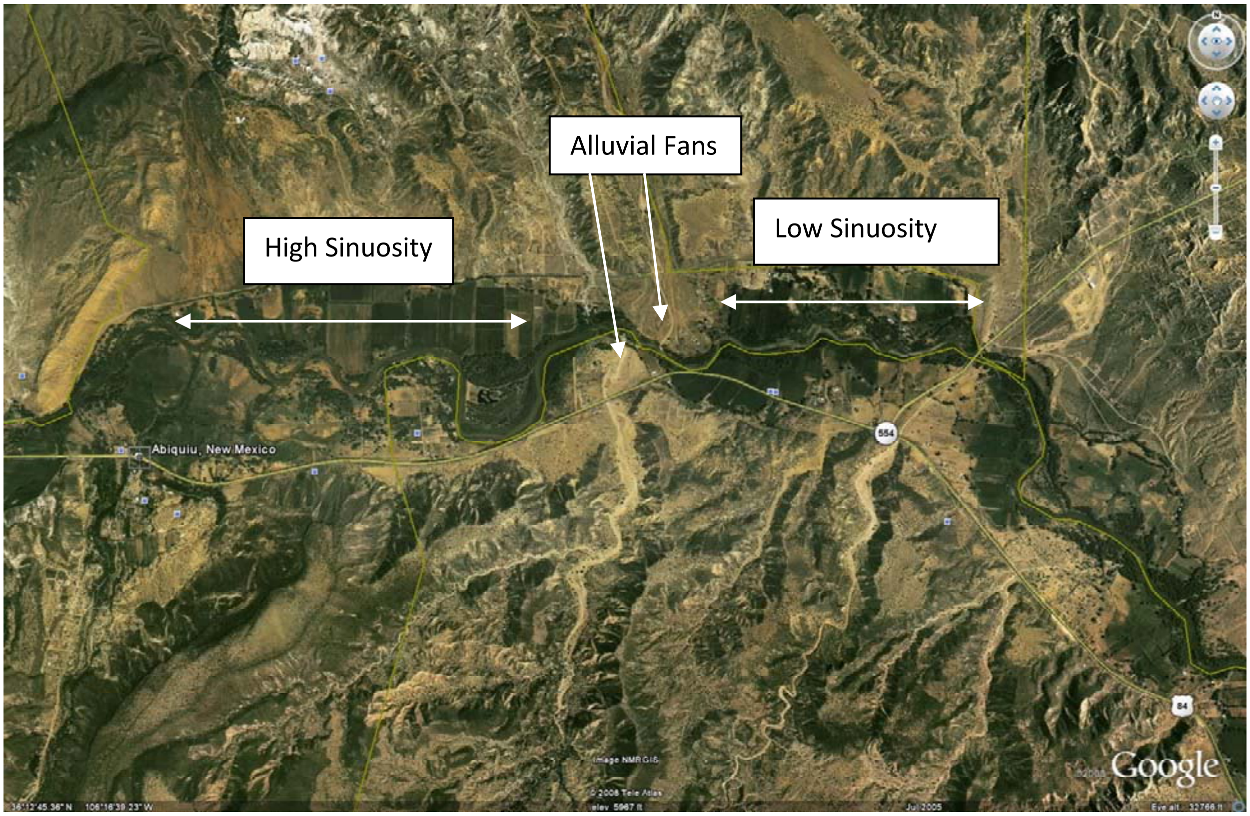
Photo: April 2008

Exhibit 2-25
Upstream View of a Spatially-Restricted Alluvial Section of the Upper Chama Sub-Reach

Photo: July 2008.

Exhibit 2-26

Effects of Local Base-Level Control by Tributary Arroyo Fans on Sinuosity of the Rio Chama



Note: Flow is from left to right.

River Geomorphology

6 What were the historical geomorphic conditions?

By about 1890, the flows in the Rio Grande had been reduced by 40 to 60 percent due to irrigation withdrawals in the San Luis Basin in Colorado (National Resource Commission, 1938), and between 1875 and 1925, the mean annual discharge at the Del Norte gage had decreased by between 60 and 70 percent (Jones and Harper, 1998). Since many of the planform and size characteristics of rivers are related to the discharge (Schumm, 1977), it would not be surprising if the characteristics of the downstream alluvial reaches of the Rio Grande were affected by changes in the basin hydrology. Jones and Harper (1998) concluded that the reduced flows were responsible for reduced meander wavelength, increased channel sinuosity, reduction in multiple channel reaches and increased channel stability in the Upper Rio Grande Basin. Upper Basin water resource development projects probably had little impact on the annual sediment loads of the Rio Grande in the Velarde reach, since historically the sediment delivery from the Upper Basin was low (Rittenhouse, 1944; Happ, 1948).

The alluvial reaches of the Rios Grande and Chama have been occupied by the Pueblo communities and their predecessors for many centuries, and during the pre-Spanish period, it is unlikely that there were significant anthropogenic influences on the rivers or their floodplains (La Calandria Associates, Inc., 2007). Expansion of irrigated agriculture in the post-Spanish period probably resulted in a significant reduction in the native bosque vegetation, but it is unlikely that there were significant impacts to the river channels (La Calandria Associates, Inc., 2007). Following the American annexation of New Mexico and the Civil War, overgrazing of the watersheds by sheep and cattle lead to a significant increase in watershed sediment yield and subsequent aggradation of the Rio Grande streambed and the floodplain (Scurlock, 1998).

Increased sediment yields and reduced flows may have resulted in some local aggradation within the predominantly gravel-bed Orilla Verde Sub-Reach, but because of the constrained nature of the reach, sediment deposition would have been locally controlled and is unlikely to have any significant effects on the channel morphology. The steep, narrow valley and confined channel in the predominantly boulder-bed Pilar Sub-Reach would have made sediment deposition within the reach unlikely, and the major anthropogenic impact is likely to have been road construction and side-casting of the spoils into the river.

The earliest photographic record of the channel conditions in the gravel-bed Velarde Sub-Reach is seen on the 1935 aerial photography (Exhibit 2-21). Upstream of the Rio Chama confluence, the Rio Grande was a low sinuosity (<1.5), gravel-bed river with a meandering planform with extensive chute channels across the point bars which suggests that the planform should be more accurately described as “wandering” (Desloges and Church,1989; Mussetter and Harvey, 2001). Although the river appears to have characteristics of a meandering river, channel change tends not to be systematic through time, but is more likely to be avulsive and controlled by episodic floods (Mussetter and Harvey, 2001). During periods between high-magnitude floods, a measure of sinuosity develops as a result of lateral migration of the channel. However, when relatively large infrequent floods occur, bends of almost any radius of curvature cut off, channel sinuosity is reduced, and the planform becomes braided (MEI, 2002; Mussetter and Harvey, 2001). On the 1935 aerial photography there is little evidence of a cottonwood-dominated bosque in this reach of the Rio Grande. The active channel appeared to be flanked by very active bars that had little vegetation and the remainder of the floodplain on both sides of the river appeared to be in agricultural production. The median (D_{50}) size of the bed material in the reach varies from about 20 to 56 mm and the D_{84} (size of which 84 percent is finer) ranges from 52 to 78 mm (BOR, 2000).

All other factors being equal, application of Schumm’s (1969) qualitative predictive relations suggest that the combined effects of the significantly increased sediment supply from the overgrazed and eroded watersheds (Scurlock, 1998) and reduced flows due to upstream irrigation abstraction from the

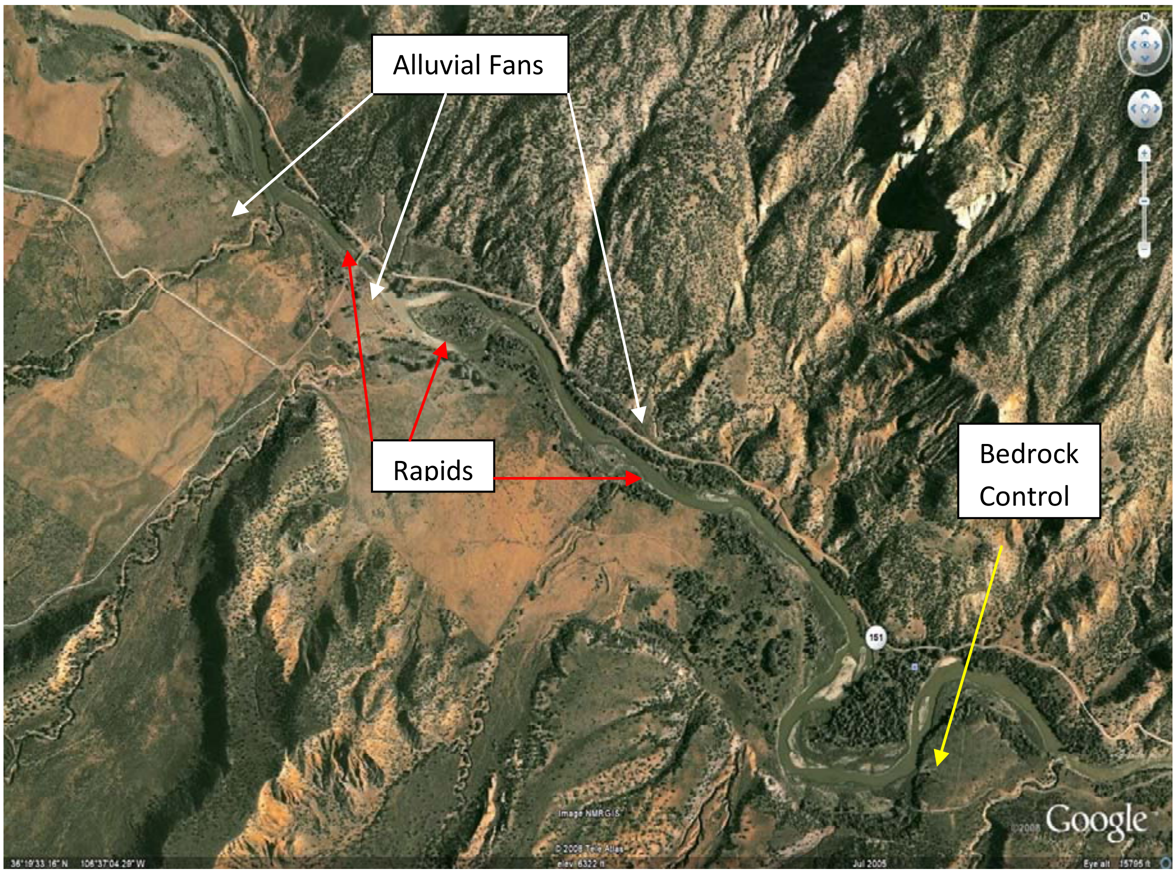
Rio Grande (Jones and Harper, 1998) would most likely have resulted in a reduction in depth of the channel, an increase in channel slope, an increase in the width-depth ratio of the channel and a decrease in channel sinuosity. The channel conditions observed on the 1935 photography and reports of the aggraded condition of the Rio Grande in the 1940s (Survey Report on the Rio Grande and Tributaries, New Mexico: June 27, 1949, House Document No. 243, 81st Congress, First Session) suggest that the river in the Velarde Sub-Reach did in fact respond as predicted by Schumm's relations.

On the 1935 aerial photography (Exhibit 2-21), the lower reach of the sand- and gravel-bed Rio Chama that includes the downstream portion of the Lower Chama Sub-Reach appears to be a low sinuosity meandering river flanked by a very active floodplain with little riparian vegetation. The channel and unvegetated bars are flanked on either side of the river by agricultural fields. The high sediment loads from the Rio Chama appear to have created a large fan/delta complex at the confluence with the Rio Grande, confirming the relative sediment contributions from the two rivers (Rittenhouse, 1944; Happ, 1948). Increased watershed sediment supply without a commensurate decrease in flows on the Rio Chama would suggest that the likely response by the river would have been an increase in width, a decrease in depth, and increase in slope and a reduction in sinuosity, all of which appear to be consistent with the observed channel patterns on the 1935 photography. Although the 1935 aerial photography does not cover the upper part of the Lower Chama Sub-Reach, modern photography (Exhibit 2-26) clearly indicates that the channel planform was freely meandering, but the sinuosity was dependent on local base-level controls provided by the tributary arroyos. The bed material gradations in the Lower Chama Sub-Reach are bimodal and reflect the range of sediments delivered by the tributary arroyos. The D_{50} of the coarser riffles is about 50 mm and the D_{84} is about 80 mm, whereas the D_{50} of the finer bed material in the pools and runs is about 15 mm and the D_{84} is about 45 mm with a sand content of about 25 percent (MEI, 2008).

Historically, the Upper Chama between Abiquiu reservoir and the Rio Gallinas confluence was a low-sinuosity, constrained, gravel-bed meandering river (Swanson et al., 2008). The planform of the river was controlled by coarse-grained tributary alluvial fans, bedrock outcrop and landslides (Exhibit 2-27), and therefore, it is unlikely that land use changes in the upper watershed (Scurlock, 1998) had a significant impact on the river morphology. In the alluvial portions of the sub-reach, the bed material has a D_{50} of about 50 mm, and a D_{84} of about 80 mm based on a visual assessment. Boulder-size material is located within the rapids at the tributary arroyo confluences, and sand accumulations are present in the pools during low-flow conditions.

Exhibit 2-27

Low Sinuosity Reach of the Upper Chama Showing the Controls Imposed by Tributary Fans and Bedrock Outcrop



Flow is from left to right.

7 How have fluvial geomorphic conditions changed and what are their impacts?

The morphology and dynamics of self-adjusted alluvial rivers are controlled primarily by the discharge, slope, sediment load, and caliber of the transported sediments (Lane, 1957; Schumm, 1977). On the Rio Grande the major changes in discharge and sediment load probably occurred before the 20th century, and therefore, the form of the channel seen on the 1935 aerial photography in the Velarde Sub-Reach reflects those changes. Channelization, bank stabilization, diversion structures, and levees have controlled the form of the channel since the 1950s (Exhibit 2-22). The nominal channel capacity of the Rio Grande up- and downstream from the Rio Chama confluence was 5,000 and 7,860 cfs, respectively (Massong et al., 2007). In the non-self-formed reaches (Orilla Verde and Pilar), where there was little adjustment to the imposed hydrologic and sedimentologic changes, the primary agent of geomorphic change is the extensive presence of non-native vegetation that effectively increases the erosion resistance of the bank materials, thereby limiting the potential for any lateral adjustment of the channel. Localized deposition of sediment at the upstream end of split flow reaches that is then colonized by native and non-native vegetation has the potential to cause simplification of the channel (Exhibit 2-28).

Exhibit 2-28

Upstream View of Vegetation Growth on Sediments Deposited at the Head of a Split Flow Reach in the Orilla Verde Sub-Reach

Photo: April 2008.

On the Rio Chama both the flows and sediment loads have changed since construction of El Vado Dam in 1935 and Abiquiu Dam in 1963. El Vado Dam reduced the 2-year peak flow (often referred to as the channel forming flow) by about 50 percent at the Below El Vado Dam Gage, and by about 33 percent at the near Chamita Gage. Abiquiu Dam further reduced the 2-year peak flow at the near Chamita Gage by another 8 percent (MEI, 2008). Prior to the construction of Abiquiu Dam, the annual sediment load (suspended sediment and bed load) at the near Chamita Gage was estimated to be on the order of 2,500 ac-ft, which represented a watershed unit yield of approximately 1 acre-foot/mi2/yr (USACE, 1953).

Following construction of Abiquiu Dam, it was estimated that the annual sediment yield to the Chamita Gage and hence the Rio Grande would be reduced by about 50 percent (1,300 ac-ft/yr) (USACE, 1953). The Otowi gage (located downstream of the Rio Grande-Rio Chama confluence) sediment record does not demonstrate an immediate reduction in annual sediment load following closure of Abiquiu Dam in 1963 (Massong and Aubuchon, 2005). However, the slope of the double mass curve (cumulative water volume vs. cumulative sediment load) for the Otowi gage flattens in about 1973 (MEI, 2002), which suggests there was a lag in the response of the system to the dam. The lagged response may have been due to dam-induced downstream channel adjustments on the Rio Chama (Williams and Wolman, 1984), and additionally, the sediment deficit could have been buffered to some extent by tributary responses to channelization-induced base-level lowering in the Española reach of the Rio Grande (MEI, 2008).

In the Upper Chama Sub-Reach, Swanson et al. (2008) based on aerial photographic analysis documented a reduction in channel width of about 60 feet (33 percent reduction) between 1935 and 2005 between the Rio Gallinas and the upstream end of Abiquiu reservoir that followed a classical relaxation curve, and attributed this to the reduced peak flows. The reduction in channel width was accompanied by an 80 percent increase in the area of islands and gravel bars that were colonized by both native and non-native plant species. Stabilization of the bars and islands by vegetation is probably due to the increased base flows as a result of the SJC project. The median flow (50th percentile on the annual flow duration curve) at the Below El Vado Dam Gage increased from about 87 to 233 cfs (a factor of 2.7) in the post-SJC period (Langman and Anderholm, 2004). The extensive presence of coarse-grained tributary fans that control the bed elevations in the reach suggests that there has been little or no vertical adjustment of the Rio Chama in this reach in response to the reduced sediment supply below El Vado Dam. Additionally, based on reservoir resurvey data there has been about 17,000 ac-ft of sediment deposited in El Vado reservoir since 1935

(Rolf Schmidt-Peterson, NMISC, personal communication, 2008), which translates to a reduction in sediment supply to the Rio Chama below El Vado Dam of about 233 ac-ft per year. This only represents about 18 percent of the estimated annual supply to Abiquiu reservoir (USACE, 1953). Suspended sediment concentrations have been reduced significantly at the Above Abiquiu gage in the post-SJC period (Langman and Anderholm, 2004), but in general suspended sediments are not morphologically significant.

No quantification of channel adjustments to the reduced flows and sediment loads appears to have been made for the Lower Chama Sub-Reach. Two-dimensional hydraulic models developed for the URGWOPS review and EIS for two separate locations, 2.7 miles downstream of Abiquiu Dam and 0.5 mile upstream of Highway 285 (Bohannan Huston, Inc. et al, 2004) indicate that the channel capacity where the channel is not flanked by terraces is about 5,000 cfs, which was about the 2-year peak flow in the pre-El Vado Dam period at the near Chamita Gage (Exhibit 2-29). This would tend to suggest that there has been little adjustment to the channel in the post-dam period. However, at both locations there are inset surfaces that correspond to flows of about 3,100 cfs (Exhibit 2-30), which is the 2-year peak flow in the post Abiquiu Dam period, and about 1,800 cfs (Exhibit 2-31), which is the non-flooding release from Abiquiu Dam. Therefore, it appears that there has been some channel adjustment to the reduced peak flows. Given the relatively high bed material sediment supply to the reach from the tributary arroyos this is not surprising, even though the suspended sediment concentrations have been reduced in the post-SJC period (Langman and Anderholm, 2004).

Exhibit 2-29

Pre-El Vado Dam Floodplain Surface on the Lower Chama Sub-Reach

Photo: April 2008. Flow is about 1,800 cfs.

Exhibit 2-30

Post-Abiquiu Dam Surface on the Lower Rio Chama that is Inundated at a Flow of about 3,100 cfs

Photo: April 2008. The flow in the river is about 1,800 cfs.

Exhibit 2-31

Post- Abiquiu Dam Surface on the Lower Rio Chama that is Inundated at a Flow of about 1,800 cfs, which is the Flow in the River

Photo: April 2008.

Surface Water Hydrology

8 How have flows changed in the Rio Grande?

Although there is a very long period of hydrologic record (1890–2007) at the Embudo Gage by 1890 flows in the Rio Grande had been reduced by 40 to 60 percent due to irrigation withdrawals in the San Luis Basin in Colorado (National Resource Commission, 1938), and between 1875 and 1925, the mean annual discharge at the Del Norte gage had decreased by between 60 and 70 percent (Jones and Harper, 1998). Therefore, the hydrologic record at the Embudo Gage does not represent pre-development conditions in the watershed. However, the peak flows at the gage have not changed significantly since the 1920s, and thus, the gage provides a long-term hydrologic record for the Velarde project reach. A relatively long record (1926–2007) also exists at the Rio Grande below Taos Junction Bridge Gage, located at the head of the Orilla Verde Sub-Reach. Average annual hydrographs for the two gages are provided in Exhibit 2-32 and they show a classical snowmelt hydrograph with flows rising in late March and receding to base flows in late June. Average annual peak flows in the Orilla Verde and Pilar Sub-Reaches are on the order of 2,000 cfs and in the Velarde Sub-Reach they are about 2,700 cfs. Over the period of record at the Embudo Gage, annual peak flows have ranged from about 16,000 cfs (1893) to 800 cfs (2002) (Exhibit 2-33). Base flows in all the sub-reaches are between 400 and 500 cfs.

Flood frequencies (i.e., recurrence intervals) for the two gages are summarized in Exhibit 2-34. The 2- and 5-year peak flows for the Orilla Verde and Pilar Sub-Reaches are 2,980 cfs and 5,610 cfs, respectively and for the Velarde Sub-Reach they are 3,940 cfs and 7,270 cfs, respectively. Historically, overbank flooding in alluvial reaches should have occurred in this range of flows. However, levees were constructed with a nominal capacity of 5,000 cfs in the Velarde Sub-Reach in the 1950s.

Based on the mean daily flow records at the Below Taos Junction Bridge Gage and the Embudo Gage, annual flow duration curves were developed for the respective periods of record (Exhibit 2-35). In the Orilla Verde and Pilar Sub-Reaches flows rarely, if ever, are less than 179 cfs, and 50 percent of the time they are equal to or exceed 472 cfs. The 2-year peak flow of 2,980 cfs (Exhibit 2-34) is equaled or exceeded for about 15 days per year. In the Velarde Sub-Reach, flows are rarely, if ever, less than 183 cfs, and 50 percent of the time they equal or exceed 536 cfs. The 2-year peak flow of 3,940 cfs (Exhibit 2-34) is equaled or exceeded for about 16 days per year.

Exhibit 2-32

Mean Annual Hydrographs for the Rio Grande at the Below Taos Junction Bridge and Embudo Gages (October through September)

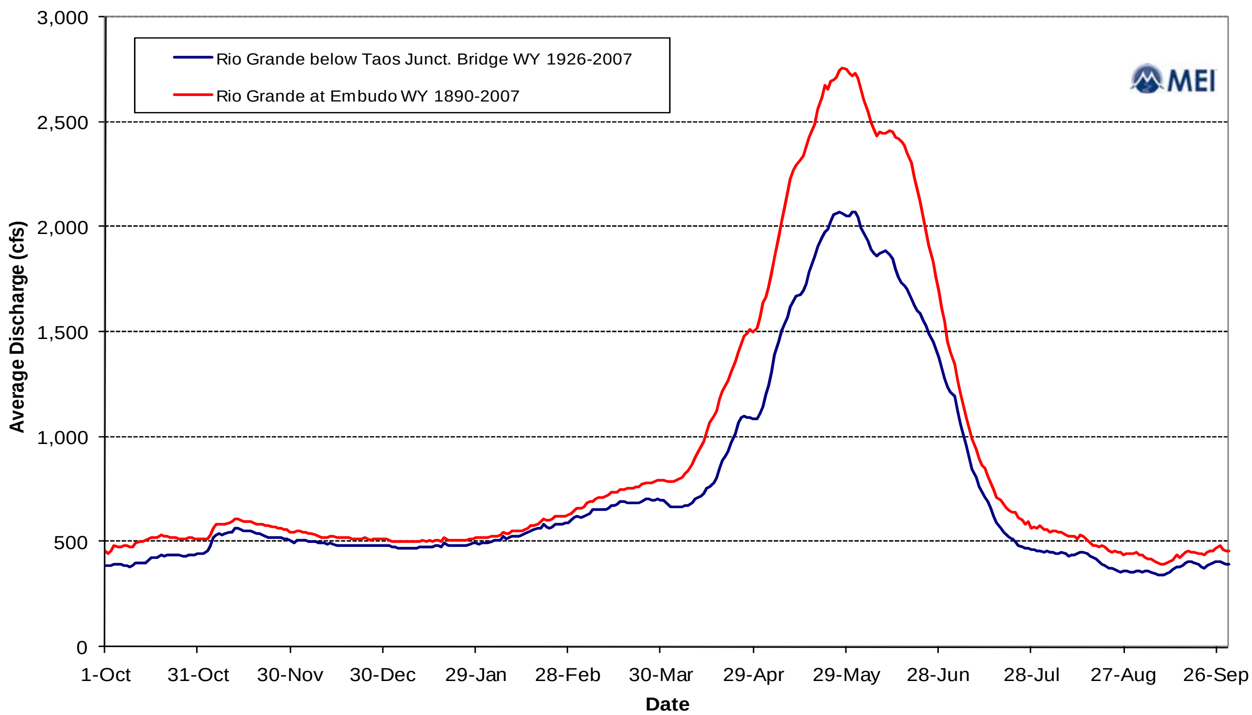


Exhibit 2-33
Annual Peak Flows for Rio Grande at the Below Taos Junction Bridge and Embudo Gages (1889 through 1999)

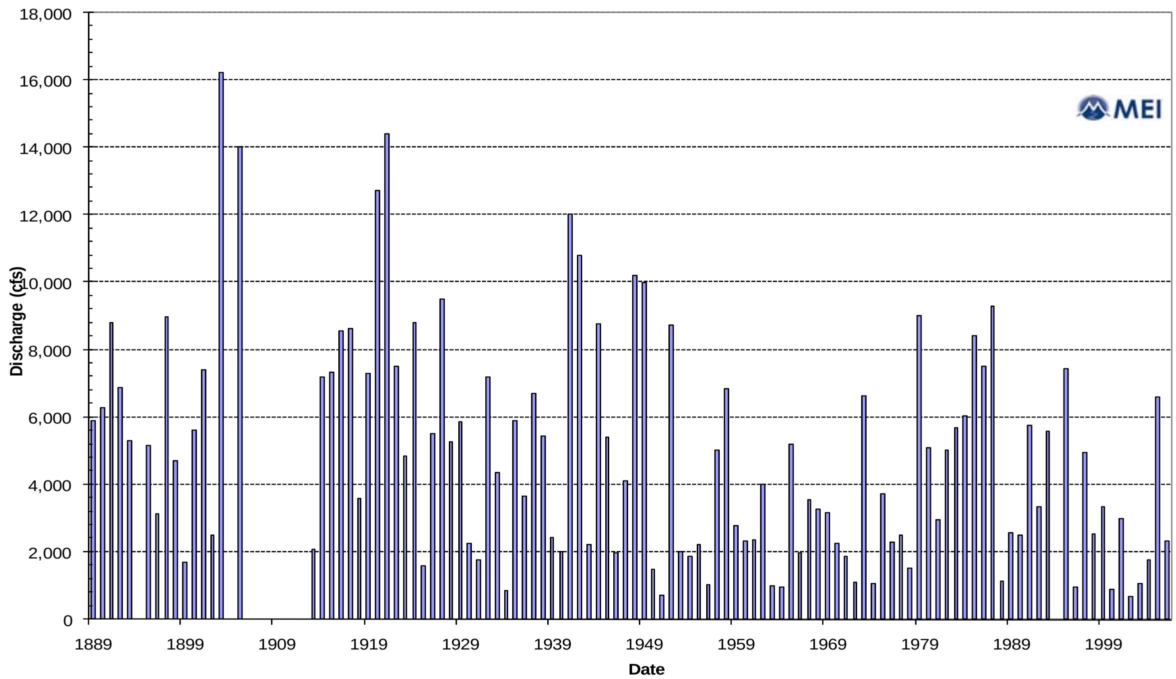


Exhibit 2-34
Summary of Flood Magnitudes (cfs) and Recurrence Intervals (years) for the Rio Grande Sub-Reaches

Gage and Period of Record	Recurrence Intervals (yrs)					
	2	5	10	25	50	100
Rio Grande Below Taos Junction Bridge 1926–2006	2,980	5,610	7,700	10,668	13,100	15,700
Rio Grande at Embudo 1889–2006	3,940	7,270	9,810	13,246	16,000	18,900

Exhibit 2-35
Summary of Annual Flow Duration Data (cfs) for Rio Grande Sub-Reaches

Gage and Period of Record	Percent Exceedance								
	99	90	75	50	25	10	5	1	0.1
Rio Grande Below Taos Junction Bridge 1926–2006	179	239	316	472	705	1,431	2,430	5,054	8,083
Rio Grande at Embudo 1890–2006	183	265	367	536	826	1,899	3,270	6,238	10,406

9 How have flows changed in the Rio Chama?

Relatively long pre-development flow records (1914–1935) exist for the Rio Chama near Chamita Gage and the Rio Chama below El Vado Dam Gage. The gage records also include the post-El Vado Dam to pre-Abiquiu Dam period (1936–1963), and the post-Abiquiu Dam to pre-SJC Project period (1963–1971) and the post-SJC period (1972–2007). Exhibit 2-36 shows the average annual hydrographs for these periods. Prior to construction of El Vado Dam in 1935, the average annual peak flow at Chamita was about 2,700 cfs and base flows were on the order of 100 cfs. Annual peak flows varied from about 15,000 cfs (1920) to about 1,700 cfs (1934) (Exhibit 2-37). The 2- and 5-year peak flows at the Chamita Gage were 5,140 and 8,140 cfs, respectively (Exhibit 2-38), and at the Below El Vado Dam Gage they were 4,500 and 6,150 cfs, respectively (Exhibit 2-39). Therefore, in the self-formed alluvial reaches of the Rio Chama, overbank flows should have occurred within these ranges of flows in the pre-development period absent the presence of locally constructed levees.

Exhibit 2-36

Average Annual Hydrographs for the Rio Chama Near Chamita Gage from 1913 to 2007

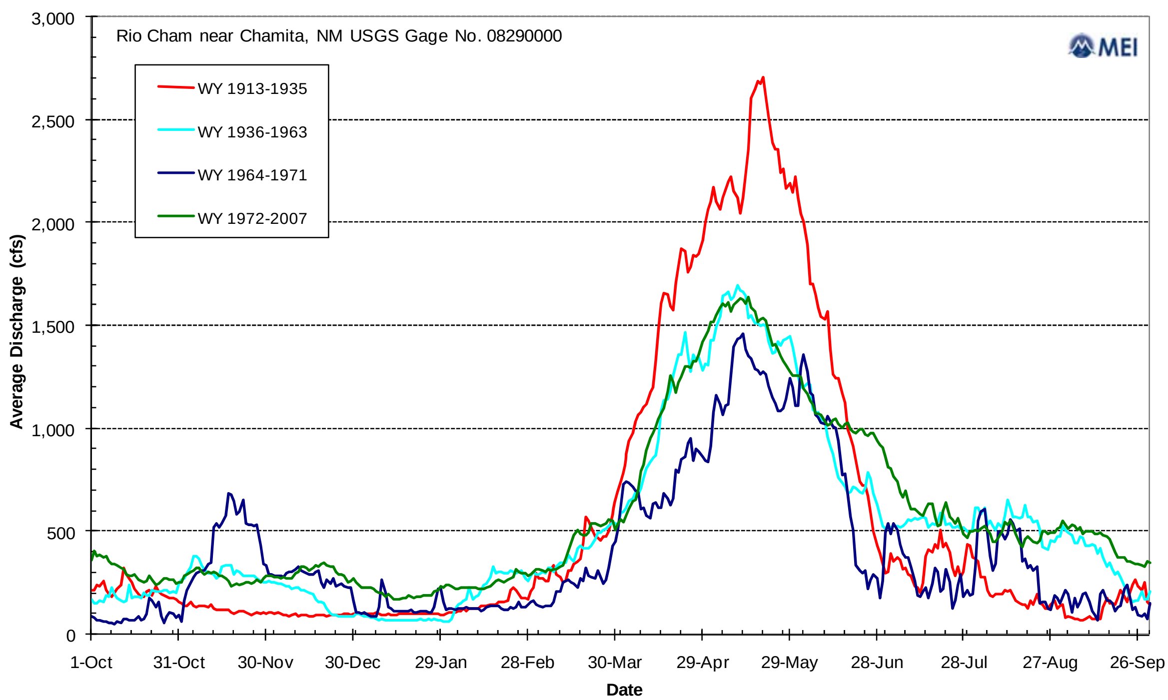


Exhibit 2-37

Annual Peak Flows for WY1915 to WY2006 at the Rio Chama Near Chamita Gage

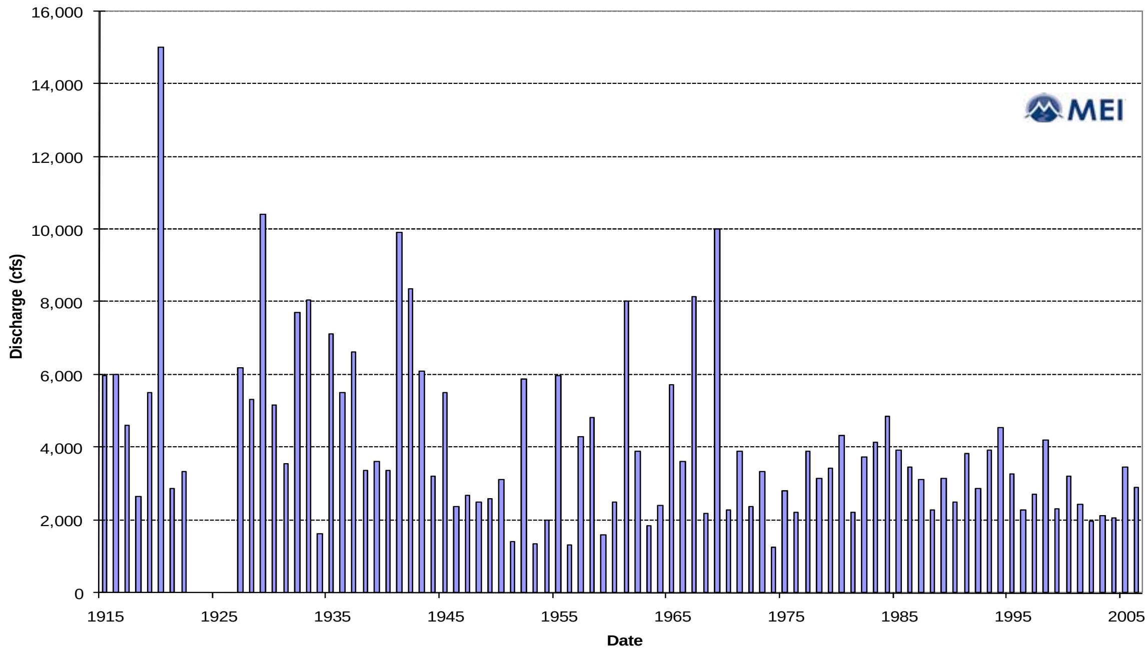


Exhibit 2-38

Summary of Flood Magnitudes (cfs) and Recurrence Intervals (yrs) for the Lower Rio Chama Sub-Reach

Gage and Period of Record	Recurrence Intervals (yrs)					
	2	5	10	25	50	100
Rio Chama Below Abiquiu 1963–2006	1,790	2,140	2,340	2,558	2,700	2,830
Rio Chama near Chamita 1915–1935	5,140	8,140	10,300	13,194	15,400	17,700
Rio Chama near Chamita 1936–1963	3,460	5,640	7,270	9,552	11,400	13,300
Rio Chama near Chamita 1972–2006	3,010	3,740	4,190	4,727	5,110	5,480

Exhibit 2-39

Summary of Flood Magnitudes (cfs) and Recurrence Intervals (yrs) for the Upper Rio Chama Sub-Reach

Gage and Period of Record	Recurrence Interval (yrs)					
	2	5	10	25	50	100
Rio Chama Below El Vado Dam 1914–1924	4,500	6,150	7,300	8,814	9,980	11,200
Rio Chama Below El Vado Dam 1936–2006	2,250	3,640	4,710	6,220	7,450	8,790
Rio Chama Above Abiquiu Dam 1963–1971	2,770	4,110	5,020	6,207	7,110	8,010
Rio Chama Above Abiquiu Dam 1972–2006	3,200	4,560	5,490	6,691	7,600	8,530

Construction of El Vado Dam in 1935 reduced the average annual peak flow at the Chamita Gage[1] to about 1,700 cfs and increased the base flow in the post-snowmelt runoff considerably (Exhibit 2-36), but the dam had considerably less impact on the magnitude of the annual floods because of limited flood storage capacity (Exhibit 2-37). At the Below El Vado Dam Gage, the 2-year peak flows was reduced from 4,500 to 2,250 cfs (about 50 percent) but the 50-year peak flow was only reduced by about 25 percent. The 2-year peak flow at the Chamita Gage was reduced from 5,140 to 3,460 cfs (about 33 percent), but the 50-year peak flow was only reduced by about 26 percent (Exhibit 2-38). The relatively small reductions in the magnitudes of the higher magnitude, lower frequency events were the primary reason that Abiquiu Dam was constructed in 1963. In the post-Abiquiu Dam period, the average annual peak flow at the Chamita Gage is not significantly different from the pre-dam peak, but the effects of the drought years between 1964 and 1971 on both the peak flow and the base flows are evident (Exhibit 2-36). The SJC flows have no impact on the average annual peak flow at the Chamita Gage, but they do increase the base flows significantly (Exhibit 2-36).

Since construction of Abiquiu Dam, the annual flood peaks at the Chamita Gage have been significantly reduced (Exhibit 2-37). The 2-year peak flow has been reduced to 3,010 cfs from 3,460 cfs (about 13 percent) but the 50-year peak flow has been reduced from 11,400 cfs to 5,110 cfs (55 percent) (Exhibit 2-38). The combined effects of El Vado Dam and Abiquiu Dam have reduced the 2-year peak flow at the Chamita Gage by about 40 percent and the 50-year peak flow by about 77 percent.

For the Upper Chama Sub-Reach, based on the post-El Vado Dam period of record, the 2-year peak flow during the drought years of the 1960s and 1970s at the Rio Chama above Abiquiu Dam Gage (No. 8286500) was 2,770 cfs, and in the wetter subsequent years (1972-2006) the 2-year peak flow increased

[1] The Chamita Gage is located shortly downstream of where NM State Highways 84 and 285 converge. The gage location is also displayed in Exhibit 2-56.

to 3,200 cfs (Exhibit 2-39). At the upstream end of the Lower Chama Sub-Reach, the 2-year peak flow at the below Abiquiu Dam Gage is 1,790 cfs, which is the non-flooding release from the dam (Exhibit 2-38). At the lower end of the Lower Chama Sub-Reach, the 2-year peak flow at the Chamita Gage is 3,010 cfs (Exhibit 2-38).

Annual flow duration data for the Below El Vado Dam Gage and the Above Abiquiu Dam Gage (Exhibit 2-40) represent the flows in the Upper Chama Sub-Reach. Prior to the SJC project (1936–1971) flows below El Vado Dam were as low as 1 cfs, but the SJC project increased the minimum flows (99th percentile) to 19 cfs. The median flows (50th percentile) increased from 87 cfs to 233 cfs as a result of the SJC project. The 2-year peak flow in the post-El Vado Dam period (2,250 cfs) is equaled or exceeded about 15 days per year. The SJC project also increased the flows at the Above Abiquiu Dam Gage. The median flows increased from about 118 cfs to 247 cfs in the post-SJC period (Exhibit 2-40). The 2-year peak flow (3,200 cfs) in the post-SJC period is equaled or exceeded about 5 days per year.

Exhibit 2-40

Summary of Annual Flow Duration Data (cfs) for the Upper Rio Chama Sub-Reach

Gage and Period of Record	Percent Exceedance								
	99	90	75	50	25	10	5	1	0.1
Rio Chama Below El Vado Dam 1936–1971	1	5	21	87	550	1,084	1,392	2,500	4,289
Rio Chama Below El Vado Dam 1972–2006	19	57	117	233	574	1,096	1,730	3,305	4,520
Rio Chama Above Abiquiu Dam 1962–1971	20	39	65	118	420	990	1,188	1,965	3,222
Rio Chama Above Abiquiu Dam 1972–2007	26	67	127	247	578	1,138	1,830	3,427	5,012

At the upstream end of the Lower Rio Chama Sub-Reach, the SJC project has had minimal effect on the flows (Exhibit 2-41). In contrast, at the Chamita Gage, the SJC project has significantly increased the lowest flows (99th percentile) and has approximately doubled the median flows. The 2-year peak flow of 1,790 cfs at the Below Abiquiu Dam Gage is equaled or exceeded about 18 days per year. At the Chamita Gage, the

2-year peak flow of 3,010 cfs is equaled or exceeded for less than half a day per year because flows in excess of about 1,800 cfs cause flooding of structures that have been built on the floodplain (Exhibit 2-42).

Exhibit 2-41

Summary of Annual Flow Duration Data (cfs) for the Lower Rio Chama Sub-Reach

Gage and Period of Record	Percent Exceedance								
	99	90	75	50	25	10	5	1	0.1
Rio Chama Below Abiquiu 1962–2007	24	48	90	252	705	1,321	1,719	2,110	2,372
Rio Chama Below Abiquiu 1972–2007	24	51	100	295	742	1,430	1,746	2,097	2,303
Rio Chama near Chamita 1913–1935	1	38	80	155	514	1,679	2,761	4,251	5,405
Rio Chama near Chamita 1936–1963	1	29	57	189	730	1,329	1,825	3,991	6,272
Rio Chama near Chamita 1964–1971	3	35	79	146	538	1,174	1,514	2,215	2,558
Rio Chama near Chamita 1972–2007	36	76	126	323	749	1,602	2,042	2,667	2,821

Exhibit 2-42

Structure Built on the Floodplain of the Rio Chama that Would be Flooded at Flows of 3,000 cfs

Photo: April 2008. Flow in the river is about 1,800 cfs.

10 How do flows vary by season in the Rio Grande and Chama?

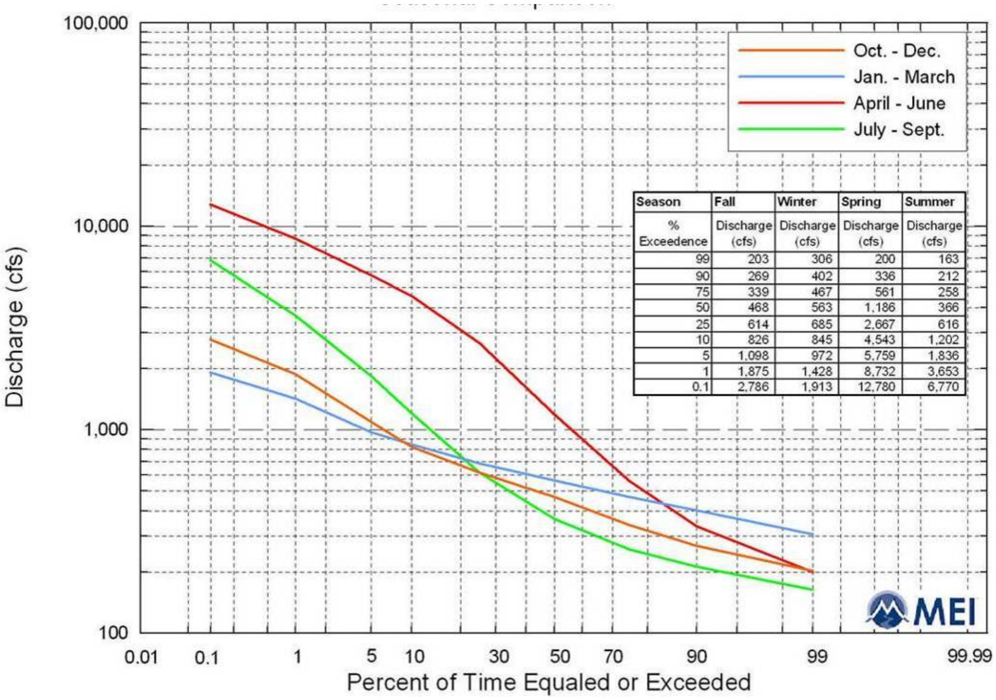
Flow duration curves were developed by-season for the Rio Grande at Embudo, Rio Chama above Abiquiu Reservoir, and Rio Chama near Chamita Gages to evaluate the seasonal distribution of flows in the Velarde Project reach. The mean daily flow records for each gage were subdivided into fall (October through December), winter (January through March), spring (April through June), and summer (July through September) periods and individual flow duration curves were developed for each period at the three gages.

For the Rio Grande Sub-Reaches (Exhibit 2-43) the highest base flows occur during the winter period (99th percentile) where flows equal or exceed 306 cfs and the lowest flows occur during the summer when they equal or exceed 163 cfs. The highest median (50th percentile) flows occur during the spring period (1,186 cfs), as do the highest flows (8,732 cfs) (1 percentile). The 2-year peak flow of 3,940 cfs occurs on average for about 12 days during the spring period. The 5-year peak flow of 7,270 cfs occurs on average for about 1 day in the spring.

For the Upper Rio Chama Sub-Reach (Exhibit 2-44), the lowest base flows occur during the winter period (99th percentile) where flows equal or exceed 15 cfs and the highest flows occur during the spring when they equal or exceed 72 cfs. The highest median (50th percentile) flows occur during the spring period (768 cfs), as do the highest flows (4,732 cfs) (1 percentile). The 2-year peak flow of 3,200 cfs occurs on average for about 6 days during the spring period. The 5-year peak flow of 4,560 cfs occurs on average for about 2 days in the spring.

Exhibit 2-43

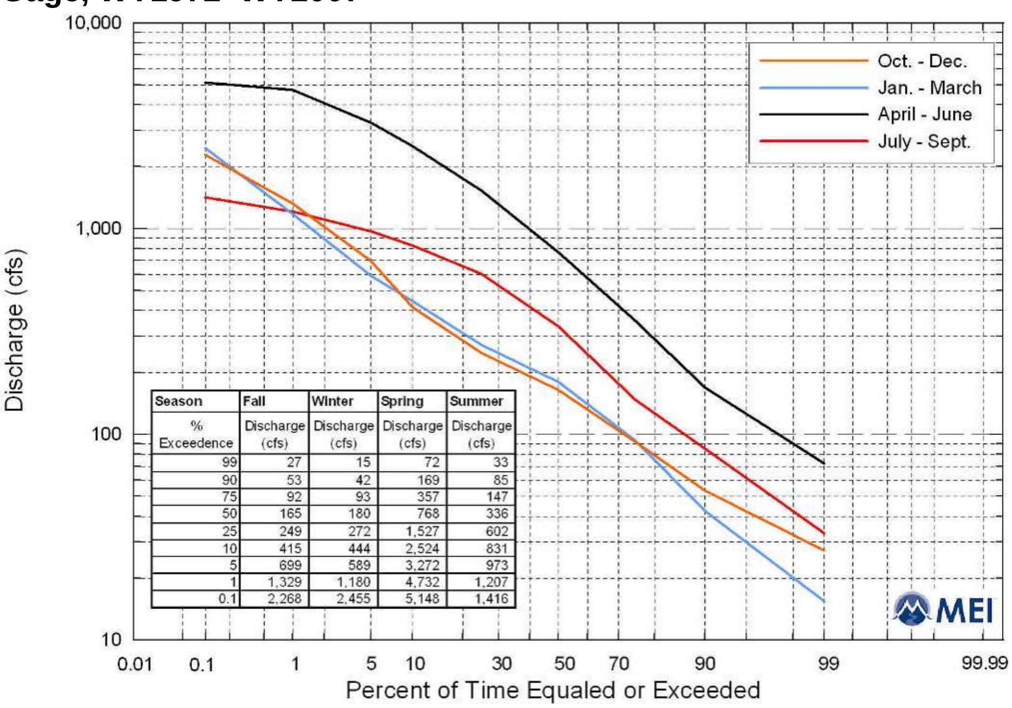
Seasonal Flow-Duration Curves for the Rio Grande at Embudo Gage, WY1889–WY2007



Season	Fall	Winter	Spring	Summer
% Exceedence	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)
99	203	306	200	163
90	269	402	336	212
75	339	467	561	258
50	468	563	1,186	366
25	614	685	2,667	616
10	826	845	4,543	1,202
5	1,098	972	5,759	1,836
1	1,875	1,428	8,732	3,653
0.1	2,786	1,913	12,780	6,770

Exhibit 2-44

Seasonal Flow-Duration Curves for the Rio Chama at Above Abiquiu Reservoir Gage, WY1972–WY2007

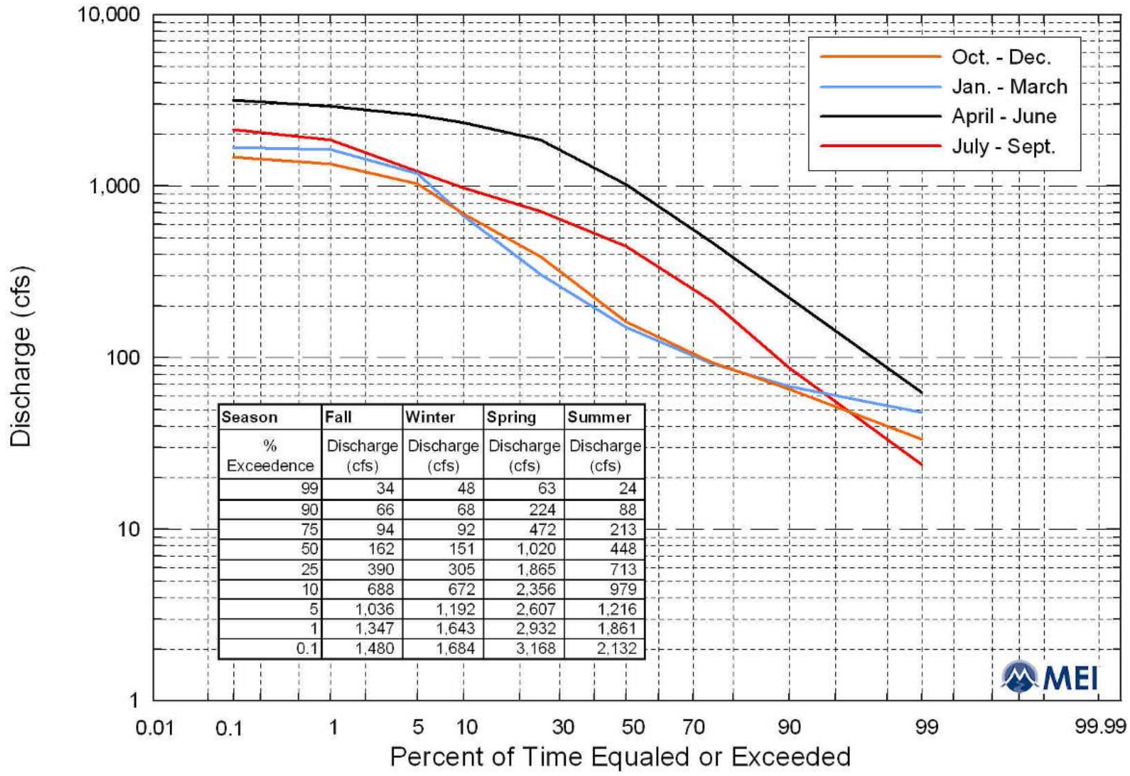


Season	Fall	Winter	Spring	Summer
% Exceedence	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)
99	27	15	72	33
90	53	42	169	85
75	92	93	357	147
50	165	180	768	336
25	249	272	1,527	602
10	415	444	2,524	831
5	699	589	3,272	973
1	1,329	1,180	4,732	1,207
0.1	2,268	2,455	5,148	1,416

For the Lower Rio Chama Sub-Reach (Exhibit 2-45), the lowest base flows occur during the summer period (99th percentile) where flows equal or exceed 24 cfs and the highest flows occur during the spring when they equal or exceed 63 cfs. The highest median (50th percentile) flows occur during the spring period (1,020 cfs), as do the highest flows (2,932 cfs) (1 percentile). The 2-year peak flow of 3,010 cfs occurs on average for less than 1day during the spring period. The non-flooding release flow of 1,800 cfs occurs for about 25 days in the spring and for about 1 day in the summer.

Exhibit 2-45

Seasonal Flow-Duration Curves for the Rio Chama near Chamita Gage, WY1972–WY2007



Season	Fall	Winter	Spring	Summer
% Exceedence	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)
99	34	48	63	24
90	66	68	224	88
75	94	92	472	213
50	162	151	1,020	448
25	390	305	1,865	713
10	688	672	2,356	979
5	1,036	1,192	2,607	1,216
1	1,347	1,643	2,932	1,861
0.1	1,480	1,684	3,168	2,132

11 How Does Groundwater Affect Potential Habitat Restoration Projects?

The effectiveness and sustainability of many riverine habitat improvement projects are related to the interaction of the water in the river and in the habitat features with the groundwater system. Groundwater that is in hydrologic connection with the river system can help maintain water in habitat features, and avoid river dewatering during dry times.

A preliminary evaluation of groundwater depth along the study reaches of the Rio Grande and Rio Chama was performed using well data available from the New Mexico Office of the State Engineer's Water Rights Abstract Bureau (WRAB) database, (formerly Water Administration Technical Engineering Resource system [WATERS] database). Using WRAB, searches for wells were performed using the Query type "POD/Surface Reports and Downloads". With this query type, location, construction, and water-depth data for individual wells may be downloaded. Queries were performed for the following Township/Range combinations: 22N 06E, 22N 07E, 22N 08E, 22N 09E, 22N 10E, 23N 04E, 23N 05E, 23N 06E, 23N 07E, 23N 08E, 23N 09E, 23N 10E, 24N 04E, 24N 05E, 24N 10E, 24N 11E, 25 N 02E, and 25 N 03E. Other sources of groundwater data, including the US Geological Survey website, were searched, but no additional groundwater data for the reaches associated with this study were found.

Using ArcGIS, well locations and measured depths to water were posted along with USGS hydrologic unit data for the Taos and Chama Hydrologic Units. The wells were filtered to retain only shallow wells, those less than 100 feet total depth. Depth-to-water data for these wells were then krigged, and the resulting map, for the entire project area, is shown on Exhibit 2-46. On this map it can be seen that, in most of the study reaches, groundwater is relatively shallow along the river corridor, suggesting hydrologic connection with the river. In these reaches, groundwater may be providing base flow to the river, but at the very least, these reaches should not lose significant quantities of river water to the groundwater system.

Two reaches within the mapped area show deeper groundwater levels near the river, which might indicate that they are regions where river water may be lost to the groundwater system. These are the reach of the Rio Chama just downstream of the confluence with Rio El Rito, near Abiquiu (Exhibits 2-47 and 2-48), and a reach of the Rio Grande between Velarde and the confluence with the Rio Chama (Exhibits 2-49 and 2-50).

An enlargement of the krigged depth-to-water surface in the reach of the Rio Chama downstream of the El Rito inflow is shown in Exhibit 2-36. In this figure, water depths between 20 and 50 feet are posted in close proximity to the river, indicating that there may be some hydrologic disconnection between the river and the groundwater system in this short reach. The aerial photograph of this reach shown in Exhibit 2-48 shows the presence of numerous alluvial fans on both sides of the river. These alluvial fans may have created significant thicknesses of coarse-grained sediments beneath and surrounding the river, which may account for the lower groundwater levels. In addition, geologic mapping in this area (Koning, et. al., 2008) suggests that the presence of numerous faults (Exhibit 2-17) in this area may affect the hydraulic conductivity and groundwater configuration.

An enlargement of the krigged depth-to-water surface in the Velarde reach of the Rio Grande is shown in Exhibit 2-49. In this reach, the enlargement shows that the deeper groundwater levels are not immediately along the river, but instead are concentrated about a half mile to the southeast, and may be the result of topography, as well as the alluvial fans present in that area (see Exhibit 2-50). In the immediate vicinity of the river, shallow groundwater depths are posted, suggesting hydraulic connection between the surface water and the groundwater.

Borton (1974), documented steep, westward gradients from the Sangre de Cristo mountains areas to the east toward the Rio Grande in the reach from Velarde to the Rio Chama confluence, further supporting the conclusion that groundwater and surface water are in hydraulic connection, and that this reach is likely a gaining reach. Borton further noted that water-table contours are mounded beneath many of the intermittent tributaries in this reach, indicating loss from these streams to groundwater, especially during snowmelt runoff and flooding events.

Upstream of the Velarde reach, in the Rio Grande Gorge, the Rio Grande has been documented by numerous studies (Bliss and Osgood, 1928; Spiegel and Couse, 1969; Wilson and others, 1978; Coons and Kelly, 1984; Johnson, 1998) to be a gaining reach, with the river in direct hydraulic connection to the groundwater system, and with increases in flow along the reach. Bauer, et. al. (2007) have documented numerous springs, both hot and cold, feeding water to the Orilla Verde and Pilar Sub-Reaches. These mapped springs are shown in Exhibit 2-51.

Exhibit 2-46

Rio Grande Velarde Reach and Rio Chama Downstream of Abiquiu Reservoir: Krigged Depth-to-Water Surface Based on WRAB Database Wells

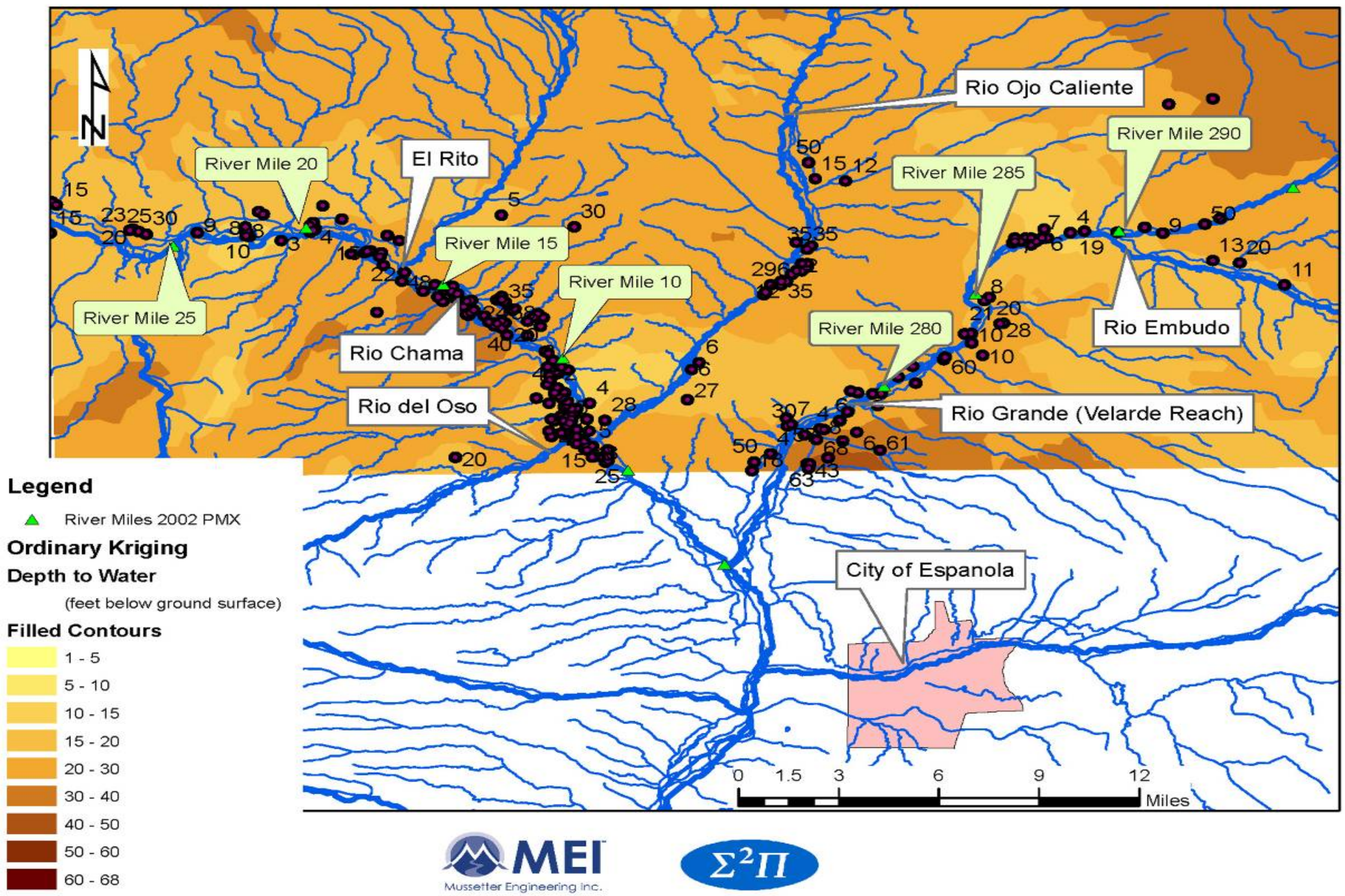


Exhibit 2-47

Enlargement of Krigged Depth-to-Water Surface in the Reach of the Rio Chama Downstream of the El Rito Confluence

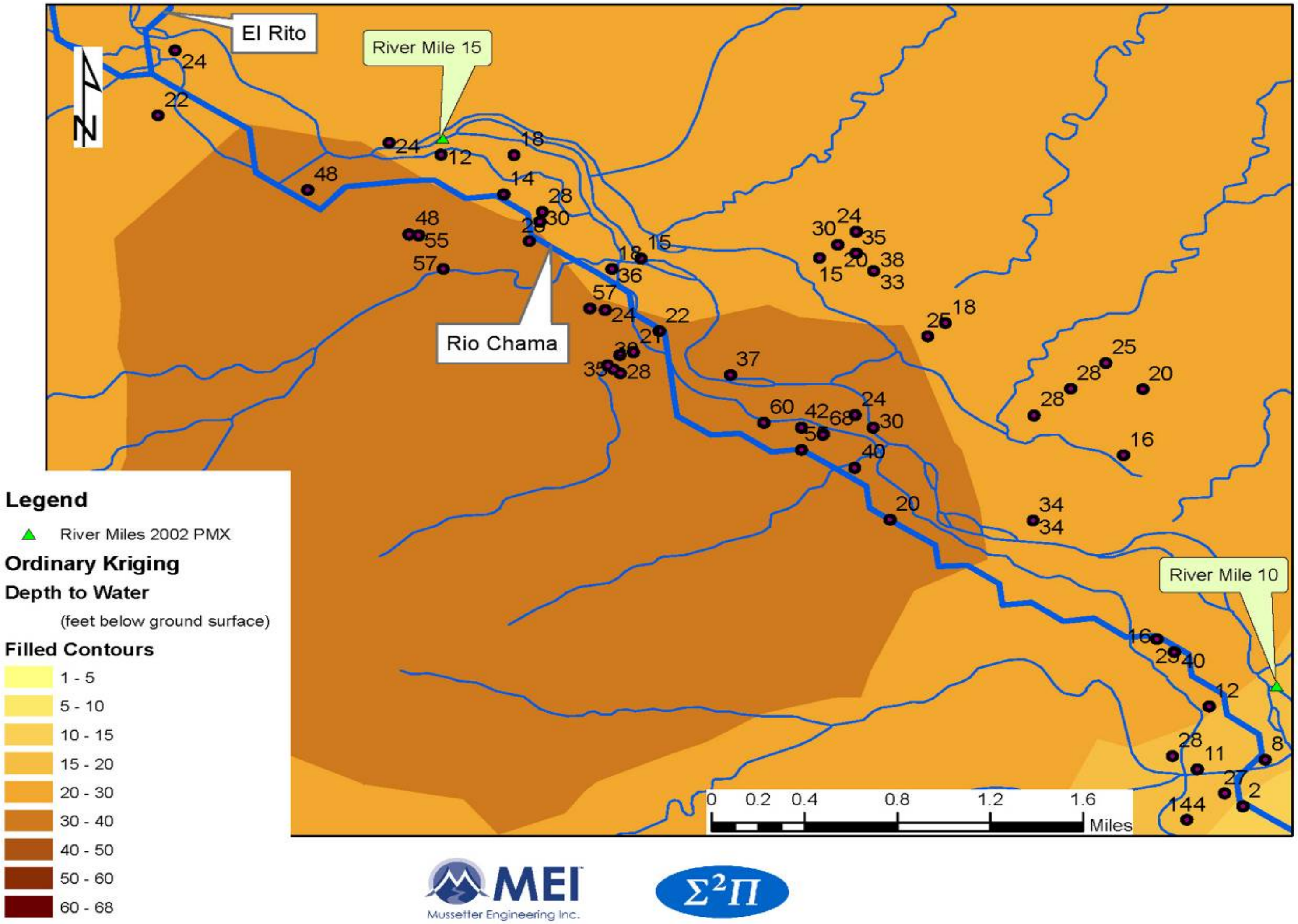


Exhibit 2-48

Aerial Photograph of the Reach of the Rio Chama Downstream of the Rio El Rito Confluence, Shown in Exhibit 2-47

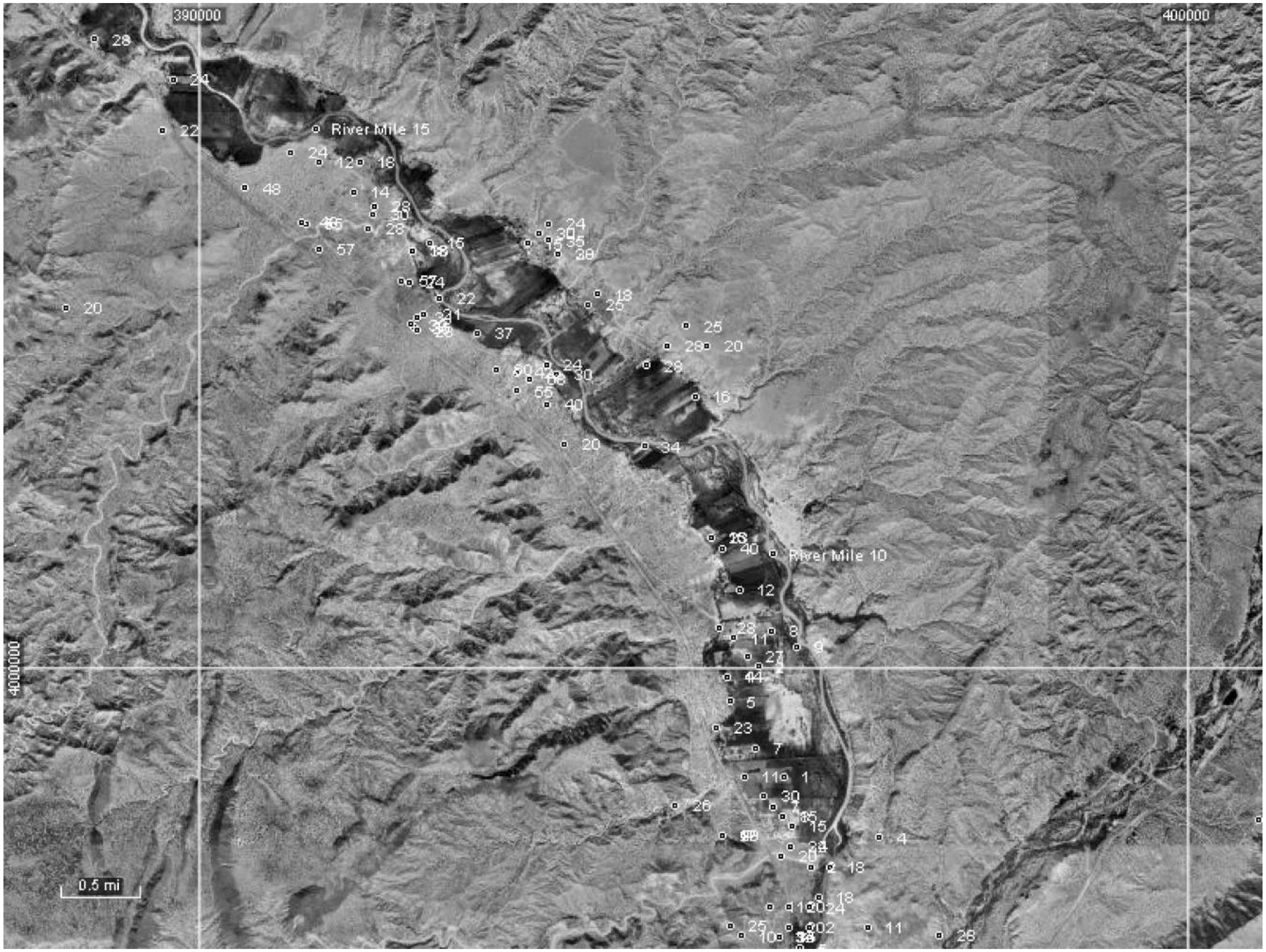


Exhibit 2-49

Enlargement of Krigged Depth-to-Water Surface in the Velarde Reach of the Rio Grande

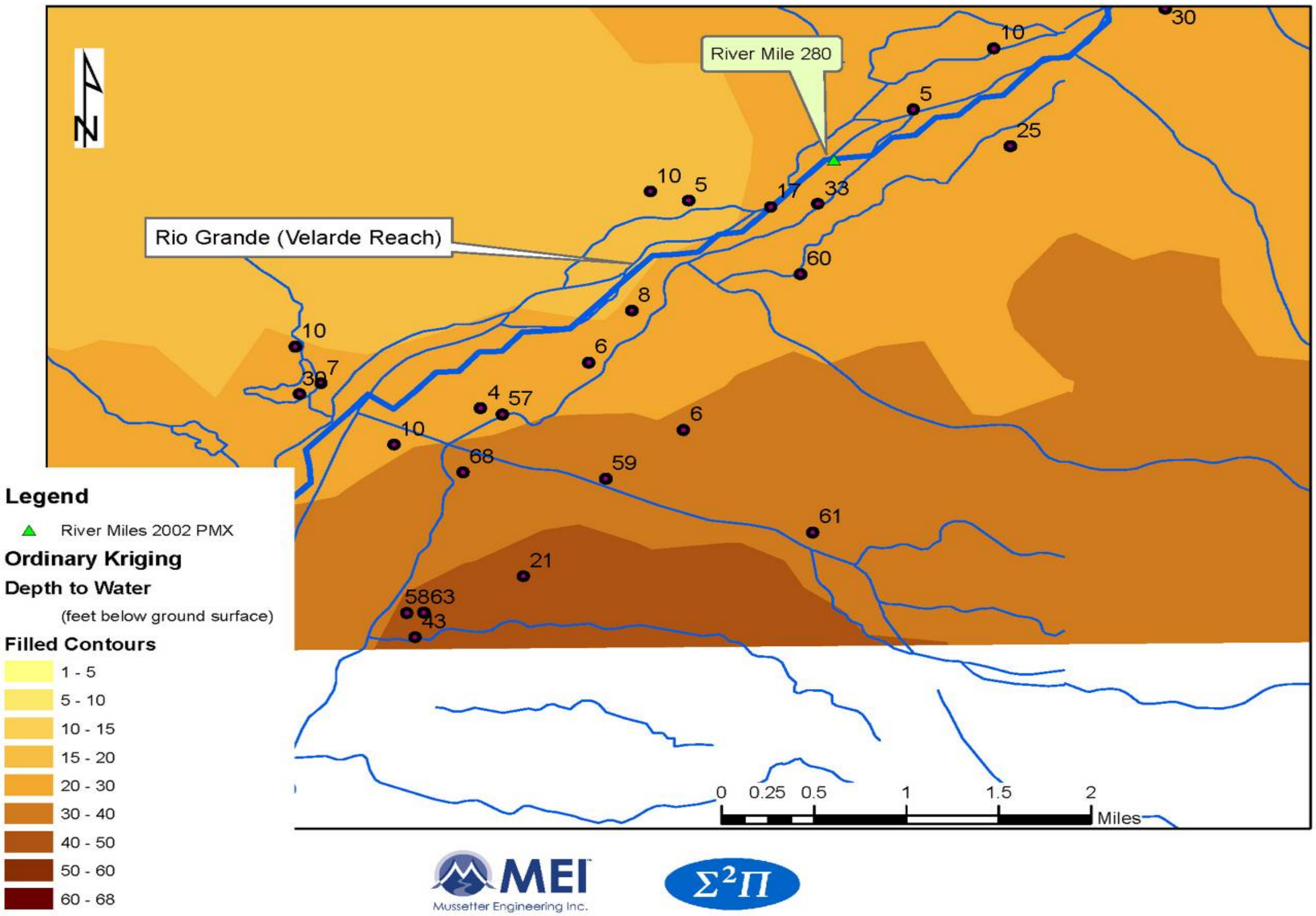


Exhibit 2-50

Aerial Photograph of the Velarde Reach of the Rio Grande, Shown in Exhibit 2-49

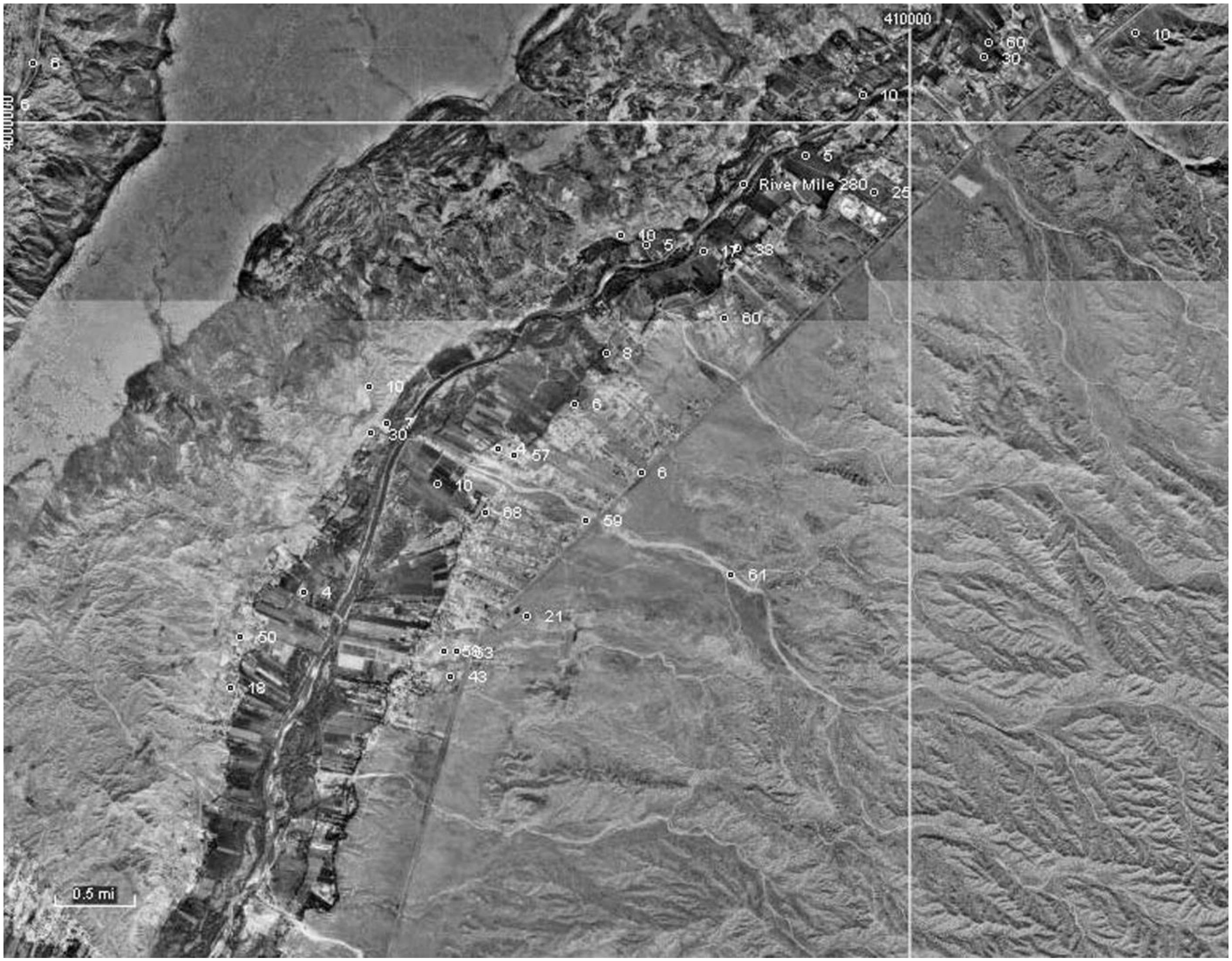
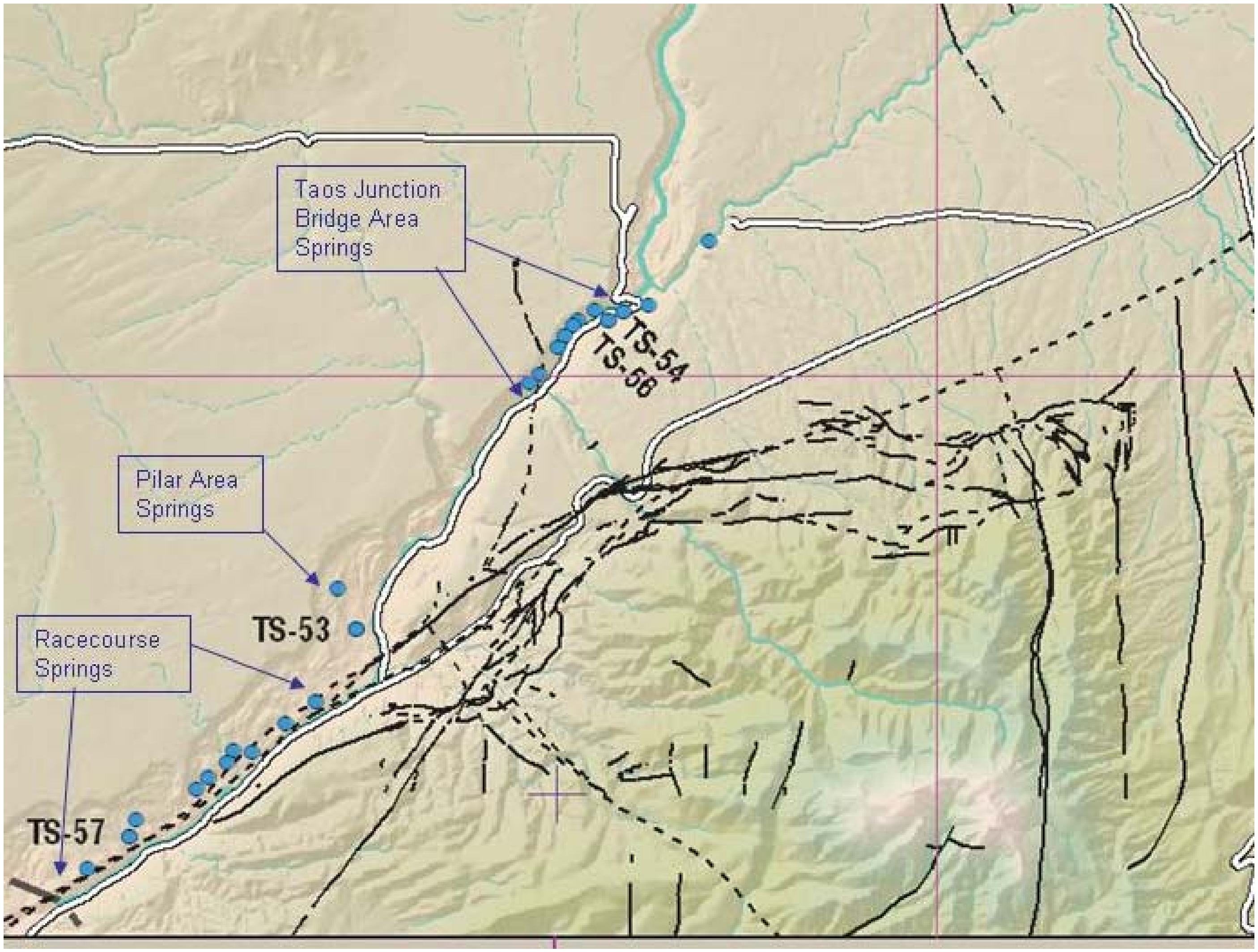


Exhibit 2-51

Springs Along the East and West Side of the Rio Grande Gorge, as Mapped by Bauer, et. al. (2007)



12 What is the extent of overbank flooding in the project reaches?

In the Orilla Verde Sub-Reach, no cross sections of the Rio Grande have been surveyed, and as a result there is no hydraulic model available to assess the extent of overbank flooding in the reach. Since the sub-reach is canyon-bound with very limited areas of discontinuous floodplain and a few mid-channel bars the potential for overbank flooding in the reach is low. Based on the hydrology of the reach (Exhibit 2-34) it is likely that some overbank flooding of the discontinuous floodplain segments and the mid-channel bars does occur in the reach at flows between about 3,000 cfs (2-year peak flow) and 5,610 cfs (5-year peak flow). Overbank flows are likely to occur for about 12 days during the spring snowmelt runoff period.

For all intents and purposes the Pilar Sub-Reach is canyon-bound and there is effectively very little overbank flooding potential. Very limited areas in the wider sections of the canyon where alluvial deposits have accumulated appear to have some potential for overbank flooding but local levees have been constructed along the channel banks, especially near the Town of Pilar. Overbank flooding does occur on the fan at the mouth of Embudo Creek as a result of combined flows in the Rio Grande and Embudo Creek.

In 2000, Reclamation surveyed 93 channel cross sections (range-lines) in the Velarde Sub-Reach between the San Juan Diversion and the Velarde Diversion. These cross sections were extended into the overbanks using the topography from the USGS 7.5 min. topographic quadrangle, and were used to develop a coarse HEC-RAS model of the reach. The diversion structures within the reach were included in the model based on field observations of their elevations. In most of the sub-reach, the channel and adjoining levees that were initially constructed in the 1950s contain at least the 5-year peak flow (7,270 cfs). However, locally there is some potential for overbank flooding, especially upstream of diversion structures. Exhibit 2-52 shows the location of two range-lines in the model, EM-4 where there is little overbank flooding potential and LC-4 that is located upstream of a diversion structure. At range-line EM-4, the 2-year peak flow (3,940 cfs) is fully contained within the channel, but it appears that there is very limited overbank flooding on the right (west) bank at the 5-year peak flow (7,270 cfs) which appears to support a very narrow band of riparian vegetation (Exhibit 2-53). In contrast, at range-line LC-4, there is significant overbank flooding on the right (west) bank at the 2-year peak flow (Exhibit 2-54), and based on the spring period flow duration curve (Exhibit 2-43) the duration of the overbank flooding is about 12 days. As can be seen on Exhibit 2-52 relatively dense riparian vegetation occupies the inundated area.

Exhibit 2-52

Locations of Range-Lines LC-4 and EM-4 in the Velarde Sub-Reach

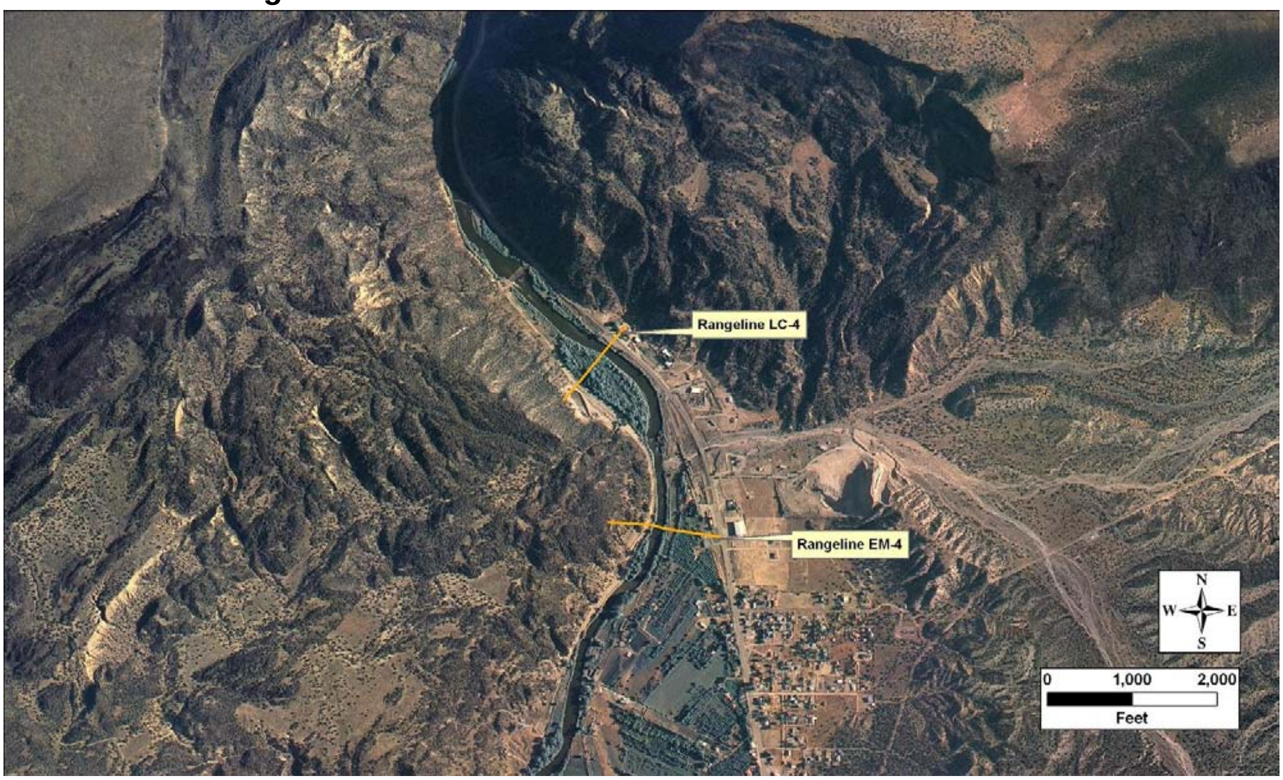


Exhibit 2-53

Cross Section of the Rio Grande at Range-Line EM-4 in the Velarde Sub-Reach Showing the Water-Surface Elevations for the 2-, 5- and 10-Year Peak Flows at the Embudo Gage

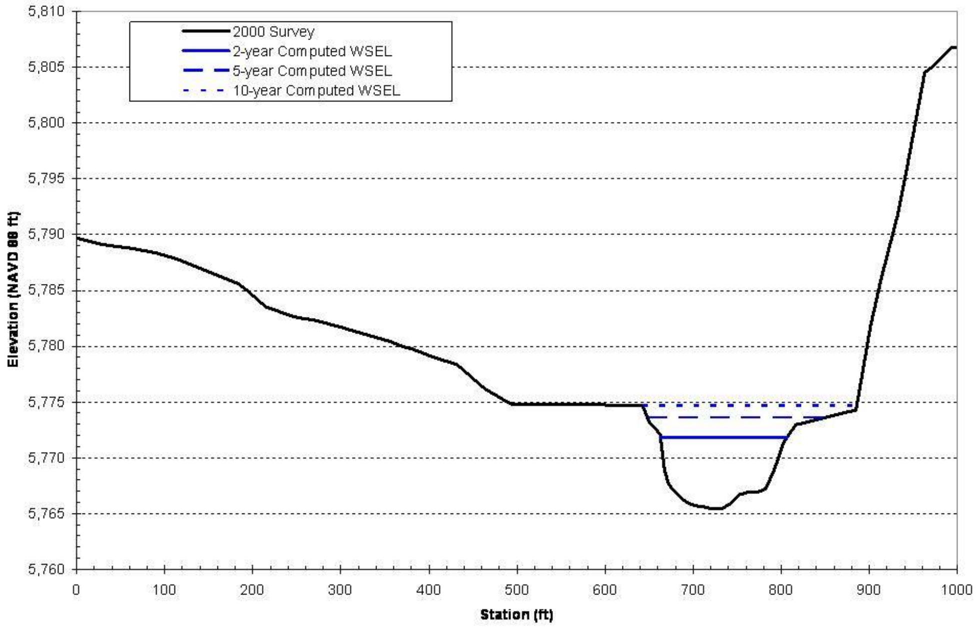
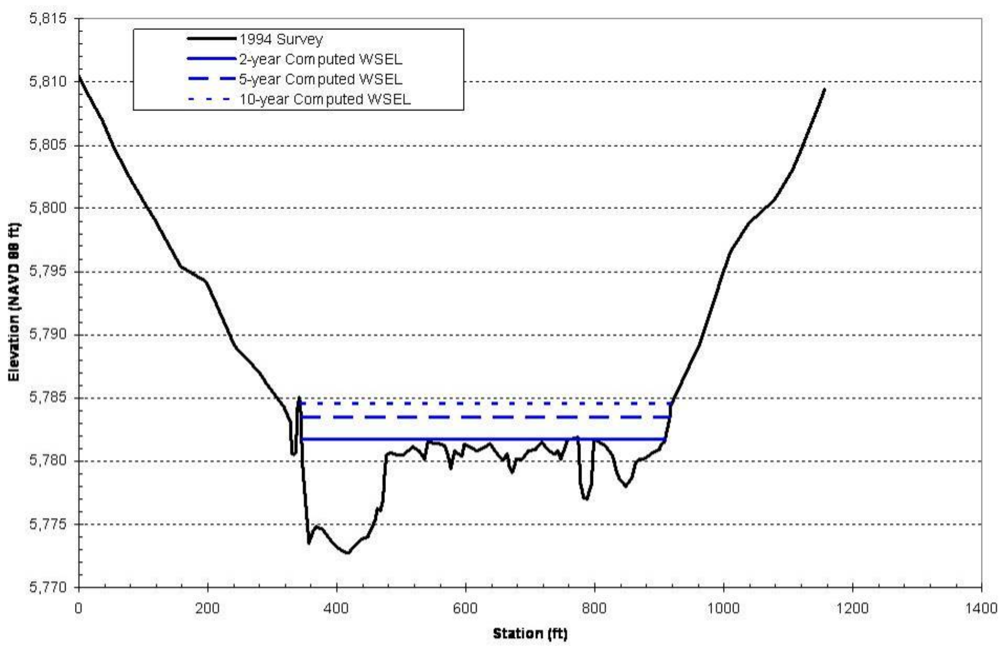


Exhibit 2-54

Cross Section of the Rio Grande at Range-Line LC-4 in the Velarde Sub-Reach Showing the Water-Surface Elevations for the 2-, 5- and 10-Year Peak Flows at the Embudo Gage



A FLO-2D model originally developed for the Rio Chama between Abiquiu Dam and the Rio Grande confluence by Tetra Tech in 2003 (Walt Kuhn, TetraTech, personal communication, 2008) for the URGWOPS Review and EIS was reformulated to evaluate the overbank flooding potential in the Lower Rio Chama Sub-Reach. The model was run for flows of 1,800 cfs (the non-flooding release from Abiquiu Dam), 3,010 cfs (2-year peak flow), 3,740 cfs (5-year peak flow) and 4,190 cfs (10-year peak flow) to quantify the extent of flooding. As expected, there is very little overbank flooding (292 acres) at a flow of 1,800 cfs (Exhibit 2-55), and the bulk of the flooding that does occur is located upstream of diversions and valley floor constrictions. Overbank flow depths are generally less than 1 foot. At the 2-year peak flow, there are about 1,680 acres of overbank flooding (Exhibit 2-56). The bulk of the overbank flow depths are less than 1 foot, but locally flow depths up to 3 feet are encountered. At the 5-year peak flow there are about 2,540 acres of overbank flooding (Exhibit 2-57), and flow depths of up to 4 feet are encountered, locally. At the 10-year peak flow there are about 3,100 acres of overbank flooding (Exhibit 2-58). The bulk of the overbank flow depths are less than 2 feet, but locally flow depths in excess of 4 feet are encountered. Comparison of Exhibits 2-56, 2-57, and 2-58 shows that the majority of the flooding occurs in specific reaches where there are local hydraulic controls.

Channel morphology and the distribution of alluvial reaches in the Upper Chama Sub-Reach are controlled by the presence of tributary fans, landslides, bedrock outcrop, and high elevation terraces (Swanson et al., 2008). A longitudinal profile of the reach was developed from the USGS 7.5 min. quadrangle (Exhibit 2-59), and the profile clearly shows the stair-step nature of the bed with the steeper reaches related to coarse-grained tributary fans and the flatter alluvial reaches being located upstream of the local controls. Based on the profile and a field inspection, the alluvial reach located upstream of the Canada de Potero fan (Station 300+00 on Exhibit 2-59) was selected to evaluate the relationships between the geomorphic surfaces, the frequency and duration of inundation of the surfaces and the riparian vegetation (Exhibit 2-60). Seven cross sections were surveyed across the channel and valley floor on July 17, 2008, and these were used to develop a HEC-RAS hydraulic model of the reach (Exhibit 2-60). The model was calibrated to the flow at the time of the survey (157 cfs) and the high-water marks for a flow of 2,400 cfs that occurred on June 1, 2008. The model was executed for a range of flows between 100 cfs and the 100-year peak flow (8,530 cfs) at the Above Abiquiu Reservoir Gage. The non-channel geomorphic surfaces at each of the cross-sections were classified in the field as being either bars (mid-channel or bank-attached), floodplain, Terrace 2 and Terrace 1.

Output from the HEC-RAS model was used to correlate the geomorphic surfaces with the corresponding overtopping flow. The T1 surface that is vegetated with xeric woodland species is not overtopped by the current 100-year peak flow and pre-dates construction of El Vado Dam. The T2 surface is overtopped by flows between 4,000 and 4,500 cfs, which is equivalent to the current 5-year peak flow. The current 5-year peak flow is equivalent to the pre-El Vado Dam 2-year peak flow, and therefore, the T2 surface represents the pre-El Vado Dam floodplain. The T2 surface is predominantly vegetated with native riparian species that include willows and cottonwoods as well as some boxelder, but young, presumably post-El Vado Dam, junipers are present on the surface. The floodplain surface that is vegetated with native riparian species dominated by sandbar willow is overtopped by flows between 3,000 cfs and 3,500 cfs, which is equivalent to the current 2-year peak flow and thus represents the active floodplain of the Rio Chama. The sand and gravel bars are inundated by flows in the range of 1,500 to 2,000 cfs, which have a recurrence interval of about 1 year. They tend to be vegetated with native riparian species that are dominated by sandbar willow. The currently active bars and floodplain surfaces most probably represent the channel narrowing that was documented by Swanson et al (2008) following construction of El Vado Dam. Based on the seasonal flow duration curves for the post-SJC period, during the spring the T2 surface is inundated for about 2 days, the floodplain surface is inundated for about 6 days and the bars are inundated for about 18 days.

Based on the distribution of the mapped vegetation categories and their association with the geomorphic surfaces at the modeled site (Exhibit 2-60) there are currently about 165 acres of inundated floodplain and bars in the Upper Chama Sub-Reach that are inundated by the 2-year peak flow for a duration of about 6 to 18 days in the spring. A further 105 acres of T2 surface that support native riparian species are inundated in the spring by the 5-year peak flow for about 2 days. An increase in the peak flow release from El Vado Dam during the spring to about 4,500 cubic feet per second (cfs) for a duration of 6 days on an annual or bi-annual basis if the water is available in storage, is likely to almost double the amount of inundated floodplain and presumably will retard or prevent the invasion of non-riparian species on the former floodplain surface. The increased flows will also increase the rate of erosion of higher terrace margins and alluvial fan margins that in turn will increase the size of the bars and floodplain within the alluvial reaches.

Exhibit 2-55

Map of the Lower Rio Chama Sub-Reach Showing the Locations and Depths of Overbank Flooding at a Flow of 1,800 cfs

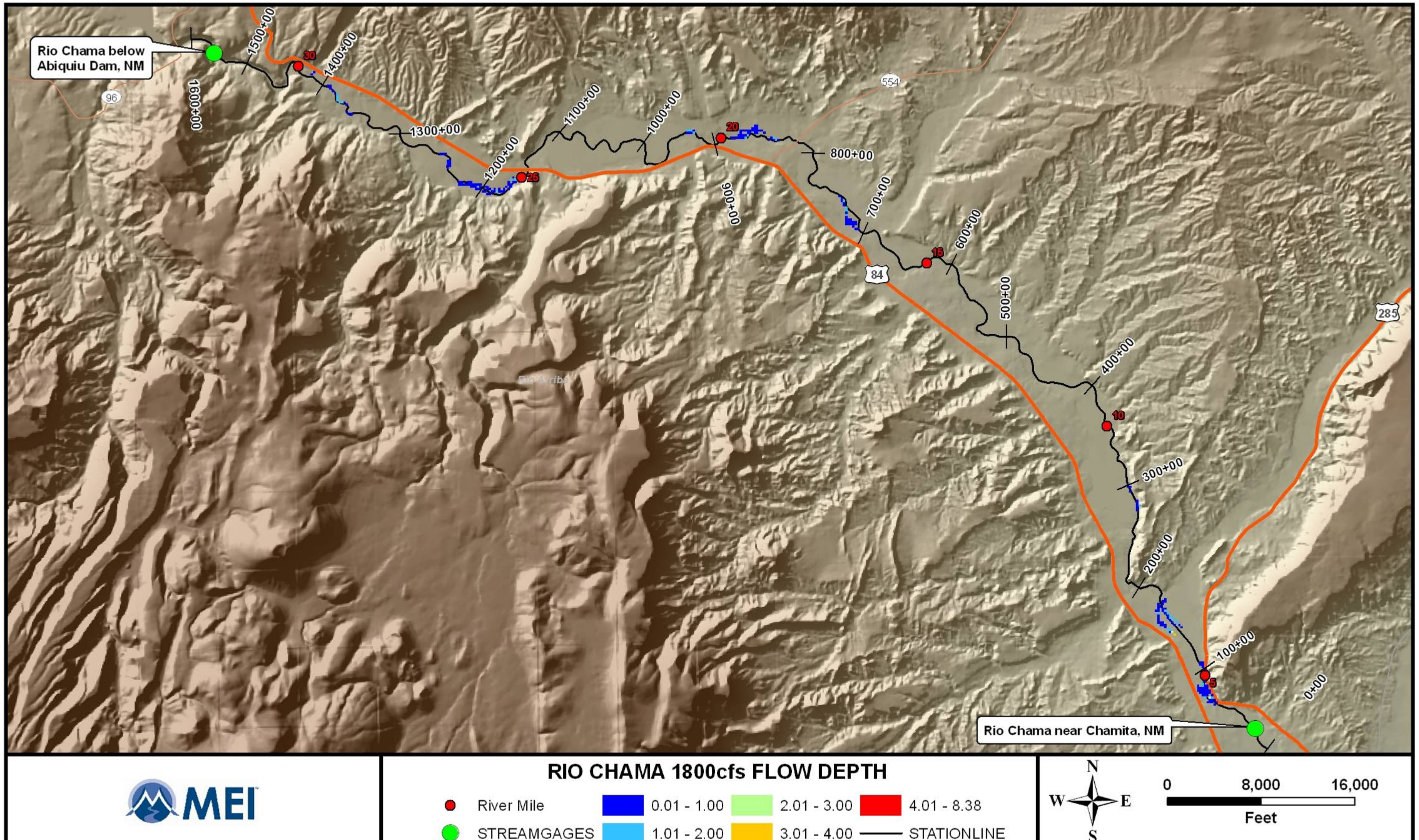


Exhibit 2-56

Map of the Lower Rio Chama Sub-Reach Showing the Locations and Depths of Overbank Flooding at the 2-Year Peak Flow

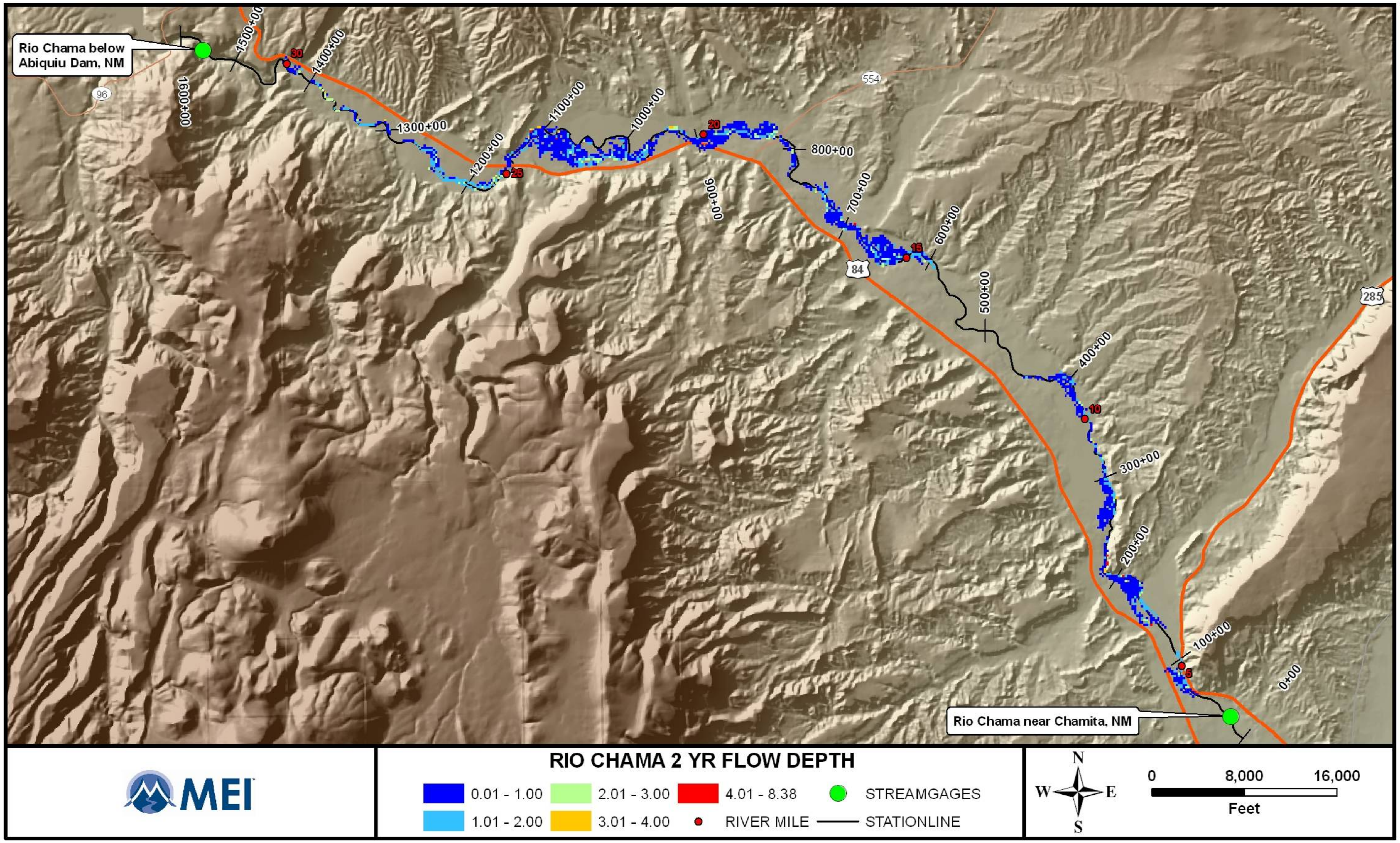


Exhibit 2-57

Map of the Lower Rio Chama Sub-Reach Showing the Locations and Depths of Overbank Flooding at the 5-Year Peak Flow

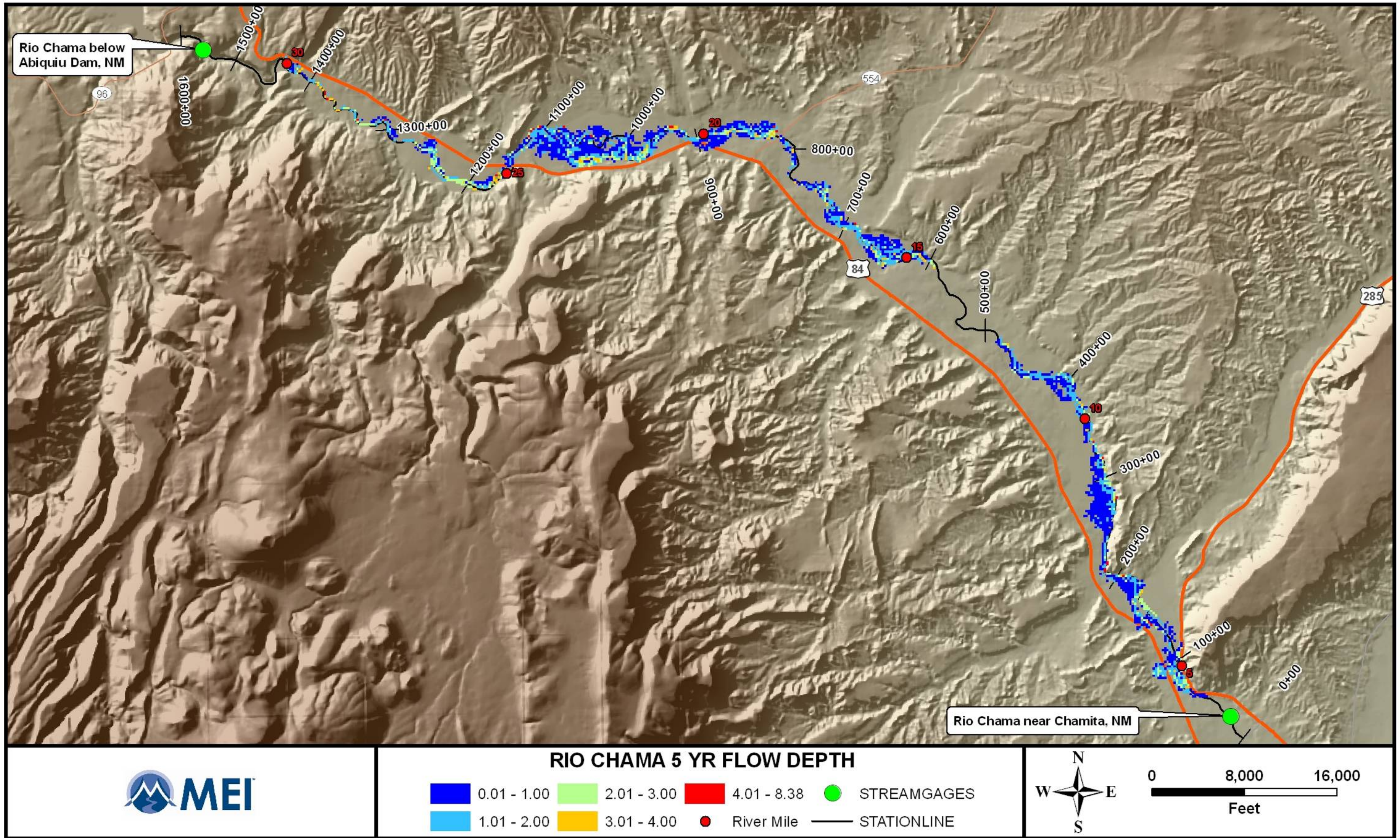


Exhibit 2-58

Map of the Lower Rio Chama Sub-Reach Showing the Locations and Depths of Overbank Flooding at the 10-Year Peak Flow

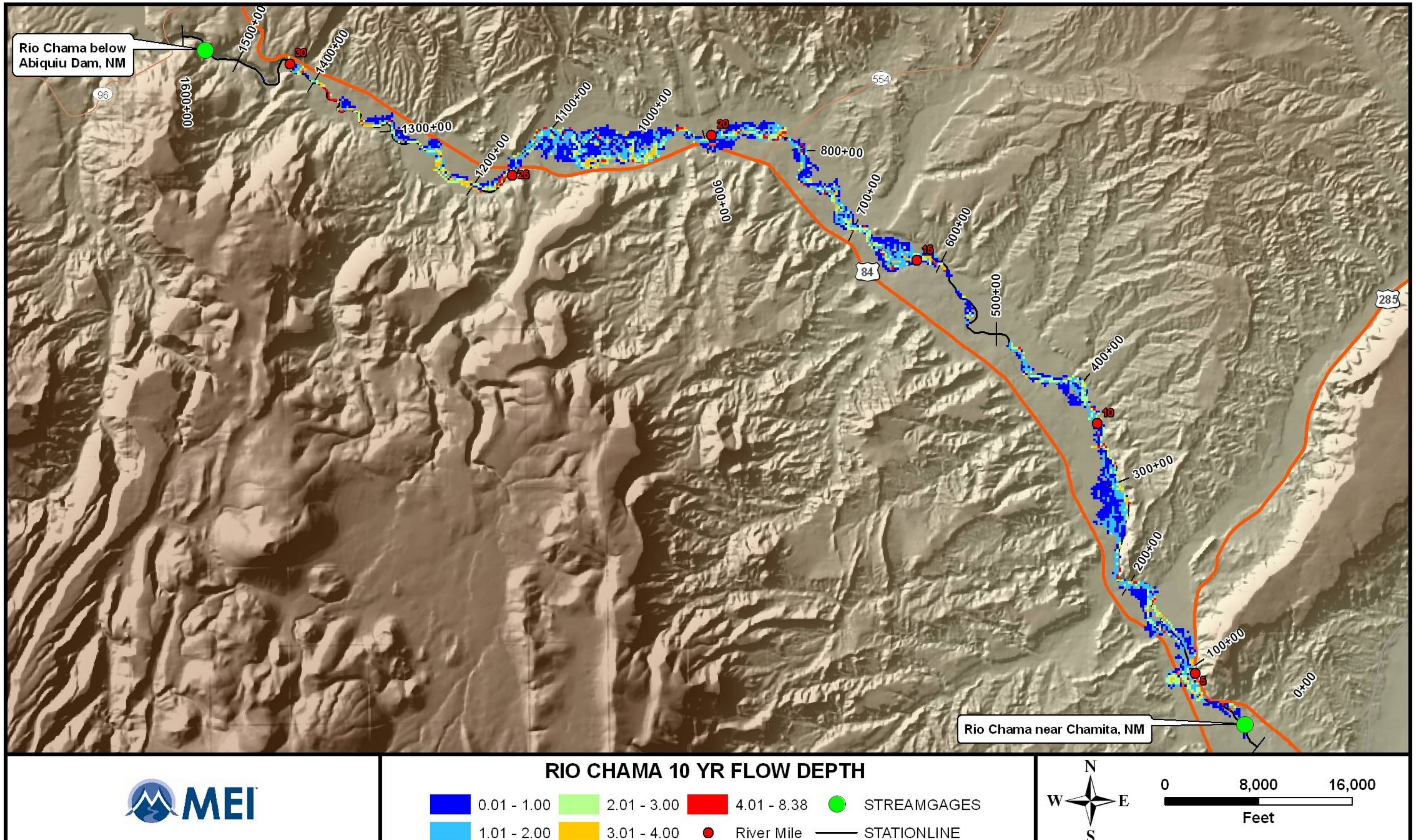
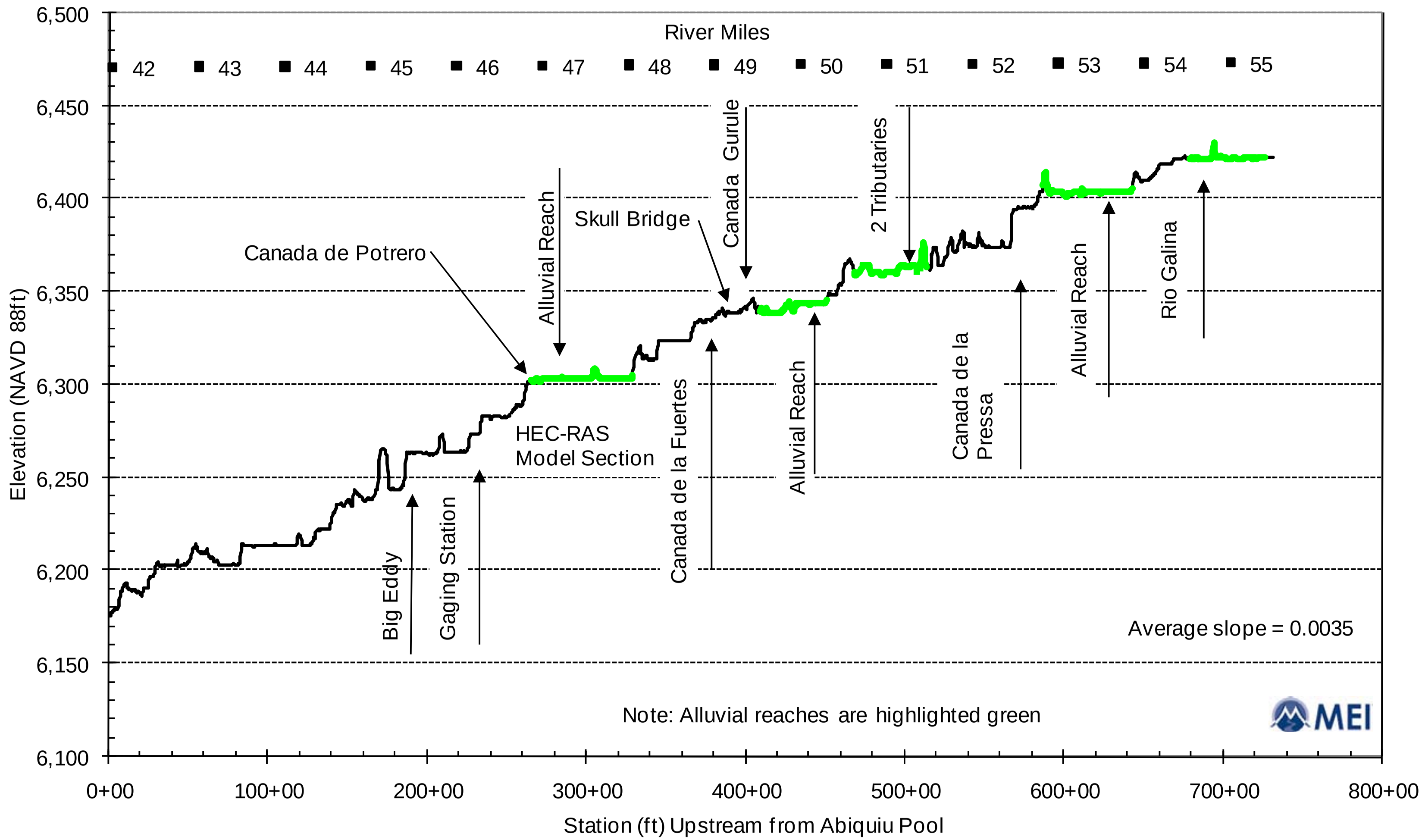


Exhibit 2-59

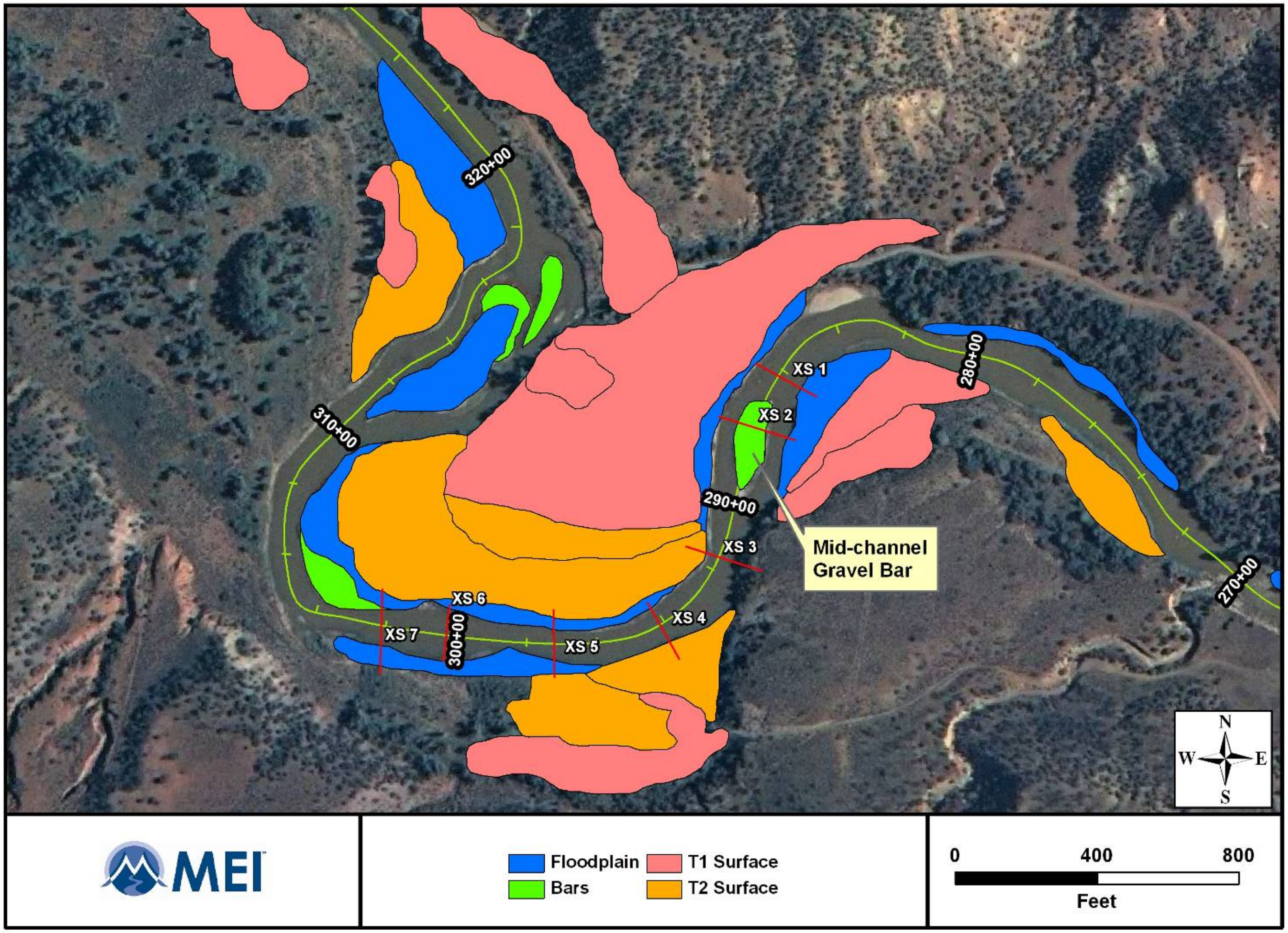
Longitudinal Profile of the Upper Rio Chama Sub-Reach Showing the Locations of the Channel Controls and the Distribution of the Alluvial Reaches



The location of the HEC-RAS modeled reach is shown just upstream of Canada de Potrero.

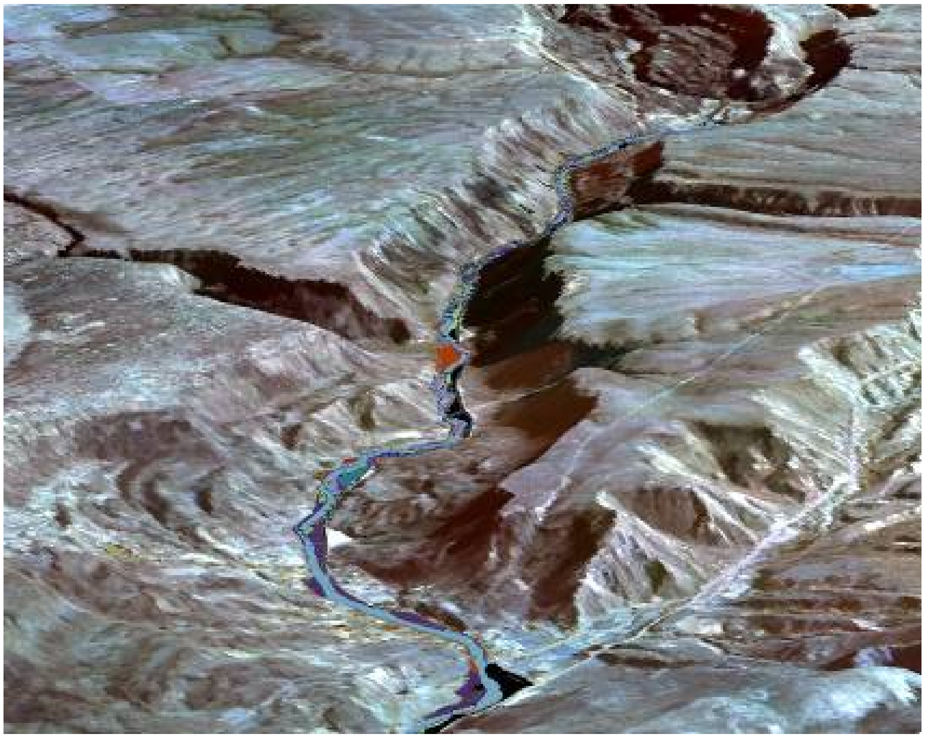
Exhibit 2-60

Map of the Modeled Reach of the Upper Rio Grande Sub-Reach Showing the Locations of the Surveyed Cross Sections and the Geomorphic Surfaces Superimposed on the Vegetation Mapping



Floodplain Vegetation

13 How do vegetation conditions in the project area generally compare to the Middle Rio Grande?



Three-dimensional view of the Cañon del Rio Grande constricting the Rio Grande floodplain through the Orilla Verde Sub-Reach.

Overall, the Rio Chama and Rio Grande segments of the project area have far less floodplain acreage than comparable river lengths along the Middle Rio Grande (MRG). The canyon walls that define the Orilla Verde and Pilar Sub-Reaches of the Rio Grande form natural constrictions that prevent formation of extensive floodplains, and riparian vegetation is mostly confined to channel bars and a narrow strip along the riverbank. The transition zone between riparian and upland vegetation in these canyon sections is abrupt, and upland species like rubber rabbitbrush (*Ericameria nauseosa*), big sagebrush (*Artemisia tridentata*), and one-seed and/or Rocky Mountain juniper (*Juniperus monosperma, J. scoparium, respectively*) are found growing in close proximity to the active river channel.

The Velarde Sub-Reach of the Rio Grande and the upper and lower sub-reaches of the Rio Chama have alluvial segments of different scales, and all have more well-defined floodplains than the constricted canyon sub-reaches. Flow reductions on the Rio Chama associated with El Vado and Abiquiu Dams, and channelization in the Velarde Sub-Reach of the Rio Grande have diminished or eliminated the channel-floodplain connection, and floodplain inundation is limited in all three of these sub-reaches.

Photo from Orilla Verde Sub-Reach showing narrow bands of riparian vegetation restricted to bars banks along the active channel. The bank line riparian strips quickly transition to upland vegetation types.

While water management in the MRG has also curtailed overbank flooding along much of its length, there is still a relatively wide, undeveloped buffer-zone between agricultural and residential development and the channel bank line downstream of Cochiti Dam. This has enabled the persistence of extensive acreage of floodplain forest (bosque) between Cochiti Dam and the San Marcial Railroad Bridge. This is not the case along the downstream alluvial sub-reaches in the project area. Alluvial floodplains, particularly in the Velarde and Lower Chama Sub-Reaches, were cleared very close to the riverbanks for agriculture by the early part of the 20th century (Exhibit 2-61). More recently home building in the floodplain in these sub-reaches has occurred, and some vegetation thinning around the properties is also evident. Like some sections of the MRG, active livestock grazing in the project area (most notably in the Rio Chama Sub-Reaches) contributes to limited recruitment and growth of native riparian species like cottonwood and willow.

Exhibit 2-61

Aerial View of the Velarde Reach of the Rio Grande Showing Agricultural Development to the Edge of the River in 1935

The riparian plant species composition in both the canyon and valley sub-reaches is strongly influenced by higher elevations and mountainous climate of Northern New Mexico. Riparian plant species associated with both the Rocky Mountains and the Colorado Plateau are relatively common components of the floodplain plant communities in the project area. For example, species including silver buffaloberry (*Shepherdia argentea*), narrowleaf cottonwood (*Populus angustifolia*), and box elder (*Acer negundo*) are relatively common in the project area compared to the MRG. Conversely, Goodding's willow

(*Salix gooddingii*) is relatively common in lower elevation floodplains of the MRG, but is less common along the Rio Chama and the upper sub-reaches of the Rio Grande. Non-native Russian olives (*Elaeagnus angustifolia*) are more widespread than saltcedar (*Tamarix chinensis,* Lour) along the Upper Rio Grande and Rio Chama, while the reverse is true in the MRG, particularly along the Isleta and San Acacia reaches (Parametrix, 2008a and 2008b).

14 Has the historic condition of riparian vegetation in the Upper Rio Grande and Rio Chama been well documented?

We have found few historic accounts of the vegetation along the Rio Chama and Upper Rio Grande. This may be partially due to the fact that Abiquiu was the northernmost Spanish settlement on the Chama until the 1800s. Areas beyond Abiquiu were still considered part of the "wild frontier" and more vulnerable to attacks by Native Americans (Hendricks, 2008). Also the steep canyons and whitewater discouraged travel, especially with livestock (Stoffle et al., 2008).

Sources cited in Scurlock (1998) mention that the Chama near Abiquiu in 1776 was composed of fertile farmlands and "very fine meadows on both banks, with corresponding groves of beautiful poplars" (cottonwoods) (Adams and Chavez, 1956 cited in Scurlock, 1998). A party of trappers also noted in 1848 that they encountered "fine grass" along the Chama River north of Abiquiu while "no grass" was found from Santa Fe to Abiquiu (Hafen and Hafen, 1993 cited in Scurlock, 1998). According to Stoffle et al., 2008, the name Abiquiu may refer to "abi-shoo" or "chokecherry place", indicating this species (*Prunus virginiana*) may have been very common in the floodplain.

Some sources cited in Scurlock also suggest that coniferous forests were present along sections of the Rio Chama upstream of Abiquiu. One source mentions that by 1880, extensive clear-cutting of ponderosa pine (*Pinus ponderosa*) occurred along the Rio Chama (Harper et al., 1943 from Scurlock, 1998).

Given the northern climate, close proximity to steep forested terrain and the often abrupt transition zone between riparian and upland habitats, it is not surprising that conifers were reported growing close to, or within the active floodplain. Most conifers (with the exception of some southeastern bottomland conifers like bald cypress; *Taxodium distichum*), however, lack the physiological adaptations to surviving prolonged root inundation (Kozlowski, 1986). As such, we suspect that coniferous trees were probably restricted to floodplain terraces that flooded infrequently. The actual extent and distribution of conifers along the active floodplain is difficult to predict as the few existing written accounts are considered anecdotal.

15 What contemporary information exists regarding floodplain vegetation in the project area?

Large segments of the Rio Grande bosque were mapped in the early 1980s by Valerie Hink and Robert Ohmart (Hink & Ohmart, 1984), although the upstream extent of their project was Espanola, NM. Natural Heritage New Mexico (NHNM) established several vegetation transects in the late 1990s as part of their statewide wetland vegetation classification (Durkin, et al., 1995; Bradley et al., 1998; Muldavin et al., 2000), but these projects did not focus on vegetation mapping.

The Santa Fe National Forest published a Terrestrial Ecosystem Survey (TES) in 1991, which primarily involves mapping soils and associated vegetation habitat types at a scale of 1:24,000. The Upper Chama Sub-Reach is within the Santa Fe National Forest and is included in their TES. The entire floodplain, however, is only assigned one soils map unit (Map Unit No. 31– Riverwash), and it does not provide any detailed vegetation mapping beyond uniform assignment of potential “climax” cover (aerial cover) by different woody and herbaceous plant species. The TES indicates that the potential vegetation composition and associated cover for the Riverwash Map Unit is: Narrowleaf cottonwood – 5%; Goodding’s willow – 15%; Coyote willow (*Salix exigua*) – 35%; Peachleaf willow (*Salix amygdaloides*) – 15%; and Rubber rabbitbrush – 1%).

EcoPlan (1991, as cited in BLM, 1992) published a report of the riparian-wetland vegetation along the Rio Chama from El Vado Dam to Abiquiu Lake. This report characterizes the riparian-wetland vegetation using the National Wetland Inventory (NWI) classification system developed by Cowardin et al. (1979). The NWI system characterizes vegetation according to five classes based upon *vegetative form*, including: 1) Aquatic Bed, dominated by plants that grow principally on or below the surface of the water; 2) Moss-Lichen Wetland, dominated by mosses or lichens; 3) Emergent Wetland, dominated by emergent herbaceous plants; 4) Scrub-Shrub Wetlands, dominated by shrubs or small trees; and 5) Forested Wetland, dominated by large trees (Cowardin et al., 1979). We have not been able to obtain a copy of the EcoPlan (1991) report, but we assume that it contains maps showing the spatial distribution of these wetland classes. BLM (1992) indicates that the EcoPlan report also performed a plant census of the area.

More recently, a few efforts over the past several years have been initiated to develop more detailed, species-level riparian vegetation maps in the river segments that flow through the Rio Chama and Rio Grande upstream of Espanola. The most complete mapping was performed in the Orilla Verde Sub-Reach (Rio Grande) by the Bureau of Land Management, Taos Field Office. They contracted the Reclamation’s Denver Technical Service Center and Natural Heritage New Mexico to develop detailed riparian vegetation maps of the OVRA. Their vegetation classification follows the Hink & Ohmart (1984) naming convention. All of the vegetation map polygons were field verified and published by NHNM (NHNM, 2007).

BOR’s Denver Technical Services Center also initiated a GIS-based vegetation mapping effort for the Rio Chama (both Upper and Lower Sub-Reaches), similar to what they developed for the Middle Rio Grande in support of the Upper Rio Grande Water Operations Program (URGWOP). Unlike the MRG effort, however, the map polygons created for the Rio Chama were not field-verified (D. Callahan, 2007, personal communication). To date, their mapping efforts have not included the Rio Grande upstream of the Rio Chama confluence (other than for OVRA).

BOR's riparian vegetation map coverage of the Rio Chama extends from the Christ in the Desert Monastery to Big Eddy boat ramp and from Abiquiu Dam to the confluence with the Rio Grande. We obtained these data and received several renditions of the mapping. The various GIS datasets did not have matching polygon shapes or vegetation types, so it was difficult to ascertain which source were more accurate.

16 How did we utilize the existing vegetation datasets for this report?

The existing digital data obtained from the BLM Taos Field Office and Reclamation were compiled for the project reach and combined into a single file. Significant data gaps existed, especially in the Pilar and Velarde Sub-Reaches where no riparian vegetation maps had yet been created. In these sub-reaches, Parametrix digitized vegetation polygons using digital orthophotography and field verified a subset of the area. It was not possible to field verify some polygons, especially if they occurred on private land and were not easily visible from the river. In most of these cases we predicted the likely vegetation type by reviewing several sources of imagery and by comparing the area of interest to adjacent areas that were verified. If the vegetation type could not be determined with confidence using this method, we did not designate a vegetation type for the particular polygon.

During field verification efforts, we determined the best available source across the existing URGWOPs datasets and assigned the vegetation type designated in that source across the polygons. If the area was visible during field reconnaissance and no existing source accurately characterized the area, we reassigned a vegetation type to best represent the actual field condition.

The updated vegetation map of the Velarde Reach identifies 1,200 distinct vegetation stands and five open water areas (not including the river channel and the irrigation canals). GIS data representing the areal extent of these vegetation stands are contained in the project geo-database. Associated spreadsheet data was used to quantify the areal extent and distribution of dominant plant species and different vegetation structure types across the project area.

For management utility and general analysis for this report, these 1,200 stands were consolidated into nine general vegetation categories. These categories are defined in Exhibit 2-62.

Exhibit 2-62

General Vegetation Categories and Groups

Category	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 almost exclusively of native species.
Gallery Forest with Exotic Understory	Mature cottonwood forests with primarily non-native trees and shrubs growing below the canopy.
Mixed Riparian and Upland	Native-dominated forests and shrublands mixed with riparian (cottonwood or coyote willow) and upland (juniper or rabbitbrush) species
Mixed Native and Exotic Riparian	Riparian forests or shrublands composed of both native and non-native species.
Exclusively Exotic Spp.	Dense stands of almost exclusively non-native woody vegetation.
Xeric Shrubland	Dry sites dominated by scrubland or grassland vegetation and with few riparian species.
Xeric Woodland	Dry sites with deep sandy soils. Often cottonwood with sparse Russian olive, rabbitbrush, Juniper and grass understory.
Group	
Agricultural	Farmlands or orchards.
Highly Disturbed	Borrow pits and/or massive disturbance (e.g., fire).
Open Water	River

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

The total area of riparian vegetation mapped varies widely across the sub-reaches; from as little as 87-acres in Orilla Verde to as many as 1,966-acres in the Lower Chama (Exhibit 2-63).

Exhibit 2-63

Total Area of Riparian Vegetation Mapped in Each Sub-Reach

Sub-Reach	Total Acres
Upper Chama	455
Lower Chama	1,966
Orilla Verde	87
Pilar	240
Velarde	496
Total	**3,244***

*** Excludes agricultural lands, highly disturbed areas, and open water.**

Exhibit 2-64 and Exhibit 2-65 show the relative proportion of major vegetation categories within and across the different project area sub-reaches. The existing data indicates that the Velarde and Lower Chama Sub-Reaches contain a relatively high proportion of *Gallery Forest* vegetation compared to other Sub-Reaches. The data indicate that the Orilla Verde Sub-Reach supports the greatest proportion of vegetation categorized as *exclusively exotic species,* although the highest proportion of vegetation in that sub-reach is still considered *Native riparian.* The Upper Chama and the Pilar Sub-Reaches also support relatively high proportions of *Native riparian* vegetation.

Xeric (*shrubland* and *woodland*) vegetation is relatively common throughout the project area, but differs between sub-reaches whether *shrubland* or *woodland* are proportionately more dominant. For example, the Pilar and Velarde Sub-Reaches each have proportionally more *Xeric Woodland* than *Xeric Shrubland,* while the opposite is true for the other three sub-reaches.

Xeric woodland along the Lower Rio Chama Sub-Reach.

Upland species including rabbitbrush and big sage grow along side coyote willows on terraces within the Upper Chama Sub-Reach.

Mixed riparian and upland communities are most common in the Upper Chama and, as mentioned previously, typically involve blending of coyote willow with rubber rabbitbrush on the lower (T-2) terraces, and relic cottonwoods mixing with juniper and big sage on the higher (T-1) floodplain terraces.

Mixed native and exotic riparian types are relatively common in all of the sub-reaches except within the Upper Chama. The data indicate that *Marsh* vegetation is proportionally more common in the Orilla Verde and Lower Chama Sub-Reaches, but overall this vegetation category is poorly represented across the project area. This is also true for *Alkali meadow* vegetation.

Exhibit 2-64

Proportion of General Vegetation Categories Across Project Sub-Reaches

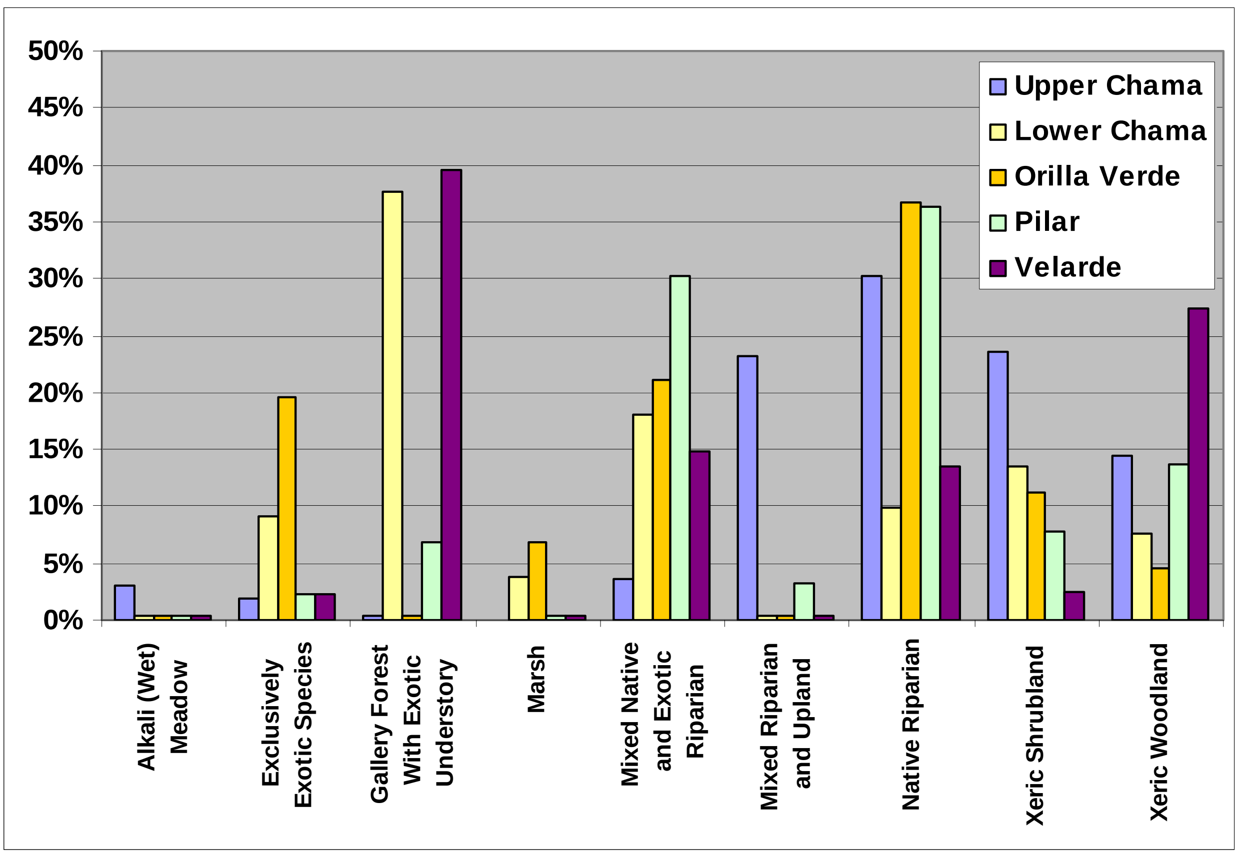


Exhibit 2-65

Proportion of General Vegetation Types by Sub-Reach

Sub-Reach	General Type	Acres	Percent of Sub-Reach
Upper Chama	Alkali (Wet) Meadow	13.8	3
	Exclusively Exotic Species	8.7	2
	Marsh	0.2	0
	Mixed Native and Exotic Riparian	16.1	4
	Mixed Riparian and Upland	105.7	23
	Native Riparian	137.7	30
	Xeric Shrubland	106.9	23
	Xeric Woodland	66.0	14
	Upper Chama Total:	**454.9**	
Lower Chama	Exclusively Exotic Species	178.6	9
	Gallery Forest With Exotic Understory	741.7	38
	Marsh	75.1	4
	Mixed Native and Exotic Riparian	353.5	18
	Mixed Riparian and Upland	8.0	0
	Native Riparian	194.6	10
	Xeric Shrubland	265.6	14
	Xeric Woodland	149.2	8
	Lower Chama Total:	**1,966.2**	
Orilla Verde	Exclusively Exotic Species	16.9	20
	Marsh	6.0	7
	Mixed Native and Exotic Riparian	18.3	21
	Native Riparian	31.8	37
	Xeric Shrubland	9.6	11
	Xeric Woodland	4.0	5
	Orilla Verde Total:	**86.6**	
Pilar	Exclusively Exotic Species	5.4	2
	Gallery Forest With Exotic Understory	16.4	7
	Mixed Native and Exotic Riparian	72.4	30
	Mixed Riparian and Upland	7.6	3
	Native Riparian	86.9	36
	Xeric Shrubland	18.6	8
	Xeric Woodland	32.6	14
	Pilar Total:	**239.9**	

Exhibit 2-65
Proportion of General Vegetation Types by Sub-Reach

Sub-Reach	General Type	Acres	Percent of Sub-Reach
Velarde	Exclusively Exotic Species	11.2	2
	Gallery Forest With Exotic Understory	196.5	40
	Mixed Native and Exotic Riparian	73.6	15
	Native Riparian	67.2	14
	Xeric Shrubland	11.9	2
	Xeric Woodland	135.9	27
	Velarde Total:	**496.4**	
	GRAND TOTAL:	**3,244.1**	

18 What is the vegetation structure within the different sub-reaches?

The vegetation mapping for the project area utilizes the vegetation classification system adopted by Hink & Ohmart (1984). In addition to naming discreet stands of vegetation according to dominant overstory and understory trees and shrubs, Hink & Ohmart also classified these stands according to the percent cover at different heights in the aerial canopy. The amount of cover in different canopy layers is used in the classification system to characterize the vegetation *structure type*. These structure type definitions were slightly modified in 2002 by Reclamation for use with URGWOP, and are displayed in Exhibit 2-66.

Monotypic saltcedar stands are common along narrow riparian areas of the Orilla Verde Sub-Reach.

By far the most prevalent vegetation structure in the Orilla Verde riparian zone is dense shrubs or young trees less than 20 feet tall (Structure Type 5). Vegetation structure begins shifting towards taller trees with dense understory vegetation further downstream. The existing data indicate that Forest Structure Types 1 and 3 are most prevalent, and relatively proportional in the Velarde Sub-Reach (Exhibit 2-67).

The data indicate a similar growth pattern downstream along the Rio Chama. Riparian vegetation structure in the Upper Chama Sub-Reach mostly retains a shrub-like stature (Structure Types 5 and 6). Downstream of Abiquiu Dam, the floodplain vegetation is dominated by 20 to 40 foot tall trees with dense understory vegetation (Structure Type 3; see Exhibit 2-66 and Exhibit 2-67).

Exhibit 2-66

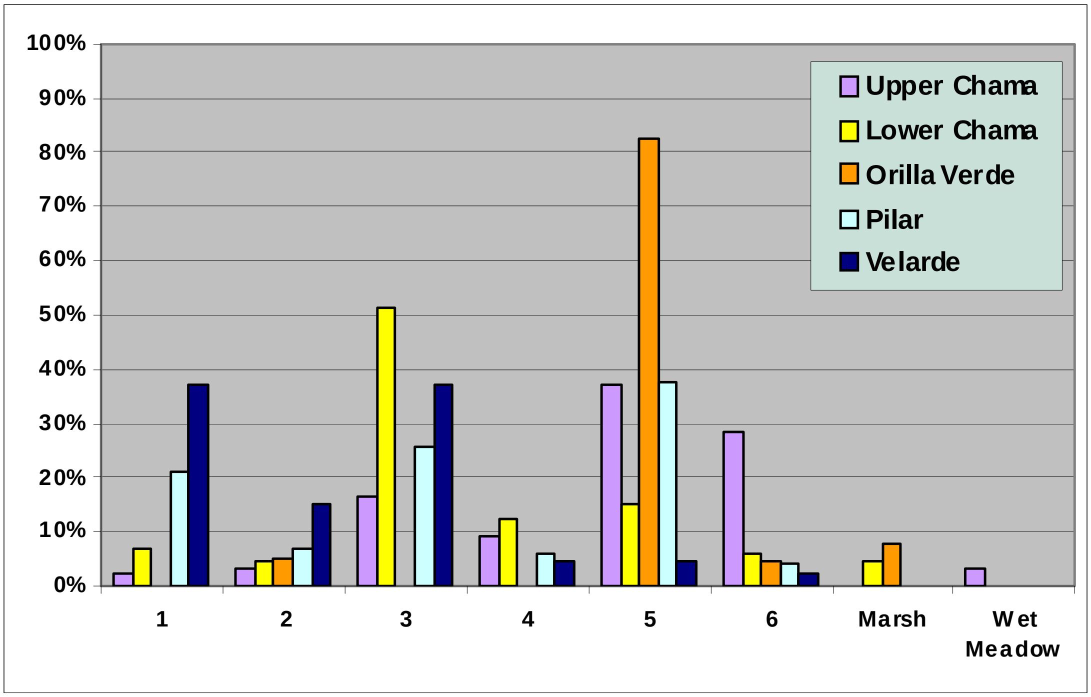
Hink and Ohmart Vegetation Classes

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 or young trees with medium density
5	<20	<25	50–75	Dense shrubs or young trees
5f	<20	<25	>75	Very dense shrubs or young trees
6	<20	<25	<25	Sparse and/or very young shrubs/trees

The structure types displayed here are a modified version of Hink and Ohmart (1984) vegetation type naming convention. It 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).

Exhibit 2-67

Vegetation Structure Distribution by Sub-Reach



19 What are the dominant floodplain/riparian plant species in the project area?

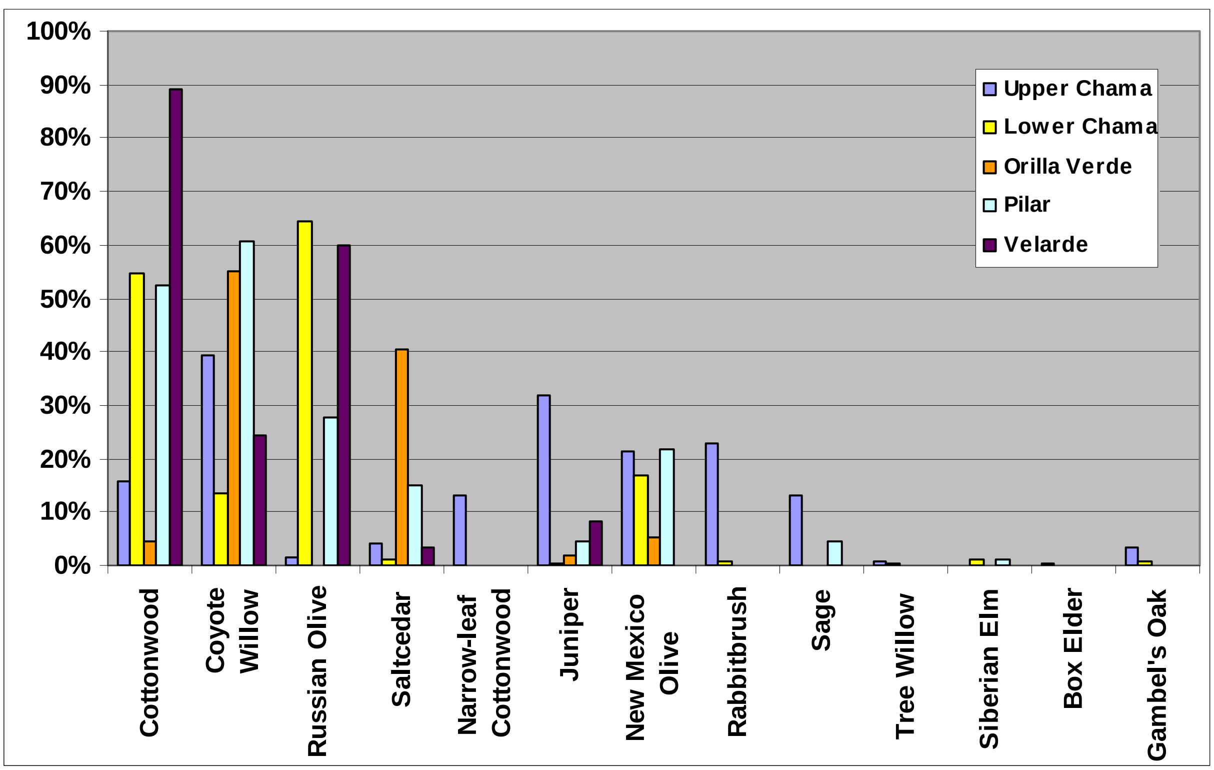
Cottonwood, coyote willow and Russian olive comprise proportionately the greatest cover of all species in the floodplain across different sub-reaches. Along the Rio Grande, coyote willow and saltcedar are the most dominant species in the Orilla Verde riparian zone. As one proceeds downstream to the Pilar Sub-Reach, coyote willows continue to dominate, but the available data indicate that Russian olive, New Mexico olive (*Forestiera pubescens*, var. *pubescens*) and cottonwood become increasingly prevalent. Further downstream in the Velarde Sub-Reach, the available data indicate that saltcedar and coyote willows become far less common than cottonwood and Russian olive (Exhibit 2-68) although limited field observations reveal that some stands, particularly upstream of some of the diversion dams, support notable amounts of both Goodding's and coyote willow.

Dense stands of coyote and Goodding's willow were observed in the Velarde Sub-Reach upstream of one of the diversion dams. Rio Grande cottonwood and Russian olive were also very common at this site.

Coyote willow is the dominant species occupying the channel bars and active floodplain along the Upper Chama Sub-Reach. Upland species like rubber rabbitbrush encroached onto the lower (T-2) floodplain terraces, and grow along side of coyote willow. On the higher (T-1) terraces, big sage co-occurs with relic stands of Rio Grande cottonwood (*Populus deltoides*, var. *wislizeni*) and narrowleaf cottonwood (*P. angustifolia*). Juniper and New Mexico olive were observed occurring on both T-2 and T-1 surfaces (Exhibit 2-69). Combined, these species comprise a relatively high proportion of mapped vegetation along the floodplain in Upper Chama Sub-Reach (Exhibit 2-68).

Exhibit 2-68

Relative Proportion of Dominant Plant Species in Project Area Sub-Reaches



The relative proportions of different plant species is based upon analysis of available data. Extensive field verification has only been performed for the Orilla Verde Sub-Reach.

Exhibit 2-69

Juniper Trees Encroaching onto a T-2 Floodplain Terrace Along the Upper Chama

The Lower Chama Sub-Reach supports comparably vast acreage and a high relative proportion of cottonwood gallery forest. The gallery forests, however, are almost all relic stands and few young trees occupy the floodplain. Cattle graze below most of the cottonwood gallery forests in this sub-reach and the understory on these mostly private lands are dominated by xeric, upland herbs and shrubs. Russian olive is the most common species along the low lying terraces that border the river channel, and along with mature cottonwood, Russian olive is the most dominant species in the reach. Coyote willow is also present, but occurs in widely scattered, disjunct populations. In some locations, however, coyote willow stands are remarkably robust, especially in close proximity to some of the diversion dams, where they form very dense stands and achieve heights of 15 to 20 feet (Exhibit 2-70).

Exhibit 2-70
Examples of Robust Coyote Willow Stands

Robust stands of coyote willow along the Lower Chama, just upstream of the diversion dam near River Mile 21.

Dense stands of mixed riparian vegetation, including coyote willow along the Lower Chama at the diversion dam near River Mile 24.6.

Russian olive dominates the low lying terraces along extensive segments of the Lower Chama. Discharge in this photo is approximately 1,800 cfs.

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Chapter 3 Species Biology and Habitat Ecology

Southwestern Willow Flycatcher

The southwestern subspecies of willow flycatcher (flycatcher, *Empidonax traillii extimus*) is one of two special status animals of particular emphasis to the Program. It is listed under both federal and State of New Mexico regulations as Endangered and, because it breeds exclusively in riparian habitats, is viewed as an important indicator of the health of these ecosystems.

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

1 What are the general biological characteristics of the flycatcher?

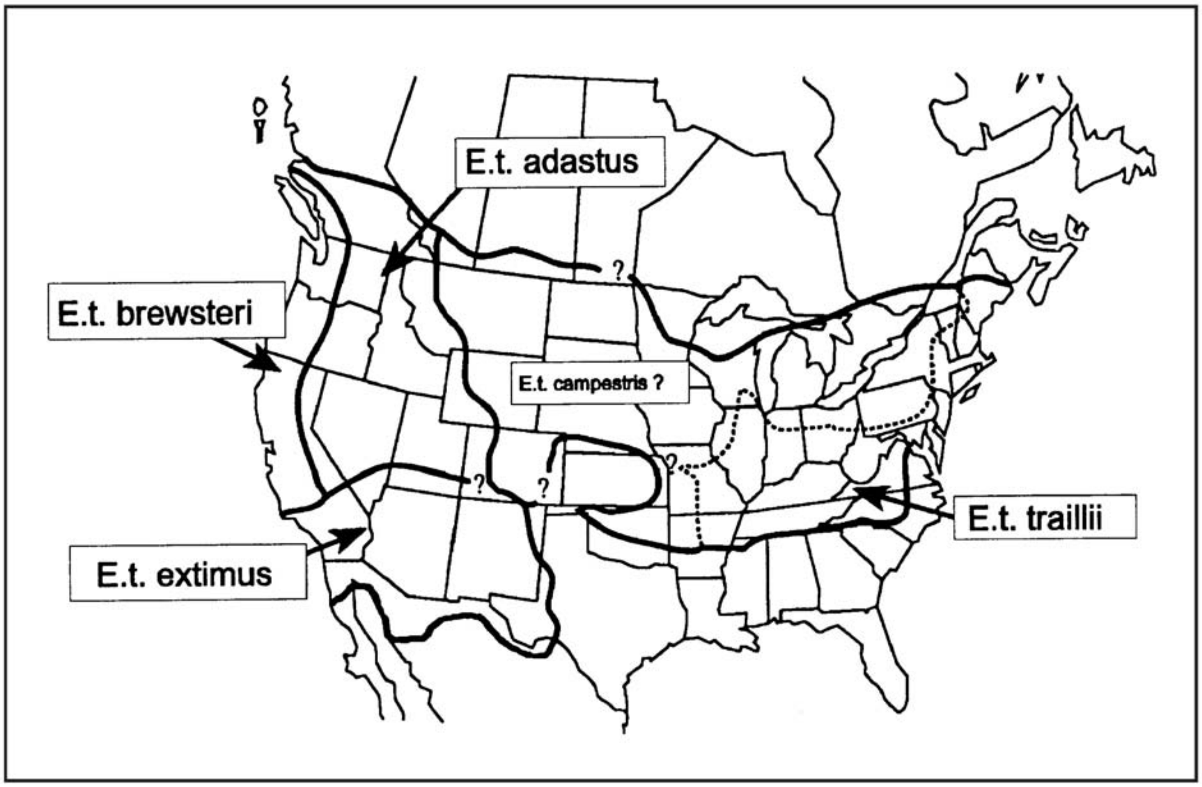
The flycatcher is a small perching bird, about 15 cm (6 inches) long. It is gray-green on its back, with a whitish throat and grey breast, a pale yellow belly, and two light-colored wing bars. The genus *Empidonax* has 11 North American species, most of which are extremely difficult to tell apart with visual characteristics. Positive identification is therefore made by the song of this bird (see sidebar).

> The primary song of all subspecies of willow flycatchers is usually described as a “fitz-bew.” Fitz-bews can sound differently based on subspecies and geographic area. Though the flycatcher has several other calls, the fitz-bew is the song that positively identifies this species. The geographic area is the key identifier for subspecies. (Link to page above for recordings of these songs.)

The Southwestern willow flycatcher has a generally recognized breeding range that includes New Mexico, Arizona, west Texas, southern California, southern Nevada, and southern Utah, southwestern Colorado, and extreme northwestern Mexico (Exhibit 3-1). 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 (Sogge et al., 1997). The flycatcher life span is 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).

Exhibit 3-1

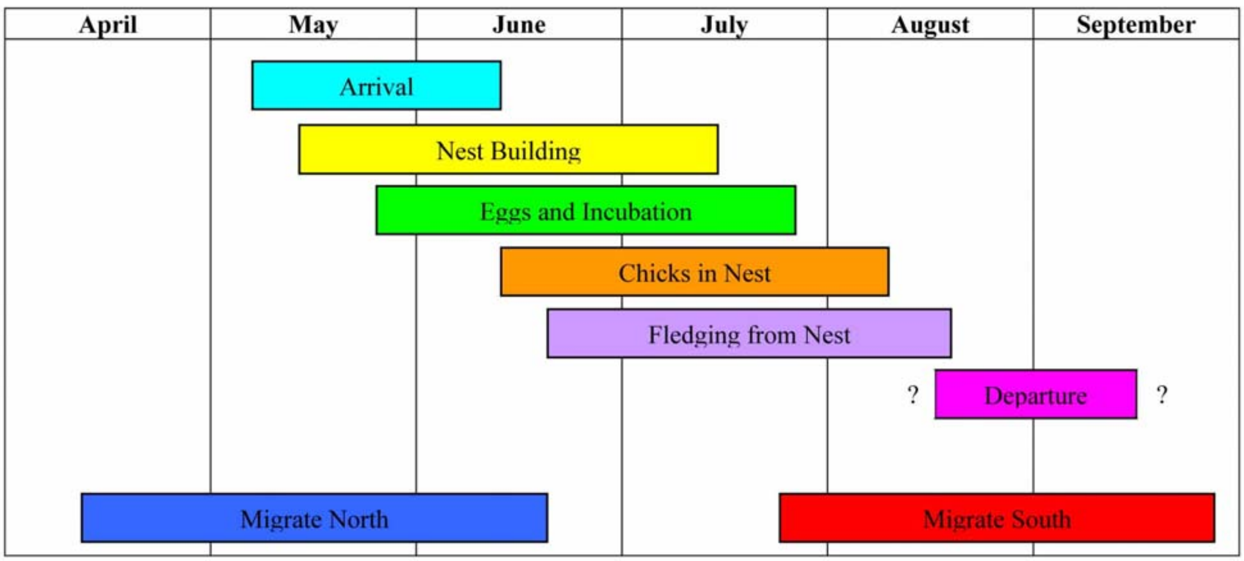
Breeding Range of the Willow Flycatcher Subspecies (Modified from Unitt [1987] and Browning [1993])



Flycatchers winter in Mexico, Central America, and northern South American and begin to arrive on New Mexico breeding sites in early May. Individual birds show some site fidelity, tending to return to the same general breeding area each year, but not necessarily to the same nesting site or territory (FWS, 2002). The reasons for this may have to do with the quality of habitat as it ages, and has implications for the conservation of the species and potential restoration efforts. Some individuals migrate to new breeding areas, occasionally in entirely different watersheds (FWS, 2002; Paxton et al., 2007). Males usually arrive a week or so ahead of females and yearlings, and begin to establish territories. 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 3-2), and the birds spend the fall, winter, and early spring on their wintering grounds.

Exhibit 3-2

General Nesting Chronology for Southwestern Willow Flycatchers in NM[1]



[1] *Adapted from BOR and COE, 2003; Sogge, 2000; and FWS, 2002.*

2 Why was the flycatcher declared endangered?

Although the reasons for the decline of the flycatcher (see Exhibit 3-3) are *"numerous, complex, and interrelated"* (FWS, 2002), threats to the species can be summarized under four major headings:

a. Loss or modification of habitat.
b. Changes in the abundance of other species.
c. Vulnerability of small populations.
d. Migration and winter range stress.

Exhibit 3-3

Reasons for the Decline of the Southwestern Willow Flycatcher

Reason for Decline	Specific Elements	Notes
Loss or Modification of Riparian Habitat	Dams and reservoirs, groundwater diversions, stream modifications (channelization and levees), grazing, fire, recreation, agricultural development, and urbanization.	All of these factors have led to reduced water, changes in riparian vegetation species and structure, changes in the prey base, and overall riparian health. ***Loss of Riparian Habitat is BY FAR the most important factor***.
Changes in the Abundance of Other Species	Exotic species, brood parasitism by brown-headed cowbirds.	Decreases in native plant vigor have opened the door for non-natives (esp. saltcedar) which are less preferred habitat.
Vulnerability of Small Populations	Demographics, Genetics.	Isolated populations have led reduced productivity and vulnerability to floods, fire, etc.; Low populations have led to low genetic variation.
Migration and Winter Range Stress	Land Conversion.	Very little wintering habitat is protected, and it's often converted to non-suitable uses.

Of the factors summarized above, loss of habitat is by far the most important, and drives many of the other factors. Reversing this trend also forms the core of the recovery plan, which includes a "dropdown outline" of actions to guide the recovery (FWS, 2002). Since listing, a number of protective regulations for flycatchers have been promulgated, including the species recovery plan (FWS, 2002), the critical habitat designation (FWS, 2005), and the MRG BiOp (FWS, 2003a).

3 What steps does the recovery plan recommend to recover the flycatcher?

The first step of the recovery plan outlines the need to *"increase and improve currently suitable and potentially suitable habitat."* Importantly, the recovery plan recognizes the connection between habitat, and the hydrologic elements that make it possible, emphasizing the need to restore the physical integrity of rivers, shallow water tables, surface water flow, and the movement of sediments and nutrients in a manner consistent with a more natural flow regime. Next, the recovery plan focuses on restoring the vegetation communities associated with suitable habitat, while recognizing that available water will typically be far below optimal.

Steps to improve flycatcher habitat would require increasing availability of surface water in active channels and in the near channel area. The recovery plan indicates that water purchases or other acquisition procedures, coupled with other water management strategies, would be required to promote a comprehensive recovery of the species.

The recovery plan additionally reminds us that, because agricultural withdrawals from rivers and groundwater are relatively large, the agricultural community must become part of developing any long-term solution. This recovery plan also indicates that, where dams are primarily flood control structures, releases of storage volumes should be undertaken to achieve flood scour and lower flows over longer periods to help maximize groundwater recharge and maintain surface flow downstream. One goal of dam operations, diversions, and groundwater pumping can include producing low-level in-stream flows to maintain surface flow and the associated wetted perimeter during low flow periods.

The flycatcher recovery plan indicates that, where possible, releases of storage volumes from flood control dams should be undertaken to achieve both flood-scouring processes and maintain base-flows over longer periods to help maximize groundwater recharge and maintain some surface flow downstream.

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

The flycatcher was listed as federally endangered in 1995. As well as being federally and state-listed, 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*.

The Rio Grande, from the headwaters in Colorado to the Pecos River confluence in Texas, supports at least 10 percent of the range-wide total for identified flycatcher territories, with the vast majority now confined to the MRG (FWS, 2002; Moore and Ahlers, 2006b).

5 What constitutes nesting habitat for flycatchers?

Though there are differences in the characteristics of nesting, migration, and wintering habitat, this report is primarily concerned with nesting habitat. Although all stages of a species life history are important, nesting is arguably the most critical element. In addition, flycatchers do not winter in U.S. territory; and migration habitat is used only briefly.

Elements of Nesting Habitat

Nesting habitat along the Rio Grande usually has the following characteristics:

- It is close to (often immediately above) still or slow-moving water, or saturated soil.
- It is usually patchy, with thickets of willow interspersed with open water or meadows, and overstory trees. Flycatchers seldom nest in mature cottonwood (*Populus* spp.) gallery forests.
- The willow or other vegetation thickets that actually hold the nest are very dense, especially in the lowest 10 to 13 feet (3 to 4 meters [m]) above the ground, and they are usually wider than 33 feet (10 m). Flycatchers are generally not found nesting in narrow strips of riparian vegetation.
- There is frequently a multi-storied structure to the site, with well-developed under-, mid-, and over-stories.
- Native vegetation usually comprises at least 50 percent of the vegetation present.

Other flycatcher sites, such as those along the Gila River in New Mexico, do not necessarily follow all the elements of this model.

6 How much habitat do flycatchers need?

Patch Size

Patch size and territory size vary markedly across sites, drainages, and states. A “patch” of territory is a contiguous grouping of similar habitat which, in the case of flycatchers, generally refers to clumps of suitable riparian vegetation. Patch sizes with occupied nesting territories range from 0.25 acre to

The average patch size used as the breeding territory by a single pair across its entire range is 2.7 (± 0.2) acres (FWS, 2002). This figure is often used as a standard in discussing how much habitat and how many birds a particular patch of habitat could support.

175 acres (Cooper, 1997, as cited in FWS, 2002). The *mean* size of the total patch of vegetation where nesting flycatchers are found is 21.2 acres, though the *median* is relatively smaller, 4.4 acres; an indication that a few larger sites tend to skew the mean. Mean patch size of breeding sites supporting 10 or more flycatcher territories is 62.2 acres.

Many flycatchers do not nest singly, however. Flycatchers have been described as *"semi-colonial"* (McCabe, 1991) because, where habitat patches are large enough, many pairs may nest in close proximity. In addition, areas with more than one nest have a higher likelihood of maintaining birds over time.

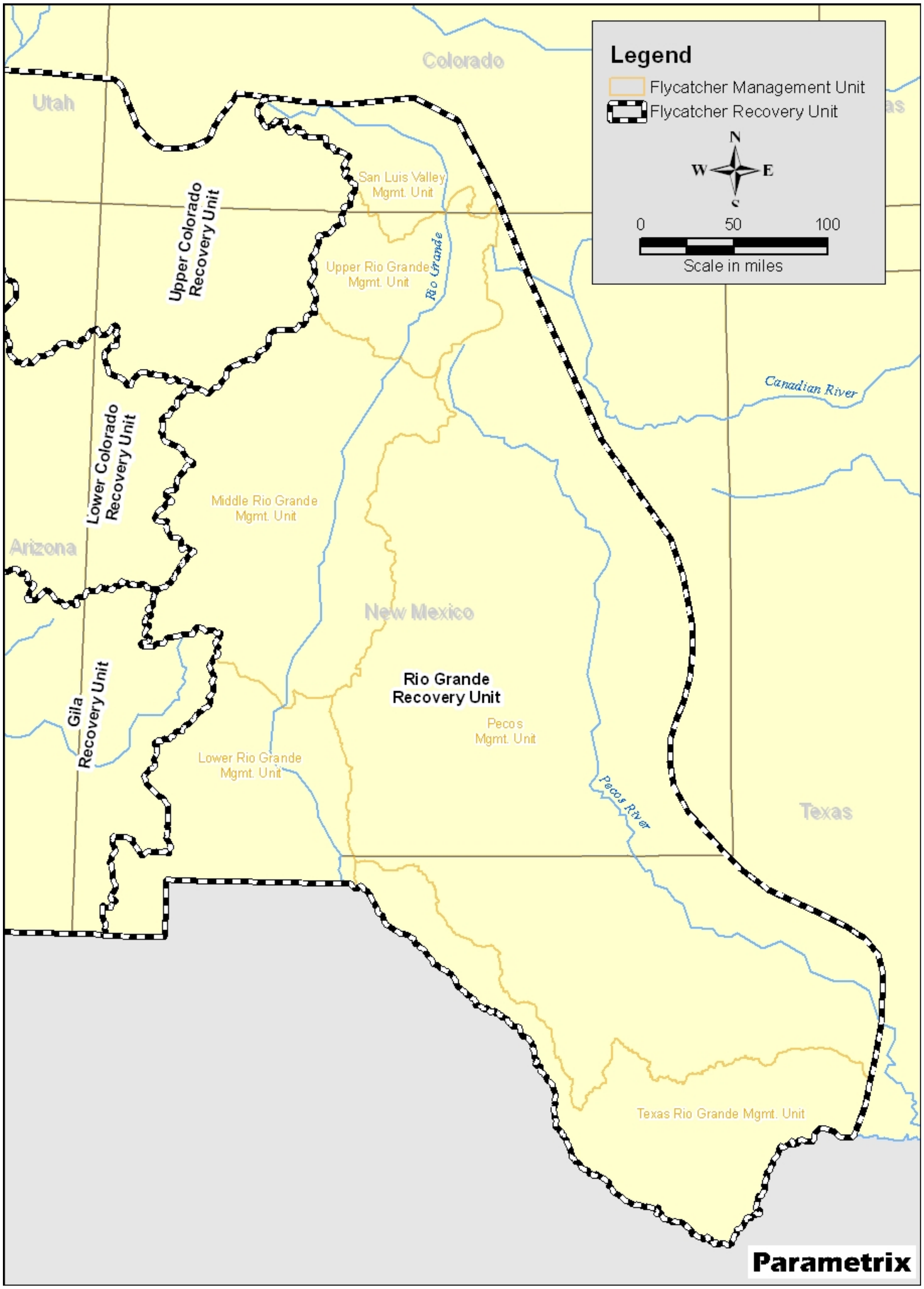
The amount of habitat needed per pair of breeding flycatchers varies based on local and regional factors (FWS, 2002). The species recovery plan includes the recommendation that, until these factors can be better quantified, **doubling the amount of breeding habitat required to support the target number of flycatchers can help assure that displaced flycatchers will have habitats in which to settle, even in the event of a catastrophic loss of local habitat. That is, based on a range-wide review of riparian patch sizes for flycatchers that gave an average of 2.7 acres of dense riparian vegetation for each flycatcher territory found within the patch, delisting would require that twice this amount of breeding habitat (i.e., 5.4 acres) be protected for each flycatcher territory.** The Biological Opinion recommends blocks of habitat in excess of 60 acres should be restored. As we will see elsewhere in this report (i.e., entire flycatcher section of Chapter 4), this goal is not feasible in the Velarde Reach.

The Biological Opinion recommends blocks of habitat in excess of 60 acres be restored. As we will see elsewhere in this report, this goal is not feasible in the Velarde Reach.

Under this requirement, using the recovery plan's goal of 75 breeding pairs in the Upper Rio Grande Management Unit (Exhibit 3-4) would require 405 acres in total of **protected** dense riparian vegetation along the Rio Grande south of Otowi Bridge to Elephant Butte Dam. This Unit also includes Bluewater Creek from headwaters to Bluewater Dam in western New Mexico.

Exhibit 3-4

The Upper, Middle, and Lower Rio Grande Management Units within the Rio Grande Recovery Unit (FWS, 2002)



Native Versus Exotic Vegetation

In 2001, habitats for approximately half of the flycatcher nesting territories documented throughout its range consisted of greater than 90 percent native plants (Sogge et al., 2003). Approximately 90 percent of the 2001 territories were in habitats dominated by willow (*Salix* spp.) or, in the Gila-Cliff Valley, box elder (*Acer negundo*). Many sites, however, are dominated by non-native saltcedar (*Tamarix* spp.). Nesting success is similar in native or saltcedar-dominated habitats (Sferra et al., 2000).

A flycatcher nest in coyote willow.

Flycatchers generally weave their nests onto small-diameter stems and twigs, typically in upward-pronged, multi-twig “cup” structures (McCabe, 1991). This type of twig structure is readily found among 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 (this element of habitat is an important aspect of the ecology of flycatchers in the Velarde Reach and is further discussed in Chapter 4, Section 4). 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).

7 Are habitat characteristics on the Rio Grande similar to those in other parts of the flycatcher’s range?

There is more data available on flycatcher habitat from the Middle Rio Grande Management Unit than for the Upper Rio Grande Management Unit. This may be due to agency priorities and/or the fact that so much of the land within the Upper Rio Grande Management Unit is privately owned and more complicated to coordinate access. From our qualitative assessment, general habitat characteristics are similar in both Management Units, so it’s not unreasonable to make inferences about Upper Rio Grande birds from data collected further south. Nesting flycatchers on the Rio Grande generally select thickets of willow with a scattered overstory of cottonwood (FWS, 2002), in the midst of native or non-native plant communities. For the actual nest itself, the flycatchers along the MRG select either native vegetation (usually coyote or Gooding's willow) or non-native vegetation (usually saltcedar or Russian olive) (Moore and Ahlers, 2003; White, 2006; Exhibit 3-5). Ahlers et al. (2002:S-5) suggested 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, data from the MRG indicate that Goodding's willow is also a preferred nesting substrate (White, 2006; Exhibit 3-5.)

Exhibit 3-5

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

Moore and Ahlers (2006b) summarized several key relationships at successful flycatcher nests:

- 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 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 to 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.
- 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).

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)

8 What are the characteristics of migratory and wintering habitat?

Flycatchers migrating between breeding and wintering grounds must replenish their energy (fat) stores to complete their migration (Yong and Finch, 1997), and the riparian woodlands along the Middle Rio Grande appear to be important stopover habitat for this purpose. The most common riparian woodlands used as stopover habitat exhibit a relatively open overstory with dense middle and lower stories, close proximity to water, and presence of native willows or non-native Russian olives (*Eleagnus angustifolia*) (Yong and Finch, 1997) or saltcedar. Migration stopover habitat may be drier than breeding habitat, and the patches may be narrower than breeding patches (Moore and Ahlers, 2003, 2004, 2005, 2006a, 2006b). The most common native vegetation used as stopover habitat by migrating flycatchers is coyote willow (*Salix exigua*).

"Early Successional" Environment

Riparian plants, like willow and cottonwood, are pioneer, "early successional" species because they are the first plants to occupy bare, moist soils after a flood.

Unless the site is periodically disturbed by subsequent floods, pioneer riparian plant communities will be replaced by later successional species that are less dependent upon flooding for reproduction.

On their wintering habitat in Central and South America, subspecies tend not to segregate (M. Whitfield, unpublished data). In general, wintering habitats have a mosaic of understory and overstory and have persistently wet conditions, and large concentrations of insects over the entire winter period

(Koronkiewicz et al., 2006). In many parts of the neo-tropics, these types of habitat are not uncommon, and tend to be concentrated in the plains along both coasts. In this regard, habitat tends to differ from that found strictly in the Southwest, where moist riparian habitat tends to be concentrated along interior rivers. However, wintering habitats in Latin America also tend to not be legally protected, and are subject to changes in land use, or even total conversion (M. Whitfield, pers. comm.).

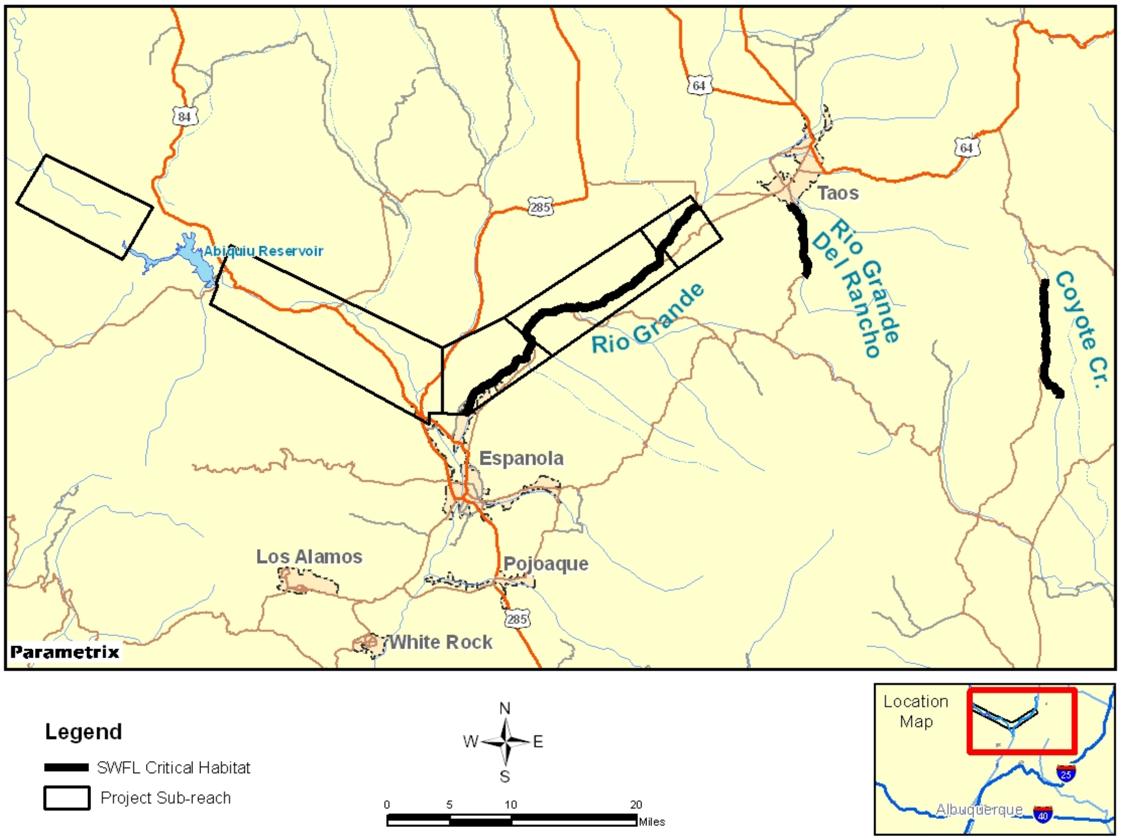
9 What is critical habitat, and where is critical habitat for flycatchers in the Velarde Reach?

In October 2005, the FWS designated critical habitat for Southwestern willow flycatcher, which included river segments within the Velarde Reach and other sites outside of the Middle Rio Grande in northern New Mexico (FWS, 2005). Critical habitat is defined by the ESA as *"the specific areas …on which are found those physical or biological features essential to the conservation of the species and that may require special management considerations or protection."* This designation may include areas not currently occupied by the species at the time it is listed. Critical habitat is legally protected under the ESA.

Critical habitat in northern New Mexico includes three disjunct river segments totaling 1,640 acres along 41 river miles. The Rio Grande segment includes the entire 29.5 river miles of the Rio Grande from the Taos Junction Bridge downstream to the upstream boundary of the Ohkay Owingeh Pueblo. The two other areas designated critical habitat occurs outside of the project area. One is a 6.5 mile reach of the Rio Grande del Rancho that extends from Sarco Canyon downstream to the Arroyo Miranda confluence. The other is a 5.8 mile reach of Coyote Creek extends from about 1 mile above Coyote Creek State Park downstream to the second bridge on State Route 518, upstream from Los Cocas. All of these fall within the Upper Rio Grande Management Unit, as designated by the flycatcher recovery plan (Exhibit 3-6).

Exhibit 3-6

Areas in the Upper Rio Grande Management Unit Designated as Critical Habitat for the Southwestern Willow Flycatcher



10 Where have flycatcher nests been detected in the project area?

Surveys by Reclamation and others have been conducted in the Velarde Reach since at least 1993 (Exhibit 3-7). Though habitat patches and population numbers are small (thus warranting caution in interpreting trends), surveys generally show a declining population. In the early to mid 1990's several sites had reliable sightings of from one to three flycatcher territories, and approximately 7 active territories in the project area as a whole. Since approximately 1998, however, there have been no more than two territories detected and, in many years, zero. La Canova, a moderate sized wetland on the west bank of the Rio Grande that once was a fairly reliable site for up to three pairs of birds, has not had a nesting pair of flycatchers since 2001.

Data concerning nesting territories should be interpreted with care, as sample sizes are relatively small, and survey methods, survey effort, and surveyor experience was not always consistent from year to year. We did not attempt to inspect all of the original data sheets, relying occasionally on summary data provided by federal and state agencies, and personal communication from local experts. In addition, some reports, surveyors, and data sheets refer to "territories" and some refer to "nesting pairs." While these are not technically the same thing, for this report, we considered a nesting territory to be a site where either 1) an active nest was found; 2) where male and female birds were found together, or 3) where a singing male was present through the breeding season. In the latter two cases, it is reasonable to assume that a nest is present, although this may not always be the case. Time and budget constraints often preclude rigorous nest searches. Even though singing birds themselves are relatively easy to find, nests are not, and nest searching is often not done when it means sacrificing the search for more territories. For many years of surveys, especially before survey protocols were firmly established and disseminated, it's possible that some workers considered a site to be a "nesting territory" only when a nest was found.

Nesting Territory

For this report, we considered a nesting territory to be a site where either (1) an active nest was found; (2) where a male and female bird were found together, or (3) where a singing male was present through the breeding season.

11 What inferences, if any, can we draw about willow flycatcher population trends in the project area?

Given that survey effort was not always consistent, it is difficult to make strong inferences concerning willow flycatcher population trends in the project area. Even with the inconsistent data and data gaps however, there are several things that we may say with some confidence:

- The largest patches of the most likely habitat have been surveyed, most of them repeatedly, since 1993. There are no large patches of habitat harboring dozens of birds that are going to be found in the project area.
- Willow flycatcher detections have never been abundant in the Upper Rio Grande Management Unit.

- Willow flycatcher numbers fluctuate from year to year and from territory to territory within the Management Unit and within the project area.
- Perhaps most importantly for this report: some sites that formerly held fairly reliable willow flycatcher territories, no longer have them.

What we don't know is: what happened to these birds? Did they move to other territories within the project area or the Management Unit, or does this reduction in numbers represent a real overall decline in local abundance? It is plausible that some flycatchers may have relocated their territories to other suitable habitat patches within the Velarde and Lower Rio Chama Sub-Reaches. Access to the river in these sub-reaches, however, is difficult because most of the land is privately owned and navigating the river is complicated by the numerous diversion dams. A concerted outreach effort to private landowners may be required to validate the degree to which flycatchers are still utilizing suitable habitat patches in these sub-reaches.

The process of flycatchers moving from one habitat patch to another is a natural phenomenon. A species such as the flycatcher could not have evolved and adapted in a dynamic riparian ecosystem without being able to adapt to the changing conditions that characterize Southwestern river systems. In addition, the flycatcher's dependence on early- to mid-successional riparian plants for nesting means that their nesting areas will naturally mature past suitability.

That said, the system that flycatcher currently inhabit cannot be considered "natural" anymore. Before large-scale changes dampened spring flows and reduced the area of floodplain wetlands, flycatchers inhabited an ecosystem that was considerably more dynamic, with new wetlands and groves of riparian willows constantly replacing those that matured. Disturbance that regenerated habitat, a necessary component of the flycatcher's ecology, has been all but lost along the Upper Rio Grande and Rio Chama.

On a more positive note, there are some areas of wetlands that have been expanding and providing additional habitat for the flycatcher. Ohkay Owingeh, in particular, has been very proactive in enhancing riparian habitat and providing additional nesting areas for flycatchers. They are, in essence, “picking up the slack” for much of the Upper Rio Grande Management Unit. Nevertheless, the concentration of birds into fewer areas should be looked at. It is nearly always “safer” biologically for a species to be distributed into more and more-widely separated habitats. In the following chapters, we discuss some ways in which habitat in historic areas might be reclaimed or regenerated.

Exhibit 3-7

Flycatcher Nesting Territories in the Velarde Reach and Other Upper Rio Grande Sites (1993 to 2008)

Site Name	Drainage	Ownership	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
VELARDE REACH SITES																		
El Guique	Rio Grande	Private	ns	ns	ns	1	1	1	ns	0	ns	0	ns	ns	ns	ns	ns	ns
Garcia Acequia	Rio Grande	Private	ns	ns	1	1	1	1	1	0	0	0	ns	0	0	0	0	0
La Canova	Rio Grande	Private	ns	1	3	3	2	0	0	1	1	0	ns	0	0	0	0	0
La Rinconada	Rio Grande	Private	ns	ns	2	0	2	1	1	1	0	0	ns	1	0	0	0	0
Orilla Verde	Rio Grande	Federal	2	1	1	2	1	0	0	0	0	0	1	0	2	0	0	2
Taos Jct Bridge	Rio Grande	Federal	1	0	ns	1	ns	0	ns	0	0	0	0	0	0	0	0	0
OTHER UPPER RIO GRANDE SITES																		
Ohkay Owingeh	Rio Grande	Tribal	2	4	4	12	10	ns	ns	16	ns	ns	ns	11	10	13	12	16
Los Ojos 95 Bridge	Chama	Private	ns	ns	1	3	ns	ns	ns	ns	4	ns	ns	1	ns	ns	ns	0
Parkview Fish Hatch	Chama	State	2	4	1	2	4	3	ns	ns	0	ns	ns	ns	ns	ns	ns	ns
Coyote Creek	Canadian	State	2	3	3	3	2	4	ns	3	ns	1	ns	ns	ns	ns	0	0
Guadalupita Bridge	Canadian	Private	ns	1	3	1	2	4	ns	6	1	2	ns	1	2	ns	0	3
Guadalupita North	Canadian	Private	ns	ns	ns	ns	ns	ns	ns	8	ns	ns	ns	ns	ns	ns	0	0
La Cueva	Canadian	State, Private	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	1	2	ns	ns
Mora	Canadian	Private	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	1	2	1	ns	ns	ns
Ponil Creek	Canadian	Private	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	4	ns	ns	1	2	1
Tierra Azul	Rio Grande	Federal	5	3	ns	2	1	2	3	4	4	5	4	3	4	5	3	ns
		Totals:	**14**	**17**	**19**	**31**	**26**	**16**	**5**	**39**	**10**	**8**	**10**	**19**	**20**	**21**	**17**	**22**

Notes: *ns = No survey done.*

This table reflects only the sites for which we were able to review data and do not reflect the total birds in the Upper Rio Grande Management. For example, the 34 territories noted in for 2006 in the Management Unit (see Exhibit 3-8) include data to which we did not have access.

12 What are the criteria for down-listing and de-listing the flycatcher from the threatened and endangered species list?

In order to maximize the distribution of viable populations, the recovery plan defines specific recovery targets for the entire species range. The plan delineates six Recovery Units: Coastal California, Basin and Mojave, Upper Colorado, Lower Colorado, Gila, and Rio Grande. Recovery Units are large geographic areas or watersheds. The Recovery Units in turn are divided into Management Units, which are smaller, more discrete watersheds or river reaches. For example, the Rio Grande Recovery Unit consists of the San Luis Valley Management Unit in Colorado, the Upper, Middle and Lower Rio Grande Management Units in New Mexico, and Pecos Management Unit (also in New Mexico).

The Velarde Reach is within the Upper Rio Grande Management Unit of the Rio Grande Recovery Unit. The recovery plan sets specific goals for each overall Recovery Unit and also for each Management Unit. The recovery plan also outlines two sets of possible criteria (A and B) whereby the species could be down-listed to Threatened or removed from the list entirely (de-listed):

Under Criteria A, three individual elements need to occur if the species is to be down-listed:

- Surveys must detect at least 1,950 territories that are geographically well-distributed, and maintained for at least 5 years.
- Each Management Unit must reach at least 80 percent of its target.
- Each Recovery Unit must reach 100 percent of its goal.

For the Upper Rio Grande Management Unit (of which the Velarde Reach is a part), the goal is 75 pairs of flycatchers. Eighty percent of this goal (that which is needed under Criteria A for downlisting) would mean that 60 pairs need to be detected. As of 2006 (the last year in which a rigorous effort was made to summarize known territories by Management Unit), 34 pairs were known to breed in the Upper Rio Grande Management Unit (see Exhibit 3-8).

Exhibit 3-8

Known Breeding Pairs by Management Unit

Management Unit	Known	Goal	Minimum (80%)
San Luis Valley	54	50	40
Upper Rio Grande	**34**	**75**	**60**
Middle Rio Grande	185	100	80
Lower Rio Grande	7	25	20
Texas	0	0	0
Pecos	0	0	0
Rio Grande Recovery Unit Total:	**280**	**250**	**250 (100%)**

By 2006 estimates, the Upper Rio Grande Management Unit is 26 pairs short of the 80 percent minimum goal, and 41 pairs short of the overall target goal. Using the figure of 5.4 acres per territory for habitat restoration:

- 5.4 acres x 41 (goal) territories = 221.2 acres restored.
- 5.4 acres x 26 (minimum) territories = 140.4 acres restored.

The recovery plan provides a mechanism whereby the tally of breeding pairs necessary to meet recovery goals may be shuffled among Management Units. In other words, a particular Management Unit does not need to meet its specific target per se if another Management Unit within the same Recovery Unit “picks up the slack” by exceeding its target – that is, provided that the total target for the Recovery Unit is still met. However, each Management Unit must maintain a minimum number of pairs (i.e., 80 percent of its goal).

Whether or not this theoretical 221 acres (or 140 acres) exists in the Upper Rio Grande Management Unit is discussed in Chapter 4.

Under Criteria B, three individual elements need to occur if the species is to be down-listed:

- Surveys must detect at least 1,500 territories that are geographically well-distributed, and maintained for at least 3 years.
- Each Management Unit must reach at least 50 percent of its target.
- Each Recovery Unit must meet at least 75 percent of its goal.

These are less stringent criteria (1,500 versus 1,950 territories; 50 percent of Management Unit target versus 80 percent of Management Unit target; and 75 percent of Recovery Unit goal versus 100 percent of Recovery Unit goal). **However, in order to be down-listed under Criteria B, the habitats that support these territories must be legally protected.** This, in fact, may make Criteria B more difficult to achieve than Criteria A.

For the Upper Rio Grande Management Unit, the goal is still 75 pairs of flycatchers. However, 50 percent of this goal would mean that only 38 pairs need to be detected (see Exhibit 3-9). This is very close to the actual number of birds that were present in 2006. However, not all of these sites are legally protected.

Exhibit 3-9
Flycatcher Recovery Progress in the Rio Grande Recovery Unit

Management Unit	Known	Goal	Minimum (50%)
San Luis Valley	54	50	25
Upper Rio Grande	**34**	**75**	**38**
Middle Rio Grande	185	100	50
Lower Rio Grande	7	25	13
Texas	0	0	0
Pecos	0	0	0
Rio Grande Recovery Unit Total:	**280**	**250**	**188 (75%)**

The Criteria for De-Listing are:

- Criteria A levels of territories need to be detected.
- These habitats need to be legally protected.
- The effectiveness of this protection needs to be demonstrated for at least 5 years.

13 Why is flycatcher habitat restoration in the Velarde Reach important?

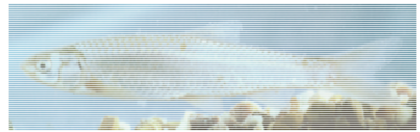
For several reasons the Velarde Reach may be particularly important for flycatcher recovery. As explained previously, the segment of the Rio Grande between Taos Junction Bridge and the upstream boundary of Ohkay Owingeh Pueblo is designated critical habitat for the flycatcher (FWS, 2002). There is particular interest by management agencies, therefore, to explore habitat restoration opportunities in this reach segment.

Furthermore, for several years flycatchers have been actively nesting in riparian habitats immediately downstream of the project area on Ohkay Owingeh (near the Rio Chama/Rio Grande confluence). In fact, the habitat at Ohkay Owingeh supports the largest concentration of nesting flycatchers along the Rio Grande north of Elephant Butte Reservoir. Researchers in Arizona banded and tracked movements of breeding flycatchers over a ten year period and found that the majority of adult birds nested less than 8.5 miles from the previous year’s nest location. Young birds establishing their first territory typically did so within 13 miles from their natal sites (Paxton et al., 2007). While dispersal distance is largely influenced by the proximity of suitable habitat, these data support the notion that flycatcher habitat restoration in the Velarde Reach could facilitate territorial expansion upstream of the existing Ohkay Owingeh flycatcher population.

The Velarde Reach is also important for the Program to facilitate down-listing (and eventually de-listing) the flycatcher from the federal endangered species list. As discussed in the previous section, restoration of stable flycatcher populations across all Management Units within the Rio Grande Recovery Unit is not only important for preventing jeopardy from federal or state management actions, but down-listing and de-listing ultimately requires meeting population recovery goals set for each individual Management Unit (FWS, 2002; G. Beatty, FWS, personal communication). In other words, regardless of how many nesting pairs occur further downstream near the Elephant Butte Reservoir delta (which falls within the Middle Rio Grande Management Unit), the flycatcher will remain a federally listed species until all other Management Units, including the Upper Rio Grande Management Unit, also attain their recovery goals.

One of the pillars of conservation biology is that more widely distributed populations are less susceptible to extinction than tightly bunched populations (Meffe and Carroll, 1997). Factors such as disease, weather, predators, natural fluctuations in habitat succession, and other unknown events cause populations and habitat to wax and wane. This is especially true for a species like the flycatcher that appears to use relatively young successional habitat. For this reason, the recovery strategy for this species emphasizes maintaining viable populations in all Recovery Units and in all Management Units. Even though the Upper Rio Grande and the Velarde Reach do not contain as much habitat or as many flycatchers as other areas, the area is an important link in the chain of flycatcher population viability.

Rio Grande Silvery Minnow



Rio Grande silvery minnow
Photo Credit: Michael Hatch

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 [NMGF], 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 increase of the silvery minnow population (Tetra Tech, 2004a).

The biological characteristics, as well as the known or suspected habitat relationships of the silvery minnow, are discussed in the reach-specific habitat assessments for San Acacia and Isleta reaches of the MRG (Parametrix, 2008a, 2008b). This assessment for the Velarde Reach project area includes, for completeness, many points from those two discussions. Many of the discussions in the following subsections, however, have been updated with the emerging understanding of habitat relationships for this species and with additional information of specific importance to the Velarde Reach project area.

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

Size: The Recovery Plan (FWS, 2007) reports that silvery minnows rarely exceed 100 millimeters (mm) in *total length* (ca. 4 in.). Dudley et al., (2005) reported that the standard length (SL) of most silvery minnows captured in the MRG typically ranges from about 40 to 60 mm (1.6 to 2.4 inches). Remshardt (2008) reports captures of silver minnows with a maximum length of 82 mm SL. Hatch and Gonzales (2008) report collecting female silvery minnows with a maximum length of 85 mm SL.

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).

Total length includes the distance from the tip of the snout on a fish to the end of the caudal fin.

Life Span: The 1999 Recovery Plan for silvery minnow states that their *"[m]aximum longevity is about 25 months and very few fish survive more than 13 months"* (FWS, 1999, page 20). That is, based on MRG collections of silvery minnows from the mid-1990s to the mid 2000s, 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 (FWS, 2007). Silvery minnows of age 2 or older typically comprised less than 10 percent of the spawning population (FWS, 2003b). Collections from the 1800s, however, indicate that at least some historical silvery minnow populations included individuals up to 5 years of age (Cowley et al., 2006). Also, laboratory cultures find silvery minnows commonly living up to about 5 years of age (K. Buhl, USGS, personal communication, 2006).

Gravid female Rio Grande silvery minnow, approximately 4 inches in length, Spring 2008. Photo Credit: Michael Hatch

Silvery minnows spawning has been reported to peak from mid to late May in various recent reports; but apparently may peak from April to June based on the historical hydrographs for spring runoff peaks.

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

Spawning can continue with lower numbers of eggs being 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 in the MRG is unknown, but 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). Some hypothesize that snowmelt runoff on the order of 2,500 cfs to 3,000 cfs over a period of approximately 5 days may represent the lower threshold necessary for producing appreciable silvery minnow recruitment (M. Porter, BOR,

Silvery minnow spawns triggered by monsoonal peak flows may not necessarily trigger either significant egg production or significant recruitment of young silvery minnows into the population.

personal communication, 2007). Data published by Dudley and Platania (2007c) indicate that silvery minnow recruitment is significantly improved when peak flows at Albuquerque exceed approximately 4,000 cfs and flows greater than 3,000 cfs are sustained for more than 30 days.

As mentioned previously, 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 appear to produce significant silvery minnow recruitment in the Middle Rio Grande (Dudley and Platania, 2007a).

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.

Egg Characteristics: Spawning silvery minnows broadcast eggs (i.e., pelagic release) that are slightly negatively buoyant and are kept in suspension by minor currents, including those generated by winds (Dudley and Platania, 1999). These eggs may be spawned into water columns of the channel if that is the only aquatic habitat available. Alternatively, eggs may be spawned within inundated floodplains, backwaters, and vegetated shorelines whenever such habitats are available. When these eggs are released or are washed into floodplains, minimal downstream displacement of eggs and developing larvae occurs (BOR and USACE, 2003).

Food Habits and Feeding: The placement of the silvery minnow mouth on the lower front (sub-terminal) portion of the head indicates that they are adapted to feed primarily along the channel bottoms and across other substrates (Sublette et al., 1990). Their comparatively longer intestine for fishes of their sizes indicates a particular reliance on vegetative and detrital material that is more difficult to digest (Sublette et al., 1990). Based on information from closely related species, laboratory observations, and stomach content assessments, larval and adult silvery minnows are opportunistic omnivores, with diets including diatoms, algae, larval insect skins, small invertebrates, plant materials, and detrital bottom sediment (Sublette et al., 1990; Shirey, 2004; Cowley et al., 2006;

Larval and adult silvery minnows are opportunistic omnivores, with diets including diatoms, algae, larval insect skins, small invertebrates, plant materials, and detrital bottom sediment.

K. Buhl, USGS, personal communication, 2006; Magaña, 2007). However, diatoms, which contain high-energy oils, may be a particularly important food source for all life stages, especially during early life stages (Shirey, 2004; Cowley et al., 2006; Magaña, 2007).

Swimming Ability: Although silvery minnow, like most riverine species, appear to prefer quieter waters, they do have relatively strong swimming abilities (Bestgen et al., 2003). The maximum swimming speed for minnows is about 3.9 feet/second (fps) (120 centimeters [cm] per second) and their anaerobic threshold is in the range of 1.5 to 2.0 fps (45 to 60 cm/s), depending on water temperature. The anaerobic threshold is the point where swimming exercise causes oxygen deficits and lactic acid accumulations to begin to develop in the muscles. Based on endurance studies, silvery minnows can swim 31 miles or more in 72 hours, or approximately 0.63 fps (20 cm/s), depending on water temperature.

Depending on water temperature, laboratory studies show that silvery minnows can swim 50 km or more in 72 hours, or about 20 cm/s (0.63 fps).

15 Why were silvery minnows listed as endangered?

The decline of silvery minnows in the Rio Grande probably began in 1916 when the gates were closed on Elephant Butte Dam (FWS, 1994); the first of the major mainstream dams constructed within the silvery minnow's habitat. The decline of silvery minnow populations has been commonly attributed to river fragmentation caused by these impoundments, modifications of stream discharge patterns, channel desiccation caused by water diversion for agriculture, and stream channelization (Bestgen and Platania, 1991; Cook et al., 1992; Dudley and Platania, 2007; FWS, 1994; FWS, 2007). Additional factors hypothesized to have contributed to their decline include diminished water quality caused by municipal, industrial, and agricultural discharges; non-native species competition or predation; and possibly other factors (FWS, 1994; FWS, 2007). These constraints appear to limit the distribution of the remaining silvery minnow population to about 5 percent of their former range—the reach of the MRG from Angostura Diversion Dam downstream to near the headwaters of Elephant Butte Reservoir (FWS, 1994; FWS, 2007).

Declines in the silvery minnow populations have been primarily attributed to modification of stream discharge patterns and channel desiccation, water diversion for agriculture, and stream channelization.

The listing of silvery minnows as endangered was also based on their extirpation from the Pecos River during the same period that the introduced plains minnow (*H. placitus*) became a dominant fish species in that river. The plains minnow is a fish species having the same taxonomic genus as the silvery minnow. It is believed they were introduced into the Pecos River around 1968, likely after being collected from the Arkansas River drainage for use as “bait” in the Pecos River. Plains minnows are considered more tolerant then silvery minnows of the modified habitat conditions now occurring in the Pecos River (FWS, 1994). Specifically, habitat alteration and flow modification are thought to have also contributed to extirpation of the silvery minnow from the Pecos River.

16 What recovery goals have been defined for silvery minnows?

The FWS 1999 Recovery Plan (FWS, 1999) for silvery minnows establishes the recovery goals as 1) stabilizing and enhancing populations of Rio Grande silvery minnow and its habitat in the Middle Rio Grande valley, and 2) reestablishing the Rio Grande silvery minnow in at least three other areas of its historic range.

The FWS 2007 Draft Revised Recovery Plan (FWS, 2007) for silvery minnows refines the original recovery goals to include:

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

b. Recover the Rio Grande silvery minnow population to an extent that is sufficient to change its status on the List of Endangered and Threatened Wildlife from e*ndangered* to *threatened* (downlisting).

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

The Draft Revised Recovery Plan defines a set of criteria under each of the three goals. Of particular note are the criteria under the first goal and first objective:

- Document the presence of Rio Grande silvery minnows (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); or
- 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.

The silvery minnow recovery plan considers the Albuquerque, Isleta, and San Acacia reaches of the MRG to be co-equal in importance in terms or recovery priorities.

Downlisting (Goal 2) for the Rio Grande silvery minnows may be considered when three populations (including at least two that are self-sustaining) have been established within the historical range of the species and have been maintained for at least 5 years.

Delisting (Goal 3) of the species may be considered when three self-sustaining populations have been established within the historical range of the species and have been maintained for at least 10 years.

The Draft Revised Recovery Plan (FWS, 2007) also calls for the establishment of two additional populations of Rio Grande silvery minnows outside of its current range of the Middle Rio Grande. The FWS indicates that doing so will require the development of additional water management strategies to help ensure suitable habitat for the species. Areas highlighted in the recovery plan outside of the MRG as having the greatest potential for successful reintroduction of silvery minnows include the Rio Grande from Presidio to Amistad Reservoir, particularly including the Big Bend area; the Rio Grande between Amistad Reservoir and Falcon Reservoir; and the Pecos River downstream from Sumner Dam.

17 What is the known distribution and present status of the silvery minnow population?

Historically, silvery minnows were one of the most common fish in the Rio Grande (FWS, 1994). Until the 1950s, silvery minnows were distributed throughout many of the larger order streams of the Rio Grande Basin upstream of Brownsville, Texas and north into New Mexico to an elevation of approximately 5,500 feet (1,676 m). This elevation coincides with the approximate vicinities of Abiquiu on the Chama River, Velarde on the Rio Grande, and Santa Rosa on the Pecos River (FWS, 2006). Sampling data from recent decades indicate the species currently occupies only about 5 percent of its historic range (Platania 1993; FWS, 1994; FWS, 2007). Currently, the entire wild population is thought to be 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; FWS, 2007).

Silvery minnows were once the most common fish in the Rio Grande from Brownsville, Texas to northern New Mexico, but now they are found in only about 5 percent of that historical range, limited to the MRG of NM.

Upstream of the present day Cochiti Reservoir on the Rio Grande there are few historic records indicating collections of silvery minnows—only 38 known specimens of the species have been reported from four collections made between 1874 and 1978 (Bestgen and Platania, 1991; see also Exhibit 3-10). To our knowledge, no collections after that date included specimens of silvery minnow. As described in the next section, no silvery minnows were collected in either the 1984 or 2004 fish sampling surveys conducted upstream of Cochiti Reservoir (Bestgen and Platania, 1991; Buntjer and Remshardt, 2005). Neither study, however, included sampling sites on the Rio Chama upstream of Abiquiu Reservoir. No documented earlier fish collections are known to have included this reach. Available information is insufficient to define how far the silvery minnow population once extended upstream in either the Rio Grande or Rio Chama. It is generally thought they would not survive in the Rio Grande much upstream of Velarde due to the canyon conditions upstream. Discussions with members of the Ohkay Owingeh have suggested that large populations of silvery minnow once existed in the waters of the Rio Grande and Rio Chama along their pueblo, and that the silvery minnow population once extended up the Rio Chama, at least to the vicinity of where the monastery is now located.

Throughout the existing historical records, there have few collections of silvery minnows from the Rio Grande drainage upstream of the present day Cochiti Reservoir.

Exhibit 3-10

Known Collections of Rio Grande Silvery Minnow Upstream of the Present Day Cochiti Reservoir (data provided by M. Hatch)

River	Date	Collector	Location
Rio Chama	15-Apr-1949	W. Koster	4 MI E OF ABIQUIU – T23N R06E
Rio Grande (Upper)	02-Jun-1875	E. Cope	SAN ILDEFONSO – T19N R08E
Rio Grande (Upper)	07-Aug-1943	W. Koster	1 MI W OF SAN ILDEFONSO – T19N R08E
Rio Grande (Upper)	09-Aug-1978	M. Sublette	1 MI SW OF VELARDE – T22N R09E

18 What is the present status of the overall fish community in the project area?

A general survey of fish species in the Rio Chama and Rio Grande above Cochiti Lake was conducted during mid-August 1984 (Bestgen and Platania, 1991). This survey included: 1) single visit collections made at three sites on the Rio Chama between Abiquiu Reservoir and its confluence with the Rio Grande; 2) three sites on the Rio Grande from this confluence upstream to Velarde; and 3) a single site each near Española and San Ildefonso. Sampling locations were selected to represent a variety of habitat types, including main and secondary channels, runs, riffles, backwaters, eddies, pools, borrow pits, and flood and irrigation canals. This survey did not sample deeper water areas or other habitats inaccessible to the 3-m × 3-m seines used during the survey (Bestgen and Platania, 1991). Also, the 1984 survey did not include a quantitative assessment of available habitat (Buntjer and Remshardt, 2005).

In 2004 the FWS and the New Mexico Department of Game and Fish conducted fish surveys and habitat assessment studies at two sites on the Rio Chama (upstream of the Highway 233 Bridge and upstream of the Highway 285 Bridge) and three sites on the Rio Grande (Alcalde, Española, and confluence with Buckman Arroyo). The intent of the 2004 collections was to assess the absence or presence of silvery minnow at the sites and to evaluate the potential suitability of these reaches as potential reintroduction sites for silvery minnows (Buntjer and Remshardt, 2005).

The fishery in the Rio Grande upstream from Cochiti Reservoir and into the Rio Chama can be generally characterized as dominated by cool- and cold-water fish species and predominated by species that spawn on cobble substrates. No silvery minnow were collected in either the 1984 or 2004 studies upstream of Cochiti Reservoir; none of the species collected had spawning characteristics similar to those for silvery minnows.

In general, the Rio Grande above Cochiti Reservoir and the Rio Chama both have been characterized as being dominated by cool- and cold-water fish species (FWS, 1999; Platania, 1991; Bestgen and Platania, 1991; Buntjer and Remshardt, 2005). During both the 1984 and 2004 surveys, four native minnow species (Rio Grande chub, fathead minnow, flathead chub, longnose dace) and one introduced species (white sucker) numerically dominated most collections from upper reaches of the Rio Grande and the Rio Chama upstream from Cochiti Reservoir (Exhibit 3-11). Three of these native minnow dominants (i.e., Rio Grande chub, flathead chub, and longnose dace) are indicative of relatively clear, cool, fast flowing water. They are all also cobble-dependent (i.e., epilithic) spawners. The forth native dominant, the fathead minnow, is typically considered a warm-water species. It is commonly collected with silvery minnows in reaches downstream of the Angostura Diversion Dam. Fathead minnows spawn sticky, attached eggs. None of the fish species collected during either the 1984 or the 2004 surveys have a reproductive strategy similar to silvery minnows and no silvery minnows were collected.

Several differences were observed between the two surveys. Non-native common carp, smallmouth bass, rainbow trout, and brown trout were more common in the 2004 collections (Exhibit 3-11). The use of electrofishing along with seines may account for the capture of greater numbers of larger fish during 2004 (Buntjer and Remshardt, 2005). The 1984 collections depended only on seining.

Exhibit 3-11

Fish Species Collections at Sampling Sites Upstream from Cochiti Reservoir in 1984 and 2004

Family and Species	Common Name	Origin	1983 Collections[1]			2004 Collections[2]		
			Chama Sites to Rio Grande	Rio Grande Sites Velarde to Chama	Rio Grande Sites Chama to Cochiti	Chama Sites to Rio Grande	Rio Grande Sites Velarde to Chama	Rio Grande Sites Chama to Cochiti
CATOSTOMIDAE (suckers)								
Carpiodes carpio	river carpsucker	RGN	–	–	17	1	21	16
Catostomus commersoni[3]	white sucker	NMN	314	124	100	95	149	263
Catostomus (Pantosteus) plebeius	Rio Grande sucker	RGN	2	4	–	–	–	–
CENTRARCHIDAE (sunfishes)								
Lepomis (Chaenobryttus) cyanellus[3]	green sunfish	USN	2	–	1	–	–	–
Lepomis macrochirus	bluegill	RGN	–	–	–	–	–	1
Micropterus dolomieu	smallmouth bass	USN	–	–	–	–	76	14
Micropterus salmoides salmoides	largemouth bass	USN	–	–	6	–	1	1
CYPRINIDAE (minnows)								
Cyprinella lutrensis	red shiner	RGN	–	–	6	–	18	8
Cyprinus carpio	common carp	Asia	6	1	5	–	67	106
Gila pandora[3]	Rio Grande chub	RGN	131	293	1	273	1	2
Pimephales promelas[3]	fathead minnow	RGN	115	7	140	140	6	19
Platygobio (Hybopsis) gracilis[3]	flathead chub	RGN	35	17	141	56	8	291
Rhinichthys cataractae[3]	longnose dace	RGN	262	340	457	601	12	89
ICTALURIDAE (bullhead catfish)								
Ameiurus (Ictalurus) melas	black bullhead	NMN	–	–	1	–	1	–
Ictalurus punctatus	channel catfish	NMN	–	–	6	–	12	58
MORONIDAE **(temperate bass)**								
Morone chrysops	white bass	NMN	–	–	–	–	9	8
POECILIIDAE **(livebearers)**								
Gambusia affinis	western mosquitofish	RGN	–	–	4	4	93	101
SALMONIDAE (trouts)								
Oncorhynchus mykiss[3]	rainbow trout	USN	1	–	–	–	–	2
Salmo trutta[3]	brown trout	Europe	–	–	–	2	12	13

Notes: RGN = Rio Grande native; RGN/E = native but extinct species in the Rio Grande of New Mexico; NMN = native of New Mexico, outside Rio Grande; USN = United States native

1 *Bestgen and Platania, 1984.*

2 *Buntjer and Remshardt, 2005.*

3 *Species collected between 1986 to 1996 between El Vado and Abiquiu reservoirs (M. Hatch, 2009, personal communication).*

Other fish community differences were also observed (Exhibit 3-11). Numbers of native Rio Grande chub, fathead minnow, and longnose dace appeared to be markedly fewer in the Rio Grande during the later sampling event. In contrast, population numbers for these native species in the Rio Chama were more similar during both sampling events, or perhaps even greater in the 2004 collections. The native Rio Grande sucker was one of the least frequently collected species (Exhibit 3-11). In contrast, the native western mosquitofish was much more common in the 2004 collections, particularly in the samples from the Rio Grande sites.

19 Where do silvery minnows feed?

Earlier in this chapter we highlighted that detritus, algae, diatoms, and small invertebrates growing along the bottom appear to be the most important foods for silvery minnows. The importance of these benthic food sources should not be confused with their planktonic (free-floating) forms, which are not significant foods for silvery minnows for two reasons. First, neither algae nor diatoms grow particularly well as freely suspended plankton in rivers and streams with turbulent flows. Second, silvery minnows lack morphological adaptations to feed on suspended (planktonic) materials.

The algae and diatom communities, which are among the most important foods for silvery minnows, grow best in rivers having relatively stable substrates for attached growth. Very limited substrate exists in the MRG to support the growth of these attached communities, except when flows velocities are low.

Benthic algae and diatoms, as well as the other microbial and small invertebrate communities they attract, grow best in rivers where there are relatively stable substrates that can be used for attached growth. Common examples of stable substrates in rivers and streams include gravel, cobble, and woody debris. Many of these substrates can also provide locations for attachment or accumulation of drifting leaf litter and fine detritus. All such accumulations can be important sources of food for silvery minnows.

Previous analyses have indicated that general habitat conditions for silvery minnows are in decline due to increasingly channelized conditions and disconnected floodplains along the MRG since the closure of Jemez Reservoir in 1954 and Cochiti Reservoir in 1975 (e.g., Massong et al., 2006; Tashjian and Massong, 2006). Historically, reaches of gravel channel appear to have been once common in the MRG channel (Nelson et al., 1914). The gravel stream bed helped to support the historical presence in the MRG of various native gravel spawning fish, including shovelnose sturgeon (*Scaphirhynchus platorynchus*), Rio Grande sucker (*Catostomus [Pantosteus] plebeius*), blue sucker (*Cycleptus elongates*), gray redhorse (*Moxostoma congestum*), and others (Sublette et al., 1990). Also, large woody debris may have been prevalent in parts of the MRG, as has been reported for many other western rivers (Sedell and Beschta, 1991). Firewood collections, however, appear to have depleted early wood supplies along some reaches of the river, at least in the vicinities of some of the pueblos (Scurlock, 1998). Historical gravel patches have now become covered with accumulated fine sediment, and considerable quantities of wood were removed during channel maintenance activities (see Tetra Tech, 2004a for summary of past channel maintenance activities and its effect in the MRG). But there is no historical evidence to support or refute that either gravel or woody substrates were once important feeding areas for silvery minnows.

Additionally, the historical channel of the MRG included dynamic conditions of regular channel avulsions, considerable channel diversity, and extensive inundation of the floodplain during the spring snowmelt (Crawford et al, 1993). When MRG floodplains inundate during flood flows, the newly flooded organic leaf litter, invertebrates, etc., on the floodplains provide important food supplies and nursery habitats for fish species (Pease et al, 2006). Additionally, algae, diatoms, and the associated microbial communities have potential to significantly colonize newly submerged floodplain substrates within a week or so (depending on water temperatures) and could have historically contributed important food supplies for many fish, including the silvery minnow.

However, in the contemporary channel of the MRG, sand, silts, and clays are the predominant bed material. This is also true elsewhere along the Rio Grande and undoubtedly also true of its historical channel as well. As such, stable sandbed substrates commonly are the predominant feeding habitat for silvery minnows for most of the year. Stable sandbed habitats of particular importance include various small ephemeral side channels that remain wet during lower flow regimes, and small back eddies produced within sandbed ripples and dune faces that form within the main channel during lower flow regimes. Drifting organic materials tend to accumulate in the small pocket eddies. These materials and the adjacent stable sand surfaces then provide growth substrates for algae, diatom, other microbial growths, and small invertebrates, which provide high value as food for silvery minnows and various other fish, as well as habitat and food for invertebrates.

High suspended sediment loads severely limit light penetration and algae and diatom growth during much of the year in the MRG. Therefore, for algal growth to occur on these substrates, water depths need to be sufficiently shallow to allow for light penetration to support photosynthesis and growth. Shallow side channels and shorelines commonly provide much of the area where light can penetrate sufficiently to allow for attach growth and the development of feeding habitat for silvery minnows. During prolonged periods of lower flows, the turbidity levels in the water decrease and allow for light penetration and potential for photosynthesis to increase. At these times, much more of the metastable sandbed can become available substrate for algal growth, enhancing its value as potentially valuable silvery minnow feeding habitat.

Algal growths accumulated along ripple faces on the recently dewatered sandbed of the MRG.

Therefore, during considerable portions of each year suitable feeding habitat for silvery minnows in the MRG is very limited. Higher flows mobilize the sandbed substrate, suspend fine organic materials, and wash away algae and diatom growths. Specifically, flow velocities at the bed of less than about 0.5 ft/s (15 cm/s) are required before the sand beds of rivers can stabilize (SEPM, 1984). Such flows would allow detritus to accumulate and algae and diatoms to grow on the stalled surfaces, whenever suitable light penetration allows.

As flows exceed 0.5 foot/sec in the MRG, much of the potential food supply for silvery minnows within the river channel would be mobilized and flushed downstream. In fact, fine detrital and plant materials can be stirred into motion at flows of an order of magnitude less than that velocity (Fisher et al., 1979).

The adequacy of such areas and overall food resources for silvery minnows in the modern day 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 potential for increasing food production, feeding areas, and recovery of silvery minnow populations.

20 Is the survival of post-spawn silvery minnows limited by the lack of suitable food and feeding habitat, particularly following spring flood flows?

The relationship between flow velocity and the production and availability of food for silvery minnows in sandbed systems naturally leads to questions about where silvery minnows feed when flows in the MRG exceed certain velocities. In particular, where do silvery minnows feed during and after the days, weeks, and months of high velocity springtime flows following their principal period of spawning?

Production of reproductive gametes and the activity of spawning are two of the three most energetically demanding activities in the life cycle of a fish. Maintaining water position during periods of high flows is the third. The co-occurrence of these three activities before and during periods of springtime flows in the MRG would tend to maximize stresses and energy demands on silvery minnows. Potential for adverse impacts due to these stress factors during the major spawning period for silvery minnows in the spring are intensified because these activities occur at the end of the winter during which the production of algae and higher energy containing diatoms have been limited by low temperatures. Thus, after “starving” through the winter, silvery minnows enter the spring with depleted energy stores caused by gamete production, spawning, and behaviorally avoiding being sweep downstream by the high-velocity spring flows.

Before dams and channelization when the MRG river channel and its floodplain were well connected, spring floodwaters could spread across the Rio Grande floodplain often for a mile or more each side of its channel, particularly in the Albuquerque reach and reaches downstream. The extent of such flooding was markedly less in the Velarde Reach, but still notable and of considerable ecological significance. We hypothesize that these flooded habitats were capable of providing extensive refuge habitat for silvery minnow to escape high channel velocities. In some river reaches, these connected floodplains may have served to dissipate channel flows such that even mid channel water velocities were a fraction of what they are today along the channelized and confined sections of the Rio Grande.

Regulation and channelization of spring flood flows between the disconnected floodplain over recent decades has led to a high proportion of premature deaths for many post-spawn, energy depleted silvery minnows in the MRG.

Assuming that silvery minnows moved from the limited confines of the defined channel and on to these broadly inundated floodplains during periods of the spring snowmelt, and other floods, it is then reasonable to hypothesize that extensive silvery minnows feeding would have occurred in these areas having extensively available food resources, as described in the previous subsection. If true, the immediate availability of food resources on the floodplains would have greatly aided the post spawn survival of both the post-spawn adult and newly hatched young silvery minnows in most years. When spring floodwater receded, undoubtedly many silvery minnows would have perished. Also undoubtedly, a relatively significant proportion of the silvery minnow populations in these overbank areas would have found their way back to the river channel with the water draining from the floodplain.

These relationships would tend to support a hypothesis that a major cause of silvery minnow populations decline throughout the MRG is due to limited floodplain inundation and limited access to their major historical springtime feeding habitats and food supplies. This channel-floodplain disconnection would tend to lead to the ultimate consequence for many energy depleted silvery minnows – death. In fact, most reports from the mid-1990s and into the 2000s indicate that very high proportions of silvery minnows die within their first or second year of life, with most mortalities occurring relatively shortly after spawning for either age (e.g., Platania and Dudley, 2003).

The early death of silvery minnows apparently is not necessarily, and may not always have been, the norm. That is, laboratory cultures find silvery minnows commonly living up to about 5 years of age (K. Buhl, USGS, personal communication, 2006). Additionally, historic collections from the 1800s indicate that silvery minnow populations in at least some collections had a more typical (i.e., non-truncated) age-survivorship curve that included individuals up to 5 years of age (Cowley et al., 2006).

Since about 2004 overbanking flows have been more commonly observed. Also, habitat restoration efforts by the Program and others have been increasing. Such habitat changes can provide improved flood-flow and post spawning refuge habitat for silvery minnows by improving feeding habitat and food resources for adult minnows following spawning. These changes could result in enhanced post-spawn survival for greater proportions of the silvery minnow population and theoretically increase proportions of older silvery minnows in the population. These relationships lead us to hypothesize that the disconnection of the active floodplain from the channel, coupled with extensive and persistent habitat drying, are two of the greatest past and present-day threats to silvery minnows along the MRG.

21 Where do silvery minnow spawn?

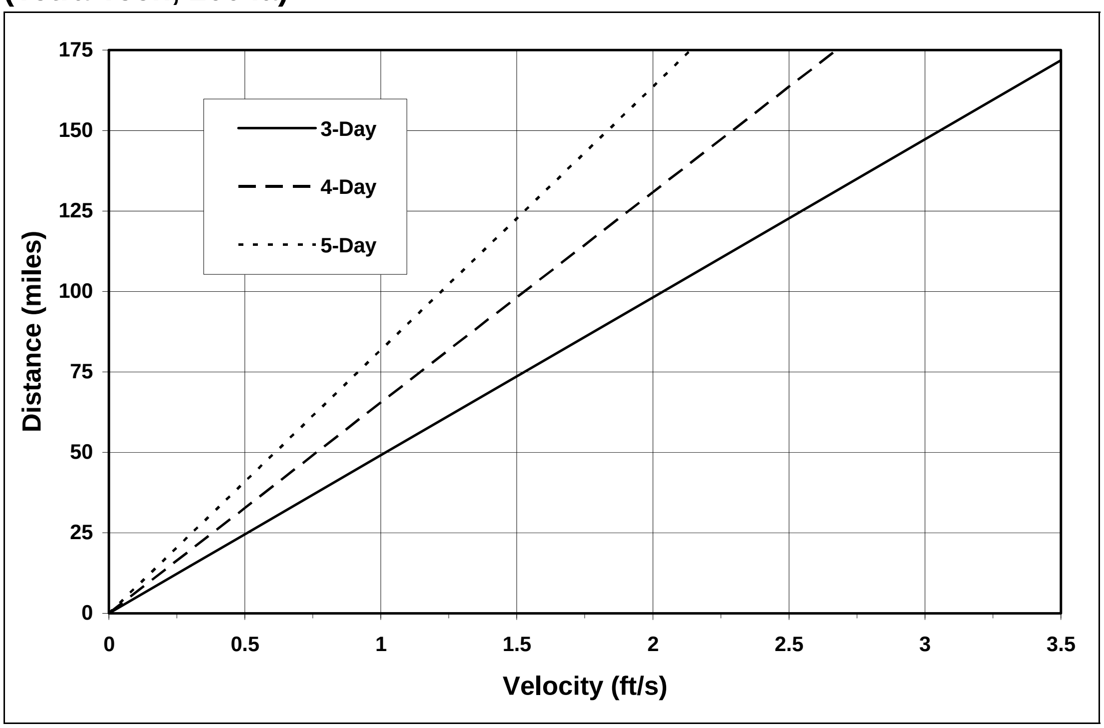
Platania and Altenbach (1998) reported that silvery minnow are pelagic spawners that produce thousands of semi-buoyant, non-adhesive eggs that passively drift downstream while developing. Pelagic (open water column) broadcast spawning can enhance the reproductive success of some fish species by reducing egg burial and suffocation in rivers with shifting sand beds (Araujo-Lima and Oliveira, 1998). This reproductive strategy was well adapted to the predevelopment aquatic habitats of the MRG (BOR and USACE, 2003).

Pelagic spawning evolved in the Rio Grande under channel conditions with greater diversity in flow velocities and floodplain connectivity than are found today. Under the more recent conditions of disconnected floodplains along the MRG;

however, pelagic broadcast spawning often would appear to be detrimental. For example, Platania and Altenbach (1998) estimated that eggs and larvae entrained mid channel in the contemporary Rio Grande could potentially be transported 100 to 200 miles downstream in the 3 to 5 days required for the minnow to develop swimming abilities after fertilization of the eggs. The actual transport distances are unknown, but the distribution of silvery minnows from the mid 1990s to the mid 2000s suggests there was indeed a net downstream displacement of the silvery minnow population. Actual distance of downstream displacement depends on current velocity, and the potential retention of eggs and larvae in quiet water areas, including backwater eddies, side channels, or floodplains (Exhibit 3-12).

Exhibit 3-12

Relationship of Water Velocity to Potential Distance of Egg Transport (Tetra Tech, 2004a)



In addition to providing potential feeding habitat for post-spawn adult silvery minnows and their young, as hypothesized in the preceding section, connected floodplains in the MRG are also considered by some as potentially providing key habitat both for retention of spawned eggs and for providing nursery areas for newly hatched larvae of silvery minnows (e.g., Massong et al., 2004; Hatch and Gonzales, 2008). This perspective is gaining attention, and may partially explain why Program-funded habitat restoration efforts to benefit silvery minnows frequently focus on projects that reconnect the floodplain and off-channel backwater and lateral pool habitats (e.g., SWCA, 2005; Hatch and Gonzales, 2008).

Alternative hypotheses about the role of the floodplain in silvery minnow reproduction have existed since at least 2000 (e.g., Tetra Tech, 2004). Support for that hypothesis subsequently came from observations made during the 2005 silvery minnow rescue efforts by the Fish and Wildlife Service. Rescue efforts to retrieve silvery minnows from drying floodplains that year resulted in collections of high numbers of both adult and young of year silvery minnows (e.g., FWS, 2006). Other recent collections have found relatively high abundances of eggs and young-of-year silvery minnow concentrated along low-rates of water exchange at the edges of over-bank areas, where efforts were unsuccessful at concentrating artificial silvery minnow eggs (M. Porter, USACE, personal communication, 2008; Porter and Massong, 2004; Hatch et al., 2008).

Collections of high numbers of silvery minnow eggs, larvae, and young-of-year in off-channel waters having very low water exchange rates points to the high probability that silvery minnows evolved spawning strategies focused on these environments as one approach to reduce potential downstream displacement and increased survival of their eggs and larvae. Spawning in off-channel habitats has also been observed for other minnow species closely related to silvery minnows (Raney, 1939; Copes, 1975).

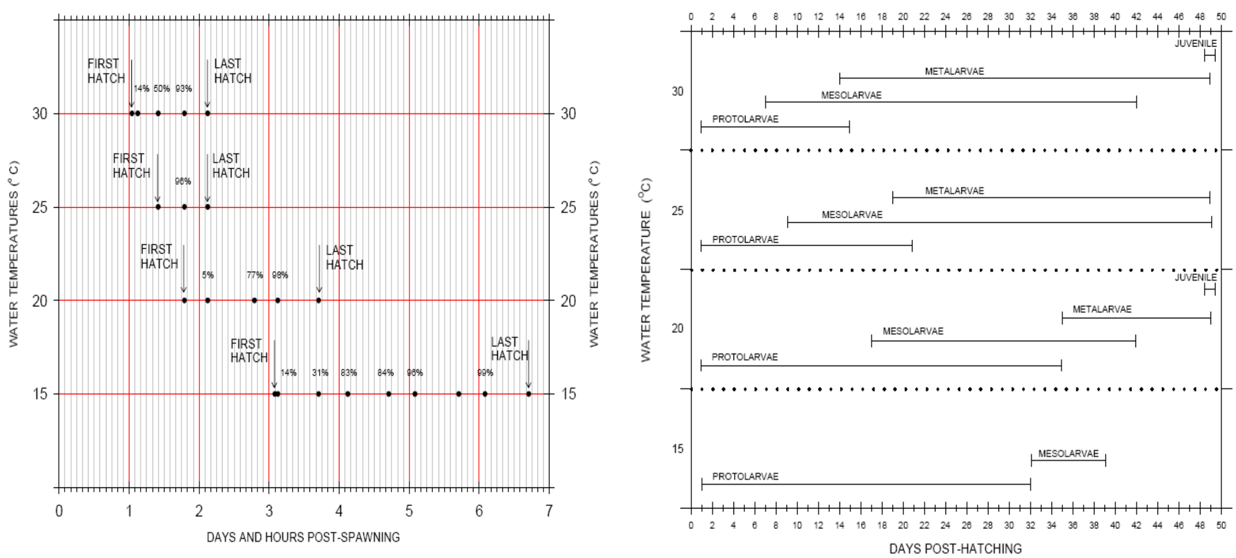
Some have surmised that drift alone may not account for the large collections of young-of-year silvery minnow in some of these floodplain collection areas (Porter and Massong, 2004; Hatch et al., 2008). Instead, it has been hypothesized that silvery minnows may also spawn in backwater and floodplain habitats, when such habitats are available (e.g., Tetra Tech, 2004; Tetra Tech, 2005; Hatch et al., 2008). The evolution of such an adaptation would tend to reduce downstream displacement of eggs and larvae and is generally consistent with observations of spawning habitats used by other silvery minnow species (Raney, 1939; Copes, 1975). Actual spawning locations for silvery minnows, however, remain a point of active speculation, and scientific literature is lacking on the species preferences for spawning habitats (Cowley et al., 2009).

22 How does water temperature affect the early development, survival, and growth rates for silvery minnows?

Effects of four water temperatures (15 degrees Celsius [C] = cold, 20 degrees C = cool, 25 degrees C = warm, 30 degrees C = hot) on survival, growth, and developmental rates of silvery minnow eggs and larvae have been assessed in laboratory aquarium studies (Platania, 2000). The four temperatures were reported to be within a range typically encountered during May and June by silvery minnow eggs and early larval stages in the Rio Grande. Warmer water temperatures lessened the time to first hatching, shortened duration for hatching of all eggs, and sped the development of assessed morphological characters and the conclusion of developmental stages for silvery minnow (Exhibit 3-13).

Exhibit 3-13

Relationships of Temperature to the Development of Early Life Stages in Silvery Minnow Development (Platania, 2000)



The lowest cumulative egg survival rates were at the two temperature extremes (15 degrees C, 68 percent; 30 degrees C, 69 percent). Egg survival rates in the two intermediate water temperatures were 80 percent (20 degrees C) and 85 percent (25 degrees C). The largest larvae hatched from eggs in the

15 degrees C tank and the smallest hatched larvae came from the 30 degrees C tank. Conversely, the mean length of larval minnows hatched from eggs in the 25 degrees C treatments was larger than for eggs held in the 20 degrees C tank. Silvery minnows in the 30 degrees C aquaria and 15 degrees C tank begin feeding at Days 6 and 8 following hatch, respectively (the experiment ended before fish in the other two temperatures started to feed). Silvery minnows in the coldest aquaria grew at half the rate of those in the three warmer tanks, with growth in the three warmer tanks nearly identical to each other. Despite the similarity of growth rates in three of the tanks, mean length of larval fish (on a given day post-hatching) was consistently greatest in the warmest water.

While these data are very useful in gaining a better understanding of water temperature relationships for silvery minnows, a limitation of this study is that it terminated while the larval silvery minnow were still developing in three of the exposure conditions (Platania, 2000). Since silvery minnows survive over winter temperatures in MRG waters near freezing (32ºF, 0ºC) and gametes must be developing during this period, an improved understanding of their cold-water physiology would greatly aid in understanding their reproductive physiological requirements at low temperatures. Therefore, it is suggested that additional studies of lower temperature exposures be completed to more clearly define lower temperature conditions that influence silvery minnow spawning and larval development.

23 How could silvery minnow benefit from water quality conditions that adversely affect other fish species?

Experimental results have shown early-age silvery minnows to have a remarkably low sensitivity to low concentrations of dissolved oxygen and high water temperatures (Buhl, 2006a and 2006b). Specifically, results from these laboratory studies on the potential effects of low dissolved oxygen concentrations showed that 50 percent of the exposed silvery minnows could survive a range of 0.5 to 1.1 mg/L oxygen for up to 96 hours under two different exposure protocols. These tests results were replicated using age 5-day, 32-day, and 93-day post hatch silvery minnows, with results obtained for each age group at 24 hours and 96 hours.

Similarly, replicated studies included in the same research presentations found low sensitivities to elevated water temperatures up to 37 degrees C (99 degrees F). The 24-h and 96-h LL50s for all three age groups ranged from 35 to 37 degrees C (Buhl, 2006a and 2006b). While these test results were described as "preliminary," subsequent dissolved oxygen and temperature experiments from the same laboratory have found responses generally in similar ranges for these and other silvery minnow life stages tested (K. Buhl, 27 January 2010, personal communication; a draft final report for this work is expected to be delivered to the Program in March 2010).

Both the low-dissolved oxygen concentrations and relatively high water temperatures found to be tolerated by 50 percent of the exposed silvery minnows over the exposure intervals assessed in Buhl's studies would often be quickly lethal to life stages of most fish and other aquatic species (USEPA 1987 and 2008). But, tolerances to low oxygen and elevated temperatures are not unique to silvery minnows or fish species in the MRG. Indeed, other fish species in arid habitats producing channel drying elsewhere are also known to possess similar resistance to conditions that are quickly lethal to most other fish (e.g., Matthews, 1987; Kerns, 1983; Kerns and Bonneau, 2006; Koehle, 2006).

Environmental conditions producing the combination of both low oxygen and high temperature extremes in surface water bodies commonly occur only in small confined pools and ponds lacking appreciable flow (cf., Hutchinson, 1957; Wetzel, 1975; Gordon et al., 1992). Such habitats can often form along and within a drying river channel. For example, historical channel avulsions and higher water tables along the Rio Grande would have been highly conducive to the formation of such pools and ponds during periods of channel drying (Leopold et al., 1964). While such ephemeral habitats can provide refuge waters for the fish, these habitats often include overnight dissolved “oxygen sags,” with dissolved oxygen concentrations approaching depletion levels due to respiration by the entire aquatic community. In these habitats, oxygen concentrations are typically lowest just prior to sunrise, when photosynthesis by algae and other groups starts again to release oxygen into the water (Hutchinson, 1957; Wetzel, 1975). Water temperatures also often can increase during the day, potentially to extreme levels in ponds and pools, due to solar heating.

The reported results of low sensitivities by silvery minnows to low dissolved oxygen and to elevated temperature conditions point to important evolutionary relationships regarding their past habitat relationships. That is, it can be reasonably hypothesized, as suggested from the information presented by Buhl (2006a; 2006b), that isolated pools along the Rio Grande once provided important refuge habitat for silvery minnows during periods of channel drying; these habitats then regularly exposed these fish to extremes of oxygen and temperature. Specifically, for the silvery minnow at the population level to have developed such resistances to low oxygen and high temperature extremes, a majority of the silvery minnow population almost certainly must have been frequently confined over evolutionary time to refuge pool and pond habitats along dry channels.

Similarly, it would appear reasonable to hypothesize that these low sensitivities of silvery minnow to dissolved oxygen and temperature, as well as to potentially other poor water quality conditions not yet assessed, may have provided important competitive adaptations that contributed to their historical success and dominance along the Rio Grande. Assuming these hypotheses are correct, a priority for habitat restoration should be to facilitate the creation and persistence of similar refuge pool and pond habitats in sub-reaches of the MRG during periods of channel drying.

24 Where has the FWS defined critical habitat for the silvery minnow along the Middle Rio Grande?

The FWS (2003b) has designated Critical Habitat for the silvery minnow to include 212 miles 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 includes the width of the areas bounded by existing levees or, in areas without levees, 300 feet of riparian zone adjacent to each side of the bankfull stage of the MRG. With the exception of Cochiti and San Felipe Pueblos, Pueblo lands downstream of Cochiti Dam are excluded from the critical habitat designation (FWS, 2003b). No critical habitat for silvery minnows was defined upstream of Cochiti Reservoir, including the Velarde Reach project area.

In defining critical habitat for silvery minnows (FWS, 2003b), areas other than the MRG were excluded from designation under section 4(b)(2) of the ESA. That analysis reported that the benefits of excluding these areas from critical habitat designation outweighed the benefits of including them. Areas they analyzed for possible inclusion as silvery minnow critical habitat included the middle Pecos River from immediately downstream of Sumner Dam to Brantley Dam, New Mexico, and the Rio Grande from the upstream boundary of Big Bend National Park to the Terrell/Val Verde county line, Texas.

25 What are the defined critical habitat requirements for silvery minnows?

In defining its critical habitat requirements, the FWS (2003b) states: *"various life history stages of the silvery minnow require shallow waters with a sandy and silty substrate that is generally associated with a meandering river that includes sidebars, oxbows, and backwaters. … Adult silvery minnows occur in shallow braided runs over sand substrate, but rarely in habitat with substrate of gravel or cobble."*

The critical habitat designation included 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”).

Many past characterizations of silvery minnow habitat requirements tend to present overly simplified needs for this species. The overall scientific understanding of required habitat relationships for silvery minnow in the MRG is constrained by observations under contemporary conditions of habitat disturbance. Observations from such investigations can easily lead to a misunderstanding of the species’ habitat preferences and needs, which can then misguide habitat restoration efforts.

In 2007, a roundtable of fish and wildlife professionals from several federal and state agencies (e.g. FWS, BOR, NMISC and USGS) defined, as part of a San Acacia fish passage study, a set of ranges considered to be favorable habitat conditions for the silvery minnow (Bovee et al., 2008) (Exhibit 3-14). These definitions of the optimal ranges for habitat variability were developed to define a set of habitat conditions as consistent as possible with the Draft Rio Grande Silvery Minnow Recovery Plan (FWS, 2007; Dudley and Platania, 1997; and Bestgen et al., 2003). These attributes were applied during an in-stream incremental flow model developed to assess how flow changes can affect silvery minnow habitat conditions in the MRG upstream of San Acacia Diversion Dam near the Rio Salado confluence (Bovee et al., 2008).

Exhibit 3-14

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
nDebris (buffer width, cm)	0	50	0	25

26 Do silvery minnow require sandy and silty substrate, or is this more correlative with low-flow velocities?

Observed conditions of locally modified habitats at collection sites can sometimes be misinterpreted as defining habitat preferences or requirements for a species. This drawback was recognized in the 2003 BA for MRG water operations, which cautioned, "…*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).

While the existing data strongly supports that silvery minnow prefer low-velocity habitats, the role of channel bed substrate is less clear. Consider the following habitat relationships noted in the report by Dudley and Platania (1997), also cited by the FWS (2003):

> *"Mesohabitat types selected by individual Rio Grande silvery minnow largely reflected their preference for low-velocity areas. The most frequently selected mesohabitat types were debris piles (40.5 percent), pools (35.9 percent) and backwaters (13.8 percent). Main channel runs were generally avoided by Rio Grande silvery minnow as only 1.3 percent were taken in this most abundant habitat."*

Dudley and Platania (1997) further state…

> *"The substrata over which different size-class Rio Grande silvery minnow were collected changed only moderately for larger individuals and seemed a function of the weak ontogenetic shift into slightly higher velocity habitats. The smallest size-class was found exclusively over a silt substrata. The next larger size-classes (21–30 mm SL and 31–40 mm SL) were predominantly collected over silt (96.9% and 94.0% respectively), but were occasionally located over sand or gravel. All other size-classes were taken, to varying degrees, over silt, sand, gravel, and cobble. Individuals <50 mm SL primarily used habitats with silt substrata whereas individuals >50 mm SL were mostly taken over sand (i.e., slightly higher velocity habitats).*
>
> *In winter, individuals [silvery minnows] at both Socorro and Rio Rancho were more commonly located in deeper and lower velocities water and mesohabitats than in summer. There was a movement to debris in winter at both sites. There were seasonal differences in the substrate over which Rio Grande silvery minnow were located at Rio Rancho but not at Socorro. At Rio Rancho in winter, individuals were more common over sand and less common over silt, gravel, and cobble than in summer. At Socorro, individuals were found over silt, sand, and gravel in almost equal proportions during both seasons."*

Other scientific literature similarly provides a relatively wide array of diverse habitat and substrate associations for silvery minnows. 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."* Watts et al. (2002) reported that silvery minnow more commonly used shoreline habitats with debris than open-water habitats lacking debris.

> The occurrence of finer-textured substrates in the lower reaches of the MRG is related to the downstream fining processes, whereby sediment size decreases with distance from the higher-gradient tributary watersheds (MEI, 2002). Therefore, because finer-textured bed materials are more prevalent in the MRG reaches currently occupied by the silvery minnow, their increased capture frequencies over silt and sand substrates may be explained by purely probabilistic reasons.

Remshardt and Tashjian (2004) reported that collections of silvery minnows were least often associated with flat-water, 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.

Laboratory studies indicate that silvery minnows regularly 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). Unpublished observations made at the Albuquerque Biological Park suggest that the silvery minnows commonly concentrate in low velocity pool habitats (Tetra Tech, 2004).

A major commonality from all field collections and laboratory observations is that both juvenile and adult silvery minnows frequent low velocity habitats. We suggest that it is reasonable to conclude that silvery minnow do prefer low velocity habitats to enhance their survival potentials. Such habitats, in fact, are commonly favored by most or perhaps all stream and river species of fish and invertebrates – low flow habitats reduce the high-energy demands that otherwise are required for swimming continuously at higher velocities. Suitable low velocity river habitats typically would include shallow, braided, side- and off-channel runs, and they include habitat associated with irregular banklines, deep pools, backwaters, and waters downstream of islands and in-channel debris piles.

We also suggest that it is reasonable to hypothesize that silvery minnows do not require fine textured bottom sediment for their survival. It has been documented, for example, that the occurrence of finer-textured substrates in the lower reaches of the MRG is related to the downstream fining processes, whereby sediment size decreases with distance from the higher-gradient tributary watersheds (MEI, 2002). Thus, because finer-textured bed materials are more prevalent in the reaches currently occupied by the silvery minnow, their increased capture frequencies over silt and sand substrates may be explained by probabilistic reasons.

We suggest that the hypothesis that silvery minnow require a substrate of predominately sand and silt merits additional scientific examination. Understanding the causal versus correlative role of substrate is particularly important during the evaluation of potential silvery minnow restoration or reintroductions sites, as it could lead to ruling out areas that might otherwise provide reasonable habitat potential.

27 What habitat restoration approaches are emphasized by the recovery plan?

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 peak flow 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.

28 Is silvery minnow habitat restoration in the Velarde Reach important?

By various accounts summarized in Chapter 4, restoration of silvery minnow and their habitat in the Velarde Reach has a low priority. Specifically, waters of the Rio Grande drainage upstream from Cochiti Reservoir are not included in the recovery plan for the species, even though the Rio Grande system extending upstream from Cochiti Reservoir and into the Rio Chama is a part of the known historical range for silvery minnows. Although the project area supports perennial flow, Buntjer and Remshardt (2005) suggested that the Rio's Grande and Chama upstream of Cochiti Lake are currently limited for silvery minnows for a variety of reasons, including:

- Entrenched channels and loss of floodplain connectivity;
- Altered hydrology with increased base flows;
- Chronic/acute contaminants exposure;
- Cold water temperatures;
- Loss of suitable channel substrate;
- Channel fragmentation caused by upstream and downstream dams, and;
- Competition with introduced non-native fish species.

Nonetheless, the Program has requested this report assess the existing data for the project area and develop independent conclusions about the potential for silvery minnows in different sub-reaches of the project area. In Chapter 4, therefore, we explore the aforementioned limiting factors raised by Buntjer and Remshardt (2005) using available data, field observations and contemporary hypotheses about the habitat needs of the fish.

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Chapter 4 Restoration Issues and Opportunities

Issues and Opportunities for Flycatcher Habitat Restoration

1 What are the attributes of flycatcher territories in the project area?

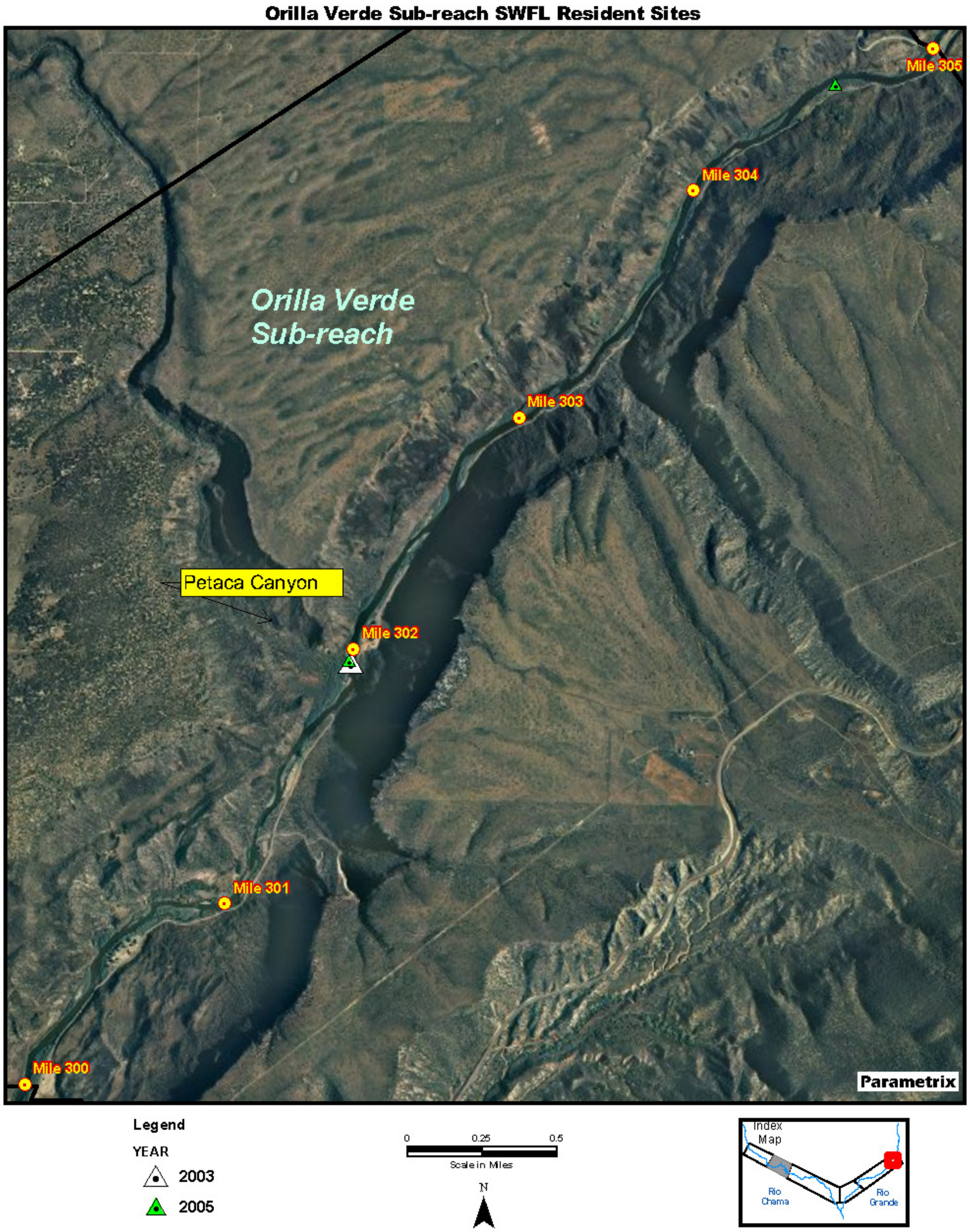
Nesting flycatchers have been detected in the project area since the early-mid 1990s in both the Orilla Verde and Velarde Sub-Reaches (Rio Grande Sub-Reaches). Although there have been no flycatchers detected in the Rio Chama Sub-Reaches, the flycatcher recovery plan (FWS, 2002, page 9) indicates that the Rio Chama was part of the historic breeding range, and contemporary surveys within the surrounding watershed (e.g., Los Ojos, El Rito) have detected nesting pairs (see Chapter 3, Exhibit 3-7).

The lack of breeding flycatcher detections in the Lower Chama Sub-Reach is not surprising however, since (to our knowledge) no formal flycatcher surveys have ever been performed on the mostly private lands that dominate this sub-reach. While the U.S. Forest Service does not implement annual flycatcher surveys on their lands in either of the Rio Chama Sub-Reaches, they do perform surveys associated with projects proposed near the riparian corridor. Nevertheless, no flycatchers have ever been detected during these surveys (M. Orr, Biologist, Santa Fe National Forest, personal communication).

Nesting flycatchers in the Orilla Verde Sub-Reach were detected yearly between 1993 and 1997, and again in 2003, 2005, and 2008 (Exhibit 4-1). Breeding flycatchers in this sub-reach have been most consistently detected within, or immediately adjacent to a relatively large saltcedar stand (mapped as SC 5 by BLM) at the terminus of Petaca Canyon. This saltcedar stand is approximately 6.5 acres and rests atop alluvial fan deposits from Petaca Canyon Arroyo. Field observations indicate the terrace created by the alluvial fan is elevated approximately 3 to 5 feet above the surface water elevation of the river, depending upon discharge. When flows exceed approximately 2,000 cfs, a small backwater near the fan terminus becomes inundated (Exhibit 4-2, page 4-4).

Exhibit 4-1

General Locations of Breeding Flycatchers in the Orilla Verde Sub-Reach, 2003 and 2005.



Map does not show nest locations prior to 2003 because there was no reliable geographic coordinate data available to plot these locations.

Exhibit 4-2

Periodic Flycatcher Breeding Area Near Petaca Canyon, Orilla Verde Sub-Reach

Dense saltcedar stand growing on the alluvial deposits from Petaca Canyon Arroyo. This photograph was taken on May 8, 2008, when mean discharge at Taos Junction Bridge was 2,280 cfs. The inundated backwater channel is visible in the photo center.

Photograph depicting the bank height above the river channel on November 2, 2007. Mean daily flow at Taos Junction Bridge (USGS Gage 08276500) was 320 cfs.

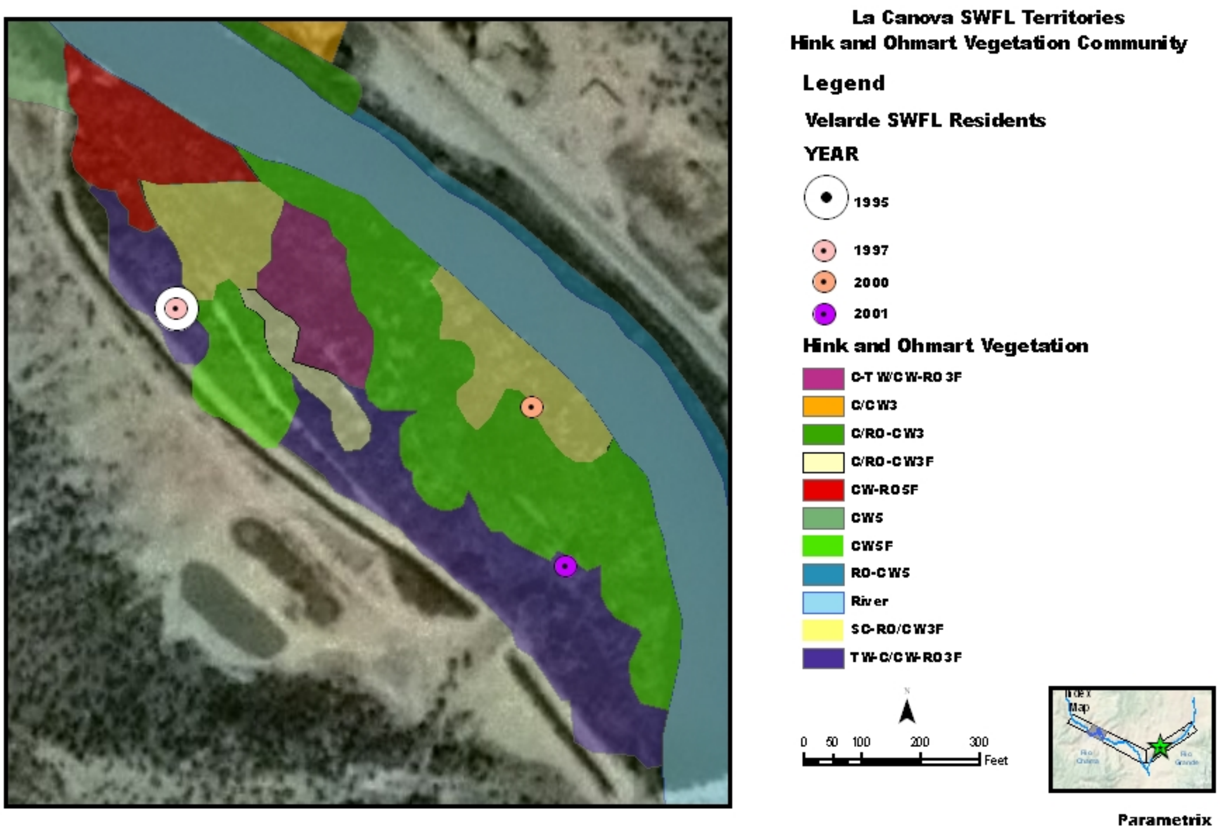
Several nesting pairs were detected in the Velarde Sub-Reach between 1994 and 1997, but the numbers decline to only one or two pairs each year between 1998 and 2001 (Exhibit 4-3). The most recent detection was at the La Rinconada site (one pair) in 2004. The only former flycatcher breeding site that we have been able to access is the area known as *La Canova*. This site supported as many as three nesting pairs each in 1995 and 1996, but no pairs have been detected here since 2001. The La Canova site is an 11-acre channel side-bar located immediately upstream of the Velarde Diversion Dam downstream of River-Mile 285. The site is composed largely of native riparian vegetation including dense stands of Gooding's and coyote willow (Exhibit 4-4, page 4-6). The HEC-RAS model results indicate this site (at cross-section LC-4) becomes inundated at the 2-year flow event (see Exhibit 4-7, page 4-11).

Exhibit 4-3

General Locations of Breeding Flycatchers in the Velarde Sub-Reach, 1994-2001

Exhibit 4-4

Vegetation and Flycatcher Nest Locations at the La Canova Site



2 Why are so few flycatchers detected in the Velarde Reach?

There are probably a handful of reasons why so few breeding flycatchers have been detected in the project area in recent years. First, it may be attributed to the fact that vast acreages of former riparian habitat, particularly in the Velarde and Lower Chama Sub-Reaches, have been converted for agriculture. Another may be due to the fact that some portions, namely the Orilla Verde and Pilar Sub-Reaches, are canyon-bound and lack the natural potential for supporting extensive riparian habitats. Third, it may be that flycatchers have abandoned former nest locations as the vegetation has aged and become less suitable for nesting. Forth, it appears that no formal flycatcher surveys have been performed in the Lower Chama

Sub-Reach, which is by far the longest river section in the project area. In other words, it is possible that breeding flycatchers are actually utilizing this sub-reach, but there is no data to validate this.

The following sections aim to address these and other issues potentially affecting flycatcher habitat throughout the project area.

3 How has floodplain development impacted riparian vegetation in the Project Area?

Velarde and Lower Chama Sub-Reaches

The floodplains in the Velarde and Lower Chama Sub-Reaches (and to a lesser extent in the Pilar Sub-Reach) were extensively developed for agriculture early in the last century. Compared to the Rio Grande floodplain below Cochiti Dam that hosts a nearly contiguous cottonwood gallery forest, there is relatively little vegetated buffer between the river and agricultural lands in the Velarde and Lower Chama Sub-Reaches. With several notable exceptions, riparian zones in these sub-reaches are generally comprised of narrow, linear bands of native and non-native riparian vegetation.

Narrow bands of native and non-native vegetation provide limited spatial separation between agricultural lands and the river in Velarde and Lower Chama Sub-Reaches.

Agricultural lands within the Velarde Sub-Reach floodplain were protected from overbank flooding by constructing earthen levees along the bankline using spoils excavated during river channelization in the 1950s. Despite the lack of flood control structures upstream, the combination of channelization and earthen levees have mostly prevented floodwaters from overtopping banks. A side-effect of this management, however, has been the elimination of riparian seedling recruitment in the floodplain. Riparian seedling recruitment is mostly limited to channel bars, although many of these bars are already densely vegetated and have limited room (i.e., germination "safe-sites") for new seedlings.

Spoil-bank levees line the east-side river channel along the Velarde Sub-Reach of the Rio Grande.

Riparian plant recruitment in the Lower Chama Sub-Reach is also very limited. Unlike the Velarde Sub-Reach where flow volumes are not influenced by flood control structures, flow releases from Abiquiu Dam are managed to prevent floodplain inundation and potential impacts to agricultural lands, irrigation infrastructure, and more recently, houses constructed within the floodplain. For these reasons, flow releases from Abiquiu Dam typically do not exceed a bankfull volume of approximately 1,800 cfs (see Chapter 2, Surface Water Hydrology, Section 9). New riparian plant recruitment in this sub-reach is mostly limited to channel bars and a few backwater areas below irrigation diversion turnouts. Like the Velarde Sub-Reach, remnant cottonwood gallery forests along the Lower Rio Chama are discontinuous and most (but not all) lack substantive understory vegetation structure sought by nesting flycatchers (Exhibit 4-5).

Exhibit 4-5

Riparian Vegetation in the Lower Chama Sub-Reach

Remnant cottonwood gallery forest along the Lower Chama Sub-Reach.

Narrow bands of Russian olive are common along banklines of the Lower Chama. These species have the advantage over native willows because flows released from Abiquiu Dam rarely exceed bankfull discharge of 1,800 cfs.

New riparian habitat recruitment occurs on a very limited basis on channel bars, or, as shown here, along backwaters associated with irrigation turn-outs.

4 What are the geomorphic and flow management impacts on riparian habitat formation?

The canyon-bound Orilla Verde Sub-Reach supports relatively small, discontinuous patches of riparian habitat. These habitats mostly lack overstory tree cover and have limited value for breeding flycatchers.

Rio Grande Sub-Reaches

As mentioned above and discussed in greater detail in Chapter 2, there are no flood control dams along the Rio Grande upstream of the project area, and flow volumes have not been drastically altered since major irrigation water diversions were completed in the San Luis Valley, Colorado near the turn of the 19th century. Neither channelization nor flood control, therefore, are limiting factors to flycatcher habitat formation in the Orilla Verde or Pilar Sub-Reaches of the Rio Grande. Instead, the principal constraints are related to geomorphic controls.

Photograph from the Orilla Verde Sub-Reach showing a large backwater habitat that formed when vegetation began growing in the upstream end of a secondary flow channel. This slow moving backwater has facilitated tree growth and more structural complexity than is found on bars adjacent to faster moving water.

The Orilla Verde Sub-Reach, for example, is canyon-bound with very limited areas of discontinuous floodplain and a few mid-channel bars. While many of the channel bars support native coyote willows, there is very little structural complexity (i.e., no overstory canopy) and most of the coyote willows are less than 7 feet tall. There is one relatively large backwater area that has formed as vegetation has begun blocking off the upstream end of secondary channels that flow around a large mid-channel bar. This site, located immediately upstream of Rio Bravo Campground, may have potential as flycatcher habitat; however; the bar elevation mostly prohibits overbank flooding, and in their current form appear relatively dry and armored with saltcedar. Both this site and the Petaca Canyon saltcedar site appear to provide marginal quality flycatcher habitat, but could potentially be enhanced through physical site manipulations (i.e., earthwork and planting native willows, cottonwoods and box-elders).

The Pilar Sub-Reach is, for all intents and purposes, also canyon-bound and there is effectively little overbank flooding potential. Very limited areas in the wider sections of the canyon where alluvial deposits have accumulated appear to have some potential for overbank flooding, but local levees have been constructed along the channel banks, especially near the Town of Pilar. Overbank flooding does occur on the fan at the mouth of Embudo Creek as a result of combined flows in the Rio Grande and Embudo Creek. Overall, the potential for riparian habitat formation in the Pilar Sub-Reach is very limited.

Unlike the upstream sub-reaches, the Velarde Sub-Reach has been channelized, and excavation spoils were used to create earthen berms along the banklines. As a result, most of the flow is contained within the channel, even during the 10-year flow event (9,810-cfs at Embudo; see Exhibit 4-6). There are few, if any, backwater habitats in this sub-reach, and recruitment of new riparian seedlings is extremely limited.

The vegetated side bar at cross-section LC-4 is one of the only locations in the Velarde Sub-Reach that inundates under the 2-year flow. This site supports dense coyote and Gooding's willow and formerly hosted nesting willow flycatchers.

The only sites in the Velarde Sub-Reach that appear to inundate at moderate flows (2- to 5-year flow event) are a few channel side bars located immediately upstream of diversion dams. For example, one side bar (the La Canova site) located immediately upstream from the Velarde diversion dam (Range-Line LC-4; Exhibit 4-7) currently becomes inundated during the 2-year flow event (3,940 cfs at Embudo). This side bar is one of the only sites in the Velarde Sub-Reach that supports dense stands of coyote and Gooding's willow and floods on a regular basis.

Exhibit 4-6

Typical Cross Section (Range-Line EM-4) of the Rio Grande in the Velarde Sub-Reach. Graphic Shows the Water-Surface Elevations for the 2-, 5- and 10-Year Peak Flows at the Embudo Gage.

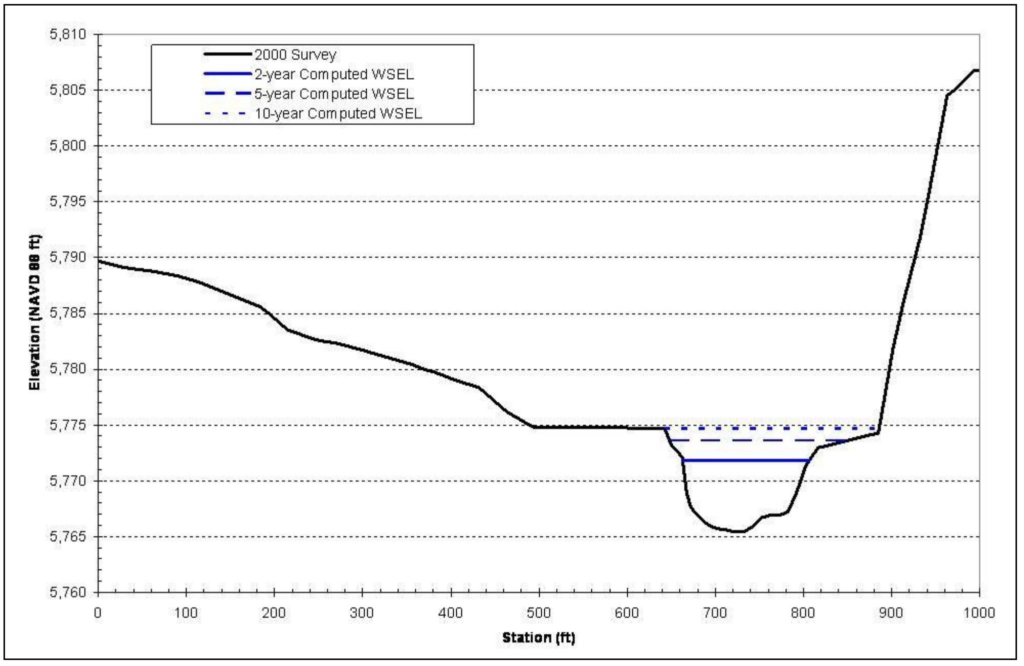
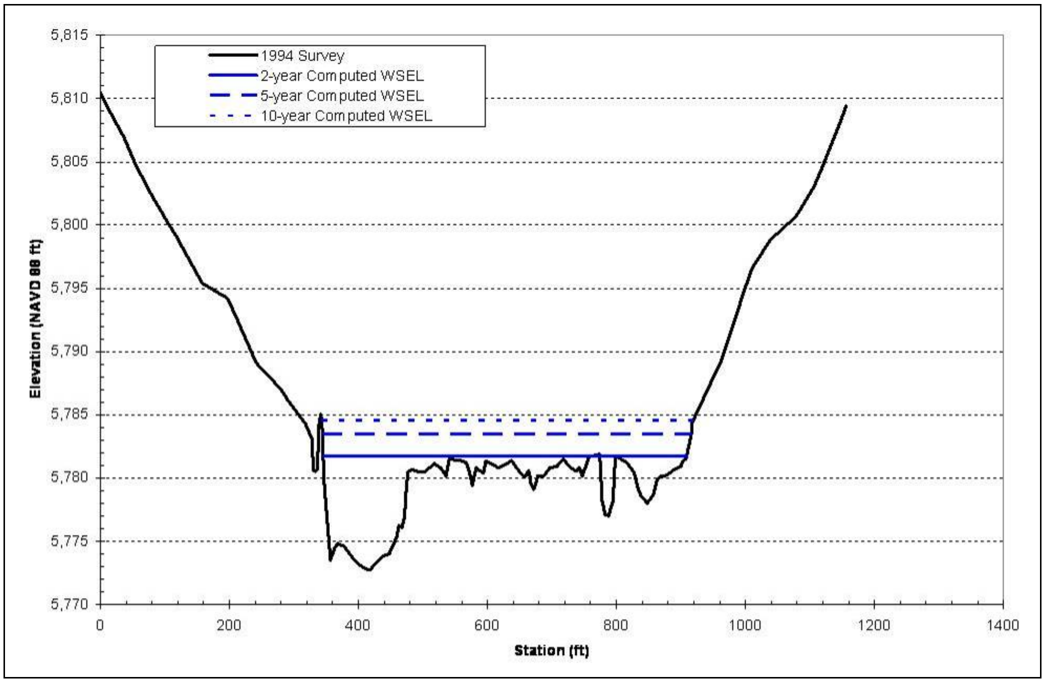


Exhibit 4-7

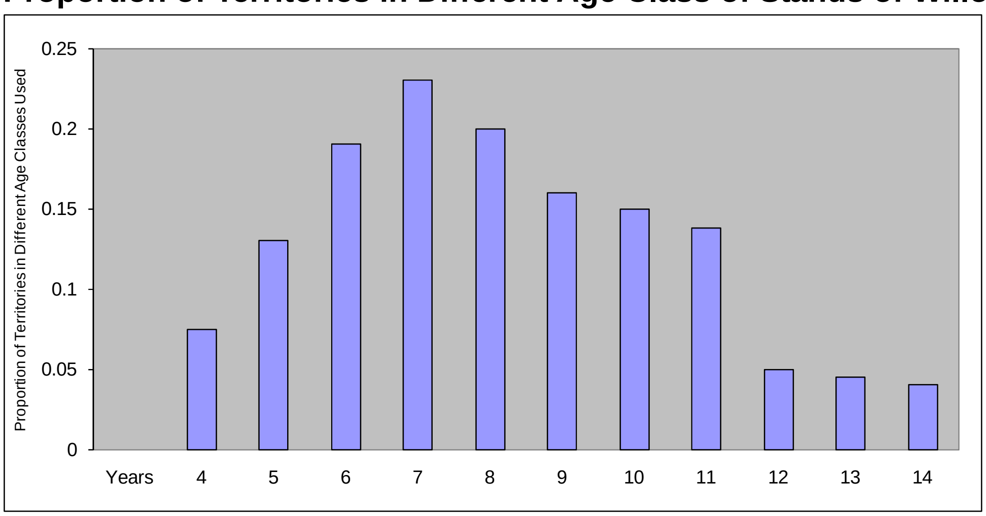
Cross Section of the Rio Grande at Range-Line LC-4 in the Velarde Sub-Reach Showing the Water-Surface Elevations for the 2-, 5- and 10-Year Peak Flows at the Embudo Gage.



Breeding flycatchers occupied several riparian sites in the Velarde Sub-Reach (El Guique, La Canova, Garcia Acequia and La Rinconada; see Chapter 3, Exhibit 3-7) between 1994 and 2004, but they have not been detected again since. Site visits to the La Canova site revealed impressive stands of native willows and cottonwoods with considerable structural diversity. Since this site also floods on a regular basis, we surmise that one plausible reason why territorial flycatchers may have stopped utilizing this site is that the willows may be "over-mature" and generally lack the foliar cover and branching structure typical of active breeding sites. For example, flycatchers generally prefer habitat of an early age or successional state (Unitt, 1987; Sedgewick, 2000; Paxton et al., 2007). The structure of the vegetation on which the birds nest—slender, vertically oriented branches, usually willows—is most abundant in these stands. As willow stands age, the stems become thicker and taller, and may lose their utility for the birds. Other changes (e.g., temperature, relative humidity, etc.) are surely taking place within stands that change their appeal as habitat, but these are less understood. Recent research has shown that many willow stands reach their maximum use by willow flycatchers at approximately 15 years before declining (Paxton et al., 2007) (Exhibit 4-8).

Exhibit 4-8

Proportion of Territories in Different Age Class of Stands of Willow



Use by flycatchers appears to peak at stands aged 6 to 8 years before tailing off. By the time a stand is greater than 15 years old, it gets little use, without some form of disturbance or regeneration (Data modified from Paxton et al., 2007).

Some, but not all of the willow stands we observed at the La Canova site lack the foliar density in the lower 1.5 m to 4.0 m, which is commonly where flycatcher nests are found (Exhibit 4-9). Physical disturbance to these aging willows would promote vigorous re-growth and may be one way to maintain the site as an active nesting territory.

Exhibit 4-9

Willow Foliar Density at Active and Inactive Flycatcher Territories

This photograph depicts the dense foliar density in the lower 3 to 4 meters of a Gooding's willow-coyote willow stand near Elephant Butte reservoir. This dense foliage around the nest is thought to provide important protection from predators. (Photo Credit: D. Ahlers).

Many of the Gooding's and coyote willows at the La Canova site have aged and lost the dense foliar cover in the lower 3 to 4 meters. Physical manipulation of these trees (e.g., beaver, chainsaws…) would re-invigorate this stand and may promote more desirable foliar cover for nesting flycatchers.

Upper Chama Sub-Reach

The Upper Chama Sub-Reach differs from the other project area sub-reaches in that the channel is relatively active and riparian habitats are regularly inundated along much of its length. Flow releases from El Vado Dam inundate lower elevation floodplain surfaces between 3,000 cfs and 3,500 cfs (2-year flow event). Flow releases between 4,000 cfs and 4,500 cfs (5-year flow event) will inundate the slightly higher elevation (T2) surfaces (Exhibit 4-10). Based on the seasonal flow duration curves for the post-San Juan Chama period, during the spring, the T2 surface is inundated for about 2 days and the floodplain surface is inundated for about 6 days. The higher elevation terraces (T-1 surfaces) are not overtopped even by the 100-year flow event.

The floodplain surfaces are mostly dominated by 5- to 7-foot-tall coyote willows, but riparian cottonwoods and tree willows (Gooding's and Peach-leaf) are conspicuously missing. The Santa Fe National Forest Terrestrial Ecosystem Survey (USFS, 1991) suggested that the potential vegetation composition for the floodplain map unit (Map Unit No. 31 -"riverwash") included approximately 5 percent cover of narrowleaf cottonwood and 15 percent cover of Gooding's willow. Nonetheless, we have observed only limited cottonwood (both narrowleaf and Rio Grande species) and no (zero) Gooding's or peach-leaf willow.

Geomorphic Surfaces Defined

Floodplain – alluvial surface adjacent to the channel that is inundated by the 2-year recurrence interval peak flow for about 6 days per year on average during the snowmelt runoff period.

T2 surface – the pre-El Vado Dam floodplain that is now inundated by the 5-year recurrence interval peak flow for about 2 days per year on average during the snowmelt runoff period.

T1 surface – a pre-El Vado Dam terrace that is located at an elevation above the 100-year recurrence interval peak flow.

Bradley et al. (1998) noted the relative dearth of cottonwood from their Rio Chama study site near the confluence with the Rio Galina, and attributed it to limited overbank flooding. However, floodplain and (to a lesser extent) T2 surfaces in the reach do become inundated on a somewhat regular basis, so there may be other factors that are limiting riparian tree establishment.

One possible explanation for limited cottonwood recruitment could be related to limited "safe-sites" for seed germination. Cottonwood seeds require relatively bare, moist alluvium for germination and establishment. Most of the channel bars (both mid-channel and side bars) and floodplain are already densely vegetated, so there appears to be few bare areas for extensive cottonwood seedling recruitment (Exhibit 4-10). As discussed in Chapter 3, overstory trees are common attributes of most MRG flycatcher territories, so their absence, combined with the relatively short stature of coyote willows in the Upper Chama Sub-Reach may limit the habitat value for breeding flycatchers.

Exhibit 4-10

Geomorphic Surfaces in the Upper Chama Sub-Reach

Floodplain (FP) surfaces currently inundate when flows exceed approximately 3,000 to 3,500 cfs. The T2 terraces currently inundate when flows exceed approximately 4,500 cfs. The T1 terraces no longer inundate, even during the 100-year flood event. Most of these surfaces are densely vegetated and lack extensive "safe-sites" for new cottonwood or tree willow seed germination.

One way to potentially increase the number of seedling safe-sites would be to encourage more erosion and deposition of sediments from steep banks associated with T1 terraces. This could involve increasing the frequency and/or duration of the historic 2-year flow (now the 5-year flow). As discussed later in this chapter (see Silvery Minnow section), a hydrograph modification might be achievable on water years with adequate snow-melt runoff. Such hydrograph modifications might promote more active formation of germination safe-sites and also inundate the T2 surfaces for longer duration, thereby potentially increasing seedling establishment on these surfaces. However, hydrograph

Erosion and deposition of sediments from these steep T1 terrace banklines might create new germination "safe-sites" for new cottonwood seedlings.

modifications for these purposes may not be prudent because there is some question about the impacts of livestock grazing on cottonwood tree establishment (see Livestock Grazing Issues section below).

5 Is soil salinity a limiting factor to riparian habitat in the project area?

Upper Chama Sub-Reach

Another potential obstacle to cottonwood establishment (and the relatively short-stature coyote willows) within the Upper Chama floodplain could relate to soil salinity. Studies examining the effects of high salinity have long established the stunting effects of salts on seedling growth for most plants, including cottonwoods and willows (multiple citations in Rowland et al., 2004). In one study, researchers reported that cottonwoods originating from the Rio Chama near Abiquiu were more salt-sensitive than cottonwoods originating from the MRG near Albuquerque and San Antonio, New Mexico (Rowland et al., 2001).

Salt accumulations on willow bars in the Upper Chama Sub-Reach were common. Photo taken April 2008.

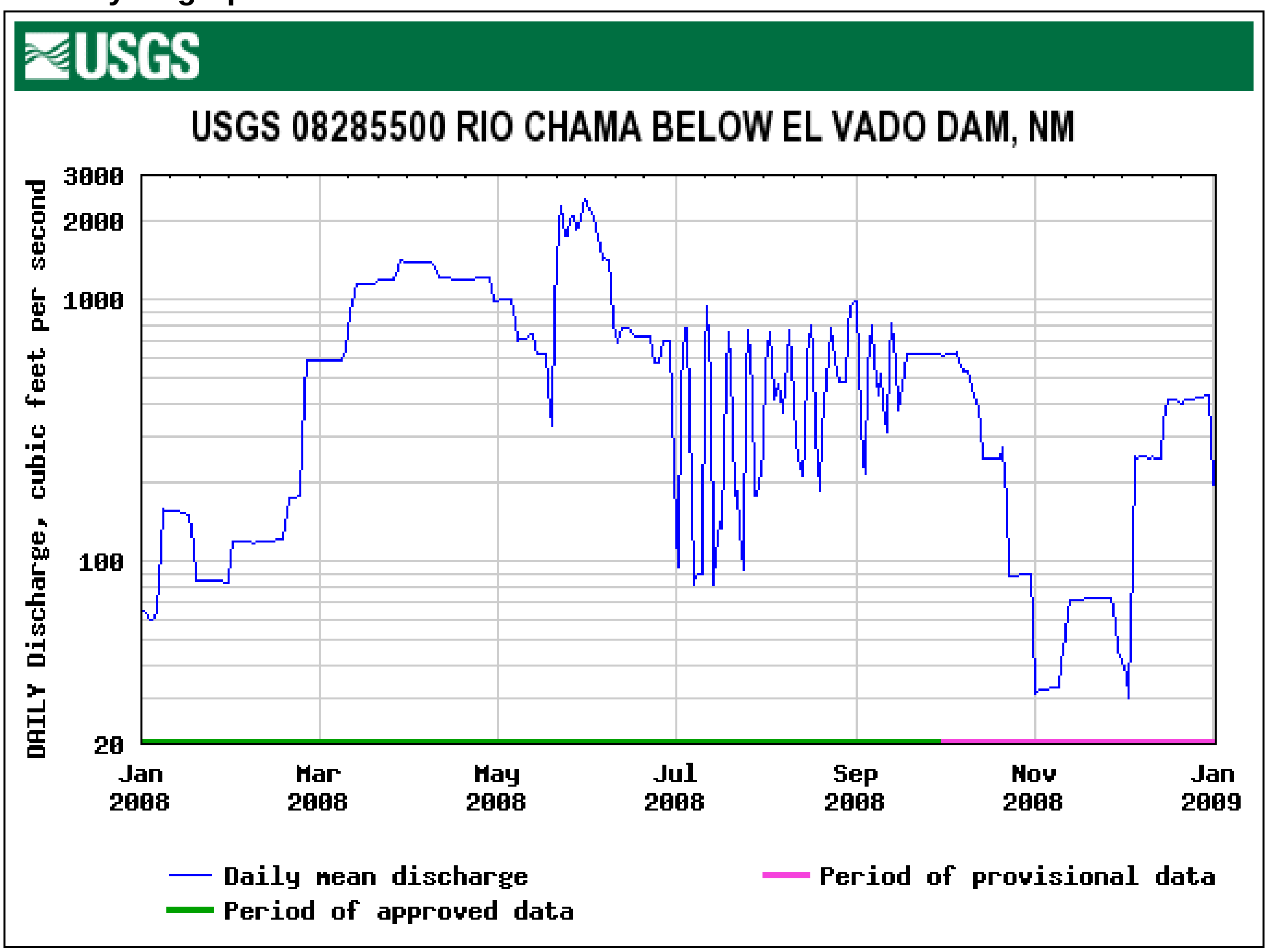
Abundant surface salt accumulations were noted by our project team during an April 2008 field reconnaissance of the sub-reach. A subsequent visit in June 2008 indicated that the salts had been mostly washed away during snow-melt runoff flows the previous month. By November 2008, however, the salts had accumulated on the surface again. The increase in surface salt accumulations between runoff events result as water moves upward towards the soil surface along an osmotic gradient. As water is extracted by plants or lost to evaporation, salts accumulate near the soil surface. The extent of this process is driven primarily by relationships between soil texture, seasonal depth to groundwater and rooting habits of different plants.

The same willow bars were virtually free of visible surface salt deposits soon after the spring snow-melt floods. This photo was taken June 2008.

It is conceivable that this process is being exacerbated by the way the mid-late summer hydrograph is managed from El Vado Dam. For example, depending upon the water year, El Vado Dam is managed to allow recreational boating on weekend days in July and August. Flows are ramped up to approximately 800 cfs on Fridays and by Monday drop to lows of approximately 70 cfs (Exhibit 4-11). This process would have the tendency to promote alluvial water table fluctuations that raise water up near the surface during the weekends then drop them down to base-flow levels again through the week. The weekend flow levels appear to wet the soil profile under the willows, but the flows are not high enough to reach the surface or overtop the banks. As such, it is plausible that salts are constantly being pushed up to the surface and allowed to accumulate to levels that might not otherwise occur under a more natural summer hydrograph.

Exhibit 4-11

Flow Hydrograph from El Vado Dam for 2008 Calendar Year



Preliminary data collected in June and November 2008 from six willow bars in the Upper Chama Sub-Reach indicate that salt levels, at the time of sampling, were mostly within the tolerance range of both cottonwood and willows (<4 dS/m; e.g., Shafroth et al., 1995) (Exhibit 4-12). It is important to recognize, however, that flushing overbank flows do not occur every year, and soil salinity levels could limit willow growth rates as salts accumulate in low runoff years. More study would be required to determine if: a) salinity is a limiting factor to cottonwood recruitment and/or willow growth in the Upper Chama Sub-Reach, and b) if the summer recreational boating hydrograph is facilitating surface salt accumulations on the bars and floodplain.

Exhibit 4-12

Preliminary Soil Salinity Data from Six Floodplain Sites in the Upper Chama Sub-Reach

Site Number	Depth (In.)	Jun-08 ECe (dS/m)	Nov-08 ECe (dS/m)
RC-1a	0 to 12	0.1	1.64
RC-1b	12 to 24	1.6	0.47
RC-2a	0 to 12	2.9	3.21
RC-2b	12 to 24	1.4	1.12
RC-3a	0 to 12	1.9	0.44
RC-4a	0 to 12	4.7	3.24
RC-4b	12 to 24	0.7	2.18
RC-5a	0 to 12	1.4	3.75
RC-5b	12 to 24	2.1	3.25
RC-6a	0 to 12	3.1	2.37

Samples were collected from the same locations in June and November, 2008.

6 How does livestock grazing potentially impact flycatcher habitat in the project area?

Upper and Lower Chama Sub-Reaches

Livestock grazing impacts on flycatcher habitat and reproduction are well documented (e.g., multiple studies published in Sogge et al., 2000). For example, we noted in Chapter 3 that flycatchers prefer nesting substrates that are especially dense in the lowest 1.5 m to 4 m above the ground. Cattle, horses, and other livestock are naturally drawn by water to riparian areas. In many cases, the elements that make a stand attractive to willow flycatchers—dense, moist vegetation with standing water—are the same that draw livestock. Even moderate use by livestock, which will eat and trample vegetation in these lowest layers, will alter habitat to make it less desirable for flycatchers in three important ways:

- It increases the presence of brown-headed cowbirds (*Molothrus ater*), a nest parasite on willow flycatchers (FWS, 2003c). Although cowbirds are a relatively minor factor in the decline of willow flycatchers compared with the loss of habitat, cowbird parasitism can prevent nests from successfully fledging young, and can hold down recovery efforts, especially in marginal areas or when flycatcher populations are low. Parasitism has been documented at willow flycatcher sites in the Velarde Sub-Reach (Ahlers, personal communication, 2008).

Brown-headed cowbirds are parasites on willow flycatcher nests, especially in areas where livestock is prevalent. (Photo Credit: Rainbow Wildlife Rescue)

- Livestock movements and grazing in normally dense riparian areas reduces the density of stems and the vigor of vegetation in the lowest layers. This can lead to increased visibility for both avian predators, such as great horned owls (*Bubo virginianus*) and coopers hawks (*Accipiter cooperii*); and land predators such as skunks (*Mephitis spp*.), raccoons (*Procyon lotor*); and foxes (*Urocyon cinereoargenteus*, and/or *Vulpes vulpes*). Predation has been documented at the flycatcher sites in Velarde (Ahlers, personal communication, 2008).
- Cattle commonly browse the proteinaceous young shoots of young cottonwood and willow trees. This affects plant growth form by limiting tree and shrub heights and canopy cover, and is especially detrimental to establishment of newly forming cottonwood-willow habitats.

Livestock grazing has occurred in the project area for at least two hundred years (Scurlock, 1998). Contemporary livestock grazing appears most prevalent along private lands of Lower Chama Sub-Reach, and along U.S. Forest Service lands of the Upper Chama Sub-Reach. Along the Lower Chama Sub-Reach, most of the riparian willows that once existed along riverbanks were probably eaten by livestock a long time ago, and the combination of continued grazing and restricted flooding have prevented new native riparian plants from establishing. Barbed-wire fencing follows the bankline edges on both sides of the river, so cattle appear to be restricted from accessing riparian vegetation growing on channel bars and within acequias backwaters (Exhibit 4-13).

Exhibit 4-13
Livestock Grazing in the Lower Chama Sub-Reach

Cattle seek shade, water, and forage along the riverbanks. Most of the riparian corridor has been utilized by cattle for a long time, so willows are essentially absent from riverbanks along the Lower Chama Sub-Reach.

Barbed-wire fencing along the riverbank follows nearly the entire length of the Lower Chama Sub-Reach.

Cattle grazing also occurs in the Upper Chama Sub-Reach, but the U.S. Forest Service implements grazing policies to minimize impacts on riparian vegetation (USFS, 1998). Under their Rio Chama Allotment Grazing Plan (USFS, 1998), the Forest Service limits riparian area grazing to winter months, with the requirement that livestock be removed by April 15th of each year to limit impacts to riparian vegetation and to reduce conflicts with recreationists. Their plan also increased the number of pastures and fencing to reduce impacts on willow growth and wildlife habitat.

Coyote willows dominate the low-set floodplain of the Upper Chama Sub-Reach (see Chapter 2, Vegetation section), but it is possible that livestock are still having some detrimental impacts on these areas, particularly on growth of new cottonwood seedlings and saplings. As mentioned previously, recruitment of new cottonwood trees might be limited by available germination safe-sites or soil salinity; however, the few cottonwood saplings that we did observe appeared stunted due to ungulate browsing (Exhibit 4-14). It is not possible to ascertain whether they were browsed by deer, elk, or cattle, although cattle dung is far more conspicuous in the Upper Chama riparian areas than that of deer or elk. Nonetheless, the lack of overstory tree recruitment and growth in the Upper Chama Sub-Reach limits the potential for attaining vegetation structure known to be favored by territorial flycatchers. Livestock browsing impacts on cottonwood saplings may or may not be perpetuating this condition.

Exhibit 4-14

Livestock Grazing and the Upper Chama Sub-Reach

There are extensive coyote willow bars in the Upper Chama Sub-Reach, but overstory trees are conspicuously absent.

The few cottonwood saplings we did observe had been browsed to the point that their growth form appeared altered (i.e., their apical buds had been browsed so they maintain a shrubby growth form).

7 How does private land access and management affect flycatcher habitat conservation and restoration in the project area?

The majority of lands along the river corridors of the Velarde and Lower Chama Sub-Reaches are privately owned. This poses considerable challenges to flycatcher conservation and restoration efforts on several fronts. Gaining access to private land parcels, for example, requires obtaining names and contact information for each riparian site of interest. We attempted to do this by obtaining landownership records for private lands along the Lower Chama Sub-Reach from the Rio Arriba County Assessor's office. These records do not include contact phone numbers, so these had to be looked up for each parcel associated with a potential habitat conservation or restoration site. Some of the records were accurate, others were not. Some of the phone numbers were listed, others were not.

The complexity of this task was also exacerbated by the fact that the private land parcels, especially along the Lower Chama Sub-Reach, are rectangular and oriented perpendicular to the river channel (Exhibit 4-15). This meant that some potential habitat areas may have more than three (and in some cases as many as eight) different landowners for relatively small (less than 10-acre) habitat patches.

We suspect that these access challenges are one reason why formal flycatcher surveys have not been performed within the Lower Chama Sub-Reach. This challenge, however, is not insurmountable, and while thorough landowner research was beyond the scope of this project, we were successful in gaining access permission to several key parcels in the project area. Some of these sites appear to already contain suitable habitat for flycatchers, and one or two sites had bird nests that might have been constructed by flycatchers within the past 1 to 2 years (Exhibit 4-16).

Exhibit 4-15

Aerial Photograph Showing Orientation of Private Land Parcels Along the Lower Chama Sub-Reach

Many of the individual agricultural fields have different property owners. The riparian habitat patch in the center of the photograph was one of the sites we identified as worth exploring for flycatcher conservation or restoration potential. Figuring out whom to contact for access permission, however, was challenging.

Exhibit 4-16

High Quality Riparian Habitats Along the Lower Chama Sub-Reach

High-quality riparian habitat at River Mile 21.5.

This nest at River Mile 15 may have been constructed by a willow flycatcher.

Another high-quality riparian habitat near River Mile 25.

In addition to the access challenges described above, the potential for restoring hydrological functions to the riparian corridor is constrained by land and water management in the Lower Chama Sub-Reach. For example, the FLO-2D model results presented in Chapter 2 (see Exhibits 2-55 through 2-58) indicate great potential for overbank flooding within the Lower Chama Sub-Reach, even during the 2-year peak flow event (i.e., 3,200 cfs would inundate 1,680 acres across the sub-reach). Yet maximum flow releases from Abiquiu Dam are held well below the 2-year peak flow (rarely exceeds 1,800 cfs) because higher flow releases could damage non-engineered irrigation diversion infrastructure and potentially effect homes and other structures constructed within the active floodplain. Unless this situation is remedied, flycatcher habitat restoration in this sub-reach would have to focus on relatively small scale (5- to 30-acre) individual projects that don't rely on overbank flooding from the river. Such projects would require varying degrees of maintenance and are not a sustainable solution to restoring riparian vegetation or breeding habitat for the willow flycatcher.

Home construction in the active floodplain of the Lower Chama Sub-Reach limits opportunities for improving flow management for ecological purposes.

8 What incentives exist for private landowners to participate in flycatcher habitat conservation and restoration?

Most of the private landowners we met with in the Lower Chama Sub-Reach expressed concern with the degraded ecological condition of the river and floodplain, and several were very interested in exploring opportunities for protecting and enhancing the habitat quality on their property. However, it is important to be sensitive to the fact that many private landowners are concerned about losing control over management of their lands (and associated water rights) should endangered species begin utilizing their well-managed property. Many are also concerned about being able to continue making financial ends meet through farming or ranching, and need financial incentives to incorporate habitat management into their overall land management program.

Several incentive programs exist for private landowners (see Appendix B), and in order for endangered species conservation and restoration to be successful in the Velarde and/or Lower Chama Sub-Reaches, we believe a concerted effort would be required to explain to landowners what these different incentive programs are, and how they work. Following is a brief introduction to a few existing incentive programs.

Safe Harbor Agreements

Authors of the Endangered Species Act sought to develop assurances for private landowners who wanted to improve their working lands without exposing themselves (or their grandchildren) to unreasonable land use restrictions. For example, Safe Harbor Agreements are arrangements between the FWS and non-federal landowners that promote voluntary management for listed species while giving assurances to participating landowners that no additional future regulatory restrictions will be imposed. Broadly speaking, through a Safe Harbors Agreement, the landowner agrees to implement management that enhances the potential survival of a listed species. In turn, the FWS authorizes incidental take through the ESA Section 10(a)(1)(A) process that essentially allows the landowner to modify habitat or "take"

A fact sheet about Safe Harbor Agreements is provided in Appendix B.1, and additional information is available on the FWS website http://www.fws.gov/endangered/landowner/index.html.

individual listed plants or animals, if they need to for whatever reason, to conditions or levels that existed immediately prior to development of the agreement (i.e., baseline conditions).

As of May 7, 2009, there are three Safe Harbor Agreements (SHAs) between FWS and landowners within the state of New Mexico. One is a multi-species agreement with owners of the Spur Ranch in Catron County, another is for the Southwestern Willow Flycatcher with the Pueblo of Santa Ana, and the third is for the Chiricahua Leopard Frog with the Malpai Borderlands Group (http://ecos.fws.gov/conserv_plans/servlet/gov.doi.hcp.servlets.PlanReport).

Conservation Easements

Conservation easements are another tool that may be desirable by some landowners interested in protecting their lands from certain development pressures. Conservation easements protect land for future generations while allowing owners to retain many private property rights and to live on and use their land, at the same time potentially providing them with tax benefits. Both the federal government and the state of New Mexico have developed considerable tax incentives for landowners who enter into conservation easements.

A brief fact sheet providing examples of conservation easements that have been established in New Mexico is presented in Appendix B.2. Additional information about conservation easements is available on The Nature Conservancy Website at: http://www.nature.org/aboutus/howwework/conservationmethods/privatelands/conservationeasements/.

Federal Tax Benefits: A landowner who donates a conservation easement can receive a deduction for the appraised value of the easement. For donations made in 2008 and 2009, landowners could deduct up to 50 percent of their adjusted gross income, and carry forward any unused deductions for an additional 5 years. In addition, eligible farmers and ranchers can deduct up to 100 percent of adjusted gross income and carry forward unused amount for a much longer time period.

State Tax Benefits: The New Mexico Land Conservation Tax Credit (HB 990) provides a state tax credit for up to 50 percent of the value of a donated conservation easement, up to a maximum of $250,000. This tax credit can also be sold (using a broker of such credits), thereby providing a direct cash benefit.

New Mexico House Bill (HB) 990 is provided in Appendix B.3.

In certain cases, there may also be funding available to compensate landowners who cannot afford to make a straight-out donation. Examples of such funding programs used in New Mexico include the federal Farm and Ranch Protection Program (administered by the National Resource Conservation Service) and the federal Forest Legacy Program (administered by State Forestry). There are very specific criteria for the properties that are eligible for such programs.

Conservation Banking

A *conservation bank* is a market enterprise that offers landowners incentives to protect habitats of listed species by allowing them to sell habitat or species *credits* to entities that need to compensate for adverse impacts to these species. For example, developers and others whose activities result in adverse impacts to species typically are required to compensate for these impacts. Mitigation could involve trying to implement a habitat restoration project to benefit the species, but it is often more cost effective and ecologically beneficial to purchase habitat credits from a landowner who already owns and manages quality habitat for the impacted species. A one-time purchase of credits saves developers time and money, and landowners can generate income, keep large parcels of land intact, and in combination with conservation easements, can reduce their taxes.

A fact sheet about Conservation Banking is provided in Appendix B.4.

Conservation banks typically work by establishing large reserves that function as compensatory mitigation areas for multiple projects. The FWS states that it costs less per acre to manage a large conservation bank than the equivalent acreage divided among many small, isolated mitigation sites. Larger reserves are also more likely to ensure ecosystem functions, foster biodiversity, and provide opportunities for linking existing habitat (http://www.fws.gov/endangered/factsheets/conservation_banking.pdf). Given that there are no *large* flycatcher habitat reserves in the Velarde project area, conservation banking opportunities may not be plausible. Nonetheless, it is another valuable conservation incentive tool, and may still be worth explaining to private landowners interested in long-term, comprehensive planning opportunities.

9 Does the *Scenic River* designation in certain segments of the project area affect the type of restoration work that can be implemented?

The Upper Chama Sub-Reach, Orilla Verde Sub-Reach, and racecourse segment of the Pilar Sub-Reach are all designated *Scenic* status under the National Wild and Scenic River Act (Act) of 1968. Rivers with this status are *"…generally free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads"* (http://www.rivers.gov/).

The Act itself does not define many specifics concerning management objectives or restrictions, instead relying on basic standards, such as prohibitions against dams and diversions, restrictions on timber cutting, etc. Instead, it leaves much of the management to the responsible managing agency, stating *"the [responsible] management agency shall prepare a comprehensive management plan for such river segment to provide for the protection of the river values."* These management plans may establish varying degrees of intensity for its protection and development, based on the "special attributes of the area." Importantly, the Act does not abrogate state or private property rights along Wild and Scenic rivers.

The Rio Chama Management Plan (USFS et al., 1990) discusses some of the ramifications that the Wild and Scenic designation has on management of the Rio Chama. The management plan references standards set forth in the Act, and the policies of the Forest Service Handbook. Some guidelines that may have impacts for restoration activities are included in Exhibit 4-17.

Exhibit 4-17
Wild, Scenic, and Recreational River Management Guidelines

Management Action	Wild	Scenic	Recreational
Timber Harvest	Not permitted except when needed to enhance recreation or protect the environment.	Permitted where no substantial adverse effect on river and immediate environment.	Permitted under standard restrictions to protect river, water quality, scenic, and wildlife values.
Agriculture	Restricted to domestic livestock grazing and hay production in effect at time of W&S designation. Row crops prohibited.	Wider range of uses permitted. Row crops permitted if no substantial adverse effect on natural appearance of river.	All current practices permitted.
Utilities (incl. Water Lines)	New lines discouraged.	New lines discouraged.	New lines discouraged.
Motorized Travel	Possible, but generally not compatible.	Depends on river values.	Permitted; controls generally similar to surrounding waterways.
Water Supply	All water supply dams and diversions prohibited.	All water supply dams and diversions prohibited.	Existing low dams and diversions allowed, provided waterway remains generally natural in appearance.

The Rio Grande Corridor Final Plan (BLM, 2000) is the current guiding management document that outlines how the BLM will manage the river corridor in alignment with the Wild and Scenic Rivers Act. The river corridor within both the Orilla Verde and Pilar Sub-Reaches is managed primarily for recreation, education, and fish and wildlife conservation purposes. Livestock grazing is prohibited from riparian areas, and the agency strictly adheres to policies for maintaining the scenic qualities of the resource. *Visual Resource Management Classes* were developed, and both the Orilla Verde and Pilar Sub-Reaches are managed according to the strictest class (Class 1). Specifically, Class 1 objectives are *"to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention"* (BLM, 1990).

This has important implications for the type of restoration work that can be performed in the Orilla Verde and Pilar Sub-Reaches. In conversations with the BLM Taos Field Office, they emphasized that riparian habitat restoration procedures would follow a recently crafted Environmental Assessment associated with exotic plant removal in the Orilla Verde Recreation Area (BLM, 2006).

To minimize visual impacts, the BLM (2006) report specifies that priority areas would be treated in 1- to 10-acre parcels at a time spread over a 10- to 15-year period. Most of the work will be done by hand crews, herbicide use will be minimized, and with some exceptions (e.g., chipping slash piles), mechanized equipment in the riparian areas will be minimized or avoided all together. Areas where flycatchers have recently been detected, including the Petaca Canyon saltcedar stand, are the lowest priority sites for saltcedar treatment.

The implications for flycatcher habitat restoration approaches are significant. Treatments that involve using heavy equipment for excavating channels or lowering terraces, for example, will likely not be allowed and riparian habitat restoration in these sub-reaches will be limited to supplemental pole planting and relatively small-scale saltcedar removal. On a more positive note, however, this emphasis on protecting existing visual resource quality provides opportunities for partnerships with local user groups (e.g., rafting companies, general public) to balance this need for visual and habitat quality.

Issues and Opportunities for Silvery Minnow Habitat Restoration

10 What key habitat issues are listed by the FWS as potentially limiting establishment of self-sustaining silvery minnow population in the project area?

Goal 3 of the draft silvery minnow Recovery Plan establishes that delisting of this species may be considered only after three self-sustaining populations have been established within the species historical range, with each maintained for at least 10 years (FWS, 2007). Toward the potentiality of addressing this goal by introducing a silvery minnow population upstream of Cochiti Lake (including the Velarde Reach), Buntjer and Remshardt (2005) assessed fish populations and habitat conditions in the Upper Rio Grande (one site in the Rio Grande Sub-Reach) and Lower Rio Chama (two sites in the Lower Chama Sub-Reach). They did not assess any sites in the Upper Chama Sub-Reach. They concluded that, while perennial flows are positive habitat features throughout these river reaches, various other limitations likely preclude the potential for successful re-population by the silvery minnow. Limitations they identified include overall habitat loss related to:

- Entrenched channels and loss of floodplain connectivity.
- Altered hydrology with increased base flows.
- Chronic/acute contaminants exposure.
- Cold water temperatures.
- Loss of suitable channel substrate.
- Channel fragmentation caused by upstream and downstream dams.
- Competition with introduced non-native fish species.

They reported that channelization of these reaches resulted in minimal change in wetted stream widths with increased flows at their assessment sites. Consequently, both water depths and velocities would increase with increasing flow volumes to a much greater extent than occurs along the lower reaches of the

Middle Rio Grande where the channels are wider and the sand beds provide for compensating form roughness (Simons and Richardson, 1962).

Buntjer and Remshardt (2005) report that the last silvery minnow apparently disappeared from the river upstream within a few years after the closure of Cochiti Dam (i.e., within one or two generations). They also suggest that the estimated 50 to 60 miles of marginal habitat for the silvery minnow available upstream of Cochiti Lake is functionally too short for silvery minnow to complete its life cycle successfully.

Based on their assessment, Buntjer and Remshardt (2005) also concluded that it is unlikely that a self-sustaining population of silvery minnow could persist in much of this upstream reach. They suggested that the colder base flow releases from Abiquiu Reservoir would likely slow the development of drifting eggs and larvae. Coupled with minimal availability of low flow refuge habitat to retain developing eggs and larvae upstream, these conditions would tend to increase potential distances that spawned eggs and hatching larvae would wash downstream during times of spawning flows.

Based on results from their assessment and of those from previous studies, Buntjer and Remshardt (2005) agreed with the 2003 Biological Opinion recommendation that it is unlikely a self-sustaining population of the silvery minnow could persist in much of this upstream reach. As such, they suggested that possible stocking of silvery minnows in this reach should be only experimental, with a highly uncertain outcome. Buntjer and Remshardt (2005) also recommended that any experimental stocking above Cochiti Lake not be considered until a surplus of cultured silvery minnows is available. The draft Recovery Plan (FWS, 2007) formally established that recommendation.

The following sections examine the individual habitat constraints described above and assess whether reasonable options may exist to overcome them in different sub-reaches of the Velarde Reach project area. Also, if experimental stocking of silvery minnow were to occur within the Velarde Reach project area, reaches in the project area are assessed to define their potentials for establishing a successful self-sustaining population.

11 What are the primary limiting factors for silvery minnows in the Rio Grande and the Lower Chama Sub-Reaches?

Hydrologic and Channel Morphology

Water flow is a basic constituent of river habitat for aquatic organisms. Chapter 2 describes how flows through the project area have been historically altered by irrigation and reservoir operations. The draft silvery minnow Recovery Plan reports that Rio Grande hydrographs upstream of Cochiti Reservoir have a relatively natural shape with a spring peak that follows snowmelt runoff (FWS, 2007). In a limited sense, this may appear somewhat true, particularly regarding the timing of the spring runoff hydrograph in the Rio Grande through the Velarde project area and downstream. Chapter 2 also highlights, however, that there have been marked long-term changes in the overall hydrograph within the project area related to both base flows and flood magnitudes. This is particularly true for the Rio Chama, which has been markedly altered by flow importation via the San Juan-Chama project, as well as limited peak flow releases below Abiquiu Dam. These changes, and major channelization efforts along the Velarde Sub-Reach, have contributed to eliminating connectivity of the channel to the floodplain in the non-canyon bounded sub-reaches of the project area.

Chapter 2 also reports that operation of Abiquiu Dam has reduced peak flows and annual sediment downstream, while total flow volumes downstream of Abiquiu Dam during the summer and fall are higher than natural base flows due to the diversion of San Juan-Chama Project water into the Rio Chama basin leading to increased reservoir releases. Abiquiu Reservoir was constructed primarily as a flood control reservoir, and sections of the Lower Chama Sub-Reach contains levees to protect against flooding, which also disconnect the historic floodplain.

Peak discharges downstream from Abiquiu Reservoir are limited to 1,800 cfs. The present peak flows in the reach are greatly constrained by the many residences constructed on the floodplain and, often, very near the river bank (see photo at right). This condition tends to minimize potential for bed scour, increases the tendency for substrate embeddedness, and has produced a very entrenched and stable channel with low habitat diversity and very limited value as aquatic habitat for most native fish species.

The lack of significant overbank flooding in the Lower Chama and all Rio Grande sub-reaches, coupled with the currently entrenched U-shaped channel condition, severely limits the potential for retention of silvery minnow eggs and larvae. This floodplain disconnection also minimizes available nursery and feeding habitat for silvery minnow. Therefore, without extensive re-engineering of much of these sub-reach channels, requiring the cooperation of the existing landowners and acequia members, the existing conditions severely minimize almost any potential for successful population recruitment and recovery of silvery minnows in these sub-reaches.

Irrigation Diversions and Habitat Fragmentation

Irrigation diversions along both the Lower Chama and the Rio Grande Sub-Reaches produce a high degree of longitudinal fragmentation within and between these sub-reaches. Thirteen diversions were observed in the Lower Chama Sub-Reach in the 28 miles downstream from Abiquiu Reservoir; two additional diversions exist downstream of the project reach in the remaining 4.5 miles to the Rio Grande confluence. The maximum distance between diversions on the Rio Chama downstream of Abiquiu Dam is roughly 7 miles. Eight large irrigation diversions also occur along the Velarde Sub-Reach between the Rio Chama confluence and Velarde. Each of these diversions produces a substantial obstacle to the upstream movement of silvery minnows.

Due to the disconnected nature of their floodplains, the entrenched channels, and the relatively high frequency of irrigation diversion structures bisecting the channel in both sub-reaches, restoring populations of silvery minnows within these sub-reaches currently have very low probabilities of producing a successful, self-sustaining, viable silvery minnow population.

12 Could installation of fish passage structures help to mitigate channel blockage by irrigation diversions in the Rio Grande and Lower Rio Chama Sub-Reaches?

In the laboratory, Bestgen et al (2003) evaluated the swimming performance of the Rio Grande silvery minnow (RGSM) and the species' ability to navigate various types of fishways including Denil and vertical slot fishways and a hydraulically roughened rock channel. Under both high- and low-flow velocity conditions with a gradient of less than 1 percent (1 foot/100 feet), about 75 percent of the silvery minnows passed the roughened rock channel, and this configuration was used to develop design characteristics for fish passage structures. In shorter channels, maximum recommended flow velocities were less than 3.3 feet/second, and in longer ones, the maximum recommended flow velocities were about 2.5 feet/second, provided that substantial lower velocity refugia were included in the structure. Channel gradients of less than 1.25 percent (1 foot/80 feet) were recommended. Higher velocity attraction flows at the downstream end of the fish passage were recommended, provided that the flows were not highly turbulent.

Based on the findings of the Bestgen et al. (2003) study, the BOR (2004) developed a conceptual design for a rock channel fish passage structure for the San Acacia Diversion Dam. The design included an open trapezoidal channel with a bottom width of between 5 and 7 feet and flow depths of 3 to 4 feet, boulder breaks (fish resting areas) located at 10- to 15-foot spacing, transverse spacing between the boulders of 1 to 2 feet, a gradient of 1 percent, downstream fish entrance structure, an upstream fish exit structure, and a design flow of 35 cfs. The channel was located through the easternmost bay of the dam. To meet design criteria, channel lengths varied from 1,900 feet to 2,100 feet to accommodate the 17 feet of head across the dam. Appraisal level cost estimates for the two channel alternatives considered, ranged from about $9.7 to $11.8 million. A value engineering study by BOR (2007) recommended a 908-foot-long baffled fishway with a 1.8 percent slope designed by HDR/Fishpro (2006) with an estimated cost of $1.7 million.

Most of the diversions in the Velarde Sub-Reach and the Lower Chama Sub-Reach are rock berm structures that range in height from 3 to 5 feet. While lower-tech options may be available for installing lower-cost engineering solutions to provide for upstream silvery minnows passage, information provided by BOR for the San Acacia fish passage is the best information currently available for silvery minnows. Based on the costs developed for the San Acacia Diversion Dam (BOR, 2007; HDR/Fishpro, 2006), the unit cost per foot of head for a baffled fishway is about $106,000. Therefore, typically, the costs for construction of a baffled fishway for the rock diversion structures would range from $318,000 to $530,000, provided that conditions are suited to construction, and sufficient flows can be diverted for fish attraction purposes. Annual maintenance costs are likely to include sediment flushing and removal of trash (HDR/Fishpro, 2006). Based on a 1.8 percent slope, the baffled fishways would range in length from 165 to 275 feet. At a 1 percent slope, they would range in length from 300 to 500 feet, and the unit costs would increase. Within the Velarde Sub-Reach, the diversion structures are more substantial (8 to 10 feet in height) and the requirements for fish passage and the attendant costs would be closer to those estimated for the San Acacia Diversion.

Fish passage facilities for silvery minnows have not been implemented along the Rio Grande. Therefore, questions remain as to the extent that silvery minnows will actually use or benefit from such devices. At this time, adding any of the existing fish passage designs to irrigation diversions would appear to involve high costs with unknown benefit to silvery minnow population sustainability.

13 What are the potential limiting factors for silvery minnow in the Upper Chama Sub-reach?

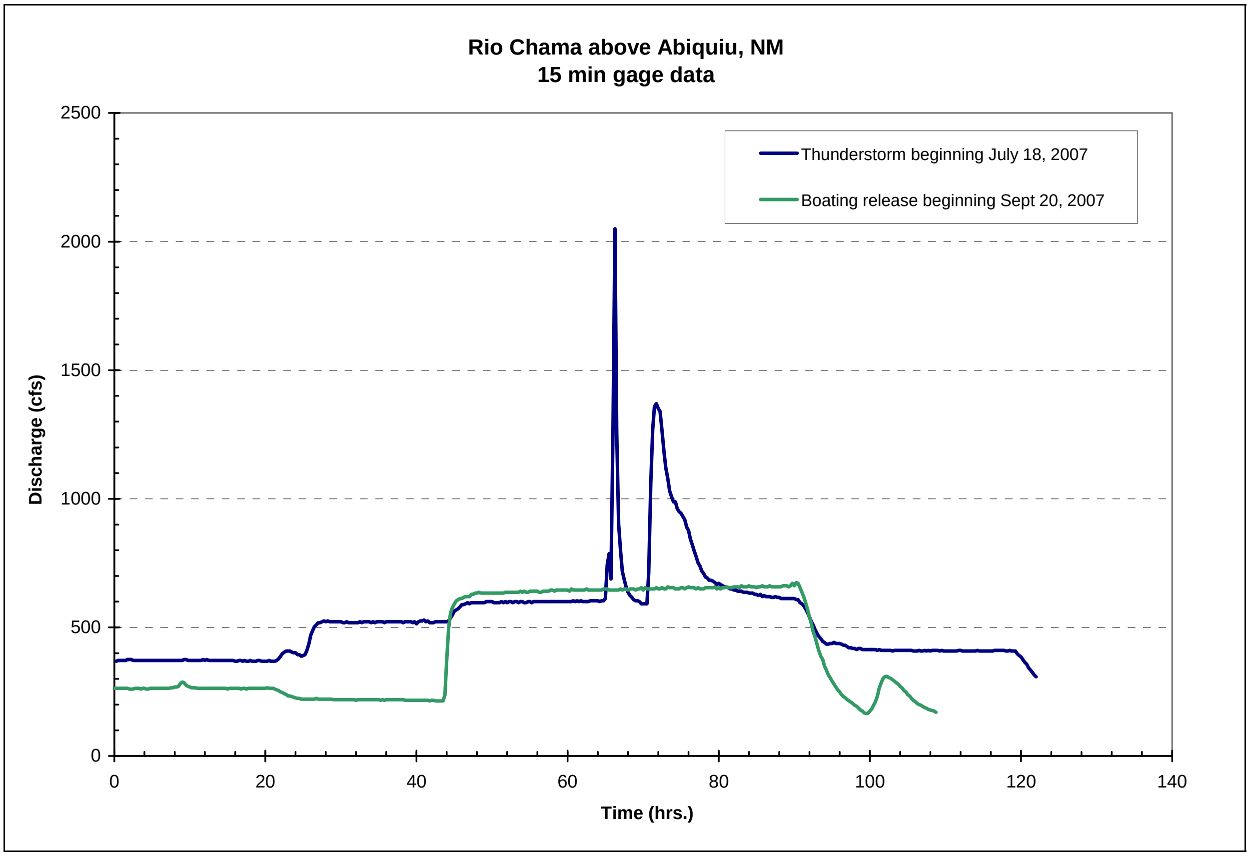
El Vado Reservoir Operations

Chapter 2 reports how the operation of El Vado Dam has lowered peak flows, increased base flows with the diversion of San Juan-Chama Project water into the Rio Chama basin, and narrowed the channel width in the spatially distributed alluvial reaches of the Upper Chama Sub-Reach. From an aquatic habitat perspective, operation of El Vado Dam continues to have a marked influence downstream on the Rio Chama throughout the spring and summer seasons. Peak flows in the spring are significantly reduced (see Chapter 2, Exhibit 2-36), which reduces the frequency and duration of inundation of the pre-dam floodplain (see Chapter 2, Exhibit 2-60).

Regular discharge of rafting/boating flow releases occurs on summer weekends and holidays. These discharges provide a regular weekly, 2-day-long increase in discharge up to about 700 cfs during the spring and summer rafting season. We hypothesize that these "block releases" may affect the streambed biota, but are unlikely to affect the morphology of the channel or the gradation of the bed material since they are below the critical discharge for bed material mobilization. However, since the hydrograph shape of these releases on the ramp-up and ramp-down slopes of the discharges are not markedly different from those produced by monsoon and other storm-flow events (Exhibit 4-18); the artificial hydrograph may not necessarily displace fish more than what would normally occur during summer monsoon events.

Exhibit 4-18

Boating Release versus Monsoon Storm Event Below El Vado Dam



The regular releases from El Vado Dam also may improve habitat conditions for aquatic life on the streambed by mobilizing the fine sediment discharged from uncontrolled tributaries and deposited over the coarser bed material in the Rio Chama (Harvey et al., 2003). Jacobi and McGuire (1992) suggested that fine sediment discharged from the Rio Nutrias, Rio Cebolla, and Rio Gallina during monsoon events appeared to be adversely impacting benthic macroinvertebrate in the Rio Chama downstream from these sources. Discharges for rafting flows would help to mobilize and flush the deposited sediment downstream.

While specific effects to stream biota from the rafting flows have not been studied, we hypothesize that these events, coupled with the naturally low water temperatures and elevated sediment concentrations from tributary streams, would adversely impact benthic productivity for both algal and invertebrate populations, with subsequent impacts to silvery minnows and other fish species in the Upper Rio Chama Sub-Reach.

This hypothesis is based on preliminary observations during a July 2008 field reconnaissance to the Upper Chama Sub-Reach where we observed a relatively low density of benthic macroinvertebrates on cobble substrates. We examined eight locations from the boat launch to Big Eddie, with relatively few aquatic invertebrates observed that exceeded 0.5 inch in length (see top sidebar photo). Despite these constraints, most of the larger cobble in the river held typical growths of periphyton (see middle sidebar photo). Also, growth of filamentous algae was commonly observed on boulders and between larger cobbles. As reported in Chapter 3, diatoms, algal, and detrital material are thought to be particularly key components of the food supply for silvery minnow. More rigorous site-specific assessments within this sub-reach would be required to assess the accuracy of the hypothesis that boating releases combined with other site factors may influence benthic productivity.

Mayfly (Heptageniidae) representing small sized benthic invertebrates observed during July 2008 site visit to Upper Chama Sub-Reach.

Typical algal and diatom coating cobble on river bottom.

In summary, if silvery minnow introduction to this sub-reach were seriously considered, we suggest pre-introduction studies would be necessary to assess the potential impacts of summer boating releases on potential displacement of silvery minnows and on benthic productivity.

Reach Length

The Upper Chama Sub-Reach, as defined by this report, is relatively short (13.5 miles), and there is reasonable concern that high flows associated with spring snowmelt, summer monsoons or boating releases discussed above could flush silvery minnow eggs, larvae and adult fish into Abiquiu Reservoir where non-native predatory fish abound. This concern is particularly relevant in light of hypotheses that the persistence of riverine fish populations that reproduce via pelagic spawning, including silvery minnow, require contiguous longitudinally connected river channel greater than 100 kilometer (62 miles) in length (Platania and Altenbach, 1998; Dudley and Platania, 2007d).

The role of connected floodplains in reducing downstream transport of eggs and larvae in the Upper Chama Sub-Reach, however, is worthy of consideration before assuming reach length to be a critical limiting factor for silvery minnows. For example, Dudley and Platania (2007d) acknowledged that physical habitat restoration (e.g., destabilizing banks and reconnecting rivers with floodplains) "*would likely decrease the transport distance of ichthyoplankton* [i.e., silvery minnow larvae in the water column, clarification added]*, further studies will be required to determine how much drift distance would be reduced as a function of flow or habitat modification*."

Seasonally inundated sidebars provide valuable off-channel refuge habitat during high-flow events.

The river channel between the monastery and the headwaters of Abiquiu Reservoir includes spatially-distributed reaches with channel braiding, island development, undercut banks, and considerable potential for moderate overbanking (see Chapter 2, Exhibit 2-59). Seasonal flow duration curves for the post-SJC period indicates that the 2-year peak flow of 3,200 cfs occurs on average for about 6 days during the spring period in the Upper Chama Sub-Reach (see Section 12 of Chapter 2). This results in inundation of the vegetated mid-channel bars for about 18 days, the floodplain surface for about 6 days, and the T2 surfaces for about 2 days. Thus, reaches of the channel between the Rio Gallina confluence and Abiquiu reservoir appear to provide considerable opportunities for off-channel refuge habitat during high flow events (see sidebar photo). The influence that this inundation would have on downstream drift of silvery minnow eggs, larvae, and adult fish is unknown but is worthy of at least cursory exploration.

Computing the effects of floodplain connectivity in attenuating downstream flood-flow volumes and main channel flow velocities can be a complex modeling endeavor through river reaches with varying degrees of floodplain connectivity and inundation. However, the significance of floodplain connectivity in reducing potential for downstream displacement of eggs and young silvery minnows can be simply estimated using the continuity equation (see Marek, 2009). This equation is the basic formulation for the conservation of mass in fluid mechanics. It is the basic hydraulic relationship used to compute discharge for open channel flows and is presented in various forms in hydrology, hydraulics, or stream ecology text books, manuals, and online introductions to discharge hydrology (e.g., Hauer and Lamberti, 2006).[2] For steady flow of an incompressible fluid, such as water, the continuity equation has the following general form:

$$Q = A_1 v_1 = A_2 v_2$$

where: Q = discharge (cfs or m3/s)
A = flow cross-sectional area (sq. ft. or m2)
v = mean cross-sectional velocity (fps or m/s, perpendicular to the flow area)

The subscripts 1 and 2 refer to successive cross sections along the flow path. In other words, the average velocity in a channel cross-section (v) equals the total discharge (Q) divided by the cross-sectional area (A) of flow perpendicular to the cross-section:

$$v = Q / A.$$

Thus, doubling the cross section of the flow area for a given discharge halves the average flow velocity, which in turn would halve the potential downstream displacement distance for transport of materials, eggs, and larvae during flood events producing floodplain inundation. Similarly, expanding the cross flow channel area during a flood by ten-times would reduce downstream displacement potential to one-tenth of the distance, and so on.

Of importance, the continuity equation provides only a general indicator and does not reflect the horizontal and vertical variations in velocity across the section. For example, velocities near the channel bottom approach zero, and the greatest velocities in the channel are typically about one-third depth below the water surface near the cross-section’s vertical location where the deepest flow exists (e.g., Hauer and

[2] Also see, http://en.wikipedia.org/wiki/Discharge_(hydrology).

Lamberti, 2006). Also, flow velocities in inundated floodplains also would be additionally reduced due to the presence of roughness factors produced by terrestrial vegetation.

Considering role of floodplain inundation in reducing channel velocities, we hypothesize that (1) regular overbank flooding in the Upper Chama Sub-Reach would significantly reduce downstream drift of silvery minnow eggs and larvae, (2) that overbank flooding in the Upper Chama Sub-Reach could result in retention of silvery minnow eggs, larvae and adult fish outside of the main channel, and (3) the potential impact of extensive downstream transport to silvery minnow in the Upper Chama Sub-Reach would be insignificant at the population level. Clearly more study would be required to validate these hypotheses, but until performed, we cannot conclude that reach length is a critical limiting factor for silvery minnow in the Upper Chama Sub-Reach.

Water Quality

Jacobi and McGuire (1992) reported that from their preliminary assessment, benthic macroinvertebrates in the Rio Chama were impaired primarily due to fine sediment delivered by tributary inflows during the monsoon season, especially from the Rio Nutrias, Rio Cebolla, and Rio Gallina. The watershed conditions have not markedly changed between the time of their study and the present. Therefore, we suggest their observations are still relevant today. However, weekly boating flows that commenced more recently may be flushing some of the tributary-introduced fine sediments, thereby reducing the fine-sediment impacts on the benthic macroinvertebrates (Harvey et al., 2003). Jacobi and McGuire (1992) also reported that additional turbidity, with potential downstream effects, accompanied discharges from El Vado Reservoir, except in the winter. In its water quality assessment of the Lower Rio Chama watershed, however, the New Mexico Environment Department (NMED) (2004) concluded that no water quality impairments existed along the mainstem of the Rio Chama. It did include specific listings related to six of its tributaries.

Currently, beyond impacts occurring during periods of channel drying, no evidence exists that water quality has limited silvery minnow populations along the MRG (Marcus et al., 2005). Additionally, toxic wastewater discharges have not resulted in a recorded fish kill involving any species in the MRG (Marcus et al., 2008). All known and documented fish kills in the area of the MRG having been associated with adverse water quality conditions occurring in waters adjacent to, but outside of the Rio Grande itself. No silvery minnows were documented to have been affected by these events (Marcus et al., 2008)[3]. That said, a screening level risk assessment of available water quality data collected between 1985 and 2003 indicated that water quality conditions recorded did, and may again, have the potential to produce limited, localized lethal or sublethal impacts to silvery minnows or other aquatic species at some times and places along the MRG (Marcus et al., 2005). Actual effects, however, have not been documented in the river. Marcus el al. (2005) provided recommendations for conducting additional field and laboratory water quality studies to help resolve uncertainties about potential effects of water quality to silvery minnow in the Rio Grande. At this time, we are unaware of any water quality problems that could affect silvery minnow in the Upper Chama Sub-Reach.

Water Temperature

The best available study assessing the effects of colder water temperature on silvery minnow was performed by Platania (2000). In that study, he monitored the development of silvery minnow eggs and larvae at four temperatures in the laboratory, in 5 degrees (°) C increments from 15°C to 30°C (59°F to 86°F). While this study provides useful insights into water temperature relationships on developmental rates of silvery

[3] The often reported fish kill occurring 26-27 June 2004 associated with storm flows through the North Diversion Channel along the MRG near Corrales, NM, was confined to that channel, and this fish kill did not extend into the Rio Grande [see slide 30 presented in Abeyta and Lusk, 2004; also, Jerry Lovato, Albuquerque Metropolitan Arroyo Flood Control Authority, phone call with M. Marcus, November 2007; Scott Anderholm, USGS, personal communication to M. Marcus, November 2007, as reported by Marcus et al., (2008).

minnow, it is important to recognize that this study did not establish a potential lower temperature limit for silvery minnow growth and survival.

For several years, the USGS continuously monitored water temperatures (at 15-minute intervals) at gages upstream and downstream of Abiquiu Reservoir, Chamita, Taos Junction, Otowi, and downstream of Cochiti Reservoir and Alameda Bridge. Exhibits 4-19 to 4-21 plot the USGS-recorded water temperatures collected at midnight, 6 a.m., noon, and 6 p.m., for each day data were collected from the Above Abiquiu, Otowi, and Alameda gages. For reference, each plot highlights the 15°C temperature line in red. Although the data available varied among the three sites shown, the plots show very similar temperature patterns among the sites, with the number of days with temperature exceeding 15°C progressively decreasing through the northern sites. The Above Abiquiu site shows more days with near zero (0°C) temperatures.

Exhibit 4-19

Daily Average Water Temperatures Recorded on the Rio Chama Above Abiquiu Lake

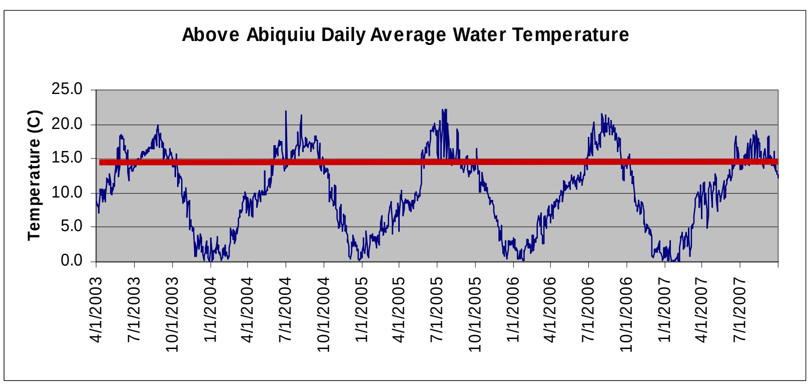


Exhibit 4-20

Daily Average Water Temperatures Recorded on the Rio Grande at Otowi Gage

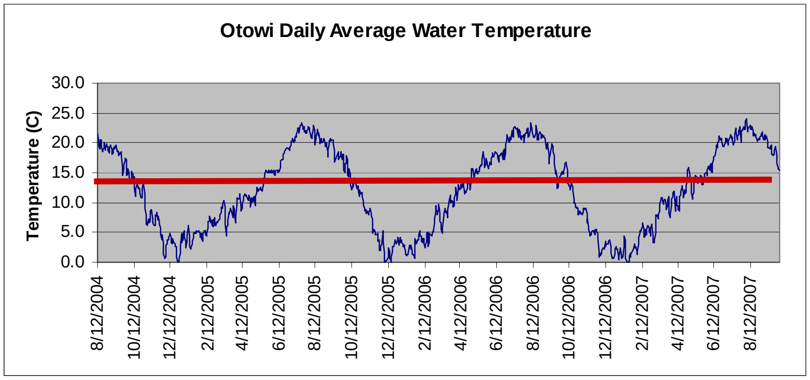


Exhibit 4-21

Daily Average Water Temperatures for the Rio Grande Near Alameda Bridge

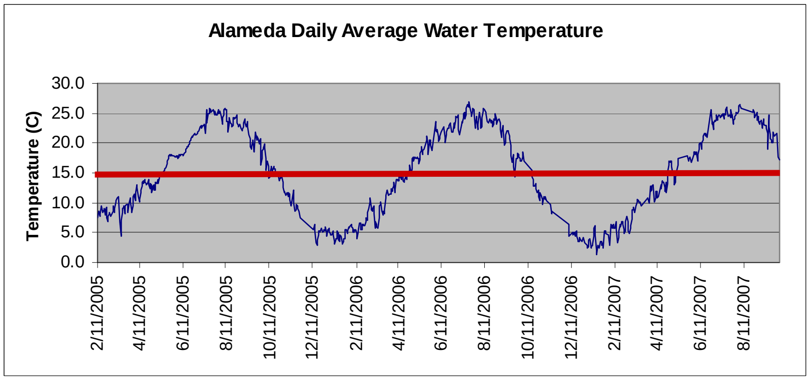
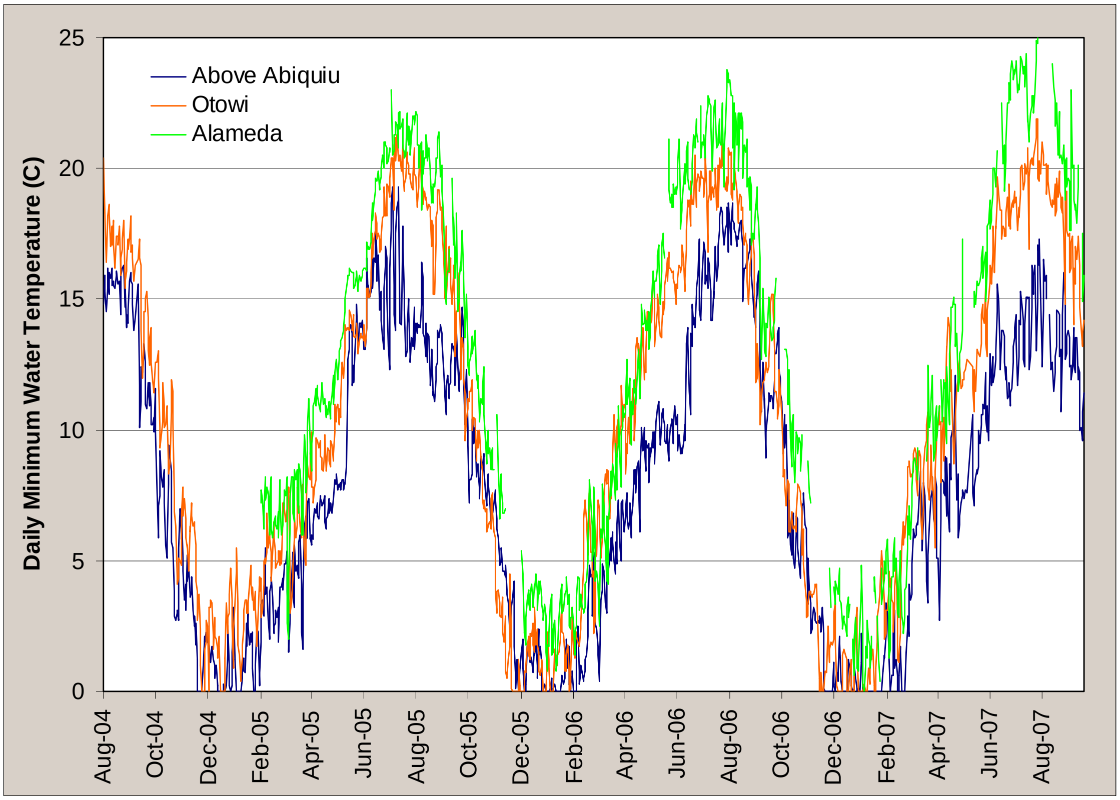


Exhibit 4-22 provides a closer view of the pattern of minimum temperatures at these three sites. Minimum daily temperatures do appear to be markedly lower at the Above Abiquiu gage during some warmer months of the year than found at the two more southern gages. There is, however, a considerable scatter in the data and a fair degree of overlapping of minimal temperatures, particularly during the colder periods of the year. Exhibit 4-23 summarizes the distribution of water temperature conditions at the three sites, trimmed to the shorter gage record available for the Alameda gage. At the Above Abiquiu gage, 58 percent of the 15-minute interval daily recordings had a *daily minimum temperature* of less than or equal to 10°C and 36 percent had a *daily maximum temperature* less than or equal to 10°C. Thirteen percent of the daily recordings had a *daily minimum temperature* greater than or equal to 15°C and 37 percent had a *daily maximum temperature* greater than or equal to 15°C.

Clearly the minimum water temperatures from the Above Abiquiu are considerably lower and extend for longer periods than those found at Alameda and Otowi, and these lower temperatures may very well have detrimental impacts on silvery minnows reintroduced to the Upper Chama Sub-Reach and perhaps other segments of the Rio Grande above Cochiti Lake. However, we propose that this should be viewed as a hypothesis rather than a statement of fact. Historical fish collections indicate that silvery minnow populations once occupied habitat upstream of Otowi (e.g., FWS, 1994; Sublette et al., 1990). Unfortunately these collections did not assess the upstream limit for the historical distribution of silvery minnow. As such, these upstream limits remain unknown. We suggest that more research is needed to determine whether water temperature is a critical limiting factor to silvery minnow reproduction and survival in the Upper Chama Sub-Reach or other portions of the Rio Grande upstream of Cochiti Lake.

Exhibit 4-22

Daily Minimum Water Temperatures Recorded at Three USGS Gages (Above Abiquiu, Otowi, and Alameda)



Data provided by S. Anderholm, USGS, 2008.

Exhibit 4-23

Distribution of Daily Water Temperatures at Three USGS Gages between February 2005 and September 2007

USGS Gage	Count (Days)	Percent Days <=10ºC	Percent Days >=15ºC
ABOVE ABIQUIU	954		
Daily Maximum Temperature		36%	37%
Daily Minimum Temperature		58%	13%
OTOWI	955		
Daily Maximum Temperature		31%	49%
Daily Minimum Temperature		47%	33%
ALAMEDA	837		
Daily Maximum Temperature		21%	61%
Daily Minimum Temperature		38%	21%

Channel Substrate

The third of the four primary constituent elements of critical habitat for the silvery minnow proposed by the FWS (2003c) are "*substrate of predominately sand and silt*." Substrate in the Upper Chama Sub-Reach is dominated mostly by cobble, gravel, and boulders, which periodically become coated with silts and clay (see photo at right). Cobble, gravel, and sand bars are also common. Under low-flow conditions, the gravel-cobble bed of the river in the pool sections within the alluvial reaches appear to be covered by sand, probably introduced from the Rio Gallina where sand-rich sedimentary rocks predominate in the watershed (see Chapter 2, Exhibit 2-17).

Cobble channel bed near the Big Eddie takeout, upstream from Abiquiu Reservoir

In general, the abundance of fish populations is rarely regulated by the mesohabitat attributes of local substrate composition, flow velocities, and water depth, unless they become severely limiting (e.g., abnormal increases in average flows, dewatering, or excess loads of fine sediment [BOR and COE, 2003; Tetra Tech, 2004b]). Previous studies (pre-Cochiti Reservoir) indicate that gravel and cobbles were prevalent in the upper reaches of the Rio Grande, with gravel becoming less abundant below Albuquerque (Rittenhouse, 1944; Culbertson and Dawdy, 1964; Nordin and Beverage, 1965).

Drying gravel and cobble channel bed at Solis, Big Bend National Park, April 9, 2003, by Raymond Skiles.

As discussed in Chapter 3, Section 26, silvery minnow behave similar to other riverine fish species in tending to favor areas with reduced flow velocities, probably as a key mechanism to conserve energy. Such slower flow areas tend also to be shallower and where sediment settles from the water column. As such, we hypothesized in Chapter 3 (Section 26) that observations of silvery minnow captures commonly associated with fine sediment is biased by the present-day dominance of fine sediment in those reaches of the MRG reaches currently occupied by the silvery minnow. Indeed, low flow, shallow water, and settled fine sediment are highly collinear variables in river systems.

We suggest that the hypothesis that silvery minnow require a substrate of predominately sand and silt merits additional scientific examination. Understanding the causal versus correlative role of substrate is particularly important during the evaluation of potential silvery minnow restoration or reintroductions sites, as assumptions of causation could lead to ruling out areas that might otherwise provide reasonable habitat potential. Until more study of this topic is performed, we cannot conclude that channel substrate is a critical limiting factor for silvery minnow in the Upper Chama Sub-Reach.

Predation by Non-Native Fish Species

The silvery minnow Draft Recovery Plan states that, "*[a]lthough it is unlikely that predation is a major factor in the decline of the Rio Grande silvery minnow, it has probably played a minor role, with increasing importance as populations have come under greater stress from other factors"* (FWS 2007, page 30). It also states, "*There have been no studies to determine if non-native piscivores (e.g. channel catfish) prey upon or compete with Rio Grande silvery minnow"* (FWS, 2007, page 79). It is noteworthy, that the potential vulnerability of silvery minnows and other small-bodied fish species to predation is benefited by increased turbidity. Specifically, non-native species including rainbow trout, brown trout, smallmouth bass and white suckers, all of which are sight predators, have less success in finding prey species in waters with higher turbidity. In contrast, the silvery minnow, which has inhabited the typically turbid waters of the Rio Grande, appear to be little affected by such conditions. Lacking information to base a reasonable assessment of potential predation effects on silvery minnows, additional monitoring would be required to assess the potential relationship of non-native fish predators to depress a silvery minnow population in the Upper Chama Sub-Reach.

14 Does the Velarde Reach project area have any restoration potential for silvery minnows?

The analysis summarized above indicates that minimal practical potential exists for habitat restoration enhancements to benefit silvery minnows within the Velarde Reach project area. The Lower Chama and Rio Grande Sub-Reaches are primarily limited by simplified channel geometry and limited overbank flow potential, presence of levees (in the Velarde

Sub-Reach), and flow release restrictions below Abiquiu Dam (Lower Chama Sub-Reach). Furthermore, multiple irrigation diversion throughout the length of both the Velarde and Lower Chama Sub-Reaches provide considerable obstacles to fish movement.

Our analysis of the Upper Chama Sub-Reach is less conclusive, and several of the limiting factors hypothesized by Buntjer and Remshardt (2005) about the Rio Grande upstream of Cochiti Lake may still apply. That said, however, we suggest further study of several of these factors is needed in order to either rule out or consider further the Upper Chama Sub-Reach for experimental silvery minnow introductions.

More specifically, research is needed in the following areas in order to determine if the Upper Chama (or other segments of the Rio Grande upstream of Cochiti Lake) has potential to support sustainable populations of silvery minnows:

- Influence of floodplain inundation on retention and downstream drift of silvery minnow eggs, larvae, and adult fish;
- Influence of cold water temperature on silvery minnow gamete production and larval development;
- Role of channel substrate as correlation versus causation of silvery minnow habitat use;
- Influence of El Vado boating flow releases on downstream transport of silvery minnow eggs, larvae and adult fish, and;
- Potential predation impacts by non-native game species on silvery minnow in the Upper Chama Sub-Reach.

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Chapter 5 Recommendations

Southwestern Willow Flycatcher

Active Restoration Projects

For this report, “active” restoration projects include any actions that involve physical manipulation of a project site. Examples include using heavy equipment to lower floodplain surfaces, using chainsaws to remove exotic trees or reinvigorate native vegetation, or installing native vegetation through pole planting or other means.

As discussed in Chapter 4, development along the Lower Chama Sub-Reach precludes the potential for riparian habitat restoration through more passive means, i.e., hydrograph manipulations from Abiquiu Dam. We also hypothesized that limiting factors for recruitment of riparian tree species on channel bars and the floodplain along the Upper Chama Sub-Reach may have more to do with lack of safe sites for seed germination and/or livestock browsing than from lack of overbank flooding. We suggest more study is needed before recommending passive approaches like hydrograph manipulations from El Vado as a means to improve riparian habitat structure for the flycatcher in the Upper Chama Sub-Reach.

1 What was the site selection process for identifying active restoration projects in the Velarde Reach?

Reach-Wide Flycatcher Site Selection Process

Flycatcher habitats across the southwestern United States are typically dominated by obligate riparian plant species that require shallow seasonal groundwater tables to survive past initial seedling establishment. In the Middle Rio Grande, most flycatcher territories are dominated by coyote willow and Gooding's willow (citations in Parametrix, 2008a, 2008b).

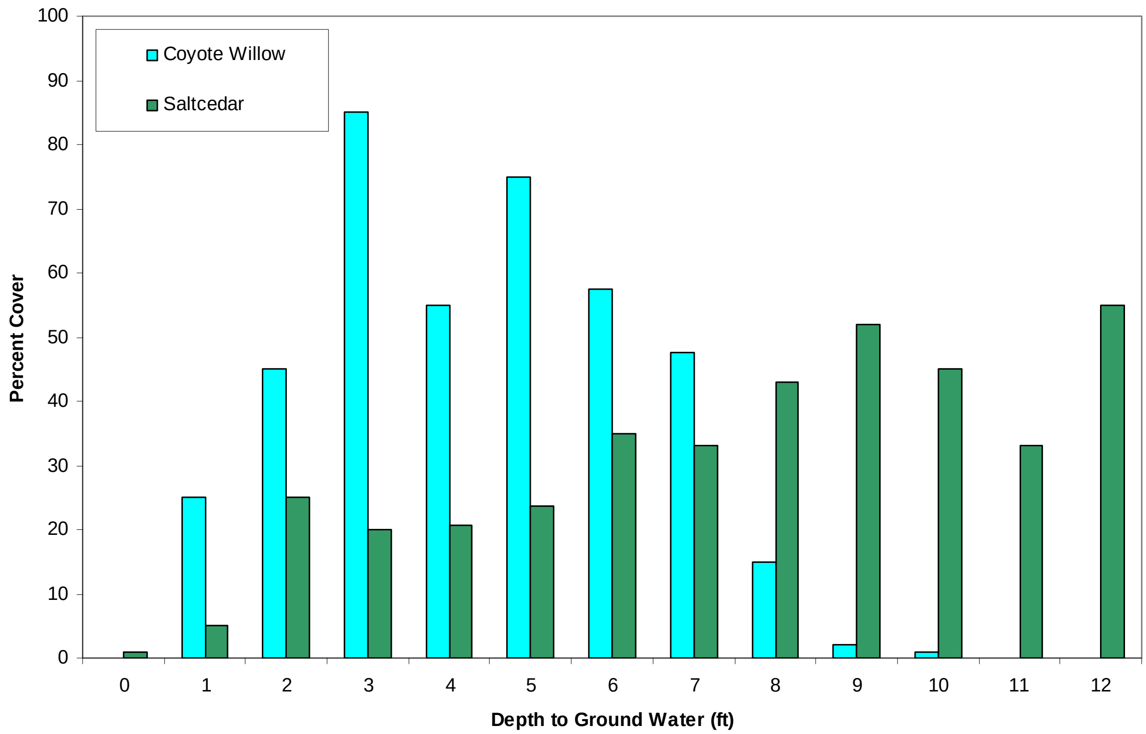
Data from different southwestern riparian ecosystems indicate that Gooding's willow become water stressed when groundwater depths exceed approximately 8 to 10 feet below the ground surface (Amlin and Rood, 2002; Glenn and Nagler, 2005; Horton et al., 2001). Observations along the MRG indicate that Gooding's willow cover is typically higher in sites with much shallower seasonal groundwater (maximum depth to groundwater on the order of 4 to 5 feet). Similarly, regional data for coyote willow indicate that they become water stressed when maximum depth to groundwater exceeds approximately 7 feet (Parametrix, unpublished data; Exhibit 5-1). These data also indicate that coyote willow foliage cover is highest when maximum groundwater depths are less than 5 feet below the surface. When groundwater depths exceed approximately 5 feet, coyote willow can become more vulnerable to competition from non-native phreatophytes like saltcedar.

These data are particularly relevant when developing criteria for screening willow flycatcher habitat restoration project sites. For example, sites with seasonal groundwater tables that exceed 5 feet below the ground surface are probably poor candidates for willow habitat restoration unless the ground surface can be cost-effectively lowered to allow willows close contact with the groundwater table. This restoration technique, frequently referred to in the MRG as willow swale construction, has been performed at numerous locations along the Middle Rio Grande (e.g., Cochiti Pueblo, Santa Ana Pueblo, Rio Grande Valley

State Park…) with mixed results. Monitoring observations from the Rio Grande Valley State Park sites indicate that willow plant heights and aerial cover is greatest at sites where the seasonal water table during spring snowmelt comes close to or above the ground surface and remains within 5 feet below the ground surface under base flow conditions (Parametrix, 2007).

Exhibit 5-1

Coyote Willow and Saltcedar Cover in Relation to Maximum Depth to Seasonal Groundwater



This graph displays monitoring data from an area within the MRG watershed. The data shows that coyote willow cover declined and saltcedar cover increased as groundwater depths exceeded 5 feet. Once groundwater levels exceeded 7 feet, coyote willow cover dropped off dramatically (Parametrix, unpublished data).

While we found no high resolution data regarding riparian groundwater conditions for any of the project area sub-reaches, field observations combined with GIS analyses and outputs from surface water hydrologic models (HEC-RAS and/or FLO-2D) indicate that there are numerous locations with seasonally shallow groundwater tables. This was the first stage of a multi-step filtering process for identifying potential flycatcher habitat restoration project sites. This approach then allowed us to prioritize where more detailed site visits were warranted for developing general restoration treatment approaches. Details associated with these and other site selection and restoration management approaches are described below.

Shallow Groundwater

For the purposes of this task, “shallow” groundwater means that the alluvial water table is close to the ground surface (approximately less than or equal to 2 feet) during average spring-time flows (i.e., 50 percent discharge exceedance). This was estimated for all project sub-reaches through a combination of field reconnaissance performed between April 27 and May 30, 2008 (Exhibit 5-2) and through the use of hydrologic models, when available. Existing hydrologic models were used to identify locations with overbank flooding during the 2-year flow event, or in the case of the Lower Chama Sub-Reach, the maximum non-flood release flow of 1,800 cfs. We assumed that sites inundated at these flow levels also have shallow alluvial groundwater tables.

Exhibit 5-2

Flows During Spring Field Reconnaissance

Gauge	Date	Flow (cfs)	50% Spring Exceedance[a]
Embudo	4/27/08 through 4/28/2008	1,940	1,186
Below El Vado	4/29/08	1,100	768
Chamita	4/30/08 through 5/30/08	1,660 to 2,100	1,020

[a] *Seasonal exceedance tables provided in Chapter 2.*

Visual observations during field reconnaissance in the Lower Chama and Velarde Sub-Reaches indicated that shallow groundwater conditions were most prevalent in riverside floodplain zones residing within approximately 0.5 mile upstream of surface water diversion structures. Field observations in the Upper Chama Sub-Reach indicated shallow groundwater conditions occur at most of the mapped floodplain surfaces and some of the higher T-2 surfaces.

Many channel bars, or at least portions of many channel bars in the Orilla Verde Sub-Reach appeared to be within 2 feet of the surface water elevation the day of our site reconnaissance. Since there was no high-resolution topographic data or hydrologic models available for this sub-reach, we utilized existing vegetation maps to supplement our field observations for estimating sites with shallow groundwater. Sites dominated or co-dominated by coyote willow were assumed to have shallow groundwater, so map polygons with this vegetation were also applied to site analyses. A similar process was implemented for the Pilar and Upper Chama Sub-Reaches.

Patch Size

Sites that met the shallow groundwater criteria were screened further based upon patch size and shape characteristics. Sites comprised of less than five contiguous acres were eliminated from further consideration. Sites that were at least 5 acres, but were less than 15 m wide were also eliminated. These screening criteria were based on median patch size (4.4 acres) of existing flycatcher territories across its breeding range. The 5-acre threshold was also based upon recommendations in the flycatcher recovery plan. For example, the recovery plan suggests protecting or restoring habitat that is at least twice the acreage of the average territory patch size (range-wide mean is 2.7 acres) across the flycatcher breeding range. This equates to protecting or restoring a minimum patch of 5.4 acres for each flycatcher territory.

The minimum patch width criteria of 15 m is based upon flycatcher nest site characteristics described in Sogge et al. (1997) in which they state that "…*flycatchers have not been found nesting in narrow, linear riparian habitats that are less than 10 m wide, although they will use such linear habitats during migration*" (p.5). We increased the minimum width threshold to 15 m as a conservative measure.

Existing Vegetation and General Restoration Treatment Approaches

A total of 40 "candidate" restoration sites were identified using the aforementioned screening criteria (Exhibits 5-5 through 5-10). General restoration management approaches were assigned to these candidate sites based upon desk-top GIS evaluations of existing vegetation. Through this process five general management treatment categories were assigned to candidate sites based upon existing vegetation stand characteristics. These management categories included:

> **Management Category 1** – These candidate restoration sites are generally dominated by native coyote willows but lack an overstory tree canopy. Management of these sites would involve planting an overstory tree canopy layer (e.g., tree pole planting).
>
> **Management Category 2** – These candidate restoration sites are composed of mixed native and non-native shrub layers but lack overstory tree canopy layers. Management of these sites would involve treating (thinning/herbicide) non-native woody vegetation and planting an overstory tree canopy layer. Supplemental coyote willow planting may also be warranted at some sites.
>
> **Management Category 3** – These candidate restoration sites have native overstory trees with dense non-native vegetation growing in the understory. Management of these sites would involve treating non-native understory vegetation layers and replacing them with native coyote (and possibly Gooding's) willow.

Management Category 4 – These candidate restoration sites are composed of exclusively non-native vegetation. Management of these sites would involve treating non-native vegetation and planting native overstory trees (i.e., Gooding's willow, cottonwood, and/or box elder) and coyote willow.

Management Category 5 – These candidate restoration sites are composed of decadent stands of coyote and Gooding's willow. Management treatments for these sites may only require applying physical disturbance (i.e., via chainsaws or mechanized equipment) to rejuvenate willow growth.

Exhibit 5-3

Representative Site Photographs with Different Restoration Management Categories

This site within the Upper Chama Sub-Reach is dominated by coyote willow but lacks an overstory tree canopy. Sites like this are assigned to Category 1.

Many channel bars within the Orilla Verde Sub-Reach currently support mixed stands of coyote willow and saltcedar. Sites like this fit into management Category 2.

This photograph shows a site within the Velarde Sub-Reach that has dense Russian olive trees growing beneath a closed canopy cottonwood gallery forest. Sites like this fit into management Category 3.

Exhibit 5-4

More Representative Site Photographs with Different Restoration Management Categories

These sites along the Lower Chama Sub-Reach are composed almost exclusively of Russian olive. Sites like this are assigned to management Category 4.

This site along within the Velarde Sub-Reach has extensive stands of over-mature Gooding's and coyote willows. These willows could be rejuvenated by cutting them with chainsaws or mowing them with small mulching tractors. This site fits into management Category 5.

Exhibit 5-5

Flycatcher Restoration Candidate Sites and Related Attributes

Sub-Reach	Site Name	River (R/L)	Acres	Current Vegetation	Management Category	Overbank Flood Potential	Within .5 mile Upstream of DD	Landowner ship	Notes/Other Mitigating Factors
Orilla Verde	RM 304B	R	5	CW, CW-SC	Category 2	No data	No	BLM	Selected due to current vegetation, acreage, and floodplain surface designation.
Orilla Verde	RM 304A	L	5	CW, Marsh, CW-SC	Category 2	No data	No	BLM	Selected due to current vegetation, acreage, and floodplain surface designation.
Orilla Verde	RM 301	L	5	SC, SC-CW, CW	Category 2/4	No data	No	BLM	
Orilla Verde	RM 300B	R	6	CW, SC, SC-CW	Category 2	No data	No	BLM	Selected due to current vegetation, acreage, and floodplain surface designation.
Orilla Verde	RM 300A	L	7	SC-CW, CW	Category 2	No data	No	BLM	Selected due to current vegetation, acreage, and floodplain surface designation.
Pilar	RM 294	L	5	C/CW, CW-NMO	Category 1	No data	No	BLM	Just downstream of racecourse takeout, nice bosque.
Pilar	RM 290	R	5	CW, C/CW	Category 1	No data	No	BLM	Selected due to current vegetation, acreage, and floodplain surface designation.
Velarde	RM 284	R	11	Mosaic of C, RO, CW, TW, and SC	Category 2/5	2-year flow (HEC-RAS)	Yes	Private	Former SWFL Residents, detailed vegetation mapping completed under this project, some CW stands decadent.
Velarde	RM 282	R	11	C/RO	Category 3	No data	Yes	Private	At fan of large Arroyo (Arroyo de la Guaje), side channel through project area.
Velarde	RM 278	L	37	C/RO	Category 3	No data	Yes	State	Los Luceros Property, mapped flow paths through site.
Upper Chama	RM 55	R	9	CW-RO, CW-RB, MS	Category 1/2	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 54C	L	9	CW-RB, C/CW-RB	Category 1	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 54B	L	10	CW5F, CW-RB	Category 1	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 54A	R	5	CW 5F, OP, CW-RB	Category 1	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 51C	L	5	CW5	Category 1	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 51B	L	5	NLC/ NMO-CW, CW	Category 1	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 51A	R	6	CW, RB-CW	Category 1	No data	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.

Exhibit 5-5

Flycatcher Restoration Candidate Sites and Related Attributes

Sub-Reach	Site Name	River (R/L)	Acres	Current Vegetation	Management Category	Overbank Flood Potential	Within .5 mile Upstream of DD	Landowner ship	Notes/Other Mitigating Factors
Upper Chama	RM 47	L	7	CW, CW-C, RB-CW	Category 1	2-year flow (HEC-RAS)	No	Forest Service	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 43	L	9	CW5F	Category 1	No data	No	Private	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 42B	L	8	CW5F	Category 1	No data	No	Private	Floodplain surface in the Upper Chama, lacks structural diversity.
Upper Chama	RM 42A	R	33	CW5F	Category 1	No data	No	Private	Floodplain surface in the Upper Chama, lacks structural diversity.
Lower Chama	RM 26	R	6	C/RO-NMO, RO-NMO, C/NMO	Category 2/3	1,800 cfs (FLO-2D)	No	Private (Abiquiu Land Grant)	Restoration potential due to overbank flooding.
Lower Chama	RM 25A	R	6	NMO-RO, CW	Category 4	No	Yes	Private (Abiquiu Land Grant)	Most of site downstream of a diversion. Influenced by water surf, elevation in the ditch and the river, Big backwater wetland; Site liked by all who saw it.
Lower Chama	RM 25B	L	13	RO, CW, NMO-CW, RO/CW	Category 1/2/4	1,800 cfs (FLO-2D)	Yes	Private (Abiquiu Land Grant)	
Lower Chama	RM 25C	R	6	RO-NMO, C/NMO-RO, C-RO/CW	Category 2/3	1,800 cfs (FLO-2D)	Yes	Private (Abiquiu Land Grant)	Upstream of diversion, just upstream of Hwy 84 crossing.
Lower Chama	RM 25D	L	17	RO-NMO, Marsh, C/RO-NMO	Category 3/4	1,800 cfs (FLO-2D)	No	Private (Abiquiu Land Grant)	Restoration potential due to overbank flooding.
Lower Chama	RM 21A	L	6	C/RO-NMO, RO-CW	Category 2/3	1,800 cfs (FLO-2D)	No	Private (Double M Ranch)	Restoration potential due to overbank flooding, diversion dam just upstream of site.
Lower Chama	RM 21B	R	12	CW, CW-RO, MH	Category 2	No	Yes	Private (Double M Ranch)	Really nice site as is and not much need for any restoration. Need to recommend SWFL surveys here.
Lower Chama	RM 21C	L	15	CW, SB-NMO, MH	Category 1	No	Yes	Private (Double M Ranch)	Not much potential based upon existing vegetation. Spent day in field mapping this site.
Lower Chama	RM 20	L	24	RO-CW, RO-NMO	Category 2/4	1,800 cfs (FLO-2D)	No	Private	Restoration potential due to overbank flooding, portions of site look dry on photography.
Lower Chama	RM 19	R	6	RO-CW	Category 2	No	Yes	Private	
Lower Chama	RM 17	R	19	C/RO, CW-RO, Marsh, NMO-RO	Category 2/4	1,800 cfs (FLO-2D)	No	Private	Restoration potential due to overbank flooding.
Lower Chama	RM 16A	R	8	RO	Category 4	No	Yes	Private	
Lower Chama	RM 16B	L	7	RO-CW	Category 2	No	Yes	Private	
Lower Chama	RM 16C	R	8	C/RO, CW-RO	Category 2	1,800 cfs (FLO-2D)	No	Private	Restoration potential due to overbank flooding.

Exhibit 5-5

Flycatcher Restoration Candidate Sites and Related Attributes

Sub-Reach	Site Name	River (R/L)	Acres	Current Vegetation	Management Category	Overbank Flood Potential	Within .5 mile Upstream of DD	Landowner ship	Notes/Other Mitigating Factors
Lower Chama	RM 10	L	8	RO-CW	Category 2	No	No	Private (Vigil)	Difficult access.
Lower Chama	RM 9	L	8	RO-CW	Category 2	1,800 cfs (FLO-2D)	Yes	Private	Difficult Access.
Lower Chama	RM 6A	L	25	CW-RO, CW	Category 2	1,800 cfs (FLO-2D)	No	Private	Restoration potential due to overbank flooding, just downstream of Rio Ojo Caliente.
Lower Chama	RM 6B	R	13	Open C, C/RO, CW-RO	Category 2/3	1,800 cfs (FLO-2D)	No	Private	Restoration potential due to overbank flooding, just downstream of Rio Ojo Caliente.
Lower Chama	RM 5	L	15	C-TW/ RO-CW, SE-C/ RO-CW, RO	Category 2/5	1,800 cfs (FLO-2D)	Yes	Private	Close to other WIFLs (Ohkay Owingeh).

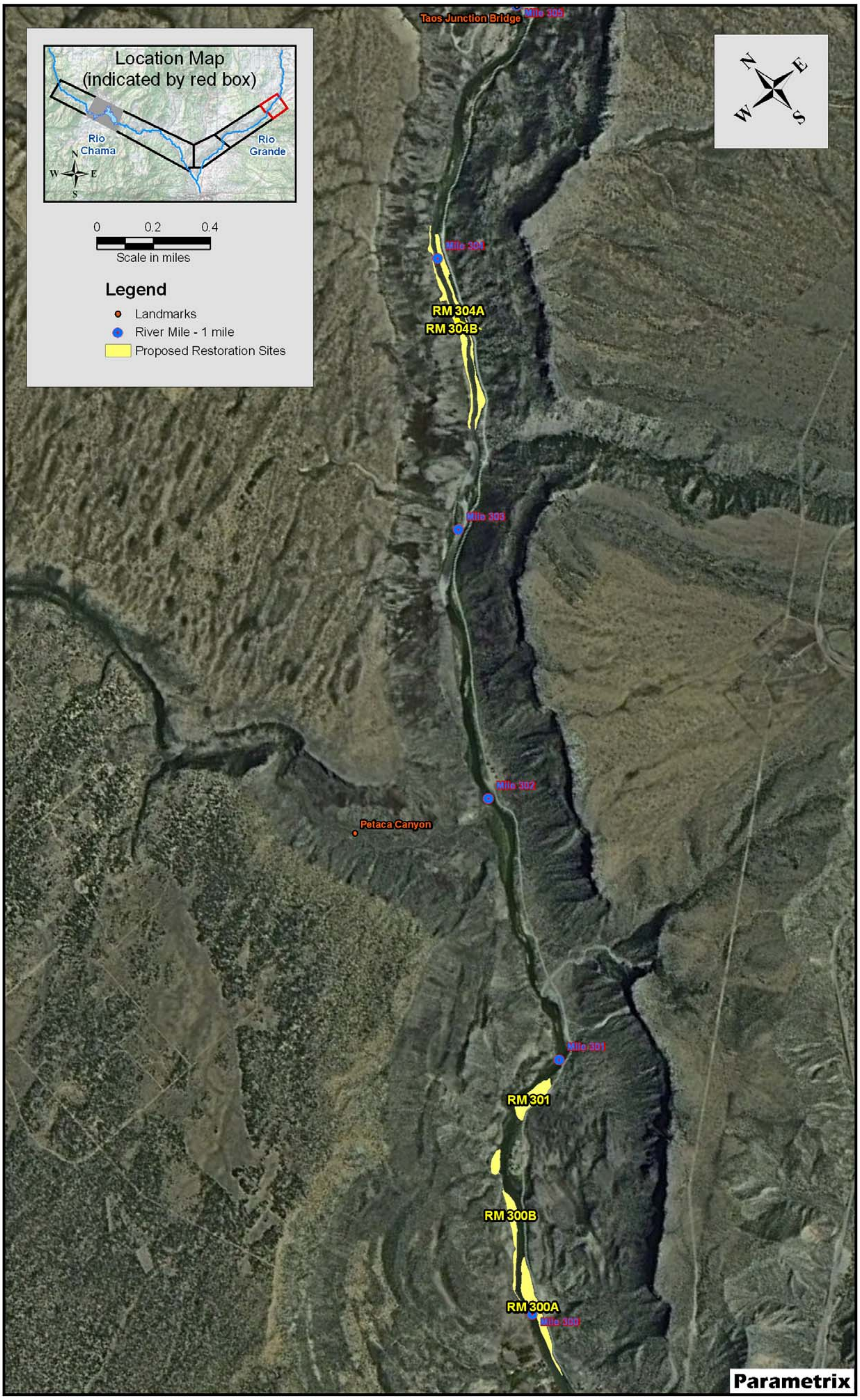
2 How much could candidate restoration sites contribute to flycatcher recovery goals for the Upper Rio Grande Management Unit?

In Chapter 3 (Section 12), we discussed down-listing and de-listing criteria for the Rio Grande Recovery Unit in general, and for the Upper Rio Grande Management Unit in particular. In Section 6 of that Chapter, we discussed patch size characteristics and related acreage recommendations for habitat restoration described in the flycatcher recovery plan (FWS, 2002) and the MRG BiOp (FWS, 2003a). Based on the number of breeding pairs documented in 2006, and assuming 5.4 acres of habitat restoration needed for each new breeding territory (see Chapter 3, Section 6), we estimated that approximately 221 acres of *suitable habitat* would need to be restored to meet the recovery goal of 75 breeding pairs (41 more breeding pairs than documented in 2006; 5.4 acres/territory x 41 breeding pairs = 221 acres of habitat restoration) in the Upper Rio Grande Management Unit. To meet the lesser criteria of 80 percent of target goal (i.e., Criteria A; see Chapter 3, Section 12), a minimum of approximately 140 acres of suitable habitat would need to be restored (enough habitat to theoretically support an additional 26 breeding pairs; 5.4 acres/territory x 26 breeding pairs = 140 acres of habitat restoration).

While the total acreage of candidate restoration sites (425 acres) presented in Exhibit 5-5 exceeds the calculated minimum acreage estimated necessary to achieve flycatcher recovery goals, it is important to remember that restoration of *quality* (i.e., highly suitable) habitat is as (if not more) important as *quantity.* The 425 acres identified in Exhibit 5-5 were derived from a combination of desktop analyses and reconnaissance-level field investigations. Considerably more site-specific investigations are required to determine where high quality flycatcher habitat could actually be created. Finally, while the total estimated acreage of candidate restoration sites in the overall Velarde Reach appears as though acreage goals of breeding territories are achievable, opportunities for facilitating territory expansion in other portions of the Upper Rio Grande Management Unit (outside the project area; e.g., Los Ojos, El Rito, etc…) must be explored for recovery goals to be realized.

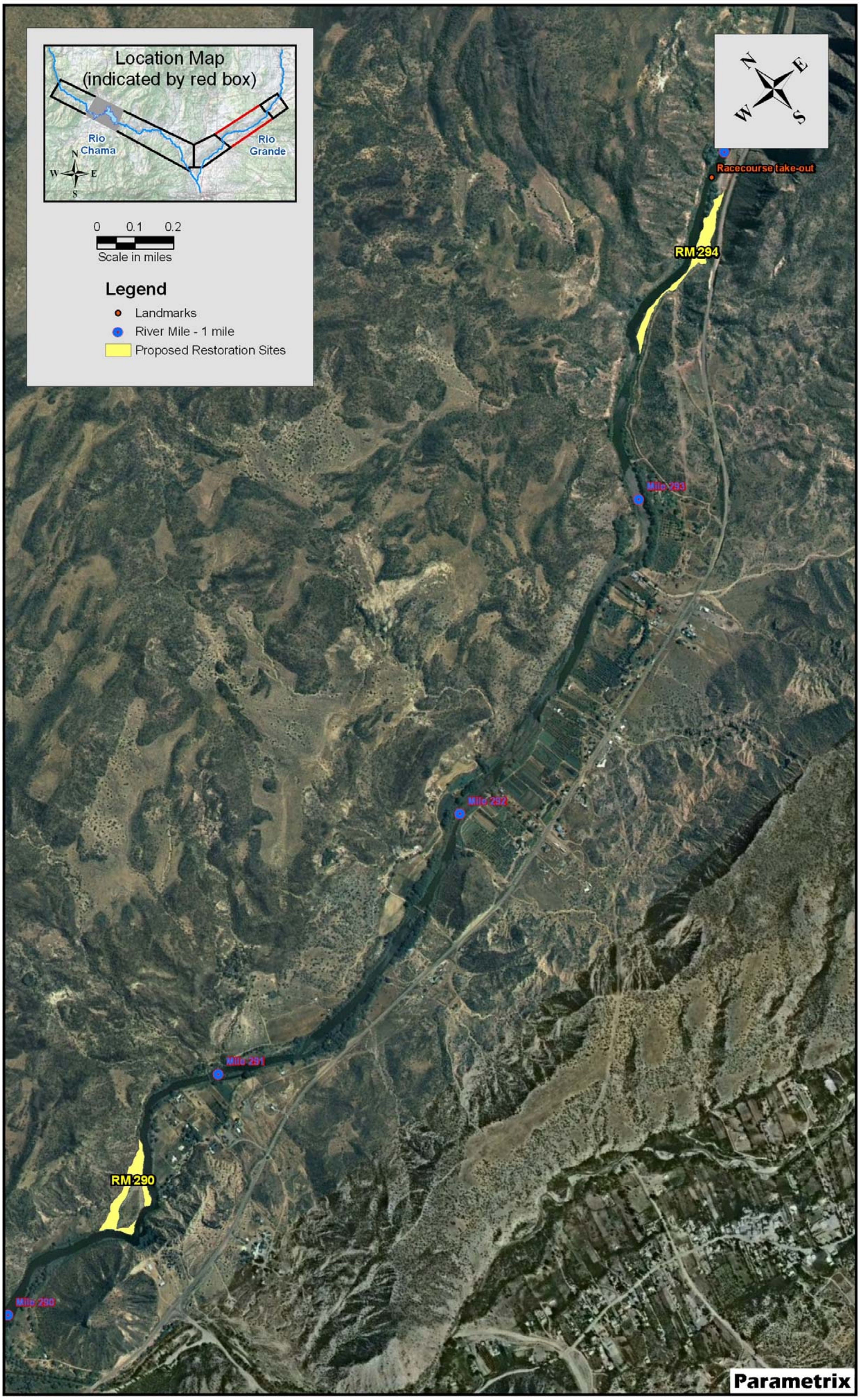
Exhibit 5-6

Candidate Sites in the Orilla Verde Sub-Reach



Background: Monochromatic imagery from 2006 CIR images

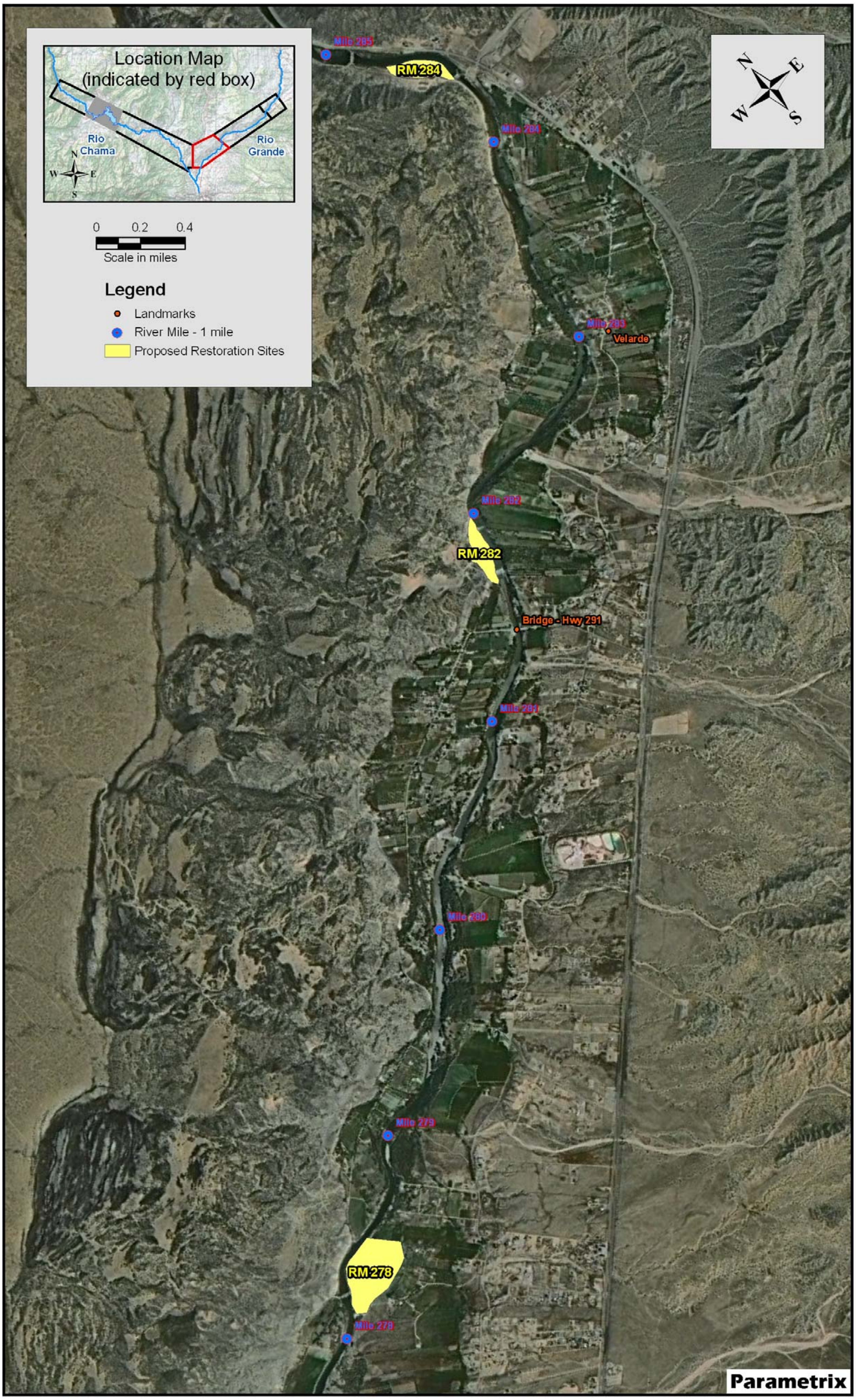
Exhibit 5-7
Candidate Sites in the Pilar Sub-Reach



Background: Monochromatic imagery from 2006 CIR images

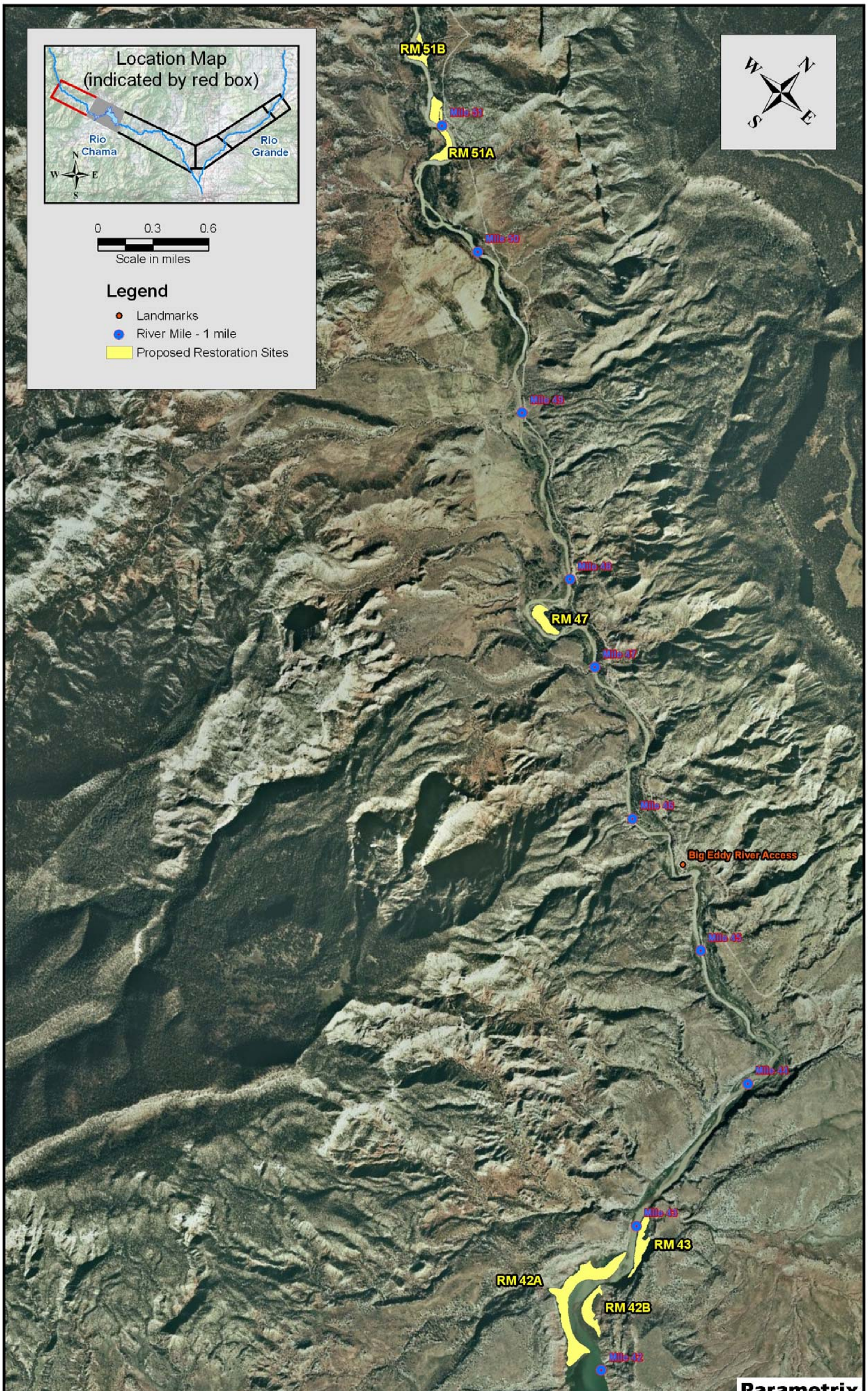
Exhibit 5-8

Candidate Sites in the Velarde Sub-Reach



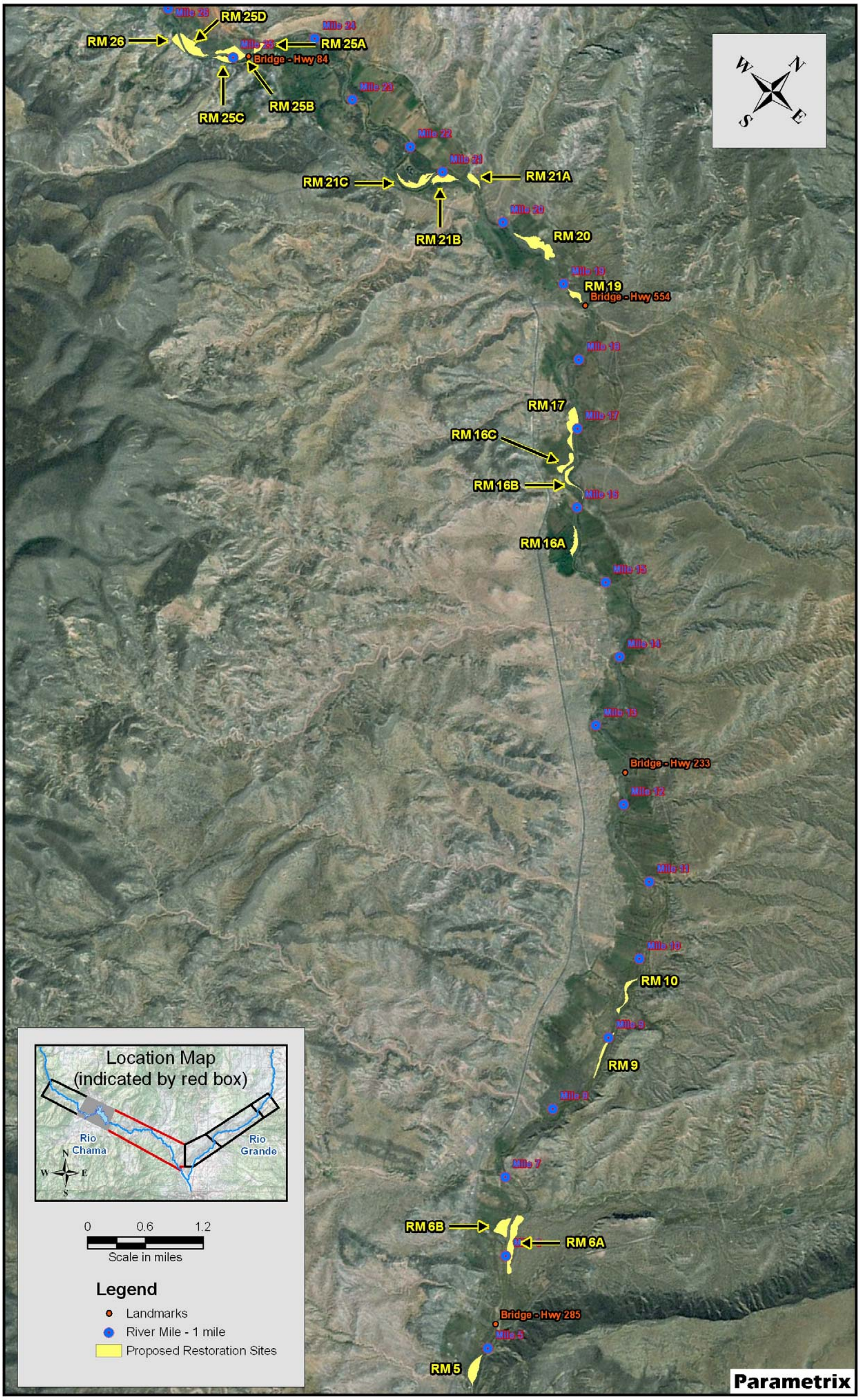
Background: Monochromatic imagery from 2006 CIR images

Exhibit 5-9
Candidate Sites in the Upper Chama Sub-Reach



Background: Monochromatic imagery from 2006 CIR images

Exhibit 5-10
Candidate Sites in the Lower Chama Sub-Reach



Background: Monochromatic imagery from 2006 CIR images

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3 Were there any especially noteworthy candidate sites?

Orilla Verde Sub-Reach

Our general impression of the Orilla Verde Sub-Reach is that it appears to have little overall flycatcher habitat restoration potential because:

- The sub-reach is canyon-bound with little riparian habitat and limited floodplain acreage.
- While many of the existing channel bars support coyote willow, they are mostly of short stature (less than 7 feet tall) and lack the overall stand structural attributes (stem and foliage densities, overstory tree cover) of typical breeding flycatcher habitats. Planting overstory trees to improve canopy structural complexity could help, although we are skeptical that it would be enough to increase the number of active flycatcher territories in the sub-reach.
- The Petaca Canyon arroyo fan, where breeding flycatchers have been inconsistently detected over the past decade, is dominated by a monotypic saltcedar stand. Converting this stand to native cottonwood-willow habitat would be extremely difficult for several reasons. First, the saltcedar plants have relatively large-diameter stems and (predictably) equally large root systems. Stand management with mechanical equipment is not an option because of restrictions associated with the Scenic River Designation (BLM, 2000) and because mobilizing equipment across the river would be problematic. This means that the saltcedar would need to be removed by hand crews using chainsaws to fell the trees and backpack herbicide sprayers to treat the stumps and kill the roots. The felled limbs would either need to be burned on-site or ferried across the river to a chipper. The former option may (or may not) conflict with their Rio Grande Corridor Management Plan (BLM, 2000)

Coyote willows occupy many of the channel bars in the Orilla Verde Sub-Reach, although they generally lack the morphological attributes (plant heights, foliage density…) typical of breeding flycatcher habitats.

The Petaca Canyon saltcedar stand is one of the larger "riparian" habitat patches in the Orilla Verde Sub-Reach. It has inconsistently supported breeding flycatchers since 1993. Improving flycatcher habitat conditions by restoring native vegetation would be exceptionally difficult.

and their EA associated with exotic plant removal (BLM, 2006). Finally, planting native vegetation would require ferrying large quantities of willow and cottonwood cuttings/poles across the river and installing them through unsorted alluvial deposits (including large cobbles and possibly boulder size material) to the groundwater table.

There was, however, one site that was considered particularly worthy of further exploration. This site, mentioned previously in Chapter 4, is a relatively large natural backwater channel located approximately 500 feet upstream of the Rio Bravo Campground. The backwater was formed when coyote willows expanded into the channel along the upstream end of a split-flow channel (Exhibit 5-12). This site was considered noteworthy because it is the only sizeable backwater area in the sub-reach, and such slow moving (i.e., lentic) surface water features are typically associated with nesting flycatcher habitats across their breeding range (Sogge and Marshall, 2000; Smith and Johnson, 2009).

Restoration management for the Rio Bravo site would involve removing saltcedar from portions of the mid-channel island (approximately 1.2 acres; see Exhibit 5-12) and the roadside (south) bankline (approximately 2.5 acres) and restoring native coyote willows along with native riparian trees including Gooding's willow, Rio Grande cottonwood, and box elder (Management Category 4). The most efficient implementation methods would involve using heavy equipment to remove the non-native vegetation and to construct willow swales. However, this approach conflicts with management guidelines for this area (BLM, 2000; BLM, 2006), so less intrusive methods would be required. General methods, assumptions and cost estimates for implementing these treatments by hand (i.e., chainsaws, herbicide, manual planting) are provided in Exhibit 5-13. Detailed cost spreadsheets are provided in Appendix C.

Exhibit 5-11

Notable Backwater Habitat Near Rio Bravo Campground, Orilla Verde Sub-Reach

Photo angle looking upstream. Willows have encroached into the upstream end of a split-flow channel, promoting the formation of a large slack-water habitat near the Rio Bravo Campground. This is the only large slack-water habitat we observed in the Orilla Verde Sub-Reach.

Photo angle looking downstream. The vegetation growing on the channel bar (right of the slack-water channel) is primarily saltcedar, but could potentially be converted to native cottonwood-willow.

Exhibit 5-12

Aerial View of the Proposed Rio Bravo Backwater Restoration Site

Saltcedar would be removed from the dense Coyote Willow-Saltcedar (CW-SC5) stand on the island (1.2 acres) and from the bankline (SC5; 2.5 acres). Native trees and additional coyote willows would be planted in these locations. Additional tree poles could also be planted on the island within the dense Coyote Willow (CW5; 1.3 acres) stand on the island. Acronyms for vegetation are as follows: CW = coyote willow; SC = saltcedar, OP = open (unvegetated). The number that follows the vegetation acronym corresponds to the Hink and Ohmart Structure type as defined in Chapter 2, Exhibit 2-65.

Exhibit 5-13

Project Summary Table – Rio Bravo Habitat Restoration, Orilla Verde Sub-Reach

Management Category	Categories 2 and 4
Principle Management Treatments	☒ Exotic Plant Removal ☒ Plant Tree Poles ☒ Plant Willows ☐ Reinvigorate Decadent Willows ☐ Swale Construction
Species Focus	☐ Silvery Minnow ☒ Willow Flycatcher ☐ Both
Location (Sub-Reach and Landmark)	Orilla Verde Sub-Reach, approximately 500 feet upstream of the Rio Bravo Campground, between RM 300-301.
Landownership/Management Agency	Bureau of Land Management
Acres Management Treatments	4 acres fuels reduction hand treatments, 3 acres willow and pole planting, 1 acre pole planting.
Project Description	Chainsaws would be used to clear saltcedar from the site. After the initial cut, saltcedar slash would be carried to a chipper staged on the adjacent road and pulverized. Chips could be hauled and piled at a nearby location, like the Rio Bravo Campground, for use in landscaping or distribution to nearby communities. A temporary footbridge or a small barge will need to be used for moving materials on the interior side of the bar to the road. An herbicide approved for aquatic use should be applied to cut saltcedar stumps. After the initial treatment, coyote willow cuttings and native tree poles should be planted with a gas-powered auger, hand auger, and/or hammer drill. Individual coyote willow cuttings should be installed every 10 square feet in areas with less than 75 percent aerial cover. Clusters of 3 to 5 tree poles should be planted at approximately 50-foot centers (every 2,500 square feet) throughout the project area to provide structural diversity in the canopy.
Assumptions	1) Use of gasoline-powered power tools is permitted. 2) Use of a temporary footbridge or ferry-barge to move materials from the bar to the road is permitted. 3) The BLM will allow chips to be temporarily piled at the Rio Bravo Campground. 4) Rock cobble will not prevent an auger or hammer drill from opening a hole to expose groundwater for planting willows.
General Estimate of Construction Costs	Planning level cost estimate indicates approximately $72,275 to implement as currently designed. Saltcedar removal including cutting, chipping, hauling, and herbicide application would cost approximately $6,500/acre (L. Gibson, 2009; Tamarisk Coalition, 2006). It is estimated that 12,250 coyote willow cuttings and 400 tree poles will be required to complete the specified planting density. Coyote willow cuttings and cottonwood/Gooding's willow tree poles typically cost $2.70 and $12 each, respectively (R. Coleman, 2009). Labor for planting willow cuttings and tree poles is estimated to cost $8,400. Detailed cost spreadsheets are provided in Appendix C.
Adaptive Management/Monitoring	Requires annual monitoring for cottonwood/willow survival and growth and exotic tree root sprouts for 3 consecutive years following implementation. Additional herbicide application may be necessary depending on the effectiveness of the initial treatment. Also, additional revegetation in subsequent years may be required to achieve suitable cover based on survival and growth of the original plantings.
Potential Water Salvage/Depletion	Net water salvage estimated to be 2.68 acre-feet (see Net Depletions Section in Appendix D).
Site Preparation and Access	Project area would be accessed from the adjacent road, State Hwy 570.
Environmental Compliance Requirements	Existing Environmental Assessment (BLM, 2006) was prepared to cover activities similar to those recommended in this report. Coordination with Reclamation, Fish and Wildlife Service and BLM would be necessary to determine additional compliance requirements.
Additional Data Requirements	Quantitative assessment of vegetation densities and heights at project site will be necessary to assist with finalizing saltcedar clearing costs and to provide baseline dataset. Drilling to groundwater with a gas-powered auger should be attempted at several locations to verify that rock cobble does not prohibit planting with this approach.
Other Implementation Issues	Close coordination with the Bureau of Land Management Taos Field Office is required.

Pilar Sub-Reach

Like the Orilla Verde Sub-Reach, the Pilar Sub-Reach is generally canyon bound and lacks well defined floodplain surfaces. Riparian vegetation is mostly restricted to very narrow linear strips along the channel bankline. Landownership in the Pilar Sub-Reach is mixed private and BLM. Most of the private land has either orchards or houses constructed close to the river bankline.

There were no noteworthy flycatcher habitat restoration sites identified in this sub-reach.

Velarde Sub-Reach

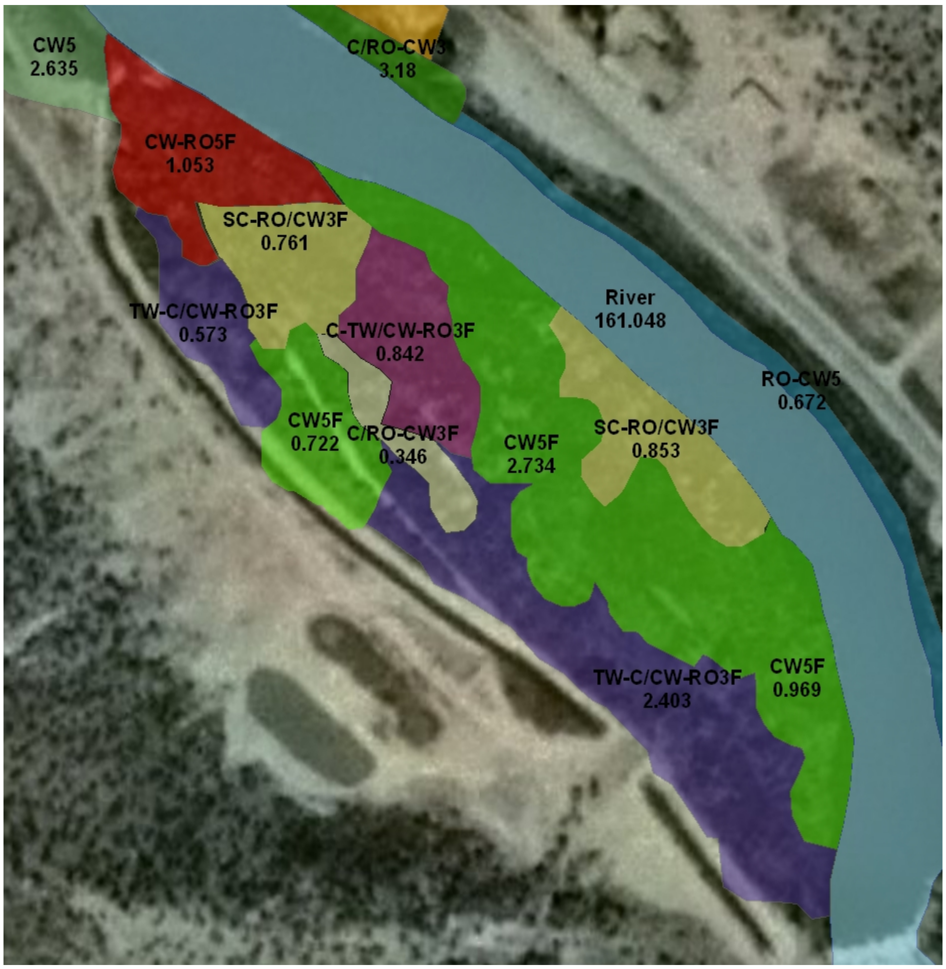
As discussed in Chapter 4, the Velarde Sub-Reach has been channelized and excavation spoils were used to create earthen berms along the banklines. As a result, most of the flow is contained within the channel, even during the 10-year flow event. There are few, if any, backwater habitats in this sub-reach and recruitment of new riparian seedlings is extremely limited.

However, we identified three sites that are deserving of focused restoration attention. The first is the La Canova site located immediately upstream of the Velarde diversion dam (between River Miles 284 and 285). This site is an 11-acre side bar composed largely of native riparian vegetation including dense stands of Gooding’s and coyote willow (Exhibit 5-14). The HEC-RAS model results indicate this site becomes inundated at the 2-year flow event.

Breeding flycatchers utilized this site in 1994 and 1995, but no pairs have been detected since 2001. A detailed site visit in April 2009 indicated that most Gooding’s willow and some coyote willow patches were probably over-mature (see Chapter 4, Exhibit 4-9). For this site, we recommend reinvigorating decadent willow patches by cutting the stems with chainsaws to ground-level and hauling the cut limbs to a stationary chipper staged in the open area immediately adjacent to the stand (Management Category 5). Existing coyote and tree willow stands in the project site total approximately seven acres, although not all stands necessarily require treatment. For conceptual-level cost estimation, however, we assume all seven acres will be treated. Removal of non-native trees (saltcedar and Russian olive) and replacement with Gooding's and coyote willow could also be performed on approximately two additional acres. General planning-level cost estimates and management recommendations are provided in Exhibit 5-15. Detailed cost spreadsheets are provided in Appendix C.

Exhibit 5-14

Aerial View of the Proposed La Canova Restoration Site, Velarde Sub-Reach



Gooding's willow and coyote willow patches would be selectively treated using chainsaws to cut decadent stems. The cut stems would be hauled to a stationary chipper and pulverized in the open area to the south. Acronyms for vegetation are as follows: TW = tree willow; CW = coyote willow; C = cottonwood; RO = Russian olive; SC = saltcedar. The number that follows the vegetation acronym corresponds to the Hink and Ohmart Structure type as defined in Chapter 2, Exhibit 2-66.

Exhibit 5-15

Project Summary Table – La Canova Habitat Restoration, Velarde Sub-Reach

Management Category	Categories 4 and 5
Principle Management Treatments	☒ Exotic Plant Removal ☒ Plant Tree Poles ☒ Plant Willows ☒ Reinvigorate Decadent Willows ☐ Swale Construction
Species Focus	☐ Silvery Minnow ☒ Willow Flycatcher ☐ Both
Location (Sub-Reach and Landmark)	Velarde Sub-Reach, between RM 284-285.
Landownership/Management Agency	Private Land
Acres of Management Treatments	11 acres selective willow thinning, 2 acres fuels reduction hand treatments, 2 acres willow and pole planting
Project Description	Chainsaws could be used to selectively thin decadent coyote willow and Gooding's willow throughout the site. Re-sprouts from these trees will add foliar cover to the 1.5- to 4-meter canopy layer. Approximately 2 acres is dominated by saltcedar. Tamarix could be cut with chainsaws and moved to a chipper staged on the road. Slash generated during willow thinning and saltcedar removal could be chipped and spread at the staging area. An herbicide approved for aquatic use should be applied to cut saltcedar stumps. In saltcedar treatment areas, coyote willow cuttings and native tree poles should be planted with a gas-powered auger. Coyote willow cuttings should be installed every 10 square feet in patches with less than 75 percent aerial cover. Clusters of 3 to 5 tree poles should be planted at approximately 50-foot centers (every 2,500 square feet) at appropriate locations (in place of removed saltcedar) to provide structural diversity in the canopy.
Assumptions	1) Landowner permission is granted. 2) Spreading chips through the staging area is permitted. 3) Rock cobble will not prevent a gasoline powered auger from opening a hole to groundwater for tree planting.
General Estimate of Construction Costs	Planning level cost estimate indicates approximately $91,600 to implement as currently designed. Saltcedar removal including cutting, chipping, hauling, and herbicide application would cost approximately $6,500/acre (L. Gibson, 2009; Tamarisk Coalition, 2006). Selective thinning, moving, and chipping willows is estimated to cost $4,500/acre. It is estimated that 7,000 coyote willow cuttings and 150 tree poles will be required to complete the specified planting density. Coyote willow cuttings and cottonwood/Gooding's willow tree poles typically cost $2.70 and $12 each, respectively (R. Coleman, 2009). Labor for planting willow cuttings and tree poles is estimated to cost $8,400. Detailed cost spreadsheets are provided in Appendix C
Adaptive Management/Monitoring	Requires annual monitoring for cottonwood/willow survival and growth and exotic tree root sprouts for 3 consecutive years following implementation. Additional herbicide application may be necessary depending on the effectiveness of the initial treatment. Also, additional revegetation in subsequent years may be required to achieve suitable cover based on survival and growth of the original plantings.
Potential Water Salvage/Depletion	Net water salvage estimated to be 1.45 acre-feet (see Net Depletions Section in Appendix D).
Site Preparation and Access	Project area would be accessed from the adjacent road, Road 59.
Environmental Compliance Requirements	Project proponent would need to coordinate with Reclamation, Fish and Wildlife Service and the Corps of Engineers to determine levels of environmental compliance.
Additional Data Requirements	Quantitative evaluations of vegetation density and height at the project site will assist with fine-tuning project costs, specific treatment locations, and to provide a pre-restoration dataset. Drilling to groundwater with a gas-powered auger should be attempted at several locations to verify that rock cobble does not prohibit planting.
Other Implementation Issues	Contact and coordination with the private landowner is necessary.

The second notable site in the Velarde Sub-Reach is located at the Los Luceros property between River Miles 278 and 279 (Exhibit 5-16). This historic property was originally owned by the Cabot family but was purchased by the State of New Mexico in 2008 (S. Ashman, New Mexico Department of Cultural Affairs, personal communication, 2009). Although an earthen levee prevents overbank flooding, the diversion dam on the downstream end of the bosque (Exhibit 5-16) elevates the groundwater table, allowing groundwater to surface in two historic irrigation canals that traverse the bosque.

Exhibit 5-16

Los Luceros Property, Velarde Sub-Reach

The 37-acre bosque within the Los Luceros property (top center) appears to have excellent restoration potential. This property was purchased by the State of New Mexico and is managed by the Department of Cultural Affairs.

These channels are currently lined with non-native Russian olive trees (Exhibit 5-17), but they could be removed and replaced with native Gooding's and coyote willows (Management Category 3). Furthermore, the ranch owns diversion rights on the order of 163 acre-feet, plus they have the ability to apply additional water for which they own rights from an artesian well at the upstream end of the bosque site. However, the landowners have indicated that these channels are charged by groundwater throughout the spring-summer seasons (because of the head from the diversion dam and from seepage resulting from adjacent flood irrigation; P. Salazar, New Mexico Department of Cultural Affairs, personal communication, 2009), so applying supplemental water to keep these channels wet is probably not necessary.

Exhibit 5-17

Groundwater-Fed Channel in the Los Luceros Bosque

Russian olive trees currently line the banks of both channels that flow through the project site. These could be removed and replaced with native Gooding's and coyote willows.

The total combined channel length within the bosque is approximately 4,011 feet (Exhibit 5-18). Russian olive trees would ideally be treated with mechanized equipment to pulverize standing biomass and remove tree roots, and willows (both coyote and Gooding's willow) could be planted in parallel trenches excavated along both sides of the existing channels without the need for lowering the ground surface elevation. The total acreage for Russian olive removal and revegetation along the channels is 9 acres. Planning level restoration concepts and cost-estimates are provided in Exhibit 5-19. Detailed cost spreadsheets are provided in Appendix C.

Exhibit 5-18

Channels Within the Los Luceros Property

Aerial photograph of channel locations within the proposed Los Luceros restoration site. The total combined channel length is approximately 4,011 feet. The blue lines depict the channel. The green lines represent the widths on either side (50 feet on either side) of the channels where Russian olives would be removed and replaced with dense willow plantings.

Exhibit 5-19

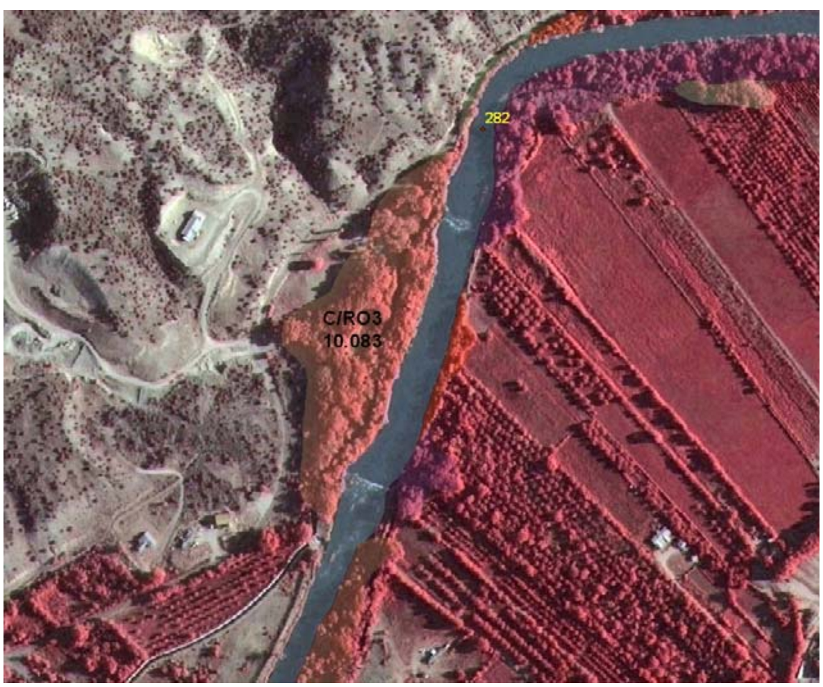
Project Summary Table – Los Luceros Habitat Restoration, Velarde Sub-Reach

Management Category	Category 4
Principle Management Treatments	☒ Exotic Plant Removal ☒ Plant Tree Poles ☒ Plant Willows ☐ Reinvigorate Decadent Willows ☐ Swale Construction
Species Focus	☐ Silvery Minnow ☒ Willow Flycatcher ☐ Both
Location (Sub-Reach and Landmark)	Velarde Sub-Reach, Los Luceros Property, between RM 278-279.
Landownership/Management Agency	State of New Mexico Department of Cultural Affairs
Acres of Management Treatments	9 acres mechanical fuels reduction, 9 acres willow swale construction
Project Description	Restoration efforts will focus on a 50-foot buffer along both sides of the existing side channels. The project would involve mechanical treatment of Russian olive and revegetation with tree willows, coyote willows, and cottonwood. Russian olive trees could be pushed over (uprooted) and mulched in place with a masticator. Five trenches, spaced 8 feet apart, should be excavated to groundwater with a small excavator or backhoe on each side of the channel. Dormant coyote willow cuttings will be planted every 4 feet along the entire length of each trench. Cottonwood and Gooding's willow tree poles should be installed at 50-foot intervals along each trench. Following planting, the trenches should be backfilled. Many Russian olive trees will be removed through pushing the trees over and during trench excavation, however, spot herbicide treatments for maintaining root sprouts should be anticipated.
Assumptions	1) Landowner permission for project implementation is granted. 2) Mechanical treatment of Russian olive is approved by the landowner.
General Estimate of Construction Costs	Planning level cost estimate indicates approximately $233,650 to implement as currently designed. The mechanical Russian olive treatments described typically cost about $2,500/acre (L. Gibson, 2009; Tamarisk Coalition, 2006). During previous projects, heavy equipment contractors estimated $2/linear foot for trench excavation 2 feet deep and backfilling (R. Spears, 2008; USFS, 2009). It is estimated that excavated trenches will need to be 4-feet deep for this project and cost approximately $4/linear foot. Including equipment mobilization, this task is estimated at $165,400. It is estimated that 10,000 coyote willow cuttings and 400 tree poles will be required to implement the specified planting density. Coyote willow cuttings and cottonwood/Gooding's willow tree poles cost $2.70 and $12 each, respectively (R. Coleman, 2009). Labor for placing willow cuttings and tree poles in the trenches is estimated to cost $11,200. Follow-up herbicide treatments are estimated to cost $2,700 total or $300/acre. Detailed cost spreadsheets are provided in Appendix C.
Adaptive Management/Monitoring	Requires annual monitoring for cottonwood/willow survival and growth and exotic tree root sprouts for 3 consecutive years. Additional herbicide application may be necessary depending on the effectiveness of the initial treatment. Also, additional revegetation in subsequent years may be required to achieve suitable cover based on survival and growth of the original plantings.
Potential Water Salvage/Depletion	Net water salvage estimated to be 5.09 acre-feet (see Net Depletions Section in Appendix D)
Site Preparation and Access	Project area would be accessed from the adjacent road, Road 41.
Environmental Compliance Requirements	Project proponent would need to coordinate with Reclamation, Fish and Wildlife Service and the Corps of Engineers to determine levels of environmental compliance.
Additional Data Requirements	Quantitative evaluations of vegetation density and height in the project site will assist with finalizing treatment costs and can be used as baseline dataset.
Other Implementation Issues	Close coordination with the State of New Mexico is required.

The third notable site in the Velarde Sub-Reach is located immediately downstream of River Mile 282. This 10-acre bosque site is currently dominated by a dense Cottonwood-Russian olive stand and resides between two diversion dams (Exhibit 5-20). The aerial photography indicates that water is diverted into an acequia flowing through the entire length of the site parallel to the river channel. Combined with converting understory vegetation from Russian olive to native willows (Management Category 3), this acequia could provide a nice habitat amenity to the site. Unfortunately, we were not able to identify or contact the private landowner, so we could not validate the restoration site potential through a field visit. As such, planning-level cost estimates for restoring this site were not developed. We do, however, recommend concentrated efforts to explore interest from the landowner and evaluate this site further for potential habitat restoration opportunities.

Exhibit 5-20

Notable Private Land Parcel Near River Mile 282, Velarde Sub-Reach



This 10-acre bosque site appears to have good restoration potential. Unfortunately, we were not able to identify the private landowner.

Upper Chama Sub-Reach

The Upper Chama Sub-Reach is relatively far from documented flycatcher breeding sites in the project area. Nonetheless, this sub-reach supports numerous floodplain and T-2 surfaces dominated by native coyote willow. Implementing supplemental revegetation to these surfaces could facilitate flycatcher territorial expansion in the project area. We identified no individual sites that necessarily stood out as being more noteworthy for this restoration treatment than others.

Supplemental planting of native riparian trees (Management Category 1) is recommended for candidate sites in the sub-reach (see Exhibits 5-5 and 5-9). The total estimated acreage of all candidate sites for this treatment is approximately 105 acres. Cottonwood pole planting should include both Rio Grande and narrowleaf species (*P. deltoides* and *P. angustifolia,* respectively) since both are locally native. Willow tree pole plantings should consider both Gooding's and peachleaf species (*S. gooddingii* and *S. amygdaloides*, respectively) because the elevation in the sub-reach is close the threshold for Gooding's willow (USDA Plants Database, http://plants.usda.gov). Experimental livestock exclosures should also be considered on a limited number of sites since grazing impacts on riparian tree species has been identified as a potential limiting factor to riparian tree establishment (see Chapter 4). More discussion of grazing exclosures is presented later under *Passive Restoration Recommendations*.

General per-acre cost estimates were developed to gain some understanding of the level of funding required for implementing supplemental tree planting within the candidate sites. Planning level restoration concepts are provided in the project summary table (Exhibit 5-21). Detailed cost spreadsheets are provided in Appendix C.

Geomorphic Surfaces Defined

Floodplain – Alluvial surface adjacent to the channel that is inundated by the 2-year recurrence interval peak flow for about 6 days per year on average during the snowmelt runoff period.

T2 surface – The pre-El Vado Dam floodplain that is now inundated by the 5-year recurrence interval peak flow for about 2 days per year on average during the snowmelt runoff period.

T1 surface – A pre-El Vado Dam terrace that is located at an elevation above the 100-year recurrence interval peak flow.

Exhibit 5-21

Project Summary Table – Upper Chama Sub-Reach

Management Category	Category 1
Principle Management Treatments	☐ Exotic Plant Removal ☒ Plant Tree Poles ☐ Plant Willows ☐ Reinvigorate Decadent Willows ☐ Swale Construction
Species Focus	☐ Silvery Minnow ☒ Willow Flycatcher ☐ Both
Location (Sub-Reach and Landmark)	Sites Throughout the Upper Chama Sub-Reach
Land Ownership/Management Agency	U.S. Forest Service
Acres of Management Treatments	105 acres pole planting
Project Description	A consistent management treatment is proposed for all candidate sites throughout the sub-reach. Restoration efforts focus on diversifying canopy structure in coyote willow dominated vegetation types with geomorphic surfaces characterized as either floodplain or T2. Also as part of the selection criteria in selecting restoration sites, the total area of each particular site is 5 acres or greater. Eleven individual restoration sites were selected for a total area of 105 acres. In these areas, native riparian tree poles could be planted in clusters of 5 trees per 50-foot center (2,500 ft^2) with a gas powered auger. Given this planting density, 87 tree poles would be planted per acre.
Assumptions	1) Landowner permission is granted. 2) Rock cobble will not prevent a gasoline powered auger or hammer drill from opening a hole to groundwater.
General Estimate of Construction Costs	Planning level cost estimate indicates approximately $228,000 to implement as currently designed. Cottonwood/Gooding's willow tree poles typically cost $12 each (R. Coleman, 2009). The cost of plant material is estimated at $1,044 per acre. Labor for planting tree poles is estimated to cost $1,120 per acre. Detailed cost spreadsheets are provided in Appendix C
Adaptive Management/Monitoring	Requires annual monitoring for cottonwood/willow survival and growth for 3 consecutive years following planting. Additional revegetation in subsequent years may be required to achieve suitable cover based on survival and growth of the original plantings.
Potential Water Salvage/Depletion	Net water depletion estimated to be 165.72 acre-feet (see Net Depletions Section in Appendix D).
Site Preparation and Access	Individual project area access varies by specific location.
Environmental Compliance Requirements	Project proponent would need to coordinate with Forest Service, Reclamation, Fish and Wildlife Service and the Corps of Engineers to determine levels of environmental compliance.
Additional Data Requirements	Quantitative assessment of vegetation characteristics (e.g. species cover, densities and heights) at each selected revegetation site will assist with finalizing planting costs and to provide pre-planting (baseline) dataset. Drilling to groundwater with a gas-powered auger should be attempted at several locations to verify that rock cobble does not prohibit planting with this approach.
Other Implementation Issues	Close coordination with the Forest Service is required. Should consider implementing planting along with experimental livestock exclosures on a few select sites to ensure livestock grazing is not detrimental to project goals before implementing across all candidate sites in the sub-reach.

Lower Chama Sub-Reach

Numerous noteworthy sites were identified along the Lower Chama Sub-Reach through combined field reconnaissance (i.e., viewing sites from the river via kayaks), hydrologic modeling, and GIS analyses. However, extensive effort to identify private landowners and obtain contact information was met with mixed success, and only a handful of on-the-ground follow-up site visits were performed. Of these, two properties were considered especially noteworthy. Descriptions of these sites and restoration/management recommendations are presented below.

Abiquiu Land Grant Property

The Abiquiu Land Grant is one of several communal land grants in the State of New Mexico. The Abiquiu Land Grant owns approximately 16,000 acres of contiguous property, including several dozen acres of floodplain habitat upstream and downstream of where the SR-84 bridge crosses the Rio Chama (G. Ferran, Abiquiu Land Grant Board Chairman, personal communication, 2009).

The riparian habitats within the Abiquiu Land Grant were identified as candidate restoration sites through our initial screening process, and field notes from our May 2008 reconnaissance indicated both shallow groundwater and extensive coyote willow stands occur along both river banks upstream of the SR-84 bridge, and below the bridge on river right near the diversion structure. The FLO-2D model also indicates some limited overbank flooding at 1,800 cfs upstream of the SR-84 bridge on both sides of the river.

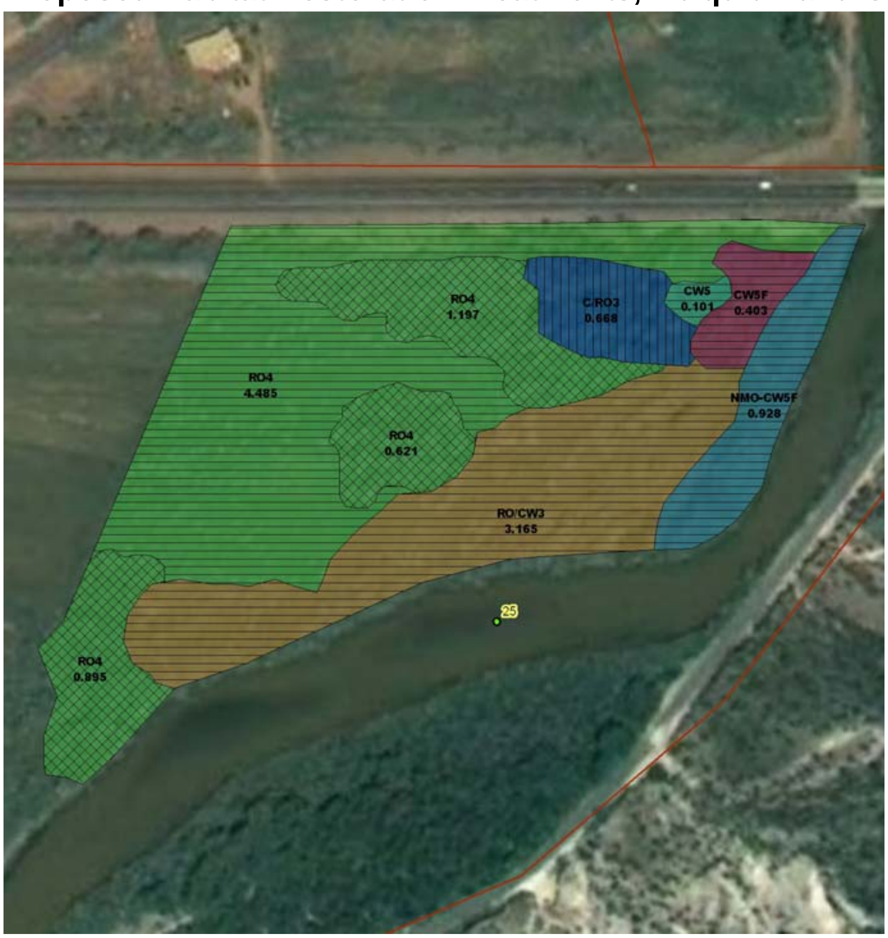
Parametrix met with the Abiquiu Land Grant board to discuss the objectives of this project in February 2009, and the board granted permission to explore habitat restoration opportunities within a 32-acre parcel immediately upstream (river left) of the SR-84 bridge (identified as RM 25B in Exhibits 5-5 and 5-10). Field reconnaissance in early June 2009 indicate that this site supports dense stands of coyote willow and New Mexico olive along the banklines and an extensive wet meadow with scattered Russian olives on the larger interior portion of the site (Exhibit 5-22).

Restoration treatment recommendations for this site include removing Russian olive trees throughout the site and replacing them with Gooding's willow (Management Category 2). We also recommend constructing three spatially separated willow swales within interior portions of the project site (Exhibits 5-22 and 5-23). These habitat features were assigned to locations with dense patches of Russian olive but are surrounded by larger openings dominated by native grasses and sedges.

Cost estimates and other relevant restoration project information are provided in the project summary sheet (Exhibit 5-24). Details planning level-cost estimates are provided in Appendix C

Exhibit 5-22

Proposed Habitat Restoration Treatments, Abiquiu Land Grant, RM 25



Several restoration approaches are recommended in this 32-acre site. Russian olive would be removed from the interior of the site. Horizontal lines represent areas where tree poles would be planted. Three willow swales would be constructed towards the interior, in cross-hatched areas. Willows would also be planted in the area overlaid with vertical lines to replace the existing Russian olive understory with coyote willow. Acronyms for vegetation are as follows: CW = coyote willow; RO = Russian olive; C = cottonwood; NMO = New Mexico olive. The number that follows the vegetation acronym corresponds to the Hink and Ohmart Structure type as defined in Chapter 2, Exhibit 2-66.

Exhibit 5-23

Conceptual Drawing of Proposed Willow Swales

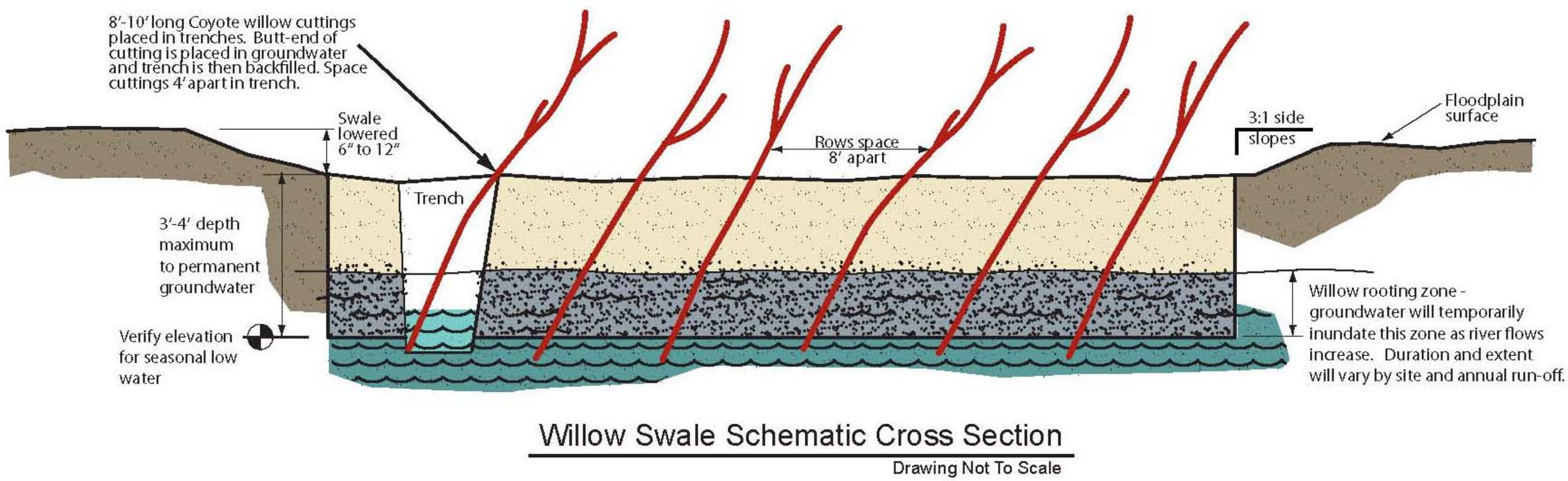


Exhibit 5-24

Project Summary Table – Abiquiu Land Grant Site, RM 25B

Management Category	Categories 1, 2, and 4
Principle Management Treatments	☒ Exotic Plant Removal ☒ Plant Tree Poles ☒ Plant Willows ☐ Reinvigorate Decadent Willows ☒ Swale Construction
Species Focus	☐ Silvery Minnow ☒ Willow Flycatcher ☐ Both
Location (Sub-Reach and Landmark)	Lower Chama Sub-Reach, at RM 25B.
Land Ownership/Management Agency	Private Land (Abiquiu Land Grant)
Acres of Management Treatments	3 acres hand treatments, 8 acres mechanical fuels reduction, 2.5 acres willow swale construction, 10 acres tree pole planting, 1 acre planting willow cuttings
Project Description	The overall 12-acre site includes a 7-acre Russian olive woodland, scattered patches of coyote willow that total 4.5 acres, and a 1-acre forest of cottonwood with a dense Russian olive understory. Russian olive trees could be removed throughout the site using hand crews in areas with dense coyote willow and mechanical treatments in the areas without dense coyote willow. In the mechanical treatment areas, Russian olive trees could be pushed over and mulched in place with a masticator. In the hand treatment areas, Russian olive trees could be cut with chainsaws and mulched at a chipper staged nearby. An herbicide approved for aquatic use should be applied to cut stumps and root sprouts. Several revegetation treatments are recommended at the site. Three willow swales could be constructed in the Russian olive woodland. In other portions of the woodland, native tree poles and wolfberry could be planted. Tree poles could also be planted in clusters of 3 to 5 plants in the coyote willow patches to add structural diversity to the canopy. Coyote willow cuttings should be installed in the small (1-acre) cottonwood forest after the Russian olive is removed.
Assumptions	1) Landowner permission is granted. 2) Rock cobble will not prevent a gasoline powered auger or hammer drill from opening a hole to groundwater.
General Estimate of Construction Costs	Planning level cost estimate indicates approximately $179,000 to implement as currently designed. Russian olive hand treatments including cutting, chipping, hauling, and herbicide application are estimated to cost $6,500/acre (L. Gibson, 2009; Tamarisk Coalition, 2006). Mechanical treatment is estimated to cost $2,500/acre. It is estimated that 7,000 coyote willow cuttings, 500 wolfberry plants, and 1,900 tree poles will be required to complete the specified planting density. Coyote willow cuttings and cottonwood/Gooding's willow tree poles typically cost $2.70 and $12 each, respectively (R. Coleman, 2009). Wolfberry plants cost approximately $22. Labor for planting willow cuttings, shrubs, and tree poles is in the woodland and cottonwood forest is estimated to cost $14,000. During previous swale construction projects, heavy equipment contractors estimated $2/linear foot for trench excavation 2 feet deep and backfilling (R. Spears, 2008; USFS, 2009). It is estimated that excavated trenches will need to be 4-feet deep for this project or $4/linear foot. Including equipment mobilization, swale construction is estimated at $67,000. Labor for planting willows and tree poles in the swale is estimated to cost an additional $2,800. Detailed cost spreadsheets are provided in Appendix C
Adaptive Management/Monitoring	Requires annual monitoring for cottonwood/willow survival and growth and exotic tree root sprouts for 3 consecutive years. Additional herbicide application may be necessary depending on the effectiveness of the initial treatment. Also, additional revegetation in subsequent years may be required to achieve suitable cover based on survival and growth of the original plantings.
Potential Water Salvage/Depletion	Net water depletion is estimated at 6.74 acre-feet (see Net Depletions Section in Appendix D)
Site Preparation and Access	Project area would be accessed from the adjacent road, Hwy 84.
Environmental Compliance Requirements	Project proponent would need to coordinate with Reclamation, Fish and Wildlife Service, and the Corps of Engineers to determine levels of environmental compliance.
Additional Data Requirements	Quantitative evaluations of vegetation density and height will assist with fine-tuning site design and will serve as pre-restoration baseline dataset. Drilling to groundwater with a gas-powered auger should be attempted at several locations to verify that rock cobble does not prohibit planting with this approach in the 1-acre forest.
Other Implementation Issues	Close coordination with the Abiquiu Land Grant is required.

Double M Ranch Property

The Double M Ranch LLC owns several land parcels along the Rio Chama near River Mile 21. Large portions of the property are managed as a commercial medicinal herb farm, although their land holdings also include relatively extensive tracts of native riparian habitat along both sides of the river. These riverside parcels were identified as candidate restoration sites through our initial screening process, and field notes from our May 2008 reconnaissance indicated extensive coyote willow stands along both river banks. This was notable because there were very few areas along the entire length of the sub-reach that supported coyote willow.

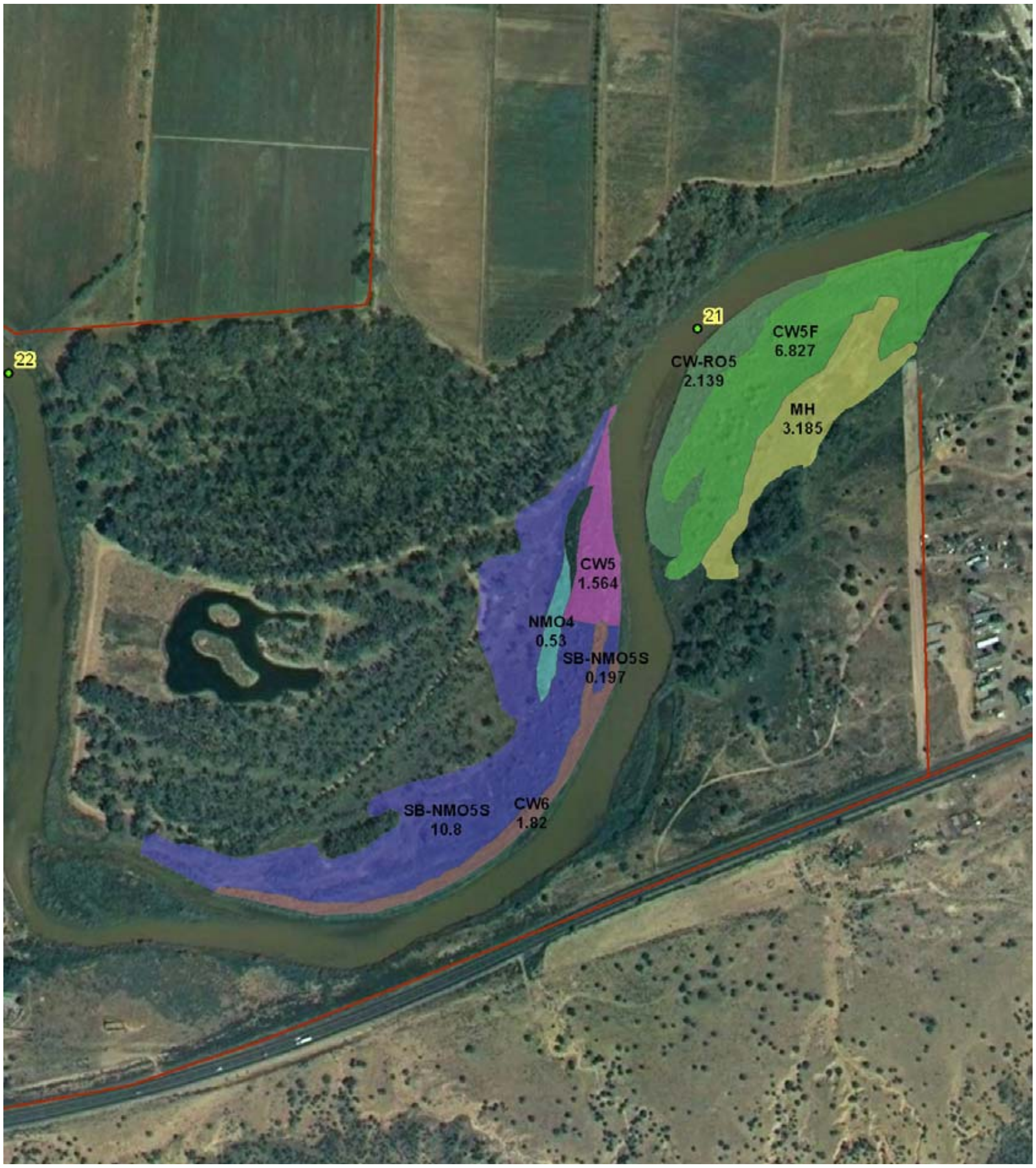
Permission was granted by the property owners in September 2008 to evaluate flycatcher habitat restoration opportunities on both sides of the river. Relevant parcels are identified in Exhibits 5-5 and 5-10 as RM 21A, RM 21B and RM 21C. Field visits to RM 21B and RM 21C revealed that these parcels are dominated by almost exclusively by native riparian vegetation (Exhibit 5-25). For example, riparian habitat at the RM 21C parcel is dominated by silver buffaloberry (*Shepherdia argentea*) and New Mexico olive (*Forestiera pubescens, ssp. neomexicana*) with minor inclusions of coyote willow, rose (*Rosa sp*.) and other native shrubs. Riparian habitat at RM 21B was dominated by very dense stands of 12- to 15-foot-tall coyote willows adjacent to a cattail marsh.

Silver buffaloberry and New Mexico olive currently dominate parcel RM 21C.

With the exception of a few widely scattered cottonwood trees, RM 21C lacked the diverse vertical canopy structure often associated with breeding flycatcher territories. Also, while native cottonwood and willow trees could be planted in this location, neither silver buffaloberry nor New Mexico olive are typically associated with flycatcher habitats in New Mexico (or elsewhere), so it is unlikely that supplemental tree planting in this location would enhance flycatcher habitat potential.

Exhibit 5-25

Native Riparian Vegetation Dominates the Riverside Parcels on Double M Ranch Property



Acronyms for vegetation are as follows: SB = silver buffaloberry; NMO = New Mexico olive; CW = coyote willow; RO = Russian olive; MH = marsh habitat (cattail and bulrush). The number that follows the vegetation acronym corresponds to the Hink and Ohmart Structure type as defined in Chapter 2, Exhibit 2-66.

The habitat conditions at the RM 21B already has many of the elements of flycatcher habitat, including a very dense coyote willow patch (Exhibit 5-26). The only potential supplemental restoration treatment at this site may be adding groups of overstory trees (Gooding's willow and cottonwood) to add more foliage canopy diversity (Management Category 1). However, before any supplemental planting is assigned to this site, we recommend that flycatcher surveys be implemented since it is feasible that breeding pairs are already utilizing the existing habitat (see *Data Gaps* section below).

Exhibit 5-26

Coyote Willow Stand at Double M Ranch Property, Site RM 21B

Monitoring Active Flycatcher Habitat Projects in the Velarde Reach

4 What is the recommended monitoring approach for evaluating success of revegetation projects on improving flycatcher habitat?

Earlier in this chapter we described several restoration Management Categories, all of which pertain to enhancing flycatcher habitat either through different revegetation techniques or by reinvigorating decadent willow stands through manual treatments with chainsaws and/or mechanical equipment. Those recommendations are based upon the premise that the restored site will produce riparian habitat with physical attributes that are similar to those found in documented breeding flycatcher habitats.

Although there are numerous published reports that have consolidated data from habitat assessments of other species that can be used to guide restoration management, we are unaware of any such reports that propose specific (quantitative) habitat suitability criteria for the southwestern willow flycatcher. For example, Habitat Suitability Index (HSI) models have been developed for a host of bird species (e.g., Gutzwiller and Anderson, 1987; Schroeder, 1982; and Short, 1985) that define specific targets for habitat attributes (e.g., plant species cover) based upon reviews of published scientific reports. While there appear to be considerable differences in certain habitat attributes of willow flycatchers across their breeding range (e.g., plant species in which nest is found), there is arguably enough consistency in certain attributes (e.g., presence of saturated soil, high foliage density; presence of discontinuous overstory tree canopy [see Chapter 3]) that it is possible to develop general criteria to guide restoration project design and effectiveness monitoring.

Below we offer a few preliminary restoration "success" criteria to consider for project monitoring. These criteria are based upon professional judgment based upon results from regional flycatcher habitat characterizations along the MRG combined with the fact that these projects are intended to restore native dominated riparian habitats. However, these attributes should by no means be considered a final and conclusive list. More work is required to fine tune/adjust these criteria. In the meantime, the preliminary success criteria we propose include:

- Achieving total aerial cover by coyote willow of at least 75 percent.
- Achieving mean aerial cover by Gooding's willow of at least 25 percent.
- Achieving total riparian tree cover between 25 percent and 50 percent.
- Restoration sites will have standing water and/or saturated soil for at least 30 days during nest establishment period (between approximately May 1 and June 30) in years with average or above-average snowmelt runoff.
- Preliminary monitoring approaches to evaluate if these criteria have been achieved are described below.

Willow Canopy Cover

Existing literature cited in Chapter 3 indicates that dense willow stands with high cover are considered important attributes of suitable flycatcher habitat in the MRG. The following restoration management objectives can be used as a starting point to guide development of a more detailed monitoring plan and analytical procedures:

> ***Management Objective #1****: Coyote willow stands at restoration sites should achieve mean aerial cover of at least 75 percent by the end of fifth growing season following project construction.*

Management Objective #2*: Gooding's willow at restoration sites should achieve mean aerial cover of at least 25 percent by the end of fifth growing season following project construction.*

Management Objective #3*: Total riparian tree cover at restoration sites should achieve mean aerial cover between 25 percent and 50 percent by the end of the fifth growing season following project construction.*

Monitoring to evaluate if these management objectives have been achieved can be performed using either quantitative or qualitative methods.

Quantitative Methods: This could involve establishing multiple permanent transects through revegetation project sites. 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 1 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 alive 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 all plant species in both understory (shrub) and overstory (tree) 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 of the second and fifth growing season (August or September), 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 revegetation site and completing a "modified Hink and Ohmart" survey form developed by Reclamation's Denver Technical Service Center (Appendix E).

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 restoration 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 monitoring program.

Presence of Saturated Soils

The restoration management objective is that saturated soil conditions exist at each revegetation site for at least 30 days between the months of May and June. This should only be expected in years with average or above average snowmelt runoff. The following restoration management objectives can be used as a starting point to guide development of a more detailed monitoring plan and analytical procedures:

> ***Management Objective #4****: Revegetation sites will have saturated soil conditions for a period of at least 30 days between the months of May and June in average or above-average water years during the 5-year project monitoring 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). For example, at flycatcher breeding sites at the Pueblo of Isleta, they installed soil temperature loggers at 50-m intervals on a predetermined 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:

Southwest Willow Flycatcher Survey Forms can be found at: http://sbsc.wr.usgs.gov/cprs/research/projects/swwf/cprsmain.asp)

- 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.

Passive (Non-Construction) Projects

Livestock Exclosures in Upper Chama Sub-Reach

In Chapter 4 we discuss the potential impacts of livestock grazing on riparian vegetation, particularly regarding its potential impact on recruitment and growth of riparian trees. Riparian tree cover is an important element of flycatcher habitat, but field observations from a limited number of floodplain and T-1 surfaces indicated few seedlings, saplings or pole sized cottonwoods or tree willows in the Upper Chama Sub-Reach. The few cottonwood saplings that were observed had altered growth forms due to ungulate browsing. Since the primary flycatcher habitat improvement recommendation presented previously in this chapter involves increasing cottonwood and willow tree cover, it seems prudent to first determine if livestock are in fact impacting riparian tree recruitment and growth before initiating a wide-spread tree planting project.

As such, we recommend erecting temporary cattle fence exclosures on at least five (for statistical purposes) revegetation candidate sites within the Upper Chama Sub-Reach identified in Exhibits 5-5 and 5-9. The purpose of this recommendation is to evaluate if livestock grazing is detrimentally impacting cottonwood and willow growth and establishment before implementing large-scale revegetation efforts, and to gain insights into riparian recruitment dynamics in the project area. There are several important points to consider before implementing this recommendation:

1. Prior to collecting any data or implementing any exclosures, hypotheses, and associated management and sampling objectives should be developed to guide the study design and statistical methodologies. Several example hypotheses are offered for consideration:

   Hypothesis #1 – After three growing seasons, foliar cover and growth rates of cottonwood and willow will be significantly greater in sites with livestock exclosures than sites without exclosures.

   Hypothesis #2 – After three growing seasons, cottonwood seedling recruitment will be significantly higher on floodplain sites with cattle exclosures compared to those without exclosures.

   Hypothesis #3 – Three years after planting, growth rates and foliar cover of cottonwood and willow pole plantings will be significantly greater in sites with livestock exclosures compared to sites without exclosures.

   These hypotheses are intended to enable an evaluation of livestock grazing impacts on a) cottonwood seedling recruitment, b) growth and cover of existing riparian vegetation, and c) growth and cover of planted cottonwood and willows.

2. Establish side-by-side (paired) exclosures/non-exclosures at each site, with a minimum of five sites.

3. Implement revegetation treatments described earlier (see Exhibit 5-22) in both the exclosure and adjacent non-exclosures.

4. Baseline data regarding key vegetation parameters should be collected immediately after setting up the exclosures. At a minimum, baseline and post-treatment data collection should include plant species cover, woody vegetation height and density, soil texture, soil salinity, and seasonal groundwater levels. This baseline data collection will enable multivariate statistical analyses of pre- and post-project data over time between treated (exclosure) and untreated (non-exclosure) sites.

5. Review the scientific literature concerning riparian livestock exclosure studies. Sarr (2002) provides a useful review and critique of riparian livestock exclosure studies and provides recommendations for future study designs. This paper, along with others provided in his reference citations may be useful in developing the final study design.

6. Utilize the study results to inform livestock management and larger scale revegetation in the sub-reach.

Rio Grande Silvery Minnow

5 Do any of the project area sub-reaches have potential for sustaining experimental re-introductions of silvery minnow?

Chapter 4 reported that all Rio Grande sub-reaches and the Lower Chama Sub-Reach hold low potential for creating self-sustaining silvery minnow populations for several reasons. First, the Orilla Verde and Pilar Sub-Reaches are canyon bound and minimal opportunities exist for the development of silvery minnow feeding habitat. Confined flows in these canyon reaches also result in limited low velocity resting habitat, and considerable potential exists for downstream displacement of any spawn and developing larva.

Orilla Verde Sub-Reach.

There are 8 irrigation diversion dams along the Velarde Sub-Reach and 13 along the Lower Chama within the project area.

Second, residential development along the floodplain within the Lower Chama Sub-Reach places severe constraints on flow releases from Abiquiu Dam, so many of the constraints identified above for the Rio Grande sub-reaches (i.e., confined flows, limited resting habitat, potential for downstream displacement…) apply to the Lower Chama Sub-Reach as well.

Third, the prevalence of multiple, closely spaced irrigation diversions within both the Velarde and Lower Chama Sub-Reaches severely constrains the upstream movement of silvery minnows in their continual search for new feeding habitats and to maintain a connected reproducing population. The feasibility of constructing multiple (13 on the Lower Chama Sub-Reach and 8 on the Velarde Sub-Reach) fish passage structures on these irrigation diversions is costly under the available reviewed engineering alternatives. Furthermore, the effectiveness of fish passage structures for silvery minnow in other MRG reaches is currently unproven.

As such, we see no meaningful habitat restoration projects to benefit silvery minnow populations along the Rio Grande and Lower Rio Chama Sub-Reaches. We project that adverse habitat conditions in these sub-reaches, which cannot be reversed without significant monetary and cultural costs, are likely to continue limiting silvery minnow recovery within these sub-reaches.

Home construction throughout the Lower Chama Sub-Reach eliminates the potential for managing flows from Abiquiu Dam for overbank flooding.

Our analysis of the Upper Chama Sub-Reach is less conclusive. There are several appealing attributes of this sub-reach that are worthy of serious consideration, including: (1) perennial flows; (2) extensive low gradient, low velocity channel segments; (3) numerous naturally occurring backwater and side channel habitats during higher flows; (4) deep pools that could provide refugia during low flow conditions, and; (5) frequent inundation of vegetated floodplains that could potentially provide nursery habitat and limit downstream displacement of eggs, larvae and fish during high flow events. These are all habitat features that restoration projects in the MRG valley have been aiming to replicate.

The Upper Chama Sub-Reach is replete with low velocity, perennially flowing channel habitats. Many of these areas also contain deep pools during low flow conditions.

That said, however, several of the limiting factors hypothesized by Buntjer and Remshardt (2005) about the Rio Grande upstream of Cochiti Lake cannot be ruled out for the Upper Chama Sub-Reach. In particular, these include concerns regarding cold water temperatures, potential for downstream displacement of fish, eggs, and larvae, and potential impact of non-native predatory fish. In Chapter 4 we assess the available information and discuss current alternative hypotheses on these (and other) topics. Our conclusion is that there is not enough information available to confidently determine, one way or another, whether a sustainable population of silvery minnow could survive in this sub-reach. In particular, we regard cold water temperature, the requirement for fine textured channel bottom substrates, and the potential for floodplain inundation to significantly reduce downstream drift as topics that require further study before determinations can be made about whether these are truly limiting factors to successful silvery minnow introduction to the sub-reach. We suggest that addressing these data gaps through research studies could facilitate a better understanding of silvery minnow habitat restoration and population recovery opportunities, not just in the Upper Chama Sub-Reach, but across its former range.

Other potential limiting factors for silvery minnow identified for the Upper Chama Sub-Reach include the potential affects of summer boating releases from El Vado Reservoir on downstream displacement of fish and on benthic productivity. If silvery minnow introduction opportunities were seriously considered for the Upper Chama Sub-Reach in the future, we suggest that evaluations of potential impacts of boating releases be considered.

Data Gaps and Research Recommendations

6 What are some important data gaps in the project area?

Cold Water Temperature Thresholds for Silvery Minnow

In Chapter 4, we suggest additional research is needed to determine at what point low water temperature can be a critical limiting factor for silvery minnow reproduction, growth, and survival. Research on this topic will facilitate better informed decisions about the appropriateness of future silvery minnow introductions into the Upper Chama Sub-Reach or other portions of the Rio Grande upstream of Cochiti Lake. In Chapter 3, we suggested that since silvery minnows apparently survive over winter temperatures in MRG waters near freezing (32ºF, 0ºC) and gametes must be developing during this period, an improved understanding of their cold-water physiology would greatly aid in understanding their reproductive physiological requirements at low temperatures. Therefore, we recommend that additional studies of lower temperature exposures be completed to more clearly define lower temperature conditions that influence silvery minnow spawning and larval development.

Potential for Cobble and Gravel Substrate to Limit Establishment of a Silvery Minnow Population

In Chapters 3 and 4, we suggest that the concept that silvery minnows require a substrate of predominately sand and silt (FWS, 2007) merits additional scientific examination. In general, the abundance of fish populations is rarely regulated by the mesohabitat attributes of local substrate composition, flow velocities, and water depth, unless they become severely limiting, (e.g., abnormal increases in average flows, dewatering, or excess loads of fine sediment [BOR and COE, 2003; Tetra Tech, 2004b]). It has been documented in the MRG that the occurrence of finer-textured substrates in the reaches below Cochiti Dam is related to the downstream fining processes, whereby sediment size decreases with distance from the higher-gradient tributary watersheds (MEI, 2002). Thus, because finer-textured bed materials are more prevalent in the reaches currently occupied by the silvery minnow, their increased capture frequencies over silt and sand substrates may be explained by probabilistic reasons. Understanding the causal versus correlative role of substrate is particularly important during the evaluation of potential silvery minnow restoration or population introduction sites, as it could lead to ruling out areas (e.g., the Upper Chama Sub-Reach) that might otherwise provide reasonable habitat potential.

Potential for Floodplains to Provide High Flow Refuge, Spawning, and Feeding Habitat for Silvery Minnows

In Chapter 4, we presented a set of hypotheses related to ways that floodplain inundation in the Upper Chama Sub-Reach may reduce or eliminate certain concerns currently viewed as limiting factors for silvery minnow survival. These hypotheses could be applied to other potential population introduction sites considered in the future. They include: (1) regular overbank flooding in the Upper Chama Sub-Reach would significantly reduce downstream drift of silvery minnow eggs and larvae, (2) that overbank flooding in the Upper Chama Sub-Reach could result in retention of silvery minnow eggs, larvae, and adult fish outside of the main channel, and (3) the potential impact of extensive downstream transport for silvery minnow introduced in the Upper Chama Sub-Reach would be insignificant at the local population level. Research on these concepts would facilitate a better understanding of the role of floodplains in silvery minnow life-history and would enable more informed evaluations of potential population introduction sites.

Nearly monotypic collections of young-of-year silvery minnow in floodplain fish collections in the Isleta Reach of the Middle Rio Grande following the recession of snowmelt floodwaters during 2005. (Photo credit Mike Hatch, SWCA).

Effects of Predation Potential on Silvery Minnows

Chapter 4, Section 13 reported that predation is generally viewed as having a minor role affecting the endangered status of silvery minnow. That discussion also noted that the potential vulnerability of silvery minnows and other small-bodied fish species to predation is benefited by increased turbidity. In particular, non-native trout and other species that are sight predators have less success in finding prey species in waters with higher turbidity. In contrast, the silvery minnow appear to be little affected by such conditions. This discussion suggests that, since appropriate studies have not been completed and information is lacking to base a reasonable assessment of potential predation effects on silvery minnows in the Rio Grande, including the Upper Chama Sub-Reach, additional monitoring and assessment studies are needed to assess the potential relationship of native and non-native fish predators to depress a silvery minnow population in the Upper Chama Sub-Reach.

Potential for Rafting Flows to Flush Young Silvery Minnows Downstream

Chapter 4 describes how regular discharge of rafting/boating flow releases occurs on summer weekends and holidays. These discharges provide a regular-weekly, 2-day-long increase in discharge up to about 700 cfs during the spring and summer rafting season. That discussion also suggested that since the hydrograph shape of these releases on the ramp-up and ramp-down slopes of the discharges are not markedly different from those produced by monsoon and other storm-flow events; these events may not necessarily displace fish more than what would normally occur during summer monsoon events.

Despite these relationships, we continue to be concerned that the abnormal regularity and extended nature of these flows (i.e., every weekend and full-holiday weekends) could produce appreciable downstream displacement of, particularly, young silver minnows (and other species) into Abiquiu Reservoir. If silvery minnow introductions to this sub-reach were to be considered further, we suggest that it would be appropriate to assess the potential displacement of young fish for other species prior to any such introductions.

Impacts of Weekend Boating Release Flows on Macroinvertebrate and Periphyton Production in the Upper Chama Sub-Reach

An important consideration associated with any potential reintroduction of a non-essential, experimental population of silvery minnows in the Upper Chama Sub-Reach is food-source availability to sustain the fish. Biological impairment of the gravel-cobble bed in the Upper Rio Chama Sub-Reach has been attributed in part to fine sediment (sand, silt, and clay) deposition on the bed of the river and the smothering effects on periphyton and macro-invertebrates (Henley et al., 2000; 1987; Jacobi and McGuire, 1992; Biggs et al., 2001). The primary sources of the fine sediments are the tributaries located downstream of El Vado Dam that drain areas underlain by erodible sedimentary rocks (see Chapter 2, Exhibit 2-5). Fine sediment delivery to the main stem Rio Chama occurs during snowmelt runoff in the higher elevation tributaries (Rio Nutrias, Rio Cebolla, Rio Gallina) when the flows in the river tend to be higher and during the summer-fall monsoon period from all the tributaries when the flows in the river are low. Field observations indicate that during the snowmelt regime, sediment concentrations in the river tend to be lower because of the higher flows, whereas in the monsoon season, the sediment concentrations in the river tend to be much higher, and are likely to be more deleterious to the biota.

Based on extensive field measurements and 2-dimensional (2-D) hydrodynamic modeling (RMA-2) in two separate reaches of the Upper Colorado River, biologically-impairing fine sediment deposition occurs when local bed shear stresses within the channel are less than 1.4N/m2 (0.03 lb/ft^2) (Rees et al., 2004; Harvey and Mussetter, 2009). This hydrodynamic condition occurs primarily on the channel margins and the extent of the deposition is more likely to be highest in pools and runs than in riffles. During the higher snowmelt flows, deposition of fines is likely to occur at higher elevations on the channel perimeter, and thus during baseflow periods, the higher-flow affected areas are dry and do not affect biological productivity. During the baseflow period, a considerably larger proportion of the wetted perimeter of the channel is likely to have shear stresses less than 1.4 N/m^2, and therefore experience fine sediment deposition should a thunderstorm cause tributary sediment delivery.

Elimination of the biological impairment requires removal (flushing) of the fine sediment either by mobilization of the bed material, or by shear stresses that are locally higher than 1.4N/m^2, but that are below the threshold for bed material mobilization (Harvey and Mussetter, 2009). In the Upper Colorado River, results from the 2-D modeling and field measurements indicated that flushing of the fine sediments in the riffles that are likely to be the most biologically productive areas (Osmundson et al., 2002), could be achieved by modest increases in flow for short durations. Such conditions may be provided by the boating flow releases on the Upper Chama Sub-Reach. By observation, weekend boating flows (up to about 800 cfs) do not cause mobilization of the bed material, but they could be causing mobilization of the deposited fine sediments in the steeper riffles where shear stresses are likely to be higher. Therefore, the boating flows could be removing the biological impediment at those locations on the channel perimeter that will be wet during the following low flow periods and available for recolonization by both periphyton and macro-invertebrates.

This hypothesis obviously requires testing through both field and modeling studies. A limited pilot study could be conducted at a single geomorphically-representative site (contains a pool/run and riffles) in the Upper Chama Sub-Reach. High resolution topographic surveys of the site would be required to develop and calibrate a 2-D hydrodynamic model (most probably SRH-2). Sampling of the bed material would be required to quantify the bed material characteristics and the boundary roughness, and mapping of the fine sediment deposits throughout the site would be required during baseflow periods prior to the onset of the monsoon flows and after a fine sediment-generating event to quantify the fine sediment depositional potential of the site and to verify output from the 2-D model. Depth and velocity measurements throughout the site would be conducted during a boating flow release and the distribution of fine sediment deposits would be measured again after the event. Concurrent sampling of the periphyton and macro-invertebrates throughout the site would be required to quantify the presence of periphyton and macro-invertebrates and their responses to fine sediment deposition and any flushing from the boating flows.

Impacts of Weekend Boating Release Flows on Soil Salt Accumulations and Willow Growth in the Upper Chama Sub-Reach

It is well established that native riparian species such as willow and cottonwood are sensitive to dissolved salts in the soil and water, and the presence of salt may prevent both the establishment of seedlings and the growth of established vegetation under certain conditions (Amlin and Rood. 2002; Blaylock, 1994; Pearson, 2004; Pockman and Sperry, 2000; Swift, 2003; Tallent-Halsell and Walker 2002; Taylor 1996; U.S. Soil Salinity Lab, 1954; Vandersande et al., 2001).

Soil salinity is a dynamic soil property. The factors that affect soil salinity include water quality, depth to shallow groundwater, duration of shallow water tables, frequency and duration of flooding, soil stratigraphy, and in some instances the type of plant community. The flow of the Rio Chama is manageable, and is already managed in such a way as to benefit multiple uses. However, there is a lack of understanding of the effects of summer boating release flows on the soil salinization dynamics in the riparian zone within the Upper Chama Sub-Reach. This becomes particularly relevant if enhancement of flycatcher habitat is a management priority in the sub-reach.

Salt accumulations on surface of channel bars was pervasive during an April 2008 field reconnaissance.

As discussed in Chapter 4, there is uncertainty about the impacts of the boating release flows (see Chapter 4, Exhibit 4-11) on soil salinity levels, particularly regarding their potential impact on willow productivity on alluvial bars and floodplain sites. Site observations during 2008 indicate sodium salts tend to accumulate on many willow bars, and could potentially explain the relatively short growth stature of coyote willows throughout the sub-reach. While spring-time overbank flooding in 2008 effectively leached these salts from the soil profile at sampled locations (see Chapter 4, Exhibit 4-12), this leaching does not necessarily occur during years with below average snow-pack. We hypothesize that the summer boating releases can increase soil salt accumulations on the willow bars, and unless they are leached on a regular basis via seasonal overbank flooding, these salt accumulations could have detrimental impacts on willow growth, and ultimately, flycatcher habitat quality.

We recommend implementing a carefully designed research study to evaluate the impacts of the summer boating release flows on sodium salt concentrations and willow growth attributes in the Upper Chama Sub-Reach. Baseline conditions for both soil and vegetation would need to be documented, and a study plan should be implemented to explore relationships between flow releases, salt accumulations and willow growth parameters on multiple willow bars. The study should focus on isolating the variable factors affecting the salinization process as much as possible. Multiple sites are needed to adequately capture the variability of conditions that occur in dynamic fluvial settings. Each site needs to be monitored periodically for 1) vegetation changes, 2) depth and duration of water table, 3) soil salinity at varying depths from the soil surface to the water table, and 4) overbank flooding, including depth, duration, timing and frequency at each sampling location. These parameters will need to be correlated with release events from El Vado reservoir, and ideally with rainfall events as well.

Flycatcher Monitoring along the Lower Chama Sub-Reach

The largest existing population of breeding flycatchers in the Upper Rio Grande Management Unit is found at Ohkay Owingeh, immediately downstream of the Lower Chama Sub-Reach. Researchers in Arizona found that the majority of flycatchers nested less than 8.5 miles from the previous year's nest location. Young birds establishing their first territory typically did so within 13 miles from their natal sites (Paxton et al., 2007). These data indicate that breeding flycatchers have potential to expand their breeding territories to suitable habitats within the project area, particularly to suitable sites within the nearby Lower Chama Sub-Reach.

To our knowledge, no formal flycatcher surveys have been performed in the Lower Chama Sub-Reach. Based on limited field reconnaissance and follow-up site visits to a few locations, we have identified a few sites within the sub-reach that appear to be suitable breeding habitat and should be considered for formal surveys.

Below are brief descriptions of potential flycatcher habitat sites identified as by our project team. Locations of these sites are displayed in Exhibit 5-10. There are likely several other sites in the sub-reach that are also worthy of formal surveys, so the list below should not be considered exhaustive. The sites we identified include:

The RM 5 site supports dense stands of coyote willow and Gooding's willow. This site floods at 1,800 cfs and may already support breeding willow flycatchers.

- Site RM 5. This 15-acre floodplain site is located on the Lower Chama approximately 3,300 feet downstream of the SR 285 Bridge crossing (river left). The habitat is composed of a cottonwood, elm, and Gooding's willow overstory with a dense understory of coyote willow and Russian olive. The site contains several ephemeral side-channels, and FLO-2D analysis indicates significant flood inundation throughout the site at 1,800 cfs. The landownership data we received from the State of New Mexico indicates the site is privately owned (see Chapter 2, Exhibit 2-6), but we were unable to determine the specific property owner.

The RM 19 site supported mixed stands of coyote willow and Russian olive. This nest, which may have been constructed by a willow flycatcher, was observed in a coyote willow at this site in October 2008.

- Site RM 19. This 6-acre site is located immediately upstream from the Route 554 Bridge (river right). The vegetation is composed mostly of Russian olive and coyote willow. The FLO-2D model indicates that this site is not inundated at 1,800 cfs. Nonetheless, we did encounter one previously used nest during a fall field reconnaissance that might have been constructed by a willow flycatcher (see sidebar photo). The landownership data we received from the State of New Mexico indicates the site is privately owned (see Chapter 2, Exhibit 2-6), but we have not identified the property owner.

- Site RM 21B. This 12-acre site is composed of a dense coyote willow stand adjacent to a large cattail/emergent marsh wetland (river right). The site is approximately 300 feet upstream of an irrigation diversion structure, and although the FLO-2D model indicates the site is not inundated at 1,800 cfs, field observations indicate the groundwater is very shallow and likely approaches the surface at this flow. This site is part of the Double M Ranch property, and the landowner has expressed interest in habitat conservation and restoration.

- Site 25B. This 4-acre floodplain bar is located immediately downstream of the SR 84 Bridge (river right). The vegetation is composed of a cottonwood overstory with dense patches of coyote willow and Russian olive throughout the understory. The site resides immediately downstream of an irrigation diversion, and surface water flows through several small channels. As a result, there is significant ground cover by herbaceous wetland plants. This site is owned by the Abiquiu Land Grant, who has expressed interest in incorporating wildlife habitat management into their overall land management planning efforts. Close coordination with the landowners would be required to allow formal flycatcher surveys on the property.

Dense coyote willow stand at site RM 21B.

Diverse native riparian-wetland habitat owned by the Abiquiu Land Grant (site RM 25B).

Public Outreach Regarding Endangered Species Conservation

It is highly improbable that flycatcher recovery goals for the Upper Rio Grande Management Unit will ever be achieved without involvement and commitment by private landowners and local community organizations. It was encouraging that most of the private landowners we met expressed concern with the degraded ecological condition of the river and floodplain, and several were very interested in exploring opportunities for protecting and enhancing the habitat quality on their property. While this perspective was common, we believe it is important to re-emphasize that many private landowners are rightfully concerned about losing control over management of their lands should endangered species begin utilizing their property. Many are also concerned about being able to continue making financial ends meet through farming or ranching, and may need financial or other incentives to incorporate habitat management into their overall land management program.

Mr. Gilbert Vigil, a private landowner along the Lower Chama Sub-Reach, expressed strong interest in habitat restoration on his ranch. We suspect there are many other private landowners with similar interest in the project area, and strongly encourage the Program to implement community outreach efforts to landowners throughout the Lower Chama and Velarde Sub-Reaches.

We have made contact with a very small number of landowners in the reach, and we suggest more intensive outreach efforts are needed to achieve river conservation and habitat restoration on a meaningful scale in the project area. These outreach efforts should include property owners as well as acequia associations and other community organizations with a vested interest the long-term future of the Rio Grande and Rio Chama.

In Chapter 4, we identified several existing incentive programs that could be presented through public meetings within the various communities that line the Lower Chama and Velarde Sub-Reaches. Given the receptiveness of the few landowners we met in the project area, we suspect that outreach and education efforts to the community at-large could go a long way to achieving successful, collaborative restoration in the project area.

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APPENDIX A

GIS Geo Database Structure

Appendix A

1. How was the GIS geo-database developed for this project, and how can Program participants access this data?

Geographic Information System (GIS) technology was an essential tool for developing this report. Datasets were acquired through an extensive network of sources and compiled into a thematically organized database. Some datasets were re-projected from their original datum to increase data compatibility. Spatial data was generally maintained as shapefiles throughout the project to allow for easy interchange between ArcGIS and other software and was later migrated into an Environmental Systems Research Institute (ESRI) geodatabase for distribution purposes. This geodatabase contains all of the final outputs for the vector-based data sets (polygons, points, and lines) and can be interchanged easily.

Data in this ESRI geodatabase were compiled in ESRI ArcGIS Version 9.3. We organized feature classes as thematically arranged feature datasets beneath a single geodatabase for distribution purposes, so a single file could be exchanged that contains all of the vector data. The base themes (or feature datasets) within the database are access, fire, geology, geomorphology, hydrology, ownership, reference, restoration, vegetation, and wildlife (see Exhibit A-1 for a schematic representation of the geodatabase structure). Each individual coverage (or feature class) is organized within the most suitable theme (feature dataset).

Data within feature datasets do not necessarily have any definitive relationships besides geographic area and general theme. Feature classes within feature datasets may have come from different sources and do not necessarily follow conventional database structures with relationships between feature classes but were organized together based on a common theme. Since data were maintained as shapefiles through most of the project, we organized data into larger attribute tables rather than several related tables as is conventional in some geodatabases. Domain values and defaults were also not populated for this reason. The primary intent of this database is for easy distribution of a comprehensive GIS dataset compiled for the Velarde Reach.

Each GIS data set in this geodatabase has Federal Geographic Data Committee (FGDC) compliant metadata associated. Existing metadata was not readily available for each coverage. In these cases, we compiled general summary information with the intention of accurately representing the original intent and accuracy of these data.

A GIS data DVD accompanies this report and will be made available on the Program's FTP site. The files contain both the geodatabase described above and shapefile versions of these data sets. Shapefiles are organized in a folder structure that matches the geodatabase scheme displayed in Exhibit A-1.

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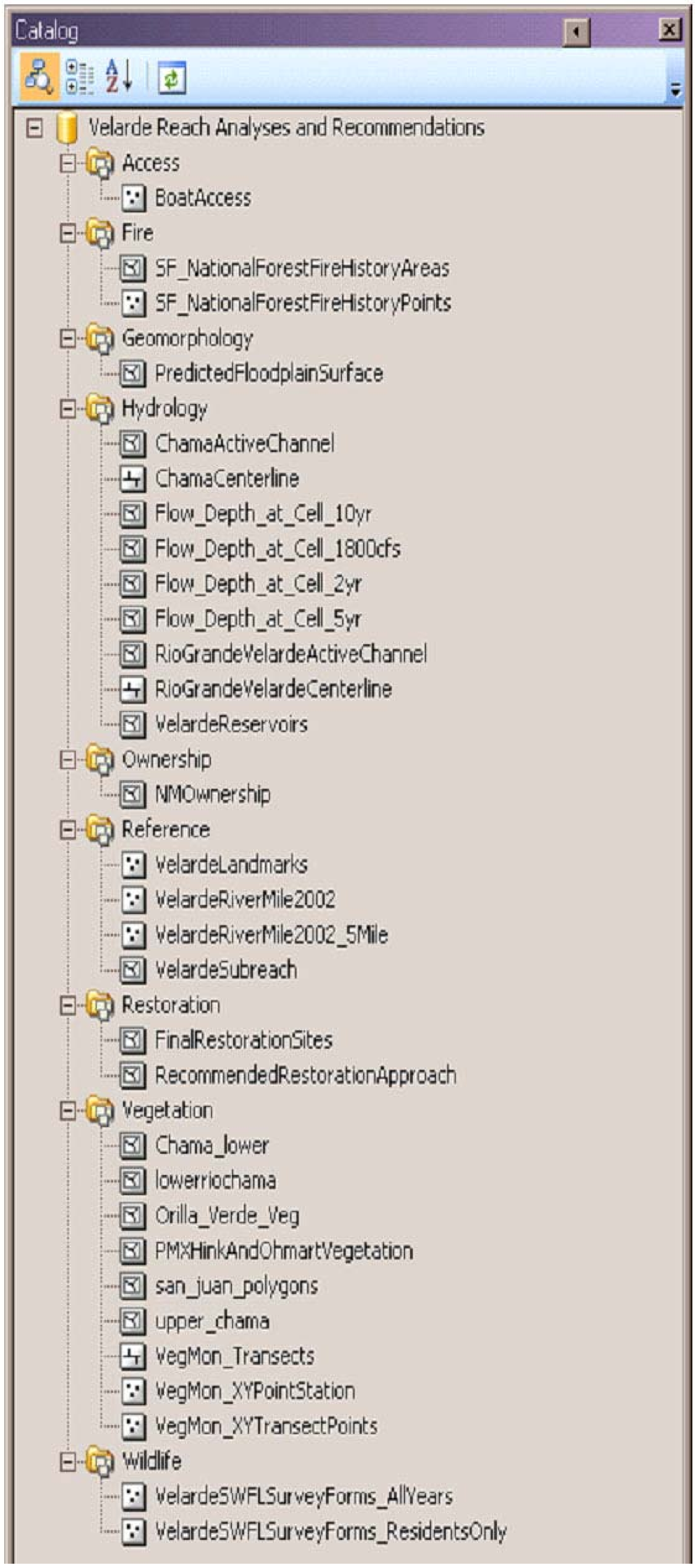
Exhibit A-1 – Geodatabase Structure



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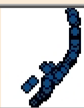
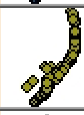
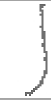
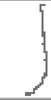
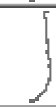
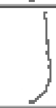
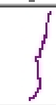
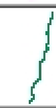
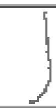
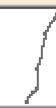
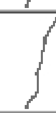
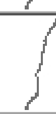
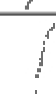
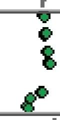
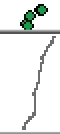
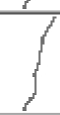
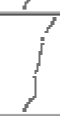
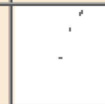
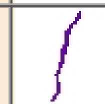
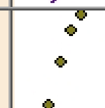
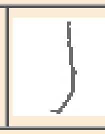
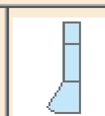
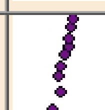
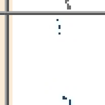
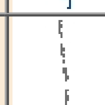
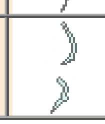
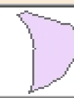
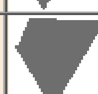
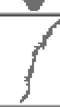
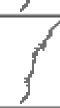
ARCGIS Diagrammer
Data Report

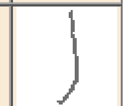
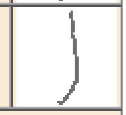
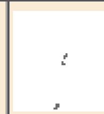
Class Name	Original Source	Geometry	General Description	Total	Extent	Snapshot
Access						
AccessInfo	U.S Bureau of Reclamation	esriGeometryPoint	Access Areas Throughout the Reach	143	303313.9917 329321.3643 3716351.665 3764018.7186	
AccessInfo_lyr	Parametrix	esriGeometryPoint	Presentation Layer For Access Areas	143	303313.9917 329321.3643 3716351.665 3764018.7186	
Park	Parametrix	esriGeometryPolygon	Parks Throughout The Reach	15	325009.6511 329197.2441 3754704.927 3790722.2686	
Fire						
Fires	Parametrix	esriGeometryPolygon	Fires Designated By Gina Dello-Russo and Doug Boykin	16	312481.5948 330680.8225 3723276.0259 3779564.1215	
FuelBreak	Parametrix	esriGeometryPolygon	Fuelbreaks Designated By Gina Dello-Russo and Doug Boykin	10	322618.0785 330156.0241 3732584.0358 3777269.4209	
Treatment	Parametrix	esriGeometryPolygon	Treatment Areas Designated By Gina Dello-Russo and Doug Boykin	21	325549.5561 330273.8818 3736721.4765 3782312.9565	
Geology						
MidRioGrandeSurfGeol1935	Lettis and Associates/New Mexico Tech	esriGeometryPolygon	Surficial Geology in 1935	670	306761.5184 330691.3762 3715739.956 3791869.7245	
MidRioGrandeSurfGeol2000	Lettis and Associates/New Mexico Tech	esriGeometryPolygon	- Surficial Geology in 2000	926	301929.448 331261.1036 3707024.2958 3794055.1619	
Geomorphology						
BORAgDegradLines	U.S. Bureau of Reclamation	esriGeometryPolyline	Aggredation/Degredation Lines	1032	297494.6759 412640.9618 3698218.5769 4004466.5098	
Channel1918	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1918	7	314515.0383 330557.6553 3728705.7956 3792276.3996	
Channel1935	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1935	12	315078.7783 329675.1641 3728469.5494 3792276.3969	
Channel1949	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1949	18	315083.4264 329752.6197 3728464.8653 3792276.3987	

Class Name	Original Source	Geometry	General Description	Total	Extent	Snapshot
Channel1962	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1962	6	315132.331 329767.1746 3728470.7708 3792276.4041	
Channel1972	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1972	2	315138.5821 329507.3695 3728470.1361 3792276.4049	
Channel1985	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1985	9	315124.826 329709.094 3728466.283 3792276.3773	
Channel1992	U.S. Bureau of Reclamation (Jan Oliver)	esriGeometryPolygon	Active Channel in 1992	12	315122.7685 329698.5224 3728465.382 3792276.3748	
DryingPotential	Mike Hatch	esriGeometryPolyline	Drying Potential Related to Silvery Minnow	22	314324.4268 346012.8805 3723237.453 3863871.0754	
Incision_Massong_2005	Tamara Massong	esriGeometryPolyline	GIS Outputs From 2005 Incision Report	3	326205.5433 343450.0759 3792138.7997 3856391.3177	
IncisionAmounts	Tamara Massong	esriGeometryPolyline	GIS Outputs From 2005 Incision Report	11	314324.4268 380327.7954 3723237.453 3942371.2037	
IncisionBoundaries	Tamara Massong	esriGeometryPolyline	GIS Outputs From 2005 Incision Report	12	313158.2399 381415.493 3722502.2863 3946397.2957	
PMX2006Channel	Parametrix	esriGeometryPolygon	Active Channel in 2006	2	315211.1142 329425.7658 3728470.6495 3792276.3743	
TerraceHeights	Tamara Massong	esriGeometryPolygon	GIS Outputs From 2005 Incision Report	354	309407.0938 332237.1563 3717852.75 3807605.5	
Hydrology						
april_05_final_all_features	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	2086	297970.2409 380297.8868 3697793.0216 3942662.1372	
april_05_final_channel	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	32	298226.0874 380297.8869 3697793.0216 3942654.1311	
april_05_final_inundated_areas	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	1023	297970.241 379973.866 3697837.9931 3942662.1372	
april_05_final_inundated_islands	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	788	304911.2576 379563.4796 3711713.536 3942372.5981	

Class Name	**Original Source**	**Geometry**	**General Description**	**Total**	**Extent**	**Snapshot**
april_05_final_non_inundated_islands	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	243	307738.7552 379873.704 3716244.0205 3942623.2564	
april_05_tamara_massong_comments	Tamara Massong	esriGeometryPolygon	Digitized Overbank Features From 2005	96	306704.1911 371952.4356 3713237.1771 3925646.3424	
BDAWellLocations	U.S. Fish and Wildlife Service	esriGeometryPoint	Groundwater Monitoring Wells at BDA	30	321752.822 330159.886 3733385.61 3749287.773	
FLO2D_Flood_inundation_250ft	Parametrix/FLO2D Engineering	esriGeometryPolygon	FLO2D Flood Inundation Output	259	315197.9314 330550.0581 3727883.2117 3788474.0336	
FLO2D_Flood_inundation_250ft_lyr	Parametrix/FLO2D Engineering	esriGeometryPolygon	FLO2D Flood Inundation Output Layer File	259	315197.9314 330550.0581 3727883.2117 3788474.0336	
Flo2DCrossSections	Wolf Engineering/FLO2D Engineering	esriGeometryPolyline	Cross-section Locations From FLO2D Model	231	315390.7668 378949.8492 3728500.6331 3940926.578	
ISCSocorroGroundwaterModel	Parametrix/ Interstate Stream Commission	esriGeometryPolygon	Depth to Groundwater Model Output	13493	324877.2988 330554.1988 3752542.3893 3792318.7893	
ISCWellLocations	Interstate Stream Commission	esriGeometryPoint	ISC Groundwater Monitoring Well Locations	136	311912.0071 329311.8178 3720964.583 3791351.1888	
june_05_final_all_features	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	2513	297886.6334 380299.5093 3697792.7428 3942666.4579	
june_05_final_channel	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	31	298217.3914 380299.5094 3697792.7428 3942655.5813	
june_05_final_inundated_areas	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	1068	297886.6334 379952.1507 3698563.3908 3942666.4579	
june_05_final_inundated_islands	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	1226	298798.4993 379874.0391 3698209.8437 3942625.2899	

Class Name	Original Source	Geometry	General Description	Total	Extent	Snapshot
june_05_final_non_inundated_islands	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	188	328857.1799 379555.4149 3793019.3597 3942355.1859	
june_05_tamara_massong_comments	Mark Horner	esriGeometryPolygon	Digitized Overbank Features From 2005	55	306991.1134 368437.8898 3713926.0821 3920985.25	
MRGCDConveyances	Middle Rio Grande Conservancy District	esriGeometryPolyline	MRGCD Infrastructure – Conveyance Channels	1573	309271.2844 380992.6057 3718370.2593 3943151.606	
MRGCDDiversions	Middle Rio Grande Conservancy District	esriGeometryPoint	MRGCD Infrastructure - Diversions	4	326224.6758 380297.5622 3792219.0019 3942324.9449	
OverbankStudyCrossSections	Wolf Engineering/FLO2D Engineering	esriGeometryPolyline	Overbank Study Cross Sections	232	314327.5551 378949.8492 3727800.1214 3940926.578	
Ownership						
PMXUpdatedOwnership2007	Parametrix, MRGCD, USBOR, Tetra Tech, USFWS, New Mexico Tech, BLM	esriGeometryPolygon	General Ownership Throughout the Reach	658	314664.6662 330511.076 3727881.9053 3792324.645	
Reference						
GeneralSubreaches	Tetra Tech, Save Our Bosque Task Force, Parametrix	esriGeometryPolygon	General Subreaches Between San Acacia and San Marcial	3	311515.7628 335891.9449 3726773.8538 3792281.7155	
Landmarks	Tetra Tech, Save Our Bosque Task Force, Parametrix	esriGeometryPoint	Primary Landmarks	10	315235.1641 346053.7234 3728519.2905 3863847.1052	
RiverMileMarks	U.S Bureau of Reclamation	esriGeometryPolyline	River Mile Markers Determined By the USBOR	287	284800.4445 412663.012 3642017.5648 4006263.2509	
Restoration						
PMXBackwater	Parametrix	esriGeometryPolygon	Proposed Backwater	6	326241.8262 328075.2317 3766544.129 3781764.0673	
PMXBankDestabilization	Parametrix	esriGeometryPolyline	Proposed Bank Destabilization	7	326137.6185 327899.5793 3771733.6083 3785619.3775	
PMXMowAndPlow	Parametrix	esriGeometryPolygon	Proposed Mowing and Plowing	34	325926.5733 329716.5431 3740501.0266 3786904.1197	
PMXRealignChannel	Parametrix	esriGeometryPolygon	Proposed Channel Relignment	2	328156.7041 330091.9698 3742072.4912 3749483.9363	

Class Name	Original Source	Geometry	General Description	Total	Extent	Snapshot
PMXRemoveExotics	Parametrix	esriGeometryPolygon	Removing Exotics Proposed	1	327904.6761 328373.8571 3768361.2327 3769071.5662	
PMXWillowSwale	Parametrix	esriGeometryPolygon	Proposed Willow Swale	5	326153.0969 327990.9024 3766627.4682 3782090.4719	
SWCDHerbicideTreatments2003_2006	Socorro County Soil and Water Conservation District	esriGeometryPolygon	Saltcedar Herbicide Application (2003-2006)	1799	149187.8302 409794.8112 3602552.4096 3974979.6785	
SWCDMechanicalTreatments2006	Socorro County Soil and Water Conservation District	esriGeometryPolygon	Mechanical Treatment of Saltcedar (2006)	1	327078.409 327305.4714 3780183.0071 3780502.9879	
TTHabitatDiversityPlan	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech Habitat Diversity Plan	149	315416.2108 330942.9695 3727918.7746 3792029.1067	
TTLongTermComprehensivePlan	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech Long Term Comprehensive Plan	173	315416.2108 330920.0402 3727918.7746 3792029.1067	
TTLytePlan	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech Lyte Plan	66	315782.4098 330857.6337 3727918.7746 3785301.6166	
TTReduceDroughtImpactPlan	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech Reduce Drought Impact Plan	89	315416.2108 330942.9695 3727918.7746 3792029.1067	
TTRiverDynamicsPlan	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech River Dynamics Plan	176	315416.2108 330920.0402 3727918.7746 3792029.1067	
TTWaterSalvagePlan	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech Water Salvage Plan	83	315416.2108 330942.9695 3727918.7746 3792029.1067	
Vegetation						
BDAHinkAndOhmartMap	U.S. Fish and Wildlife Service	esriGeometryPolygon	BDA Vegetation Map Assigned Hink and Ohmart Classes	12611	321629.0001 330315.0001 3732617.9998 3749328.0003	
BDAVegetation	U.S. Fish and Wildlife Service	esriGeometryPolygon	BDA RLGIS Vegetation Map	60256	317347.0002 337430.9997 3728870.0001 3749433.9995	
MidRioGrandeNWIMap	U.S. Fish and Wildlife Service	esriGeometryPolygon	National Wetlands Inventory Mapping	6127	302477.5195 439858.3637 3705380.8207 4025792.4157	
MidRioGrandeNWIWetlands	U.S. Fish and Wildlife Service	esriGeometryPolygon	National Wetlands Inventory Mapping	3263	302477.5208 439858.3613 3705380.8183 4025792.4148	
TetraTechVegetation2000	Save Our Bosque Task Force/Tetra Tech	esriGeometryPolygon	Tetra Tech General Vegetation Map	796	314079.6067 330511.076 3721655.2917 3792676.4051	

Class Name	Original Source	Geometry	General Description	Total	Extent	Snapshot
UpdatedHinkOhmart2007	U.S. Bureau of Reclamation/Parametrix	esriGeometryPolygon	Parametrix Updated 2007 Hink and Ohmart Map	619	315215.6923 330713.2369 3727881.9053 3792229.888	
URGWOPSHinkOhmart2002	U.S. Bureau of Reclamation/URGWOPS	esriGeometryPolygon	2002 URGWOPS Hink and Ohmart Mapping	578	315200.2341 330713.2369 3727881.9053 3792229.888	
Wildlife						
SilveryMinnowRescueSites	Mike Hatch	esriGeometryPolygon	Rio Grande Silvery Minnow Rescue Sites	63	307000.8368 343723.6082 3713703.7627 3861150.7684	
TamarixWIFLPotential	U.S. Bureau of Reclamation	esriGeometryPolygon	Southwestern Willow Flycatcher Habitat Potential in Saltcedar Stands	26	317941.7007 346189.176 3728126.6589 3868695.0588	
WIFLDetections072306	U.S. Bureau of Reclamation	esriGeometryPoint	2006 Southwestern Willow Flycatcher Detections	281	298960 343313 3697587 3854558	

APPENDIX B

Landowner Incentives

Appendix B.1

Fact Sheet: Safe Harbor Agreements for Private Landowners

Safe Harbor Agreements for Private Landowners

Safe Harbor Agreements are voluntary arrangements between the U.S. Fish and Wildlife Service (FWS) or the National Oceanic and Atmospheric Administration–Fisheries and cooperating non-Federal landowners. This policy's main purpose is to promote voluntary management for listed species on non-Federal property while giving assurances to participating landowners that no additional future regulatory restrictions will be imposed. The agreements benefit endangered and threatened species while giving landowners assurances from additional restrictions.

Following development of an agreement, the FWS will issue an "enhancement of survival" permit, to authorize any necessary future incidental take to provide participating landowners with assurances that no additional restrictions will be imposed as a result of their conservation actions.

Preserving Habitat
Because many endangered and threatened species occur primarily or exclusively on privately owned property, we believe it is critical to their protection to involve private landowners in their conservation and recovery. Many property owners, however, are concerned about land use restrictions that may occur if listed species colonize on their property or increase in numbers as a result of land management. Thus they often avoid or limit land and water management practices that could enhance and maintain habitat.

Landowner Initiatives
Any non-Federal landowner can request the development of a Safe Harbor Agreement. These agreements are between the landowner and the FWS or between the FWS and other stakeholders (such as State natural resource agencies, Tribal governments, local governments, conservation organizations, businesses). Even if a landowner and the FWS develop an agreement, other stakeholders, at the landowner's request, can participate in many ways in the development phases of the agreement. However, the assurances only apply to the participating landowners and for lawful activities within the enrolled lands.

Non-Federal landowners have been seeking and insisting on assurances that their voluntary actions will not result in future land-use restrictions. This policy could help all non-Federal landowners interested in using their lands to aid conservation but who also fear subsequent restrictions on land use.

No Surprises
The FWS will provide assurances (by issuing an "enhancement of survival" permit) that, when the agreement's term ends, the participating landowner may use the property in any otherwise legal manner that doesn't move it below baseline conditions determined in the agreement. These assurances operate with the enrolled lands and are valid for as long as the participant is complying with the Safe Harbor Agreement and associated permit.

In return for the participant's efforts, the FWS will authorize incidental take through the section 10 (a)(1)(A) process of the Endangered Species Act (ESA). This permit would allow participants to take individual listed plants or animals or modify habitat to return population levels and habitat conditions to those agreed upon as baseline.

Enhancing Wildlife
Before entering into a Safe Harbor Agreement, we must make a written

Aplomado falcon. Photo by Steve Bentsen

finding that the covered endangered or threatened species will receive a "net conservation benefit" from the agreement's management actions. Examples of such benefits include:

- reduction of habitat fragmentation;
- maintenance, restoration, or enhancement of existing habitats;
- increase in habitat connectivity;
- maintenance or increase of population numbers or distribution;
- reduction of the effects of catastrophic events;
- establishment of buffers for protected areas; and
- areas to test and develop new management techniques.

The finding must clearly describe the expected net conservation benefits and how the FWS reached that conclusion. Net conservation benefits must contribute, directly or indirectly, to the recovery of the covered species. This contribution toward recovery will vary and may not be permanent. The benefit to the species depends on the nature of the activities to be undertaken, where they are undertaken, and their duration.

Starting the Process
Generally, the steps are:

1. Contact the nearest FWS Ecological Services field office and ask to speak to someone about the Safe Harbor Program.

2. You (the landowner), with the aid of the FWS, must gather some general information. This includes, but is not limited to, a map of the property, proposed management actions, information on the listed species that occur on the property, and any other pertinent information.

3. We (or appropriate cooperators approved by you) will describe the baseline conditions for the enrolled property in terms appropriate for the covered species. Using the baseline determination, you and our staff will discuss land use objectives, assess habitat quality, and identify any other information needed to develop an agreement that meets the standards of the policy.

4. Based on all the information you provide, information gathered during site visits, and the FWS's technical assistance, you and our staff (and any other pertinent entity, such as a State fish and game agency) develop a draft Safe Harbor Agreement. The draft agreement would include a monitoring program designed to assess the success of the management practices.

5. To apply for a permit, you would complete an "enhancement of survival" permit application form, attach the draft Safe Harbor Agreement, and submit them to us. This is your complete application.

6. After we comply with all applicable ESA provisions (internal section 7 review and public comment period on your permit application), we will issue you a 10(a)(1)(A) permit and finalize the agreement. This permit will allow you to return your property to the baseline conditions at the end of the agreement.

If continuation of permitted activities would likely result in jeopardy to covered species, the FWS may, as a last resort, revoke the permit. Prior to revocation, the FWS would exercise all possible measures, including offering to purchase the property or relocate the species, to remedy the situation. We may also suspend or revoke a permit for cause in accordance with the laws and regulations in force at the time of such suspension or revocation.

Determining a Baseline
We will describe the baseline of the enrolled property in terms appropriate for the target or covered species, such as number and location of individuals, if it can be determined. Probably the most common method will be a measurement of the habitat. For example, in a stream restoration project to benefit listed streamside songbirds, we may use the miles of occupied stream habitat being restored as the baseline measurement. We will also use other information, such as habitat characteristics that support the covered species and any other information that helps to document the current conditions.

Timeline
Many agreements can be developed within 3-4 months. More complex agreements may take at least 6-7 months. It depends on a number of factors including:

- the species' ecology,
- size of project,
- number of parties to the agreement,
- state of scientific knowledge regarding the species, and
- funding available for the Safe Harbor program.

Public Involvement
As with other similar ESA permits, we will publish a notice in the *Federal Register* when we receive the permit application. We will announce receipt and availability of the application and agreement. We will accept and consider comments from the public before making a final decision on issuance of the permit.

If a non-covered listed species or a newly listed species occupies the enrolled lands, the participant can request an amendment to the agreement and/or the permit to add the species. The FWS and the participant will agree on the enhancement or maintenance actions for the newly covered species, baseline conditions, and a net conservation benefit to that species. We would revise the permit and agreement to address the presence of additional listed species in much the same way as the species covered in the original agreement.

Selling the Land
If you sell or give away your enrolled lands, we will honor the agreement, providing the new owner willingly signs the original agreement or a new mutually agreeable one.

Renewing the Agreement
These agreements can be renewed for as long as the landowner wishes and follows its terms.

Statewide Agreement
Statewide agreements authorize individual States to implement Safe Harbor programs. We provide a permit to the State, which can then offer individual landowners authorizations through a "certificate of inclusion." This has tremendous potential for efficiently providing assurances to non-Federal landowners. These "programmatic" agreements can be provided to other groups, such as local government or non-governmental conservation organizations. Statewide agreements have been developed for the red-cockaded woodpecker in Texas and South Carolina.

U.S. Fish and Wildlife FWS
Endangered Species Program
703/358-2105
http://endangered.fws.gov
February 2004

Appendix B.2

Fact Sheet: Conservation Easements in New Mexico

Conservation easements in New Mexico

Sid Goodloe started a land trust and put an easement on 3,500 acres of his ranch. ©Michael J. Gallegos

Carrizo Valley Ranch, Capitan

PUBLIC BENEFITS

- Preserves open space
- Protects wildlife habitat
- Protects water quality
- Maintains character of rural community
- Property remains on public tax rolls

LANDOWNER BENEFITS

- Keeps ranch in the family
- Maintains sustainable, holistic management
- Maintains ranching tradition
- Preserves options for children and grandchildren to ranch

A few years ago, rancher Sid Goodloe realized that his kids would not be able to pay the inheritance tax on his ranch after he died. He felt compelled to do something so his family could continue ranching. Consequently, Goodloe decided to put a conservation easement on his Carrizo Valley Ranch. He investigated the state's land trusts, but none were specifically ranch-oriented. So Goodloe and several like-minded friends formed the Southern Rockies Agricultural Land Trust, and Goodloe placed 3,500 acres of his ranch under easement. Goodloe is protecting the values, such as sustainable land management and ecosystem health, he worked so hard to re-establish after arriving here in the late '50s.

"I certainly didn't want my grandkids to drive by a new subdivision and say, 'that used to be my granddad's ranch.' The main reason we're doing an easement is because I want my grandkids and great-grandkids to be able to raise their children in the ranching atmosphere... to develop a dependability, a work ethic, an ability to improvise and solve problems, and a love and respect for the land. I spent 45 years developing this land into a sustainable, holistic property. What good is all that if, when I die, it all changes? If I don't protect it, I've wasted my time."

— Sid Goodloe, rancher

NEW MEXICO AT A GLANCE

266,630	acres under conservation easement with The Nature Conservancy
76,167	acres under conservation easement with other regional and local land trusts
10	number of land trusts in New Mexico; half of these hold 89 conservation easements

ABOUT CONSERVATION EASEMENTS

Conservation easements are one of the most powerful, effective tools available for the conservation of private lands. Their use has successfully protected millions of acres of wildlife habitat and open space, and hundreds of miles of rivers, all while keeping property in private hands and generating significant public benefits.

Often, some of the most ecologically significant lands and waters in the country are those found in rural and agricultural landscapes. Easements have been instrumental in preserving these landscapes, from family farms to working ranches and timberlands. Between 1992 and 1997, more than 11 million acres of rural land in the United States were converted to developed use – an area five times the size of Yellowstone National Park. As people struggle to keep family farms and ranches together in the face of steep taxes and unpredictable markets, conservation easements are often the tool of choice.

In New Mexico, conservation easements protect essential water resources, maintain rural communities, provide open space and preserve rich cultural traditions. They help sustain family-run farms and ranches statewide. They preserve New Mexico's enchantment forever.

Public benefits of conservation easements

- Protect water quality
- Conserve wildlife habitat
- Preserve open space
- Preserve farmland, ranchland, timberland
- Maintain character of rural communities
- Buffer public lands
- Maintain landscapes for tourism
- Require less in public services, generate more in local revenues

An easement on the Armstrong/Trujillo Ranch conserves ancestral lands and protects the largest piece of undeveloped farmland in San Cristobal. ©Elizabeth Byers

The late Charlie Disert and his wife did not want their working cattle ranch to be sold and subdivided after their lifetimes. ©TNC

Armstrong/Trujillo Ranch, San Cristobal

PUBLIC BENEFITS

- Conserves wildlife habitat
- Preserves open space
- Maintains character of rural community
- Property remains on public tax rolls

LANDOWNER BENEFITS

- Keeps ranch intact
- Prevents subdivision, development
- Keeps ancestral land in the family

North of Taos lies Crestina Trujillo Armstrong's 50-acre ranch, the largest contiguous piece of undeveloped farmland in San Cristobal. Five years ago, Crestina and her brother Jose Trujillo worked with the Taos Land Trust to place a conservation easement on 38 acres of the ranch. The land has been in their family for four generations. With this easement, Armstrong and Trujillo have ensured that the agricultural values and openness of their lands will be preserved forever. According to the U.S. Census Bureau, Taos County lost 29 percent of its farmland to development in the last 10 years, compared to 18 percent nationwide.

"I am protecting these acres as a gift to our ancestors, remembering and appreciating all the hard work they put into this land. I feel really good about knowing that this land will be preserved forever."

– Crestina Trujillo Armstrong

"Our father used to say, 'They're making new cars, new homes and so on, but they're not making any more land, so we need to protect it'."

– Jose Trujillo

D Diamond Ranch, Mimbres Valley

PUBLIC BENEFITS

- Protects water quality of Mimbres River
- Conserves wildlife habitat
- Preserves open space and historic landscape
- Preserves ranchland and area economy
- Maintains character of rural community
- Property remains on public tax rolls

LANDOWNER BENEFITS

- Maintains ranching tradition
- Keeps ranch intact
- Prevents subdivision, development

Charlie Disert ran cattle on the D Diamond Ranch for 23 years. When he approached the age of retirement, Disert worried that the D Diamond might go the way of other ranchland in the Mimbres Valley — sold and subdivided when land changed hands. Disert wanted the D Diamond to stay intact for generations to come. The ranch is not only rich in cottonwood-willow forests along the Mimbres River and home to an endangered fish, but it contains much evidence of early Native American cultures. So in the late 1990s, Disert contacted The Nature Conservancy, which bought the D Diamond and placed a conservation easement on 5,200 acres of it. After he died in 1999, the Conservancy sold the D Diamond to two ranchers committed to preserving the ranch's ecosystem and history, just as Disert wanted. Today the D Diamond flourishes as a working cattle ranch while important ecological values are protected.

"I'd like to see the land kept open and preserved for good."

– the late Charlie Disert, rancher

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

TAOS LAND TRUST

We use conservation easements because they are a cost-effective and highly efficient conservation tool on private lands.

For more information about our work in New Mexico, please contact:
William R. Waldman, director, New Mexico program
The Nature Conservancy, (505) 988-3867

Appendix B.3

New Mexico HB 990

AN ACT

RELATING TO TAXATION; PROVIDING FOR THE SALE, EXCHANGE OR TRANSFER OF THE INCOME TAX CREDIT AND THE CORPORATE INCOME TAX CREDIT THAT MAY BE CLAIMED FOR CERTAIN CONVEYANCES OF REAL PROPERTY; INCREASING THE AMOUNT OF THE CREDIT.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF NEW MEXICO:

Section 1. Section 7-2-18.10 NMSA 1978 (being Laws 2003, Chapter 331, Section 7) is amended to read:

"7-2-18.10. TAX CREDIT--CERTAIN CONVEYANCES OF REAL PROPERTY.--

A. There shall be allowed as a credit against the tax liability imposed by the Income Tax Act, an amount equal to fifty percent of the fair market value of land or interest in land that is conveyed for the purpose of open space, natural resource or biodiversity conservation, agricultural preservation or watershed or historic preservation as an unconditional donation in perpetuity by the landowner or taxpayer to a public or private conservation agency eligible to hold the land and interests therein for conservation or preservation purposes. The fair market value of qualified donations made pursuant to this section shall be substantiated by a "qualified appraisal" prepared by a "qualified appraiser", as those terms are defined under applicable federal laws and regulations governing charitable contributions.

B. The amount of the credit that may be claimed by a taxpayer shall not exceed one hundred thousand dollars ($100,000) for a conveyance made prior to January 1, 2008 and shall not exceed two hundred fifty thousand dollars ($250,000) for a conveyance made on or after that date. In addition, in a taxable year the credit used may not exceed the amount of individual income tax otherwise due. A portion of the credit that is unused in a taxable year may be carried over for a maximum of twenty consecutive taxable years following the taxable year in which the credit originated until fully expended. A taxpayer may claim only one tax credit per taxable year.

C. Qualified donations shall include the conveyance in perpetuity of a fee interest in real property or a less-than-fee interest in real property, such as a conservation restriction, preservation restriction, agricultural preservation restriction or watershed preservation restriction, pursuant to the Land Use Easement Act and provided that the less-than-fee interest qualifies as a charitable contribution deduction under Section 170(h) of the Internal Revenue Code. Dedications of land for open space for the purpose of fulfilling density requirements to obtain subdivision or building permits shall not be considered as qualified donations pursuant to the Land Conservation

Incentives Act.

D. Qualified donations shall be eligible for the tax credit if the donations are made to the state of New Mexico, a political subdivision thereof or a charitable organization described in Section 501(c)(3) of the Internal Revenue Code and that meets the requirements of Section 170(h)(3) of that code.

E. To be eligible for treatment as qualified donations under this section, land or interests in lands must be certified by the secretary of energy, minerals and natural resources as fulfilling the purposes as set forth in Section 75-9-2 NMSA 1978. The use and protection of the lands, or interests therein, for open space, natural area protection, biodiversity habitat conservation, land preservation, agricultural preservation, historic preservation or similar use or purpose of the property shall be assured in perpetuity.

F. A taxpayer may apply for certification of eligibility for the tax credit provided by this section from the energy, minerals and natural resources department. If the energy, minerals and natural resources department determines that the application meets the requirements of this section and that the property conveyed will not adversely affect the property rights of contiguous landowners, it shall issue a certificate of eligibility to the taxpayer, which shall include a calculation of the maximum amount of tax credit for which the taxpayer would be eligible. The energy, minerals and natural resources department may issue rules governing the procedure for administering the provisions of this subsection.

G. To receive a credit pursuant to this section, a person shall apply to the taxation and revenue department on forms and in the manner prescribed by the department. The application shall include a certificate of eligibility issued by the energy, minerals and natural resources department pursuant to Subsection F of this section. If all of the requirements of this section have been complied with, the taxation and revenue department shall issue to the applicant a document granting the tax credit. The document shall be numbered for identification and declare its date of issuance and the amount of the tax credit allowed for the qualified donation made pursuant to this section.

H. The tax credit represented by a document issued pursuant to Subsection G of this section for a conveyance made on or after January 1, 2008, or an increment of that tax credit, may be sold, exchanged or otherwise transferred, and may be carried forward for a period of twenty taxable years following the taxable year in which the credit originated until fully expended. A tax credit or increment of a tax credit may only be transferred once. The credit may be transferred to any taxpayer. A taxpayer to whom a credit has been transferred may use the credit for the taxable year in which the transfer occurred and unused amounts may be carried forward to succeeding taxable years, but in no event may the transferred credit be used more than twenty years after it was originally issued.

I. A tax credit issued pursuant to this section shall be transferred through a qualified intermediary. The qualified intermediary shall, by means of a sworn notarized statement, notify the taxation and revenue department of the transfer and of the date of the transfer within ten days of the transfer. Credits shall only be transferred in increments of ten thousand dollars ($10,000) or more. The qualified intermediary shall keep an account of the credits and have the authority to issue sub-numbers registered with the taxation and revenue department and traceable to the original credit.

J. If a charitable deduction is claimed on the taxpayer's federal income tax for any contribution for which the credit provided by this section is claimed, the taxpayer's itemized deductions for New Mexico income tax shall be reduced by the amount of the deduction for the contribution in order to determine the New Mexico taxable income of the taxpayer.

K. For the purposes of this section:

(1) "qualified intermediary" does not include a person who has been previously convicted of a felony, who has had a professional license revoked, who is engaged in the practice defined in Section 61-28B-3 NMSA 1978

and who is identified in Section 61-29-2 NMSA 1978, and does not include any entity owned wholly or in part or employing any of the foregoing persons; and

(2) "taxpayer" means a citizen or resident of the United States, a domestic partnership, a limited liability company, a domestic corporation, an estate, including a foreign estate, or a trust."

Section 2. Section 7-2A-8.9 NMSA 1978 (being Laws 2003, Chapter 331, Section 8) is amended to read:

"7-2A-8.9. TAX CREDIT--CERTAIN CONVEYANCES OF REAL PROPERTY.--

A. There shall be allowed as a credit against the tax liability imposed by the Corporate Income and Franchise Tax Act an amount equal to fifty percent of the fair market value of land or interest in land that is conveyed for the purpose of open space, natural resource or biodiversity conservation, agricultural preservation or watershed or historic preservation as an unconditional donation in perpetuity by the landowner or taxpayer to a public or private conservation agency eligible to hold the land and interests therein for conservation or preservation purposes. The fair market value of qualified donations made pursuant to this section shall be substantiated by a "qualified appraisal" prepared by a "qualified appraiser", as those terms are defined under applicable federal laws and regulations governing charitable contributions.

B. The amount of the credit that may be claimed by a taxpayer shall not exceed one hundred thousand dollars ($100,000) for a conveyance made prior to January 1, 2008 and shall not exceed two hundred fifty thousand dollars ($250,000) for a conveyance made on or after that date. In addition, in a taxable year the credit used may not exceed the amount of corporate income tax otherwise due. A portion of the credit that is unused in a taxable year may be carried over for a maximum of twenty consecutive taxable years following the taxable year in which the credit originated until fully expended. A taxpayer may claim only one tax credit per taxable year.

C. Qualified donations shall include the conveyance in perpetuity of a fee interest in real property or a less-than-fee interest in real property, such as a conservation restriction, preservation restriction, agricultural preservation restriction or watershed preservation restriction, pursuant to the Land Use Easement Act; provided that the less-than-fee interest qualifies as a charitable contribution deduction under Section 170(h) of the Internal Revenue Code. Dedications of land for open space for the purpose of fulfilling density requirements to obtain subdivision or building permits shall not be considered as qualified donations pursuant to the Land Conservation

Incentives Act.

D. Qualified donations shall be eligible for the tax credit if the donations are made to the state of New Mexico, a political subdivision thereof or a charitable organization described in Section 501(c)(3) of the Internal Revenue Code and that meets the requirements of Section 170(h)(3) of that code.

E. To be eligible for treatment as qualified donations under this section, land or interests in lands must be certified by the secretary of energy, minerals and natural resources as fulfilling the purposes as set forth in Section 5-9-2 NMSA 1978. The use and protection of the lands, or interests therein, for open space, natural area protection, biodiversity habitat conservation, land preservation, agricultural preservation, historic preservation or similar use or purpose of the property shall be assured in perpetuity.

F. A taxpayer may apply for certification of eligibility for the tax credit provided by this section from the energy, minerals and natural resources department. If the energy, minerals and natural resources department determines that the application meets the requirements of this section and that the property conveyed will not adversely affect the property rights of contiguous landowners, it shall issue a certificate of eligibility to the taxpayer, which shall include a calculation of the maximum amount of tax credit for which the taxpayer would be eligible. The energy, minerals and natural resources department may issue rules governing the procedure for administering the provisions of this subsection.

G. To receive a credit pursuant to this section, a person shall apply to the taxation and revenue department on forms and in the manner prescribed by the department. The application shall include a certificate of eligibility issued by the energy, minerals and natural resources department pursuant to Subsection F of this section. If all of the requirements of this section have been complied with, the taxation and revenue department shall issue to the applicant a document granting the tax credit. The document shall be numbered for identification and declare its date of issuance and the amount of the tax credit allowed for the qualified donation made pursuant to this section.

H. The tax credit represented by a document issued pursuant to Subsection G of this section for a conveyance made on or after January 1, 2008, or an increment of that tax credit, may be sold, exchanged or otherwise transferred, and may be carried forward for a period of twenty taxable years following the taxable year in which the credit originated until fully expended. A tax credit or increment of a tax credit may only be transferred once. The credit may be transferred to any taxpayer. A taxpayer to whom a credit has been transferred may use the credit for the taxable year in which the transfer occurred and unused amounts may be carried forward to succeeding taxable years, but in no event may the transferred credit be used more than twenty years after it was originally issued.

I. A tax credit issued pursuant to this section shall be transferred through a qualified intermediary. The qualified intermediary shall, by means of a sworn notarized statement, notify the taxation and revenue department of the transfer and of the date of the transfer within ten days of the transfer. Credits shall only be transferred in increments of ten thousand dollars ($10,000) or more. The qualified intermediary shall keep an account of the credits and have the authority to issue sub-numbers registered with the taxation and revenue department and traceable to the original credit.

J. If a charitable deduction is claimed on the taxpayer's federal income tax for any contribution for which the credit provided by this section is claimed, the taxpayer's itemized deductions for New Mexico income tax shall be reduced by the amount of the deduction for the contribution in order to determine the New Mexico taxable income of the taxpayer.

K. For the purposes of this section:

(1) "qualified intermediary" does not include a person who has been previously convicted of a felony, who has had a professional license revoked, who is engaged in the practice defined in Section 61-28B-3 NMSA 1978

and who is identified in Section 61-29-2 NMSA 1978, and does not include any entity owned wholly or in part or employing any of the foregoing persons; and

(2) "taxpayer" means a citizen or resident of the United States, a domestic partnership, a limited liability company, a domestic corporation, an estate, including a foreign estate, or a trust."

Appendix B.4

Fact Sheet: Conservation Banking Incentives for Stewardship

Conservation Banking

Incentives for Stewardship

Conservation banks are permanently protected lands that contain natural resource values. These lands are conserved and permanently managed for species that are endangered, threatened, candidates for listing, or are species-at-risk. Conservation banks function to offset adverse impacts to these species that occurred elsewhere, sometimes referred to as off-site mitigation. In exchange for permanently protecting the land and managing it for these species, the U.S. Fish and Wildlife Service (FWS) approves a specified number of habitat or species credits that bank owners may sell. Developers or other project proponents who need to compensate for the adverse impacts their projects have on species may purchase the credits from conservation bank owners to mitigate their impacts.

Michelle Morgan/USFWS

The 1200 acre Wilson Valley Mitigation Bank, Riverside County, California.

Conservation banking offers opportunities for a variety of landowners through preservation, enhancement, restoration and/or establishment of habitat for species. Lands used for ranching, farming, and timber operations or similar agricultural purposes can function as conservation banks if they are managed as habitat for species. Degraded habitat, such as retired croplands or orchards, may be restored. Linear areas or corridors, such as stretches of streams and their associated riparian habitat that link populations of species, may also qualify as conservation banks.

Who benefits?

A conservation bank is a market enterprise that offers landowners incentives to protect habitats of listed species, candidates, and other species-at-risk. Landowners can profit from selling habitat or species credits to parties who need to compensate for adverse impacts to these species. Landowners can generate income, keep large parcels of land intact, and possibly reduce their taxes.

Developers and others whose activities result in adverse environmental impacts typically are required to compensate for such impacts. Providing compensatory habitat off-site is often the best solution. However, it can be difficult for individual project proponents to locate appropriate lands and costly to restore, protect, and provide for the long-term management of these lands. Conservation banks provide a simple, economical alternative for developers and other project proponents. A one-time purchase of credits saves developers time and money and provides regulatory certainty.

Conservation banking benefits species by establishing large reserves that function as compensatory mitigation areas for multiple projects. It costs less per acre to manage a conservation bank than the equivalent acreage divided among many small isolated mitigation sites. Larger reserves are more likely to ensure ecosystem functions, foster biodiversity, and provide opportunities for linking existing habitat. In coordination with other tools, this collaborative, incentive-based approach to conservation may aid in the recovery of listed species.

Conservation banking also benefits the public by protecting open space and contributing environmental services such as nutrient recycling, pollination services, and climate regulation.

Conservation banking works best in concert with regional conservation planning where the community is involved in determining which areas are conserved and which are developed to achieve a healthy environment and economy.

Background

Conservation banking for federally-listed species has its roots in wetland mitigation banking. In the early 1990s, the FWS began working with other Federal agencies to establish wetland mitigation banks. In 1995, the final policy on wetland banking, *Federal Guidance for the Establishment, Use, and Operation of Mitigation Banks*, was published (60 FR 58605-58614). In that same year, the State of California established a policy to promote regional conservation by encouraging a second generation of mitigation banks, called conservation banks, to preserve existing habitats. In the early 1990s, The FWS began approving conservation banks for a variety of federally-listed species, often in cooperation with other Federal agencies and the State of California, in the early 1990s. As of January 2009, more than 90 conservation banks have been approved by the FWS, most of them in California.

In May 2003, in what has been termed "a hallmark event in the 30-year history of the Endangered Species Act," the FWS issued the first comprehensive Federal guidelines designed to promote conservation banks as a tool for mitigating adverse impacts to species. Although no two banks will be developed or used in an identical fashion, the guidelines foster national consistency by standardizing establishment and operational criteria. A copy of the guidance is available at http://endangered.fws.gov/policies/conservation-banking.pdf.

What lands are eligible?
Private, Tribal, State and local government lands are eligible to become conservation banks. Federal lands may require special consideration concerning applicability of the lands for mitigation purposes and review and approval by the FWS for consistency with other regulations and policies. Generally, lands previously designated for conservation purposes through another program are not eligible unless designation as a bank provides an additional conservation benefit to the species. Before the FWS can approve a conservation bank, landowners are required to:

- enter into a Conservation Banking Agreement with the FWS;
- grant a conservation easement to an eligible third party, precluding future development of the property and restricting certain land uses;
- develop a long-term management plan for the conservation bank; and
- provide funding for monitoring and long-term management of the conservation bank.

In return, the FWS approves landowners to sell a specified number of credits to project proponents requiring mitigation for species that occur on the conservation bank and are within the bank's designated service area.

What is a conservation easement?
A conservation easement is a legal contract between the landowner (grantor) and the easement holder (grantee) in which the landowner gives up certain development rights and agrees to certain restrictions on the property. Public agencies, land trusts, and other nonprofit conservation organizations are typical groups that States authorize to hold conservation easements. Restrictions on the property may include a reduction in the number of livestock that may be grazed, prohibition of recreational off-road vehicle use, or prohibition of construction of new roads and buildings. Any activities inconsistent with the purposes of the conservation bank are restricted under the easement. Because perpetual conservation easements are binding on future owners, the resource values of these properties are protected in perpetuity. Many States and local governments offer tax benefits associated with this type of property encumbrance.

What is a management plan?
A management plan identifies tasks for operating and maintaining a bank site as well as methods for monitoring and maintaining desired habitats for species. A management plan may include removing trash on a regular basis, mending and replacing fencing, monitoring the listed species or habitat conditions, controlling invasive species that interfere with the naturally functioning ecosystem, conducting prescribed burns, and other activities to maintain the habitat. A management plan is long-term, requires careful development, and should take into account any foreseeable changes that may affect property management. A management plan should be as specific as possible, but flexible enough to allow changes in management practices in response to monitoring results.

How is management funded?
Most often an endowment is established to fund the long-term management of the conservation bank. The endowment is an interest-bearing account in an amount sufficient to generate enough yearly income to fund the annual management of the conservation bank. Since only the interest is available for use and the principal is not withdrawn, the endowment is "non-wasting," providing a perpetual source of funding for management of the conservation bank. The endowment may be funded in full at the time of conservation bank approval or in increments, but should be fully funded within five years.

What are credits?
Credits are units on the conservation bank representing listed species, candidates, and other species-at-risk, or habitat for those species. A credit may be equivalent to:

(1) an acre of habitat for a particular species;

(2) the amount of habitat required to support a breeding pair;

(3) a wetland unit along with its supporting uplands; or

(4) some other measure of habitat or its value to the listed species.

Methods of determining available credits may rely on ranking or weighting of habitats based on habitat condition, size of the parcel, or other factors.

What is a service area?
The service area for a conservation bank is the area outside the bank property within which the bank owner may sell credits. The FWS determines service areas for conservation banks based on physical and ecological attributes such as watersheds, soil types, species recovery units, and/or species and population distributions. Banks with more than one type of credit may have different service areas designated for different credit types.

What projects are eligible?
Only projects that would otherwise be permitted and are suitable for off-site mitigation may use conservation banks. The species and habitats for which the project proponent requires mitigation must be present at the conservation bank. Conservation banking is not a substitute for avoiding and minimizing effects on listed species on-site. The purpose of conservation banking is not to encourage development of listed species' habitats, but rather to provide an ecologically effective alternative to small on-site preserves which are not defensible.

Contact Us
If you would like more information on conservation banking, please contact the FWS Regional Office with responsibility for the State or Territory in which the project is being proposed. A map of our Regional Offices can be found at http://offices.fws.gov/directory/listofficeregion.cfm

U. S. Fish and Wildlife Service
Endangered Species Program
4401 N. Fairfax Drive, Room 420
Arlington, VA 22203
703-358-2106
http://www.fws.gov/endangered/

January 2009

APPENDIX C

Restoration Project Cost Spreadsheets

Appendix C – Restoration Project Cost Spreadsheets

Exhibit C-1

Upper Chama Restoration Project Cost Spreadsheet

Subreach	Site Name	BESTHO2008	Category	Acres	Per Acre Cost	Unit Cost
Upper Chama	RM 42A	CW5F	Floodplain Surface	32.7	$2,164.00	$70,769.59
Upper Chama	RM 42B	CW5F	Floodplain Surface	8.2	$2,164.00	$17,718.13
Upper Chama	RM 43	CW5F	Floodplain Surface	8.6	$2,164.00	$18,708.55
Upper Chama	RM 47	RB-CW6	T2 Surface	1.5	$2,164.00	$3,254.71
Upper Chama	RM 47	CW-C5	Floodplain Surface	5.3	$2,164.00	$11,567.23
Upper Chama	RM 51A	RB-CW6	T2 Surface	0.3	$2,164.00	$557.02
Upper Chama	RM 51A	RB-CW6	T2 Surface	0.2	$2,164.00	$469.28
Upper Chama	RM 51A	CW5F	Floodplain Surface	5.4	$2,164.00	$11,768.29
Upper Chama	RM 51B	CW5F	Floodplain Surface	0.7	$2,164.00	$1,600.16
Upper Chama	RM 51B	CW5F	Floodplain Surface	3.5	$2,164.00	$7,579.59
Upper Chama	RM 51B	J-NLC/NMO-CW3	T2 Surface	0.9	$2,164.00	$1,966.91
Upper Chama	RM 51C	CW5	Floodplain Surface	4.9	$2,164.00	$10,707.43
Upper Chama	RM 54A	CW-RB6	T2 Surface	0.9	$2,164.00	$1,939.51
Upper Chama	RM 54A	CW5F	Floodplain Surface	1.7	$2,164.00	$3,700.83
Upper Chama	RM 54A	CW5F	Floodplain Surface	3.4	$2,164.00	$7,279.03
Upper Chama	RM 54B	CW5F	Floodplain Surface	1.6	$2,164.00	$3,506.50
Upper Chama	RM 54B	CW5F	Floodplain Surface	5.2	$2,164.00	$11,297.55
Upper Chama	RM 54B	RB-CW5	T2 Surface	2.8	$2,164.00	$6,057.84
Upper Chama	RM 54C	C/CW-RB3	T2 Surface	0.6	$2,164.00	$1,340.34
Upper Chama	RM 54C	CW-RB5	T2 Surface	2.0	$2,164.00	$4,362.97
Upper Chama	RM 54C	CW-RB6	T2 Surface	6.0	$2,164.00	$13,041.81
Upper Chama	RM 55	CW-RB6	T2 Surface	2.5	$2,164.00	$5,382.24
Upper Chama	RM 55	CW-RO6	T2 Surface	6.2	$2,164.00	$13,412.80
				105.4		**$227,988.33**

Exhibit C-2
RM 25 Restoration Project Cost Spreadsheet

Task	Unit Cost	Units	Unit Description	Total Cost
Coyote Willow Cuttings	$2.70	7,000	Plant	$18,900.00
Excavate and Backfill Swale Trenches	$4.00	15,400	Linear Foot	$61,600.00
Wolfberry Shrubs	$22.00	500	Plant	$11,000.00
Goodings Willow/Cottonwood Poles	$12.00	1,900	Plant	$22,800.00
Follow-up Herbicide Treatment	$300.00	11	Acre	$3,300.00
Hand Russian Olive Treatment	$6,500.00	3	Acre	$19,500.00
Mechanical Russian olive treatment	$2,500.00	8	Acre	$20,000.00
Equipment Mobilization for Willow Construction	$5,000.00	1	Cost	$5,000.00
Labor for Planting Tree Poles, Shrubs, and Willow Cuttings in the Woodland and Forest	$35.00	400	Hour	$14,000.00
Labor for Planting Willows and Tree Poles in the Willow Swale	$35.00	80	Hour	$2,800.00
				$178,900.00

Exhibit C-3
La Canova Restoration Project Cost Spreadsheet

Task	Unit Cost	Units	Unit Description	Total Cost
Coyote Willow Cuttings	$2.70	7,000	Plant	$18,900.00
Goodings Willow/Cottonwood Poles	$12.00	150	Plant	$1,800.00
Labor for Planting Willows and Tree Poles	$35.00	240	Hour	$8,400.00
Saltcedar Thinning	$6,500.00	2	Acre	$13,000.00
Selective Willow Thinning	$4,500.00	11	Acre	$49,500.00
				$91,600.00

Exhibit C-4
Rio Bravo Restoration Project Cost Spreadsheet

Task	Unit Cost	Units	Unit Description	Total Cost
Coyote Willow Cuttings	$2.70	12,250	Plant	$33,075.00
Goodings Willow/Cottonwood Poles	$12.00	400	Plant	$4,800.00
Saltcedar Thinning	$6,500.00	4	Acre	$26,000.00
Labor for Planting Willows and Tree Poles	$35.00	240	Hour	$8,400.00
				$72,275.00

Exhibit C-5
Los Luceros Restoration Project Cost Spreadsheet

Task	Unit Cost	Units	Unit Description	Total Cost
Coyote Willow Cuttings	$2.70	10,000	Plant	$27,000.00
Excavate and Backfill Swale Trenches	$4.00	40,110	Linear Foot	$160,440.00
Goodings Willow/Cottonwood Poles	$12.00	400	Plant	$4,800.00
Follow-up Herbicide Treatment	$300.00	9	Acre	$2,700.00
Mechanical Russian olive treatment	$2,500.00	9	Acre	$22,500.00
Equipment Mobilization for Willow Construction	$5,000.00	1	Cost	$5,000.00
Labor for Planting Willows	$35.00	320	Hour	$11,200.00
				$233,640.00

APPENDIX D

Net Depletion Analysis

Appendix D

Net Depletion Analysis

How were rates of consumptive use for projects in the Velarde Reach determined? [1]

Consumptive use estimates used in this Report to estimate riparian vegetation evapotranspiration loss rates are based on the Blaney-Criddle method. The Blaney-Criddle method is based on monthly temperature, monthly percentages of annual daytime hours, quantity and occurrence of precipitation and the length of the growing season. Temperature and precipitation data are collected from weather stations in the vicinity of each specific site. For some projects, data from two sites are averaged to arrive at consumptive use rates used in this analysis.

Monthly empirical crop consumptive use coefficients (k) used in the Blaney-Criddle method were obtained from the sources identified below and the values are tabulated in Exhibit D-1.

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[1] **Depletions Disclaimer**

The depletions analysis in this report, while providing a reasonable comparison of water use by vegetation types, is not a method generally accepted by the New Mexico Office of the State Engineer for determining the need for permitting of a habitat restoration project nor for determining the need for offsetting increased depletions. All groups planning habitat restoration projects should consult with the appropriate OSE District Office to determine if a permit will be required and if depletions offset will be required.

Exhibit D-1

Empirical Vegetation Consumptive Use Coefficients (for use with Blaney-Criddle Method)

	Saltcedar	Cottonwood	Willow	Russian Olive
Jan	0.50	0.42	0.34	0.25
Feb	0.41	0.34	0.27	0.25
Mar	0.34	0.28	0.23	0.28
Apr	0.32	0.27	0.21	1.15
May	0.87	0.72	0.58	1.15
Jun	1.22	1.01	0.82	1.15
Jul	1.37	1.14	0.92	1.15
Aug	1.36	1.13	0.91	1.15
Sep	1.19	0.99	0.80	1.15
Oct	0.88	0.73	0.59	1.00
Nov	0.73	0.61	0.49	0.25
Dec	0.60	0.50	0.40	0.25

The consumptive use coefficient used in estimating the consumptive use of saltcedar was obtained from the Report entitled *Comparison of Evaporation Estimation Methods for a Riparian Area* by J. Nichols, et al., IIHR-Hydroscience & Engineering, College of Engineering, University of Iowa, Iowa City, Iowa, IIHR Technical Report No. 436, April, 2004. The consumptive use coefficients used in estimating depletions associated with willows and cottonwood trees are based on data found in NM State Engineer Technical Report 32, *Consumptive Use and Water Requirements in New Mexico*, by Blaney and Hanson, 1965. The consumptive use coefficients used in estimating depletions associated with Russian olive trees are based on data found in the Report entitled *ET Toolbox- Evapotranspiration Toolbox for the Middle Rio Grande, A Water Resources Decision Support Tool* by Al Brower, Water and Environmental Resources Division, Bureau of Reclamation, Denver, Colorado, October 8, 2008.

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 site conditions and under the “with project” condition. The net depletion is assumed to be the difference between the depletion occurring under existing conditions and the depletion that might occur as a result of implementation of the proposed restoration projects. 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 and proposed restoration vegetation are categorized as cottonwood, willow, saltcedar and Russian olive for the purpose of estimating evapotranspiration loss. 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.

Site Specific Depletion Analyses – Rio Grande

Exhibit D-2 summarizes the consumptive use computations associated with the proposed restoration management activities at the Rio Bravo site (RM 300-301). This project involves removing 3.7 acres of saltcedar and restoring this area by establishing native coyote willows along with native riparian trees including Goodding’s willow, Rio Grande cottonwood, and box elder. For the purpose of this analysis, it is assumed that the restoration activities will involve the establishment of equal areas of willows and trees. Climate data used to estimate consumptive use at this site is based on the average of growing season data collected from the Taos and Española weather stations.

Exhibit D-2
Net Depletion Computation Summary for Rio Bravo Site (at Orilla Verde)

Month	Existing Conditions Depletion (af)	"With Project" Depletion (af)		Net Depletion (af)
	Saltcedar	Trees	Willows	
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.00	0.00
May	0.49	0.19	0.15	-0.15
Jun	2.25	0.92	0.72	-0.61
Jul	2.54	1.02	0.78	-0.74
Aug	2.24	0.89	0.67	-0.68
Sep	1.62	0.65	0.50	-0.48
Oct	0.06	0.02	0.02	-0.02
Nov	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00
Total	**9.21**	**3.69**	**2.83**	**-2.68**

Based on the methods and assumptions used in this analysis, implementation of the proposed restoration activities at the Rio Bravos site at Orilla Verde might result in a net gain (salvage) in water use of approximately 2.68 acre-feet per annum.

Exhibit D-3 summarizes the consumptive use and net depletion computations associated with the restoration management activities at the La Canova site on the mainstem Rio Grande (RM 284-285). This activity involves removing approximately two acres of saltcedar and planting a mixture of native coyote willows along with native riparian trees. Again, for the purpose of this analysis, it is assumed that the restoration activities will involve the establishment of equal areas of willows and trees. Climate data used to estimate consumptive use at this site is also based on the average of growing season data collected from the Taos and Española weather stations.

Exhibit D-3
Net Depletion Computation Summary for La Canova Site

Month	Existing Conditions Depletion (af)	"With Project" Depletion (af)		Net Depletion (af)
	Saltcedar	Trees	Willows	
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.00	0.00
May	0.27	0.10	0.08	-0.08
Jun	1.22	0.50	0.39	-0.33
Jul	1.37	0.55	0.42	-0.40
Aug	1.21	0.48	0.36	-0.37
Sep	0.88	0.35	0.27	-0.26
Oct	0.04	0.01	0.01	-0.01
Nov	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00
Total	**4.98**	**1.99**	**1.53**	**-1.45**

Based on the methods and assumptions used in this analysis, implementation of the proposed restoration activities at the La Canova site on the Rio Grande might result in a net gain (salvage) in water use of approximately 1.45 acre-feet per annum.

Exhibit D-4 summarizes the consumptive use and net depletion computations associated with the restoration management activities at the Los Luceros site on the mainstem Rio Grande (RM 284-285). This activity involves removing existing stands of Russian olive trees that line 4,011 feet of existing channels at the site. Restoration efforts will focus on an area fifty feet on each side of the channels, for a total area of approximately 9.2 acres. The project will involve mechanical treatment of Russian olive and re-vegetation with willows and cottonwood. For the purpose of this analysis, it is assumed that the restoration activities will involve the establishment of equal areas of willows and trees. Climate data used to estimate consumptive use at this site is based on the growing season data collected from the Española weather station.

Exhibit D-4
Net Depletions Computation Summary for Los Luceros Site

Month	Existing Conditions Depletion (af)	"With Project" Depletion (af)		Net Depletion (af)
	Russian Olive	Trees	Willows	
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.00	0.00
May	2.71	0.75	0.62	-1.35
Jun	5.50	2.40	1.90	-1.20
Jul	5.38	2.66	2.05	-0.67
Aug	4.71	2.31	1.75	-0.65
Sep	4.12	1.73	1.34	-1.05
Oct	0.38	0.12	0.09	-0.17
Nov	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00
Total	**22.81**	**9.97**	**7.75**	**-5.09**

Based on the methods and assumptions used in this analysis, implementation of the proposed restoration activities at the Los Luceros site on the Rio Grande might result in a net gain (salvage) in water use of approximately 5.09 acre-feet per annum.

Site Specific Depletion Analyses – Rio Chama

Exhibit D-5 summarizes the consumptive use computations and net depletion estimates for restoration projects in the Upper Chama Sub-Reach. This restoration activity involves planting of native riparian trees at eleven individual restoration sites between Christ in the Desert Monestary and the Big Eddy boat landing upstream of Abiquiu Reservoir for a total area of 105 acres. Climate data used to estimate consumptive use at this site is based on the growing season data collected from the Tierra Amarilla weather station.

Exhibit D-5
Net Depletion Computation Summary for Upper Chama Sub-Reach Projects

Month	Net Depletion (af)
Jan	0.00
Feb	0.00
Mar	0.00
Apr	0.00
May	11.55
Jun	45.94
Jul	50.90
Aug	41.40
Sep	15.93
Oct	0.00
Nov	0.00
Dec	0.00
Total	**165.72**

Based on the methods and assumptions used in this analysis, implementation of the proposed restoration activities in the Upper Chama Sub-Reach might result in a net depletion (increase) in water use of approximately 165.72 acre-feet per annum. This computation is based on the simplifying assumption that the existing vegetation conditions at each of the restoration sites will not change and that depletions will increase above the existing levels due to the implementation of the restoration activities.

Exhibit D-6 summarizes the consumptive use computations and net depletion estimates for projects in the Lower Chama Sub-Reach. This restoration activity involves vegetation restoration activities on an approximately 12.5 acre site along the Rio Chama near the village of Abiquiu. For the purposes of this analysis, the existing conditions depletions assume that approximately 7.5 acres of Russian olives (and associated depletion) with be removed. The “with-project” depletion analysis assumes that approximately 3.5 acres of willows will be established and approximately 9.5 acres of tree poles will be planted at the site. Climate data used to estimate consumptive use at this site is based on the average of growing season data collected from the Tierra Amarilla and Española weather stations.

Exhibit D-6
Net Depletion Computation Summary for Abiquiu Site

	Existing Conditions Depletion (af)	“With Project” Depletion (af)		
Month	**Russian Olive**	**Willows**	**Trees**	**Net Depletion (af)**
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.00	0.00
May	1.11	0.23	0.78	-0.10
Jun	3.89	1.24	4.28	1.63
Jul	4.04	1.41	5.04	2.42
Aug	3.44	1.16	4.25	1.97
Sep	2.39	0.70	2.50	0.81
Oct	0.16	0.03	0.13	0.00
Nov	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00
Total	**15.01**	**4.77**	**16.98**	**6.74**

APPENDIX E

H&O Classification Form

H&O Classification Form

Date		**Update Polygon** Y or N	Rev. 01/29/2008	
Recorder	**Parametrix**	**Phone Number**	505-821-4700	
Polygon ID		**Photo Number**		
UTM NAD83, Zone 13N	**X**	**Declination**		
	Y	**Burn** Y or N	**Cleared** Y or N	
GPS File Name		**Time**	**Previous Treatment Notes**	
2002 Classification				
Updated Hink and Ohmart Classification (2008)				

Riparian Vegetation

A = False Indigobush		**Height and Cover**					**TW Present**
ATX= Fourwing Saltbush		Canopy Cover	>40 Ft	1-25%	25-75%	75-100%	**Y or N**
B = Baccharis (Seep Willow)	C		20-40 Ft	1-25%	25-75%	75-100%	
C = Rio Grande Cottonwood	a	%Dead	1-25%	25-50%	50-75%	75-100%	
CW - Coyote Willow	n	**Species (Relative species cover)**					**Notes on Species**
J = Juniper	o	(Circle One for each species present)					
LY = Wolfberry	p		1-25%	25-50%	50-75%	*75-100%*	
MB= Mulberry	y		1-25%	25-50%	50-75%	*75-100%*	
MES = Mesquite			1-25%	25-50%	50-75%	*75-100%*	
NMO – New Mexico Olive			1-25%	25-50%	50-75%	*75-100%*	
RO = Russian Olive			1-25%	25-50%	50-75%	*75-100%*	
SB = Silver Buffaloberry		**Height and Cover**					
SBM=Screwbean Mesquite	U	Height	5-15 Ft	1-25%	25-75%	75-100%	
SC = Salt cedar	n		<5 Ft	1-25%	25-75%	75-100%	
SE = Siberian Elm	d	%Dead	1-25%	25-50%	50-75%	75-100%	
TW = Tree Willow	e	**Understory Species (Relative species cover)**					
TH = Tree of Heaven	r	(Circle One for each species present)					
Other Woody Spp Present	s		1-25%	25-50%	50-75%	*75-100%*	
	t		1-25%	25-50%	50-75%	*75-100%*	
	o		1-25%	25-50%	50-75%	*75-100%*	
	r		1-25%	25-50%	50-75%	*75-100%*	
Subtypes	y		1-25%	25-50%	50-75%	*75-100%*	
f=dense understory >75%			1-25%	25-50%	50-75%	*75-100%*	
s=sparce understory 25-50%			1-25%	25-50%	50-75%	*75-100%*	

Wetland

MH- Cattail Marsh	OW-Open Water	WM - Wet Meadow		

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

APPENDIX F

Draft Report Comments and Parametrix Team Responses

REVIEWER COMMENT FORM - VELARDE REACH RESTORATION ANALYSIS AND RECOMMENDATIONS

Comments by the Collaborative Program Habitat Restoration Workgroup received by Parametrix September 1, 2009.

Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
Chapter 1, Page 1 (exam	1 (example)		
xi		OVRA- Orilla Verde Recreation Area	Done
2-1	10	First mention of Orilla Verde Recreation Area, please include acronym.	Done
2-2	Ex 2-2 (OVRA)	Pilar should be labeled on the map since it is referenced in the text on p. 9.	Done
2-4	Ex 2-3 (Pilar)	Pilar should be on the map since it is referenced in the text on p. 10. Also label the Velarde Diversion vs. the Embudo Diversion because they show up again in Ex. 2-4 (Velarde Reach).	Done
2-5	Ext 2-4 (Velarde)	Label Velarde, Canova, Lyden, and Estacia on the map since they are referenced in the text on p. 11. Label the San Juan Diversion and the Velarde Diversion since they are referenced on p. 15. The text talks about eight diversions but there are nine on the map (Ex. 2-4), so labeling will help with any confusion because of overlap of maps.	Done
2-6	Ex 2-5 (Upper Chama)	Christ in the Desert Monastery and Big Eddy rest should be on the map as reference. And, the map legend shows BLM ownership when the text on p. 12 describes Santa NF *ownership* and BLM management.	Done
2-7	Ex 2-6 (Lower Chama)	Show State Hwy. 84 river crossing since it is referenced in the text on p. 13. Show State Hwy 554 Bridge crossing and the villages mentioned in the text on p. 14.	Done
2-9	Ex 2-7 (photos)	Individual captions and photo dates would be informative.	Done
2-11	Ex 2-8 (photos)	Photo dates would be informative.	Done
2-11	9	Use Reclamation in place of BOR.	Done
2-12	Ex 2-9 (photos)	Photo dates would be informative and the middle photo caption should say if the water channel is the river, a diversion, or an irrigation ditch.	Done
2-13	Ex 2-10	Photo captions and dates would be informative.	Done
2-13	25	Typo ? Please delete, " (Exhibit 2-2 through ."	Done
2-14	Ex 2-11	Photo dates would be informative.	Done
2-15	31	Ownership of El Vado, and all MRGCD facilities are currently in dispute, according to last Parker decision, it is in federal ownership. The statement in the report should be removed.	Done
2-16	16	Remove excess semi-colon after SJC.	Done
2-16	30	Has "median stream flow" increased due to reservoir operations? This value may have decreased due to reservoir operations?	The USGS gage data indicate that the median flows have increased.
2-16	32	Should annual be substituted for overall? What is overall stream flow?	The overall stream flow refers to the total stream flow and is a correct usage of the term.
2-17	25	Need beginning parenthesis on "source."	Done
2-18	1	Need beginning parenthesis on "source."	Done
2-18	9-18	Probably important to note the period of record for both Rio Grande and Rio Chama data.	The Rio Grande at Embudo record is from 1890-2007 and the Rio Chama at Chamita is from 1913 to 2007. However, these graphs represent specific years within this period of record and we already have legends showing the years displayed in the graphs. We suggest that adding the period of record to these figures will be misleading so will leave as is.
2-20	6-10	It would be helpful to cite a specific page or section of the chapter to refer to.	Done
2-20	20	Typo? It should be Exhibit 2-16 and Exhibit 2-17.	Done
2-22	19	The major supplies of sediment for the Rio Grande as a whole are all downstream of the Chama?	The long term sediment record at the Rio Grande at Otowi gage indicates that the Rio Chama is the major sediment supplier to the Rio Grande upstream of Cochiti Dam. We left out that important detail and will amend the sentence, thank you.

Comments by the Collaborative Program Habitat Restoration Workgroup received by Parametrix September 1, 2009.

Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
2-23	Ex 2-16 (geologic map)	If you are going to use this map you should include a legend. It is also labeled as Ex 2.5 but in this report it is being used as Ex. 2-16.	Done
2-24	Ex 2-17 (geologic Map)	If you are going to use this map you should include a legend. It is also labeled as Ex 2.5 but in this report it is being used as Ex. 2-17.	Done
2-25	photos	Photo dates would be informative.	Done
2-28	photos	Photo dates would be informative.	Done
2-29	photos	Photo dates would be informative.	Done
2-32	31	"Fiber" should be finer?	Done
2-36	photo	Photo date would be informative.	Done
2-39	photos	Photo dates would be informative.	Done
2-40	photo	Photo date would be informative.	Done
2-40	1	Is this the correct caption for this photo? Either the flow in the river is not 1,800 cfs, or the surface the photo shows is not correct? It appears as if there is 6-12 inches of freeboard on that surface?	Exhibit 2-30 was replicated. The correct photo will be inserted.
	3	Were duration curves utilized in the overall analysis in the A and R or should duration data as indicated in the exhibit be substituted.	Duration data were used throughout the report.
2-43	1	Exhibit 2-33 does not show mean annual hydrographs, but what looks instead to be instantaneous peak discharges or annual peak discharges?	The caption should read: Annual peak flows not mean annual hydrographs. Will make the change, thanks.
2-46	2	A description of the location of the Chamita gage would be instructive, or note see Exhibit 2-56.	A footnote was added to clarify location.
2-46	4	"the dam had little impact on the magnitude of the annual floods" 25-26% reduction in the 50-yr peak flow for the two gages in question does not appear to correspond with "little impact."	El Vado Dam had less impact on the larger floods because of limited flood storage, but did substantially affect the more frequent floods. We'll modify the sentence to make this more clear.
2-48	1	The presentation of the data is not clear in this table. The period of record for the Chama below Abiquiu has overlapping dates, while the Chamita gage does not. Is the first period of record supposed to be 1962-1971?	The non-overlapping period shows the impact of the San Juan Chama Project that came on line in 1972.
2-48	photo	Photo date would be informative.	Done
2-52	12	WATERS acronym- Water Administration Technical Engineering Resource System, *"I"* - internet, that section of the OSE is now referred to as Water Rights Abstract Bureau (WRAB).	Done
2-52	31	Hard to see on any of the GW maps, especially 2-46 that GW is relatively shallow along the river corridors. Maybe?	The map in Exhibit 2-46 will be expanded to make the data more easily read.
2-53	7	Is Exhibit 2-48 erroneously included here?	No. It shows the location of the wells that were included in the Rio Chama groundwater analysis.
2-53	10	Should this be Exhibit 2-47?	Yes, thanks will modify.
2-60	9	See comment on Row 14 .	Okay
2-61	Ex. 2-52	Should a gage be on the map? It is in the legend.	Fixed, thanks.
2-63	1	Remove the word "by."	Done
2-63	1-23	A maximum flood release of 1,800 cfs in the lower Chama Sub-Reach makes this entire paragraph sort of moot?	A higher flow could be released if local protection such as ring levees were constructed to protect dwellings located on the floodplain.
2-77	20	Missing the beginning parenthesis for the reference.	Done

Comments by the Collaborative Program Habitat Restoration Workgroup received by Parametrix September 1, 2009.

Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
Chapters 3 and 4		How much could candidate restoration projects contribute to flycatcher recovery goals for the Upper Rio Grande? 38 more territories are needed and at least 40 areas were identified as candidates but more than half are on private land. What is the potential for restoration and new territories on the tributaries in the Upper Rio Grande recovery unit (outside the project area)? Is land ownership the primary challenge or physical/hydrological constraints? It would be helpful to have an opinion on this point.	Good questions and we will add language regarding potential contribution of candidate restoration projects to meeting URG recovery goals. Regarding potential for restoration outside the project area, we don't know because we didn't evaluate these sites. We also like the question about private landownership and will add language to relevant sections of Chapters 4 and 5 where these topics are currently discussed. To briefly address here, we believe that land ownership and land use IS a major constraint to restoring hydrologic functions, especially along the Lower Chama Sub-Reach. The FLO-2D model presented in Chapter 2 shows that >1,600 acres could be inundated by the 2-year peak flow (3,100 cfs), but flow releases from Abiquiu Dam are capped around 1,800 cfs to prevent damage to non-engineered irrigation diversion dams and to houses constructed on the active floodplain. If there was only one land owner for the entire sub-reach, it would (arguably) be much easier to engage them in discussions about land use changes and associated incentives than when there are 100s of individual landowners (who are difficult to identify and contact) and acequia organizations that need to be engaged in such a process.
3-1	sidebar	Should "Link to page *above…" be removed,* there is nothing below.	Done
3-4	Ex 3-3	Substitute it's for its in last entry of notes.	Done
3-7	24-27	Does the Velarde reach have the physical condition to support elements in the BO for flycatcher, if not, what type of restoration should follow?	The flycatcher sections in Chapters 4 & 5 are devoted towards answering this question. In short, the answer was "yes", but not in all sub-reaches. However, the 60-acre goal for individual restoration projects stated in the BiOp (RPA J) is not at all achievable. This is very clearly depicted in Chapter 5. That said, this 60-acre goal doesn't appear achievable in most of the MRG either (see Parametrix 2008a, and 2008b).
3-7	26-27	Can you cite more specifically where to look for more info? Someone might want to jump ahead in the report.	Done
3-9	19	Can you cite more specifically where to look for more info? Someone might want to jump ahead in the report.	Done
3-11	Sec 8	What is the value of this section?	Although the link between this section and the ones preceding it and following it could be made more clear, I believe the section has value for several reasons. Firstly, it's important to describe elements of willow flycatcher habitat in some detail <u>across its range</u> because they differ widely in different states and watersheds. The elements of habitat that make good WIFL habitat in the Upper Rio Grande are different from those in California and Arizona, and even the Lower Rio Grande This is accomplished in Section 7. Similarly it's important to differentiate between habitat used by birds migrating through and those that remain to breed. The Rio Grande is an important migratory corridor for this species, and many birds use riparian areas of the river, even if they are on their way to or from areas further north. These areas should be managed and protected, even if they do not or will never provide breeding habitat.
3-11	28	Insert "be", may *be* narrower.	Done
3-13	4	See comment on Row 14.	Done
3-14	19-22	If historic surveys only counted "nesting territory" --- how would this effective historic number of birds be counted?	I assume the question means given the possible discrepancy in methods, how would it affect our analysis of historic numbers. In essence – we don't know. This portion of the text was intended as a disclaimer and a warning to not use the numbers very strictly. For example, just because two birds were found in one year, and four the next, it does not mean the population doubled. Survey methods and definitions about what constitute a "territory" were not standardized, and in most cases the data sheets (which we examined) did not provide enough information to interpret them in light of more recent definitions. That said, more recent surveys *have* been standardized and do provide much more accurate information about trends.
3-14	Sec 11	A lot of this section is speculative given the lack of survey data.	Agreed. Perhaps, however, we were too cautious in giving our disclaimers about reliability of the data. While it is difficult to say with certainty what the exact numbers were or are, several important trends concerning the birds and habitat are quite clear, and these are outlined in the four bullets. We are very confident of these assertions.
3-15	16-19	A concerted outreach effort ---- this sentence appears to be a suggestive behavior or an action and should be placed in the recommendations section as well.	This is one of the recommendations in the "Passive Restoration" section of Chapter 5. It is also discussed in Chapter 4.
3-18	Sec 12	Would this section be better placed in Chapter 4?	We will leave this section in Chapter 3 but will reference some of the key points about the potential for meeting recovery plan goals in Chapters 4 and 5.
3-21	18	Suggest changing project area on lands owned by… to project area on Ohkay Owingeh land.	Done

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Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
3-27	3	Should the existing recovery plan be included as the draft plan has not been finalized to date or at a minimum be documented?	A brief introduction of the 1999 plan is now included.
3-34	1-4	Importance of the flood plain may be expanded to include the historic conditions, pre-hydromodification when the river channel configuration was different -- and -- the species evolved within this dynamic river channel.	The sentence indicates that there is more discussion on the topic in the next section. We also now include in this paragraph a slightly expanded discussion of the historical habitat, acknowledging that this minnow evolved under the different historical conditions.
3-34	30 -31	Should macroinvertebates be included as a food source?	Macroinvertebrates are not considered to be significant food source for silvery minnows, although smaller macroinverts and other inverts can be consumed. Therefore, the sentence has been modified to read, "These materials and the adjacent stable sand surfaces then provide growth substrates for algae, diatom, other microbial growths and small invertebrates, which provide high value as food for silvery minnows and various other fish, as well as habitat and food for invertebrates, during periods of lower flow velocities."
3-36	24	A mile or more of flood plain in the Velarde reach? Statement should be directed to section being discussed.	Section edited for clarification by reach discussed.
3-51	17 - 19	Should reconsider the statement, "the Velarde reach is low priority" as a 10J population in the Velarde reach may have opposition.	The statement refers to the fact that this reach is characterized as a low priority. The section and chapter goes on to assess the correctness of those conclusions. In the end, we specifically recommend introducing a 10J population in the upper Chama Sub-Reach.
4-1	1-16	Have flycatchers ever been observed along the Chama? Does not appear so.	The SWFL recovery plan indicates that the Rio Chama was part of the historic breeding range, and contemporary surveys have indicated that SWFLs have been detected in the Chama "watershed" (FWS 2002; page 9) but these sites maybe outside the Velarde Reach project area. We will add some language to make this point more clear.
4-2	Figure 4-1	Locations of flycatchers nests from 1993-97 and 2008 are not indicated on the photo. Some additional reference points like bridges and roads or mile markers should be provided.	We'll add a landmark for reference (ie. Petaca Canyon). The geo-coordinates for the pre-2003 nest locations in this sub-reach are unreliable. We'll add a caption below the map and edit the Exhibit title.
4-3	15-16	Can you be more specific in what part of Chapter 2, Hydrology, so a quicker reference can be made?	Sentence modified and references Exhibit 4-7 for quick reference.
4-3	Ex 4-2	2nd photo, "Mean flow" should probably read "Mean daily flow."	Okay
4-6	28	Insert "of" ….elimination *of* riparian……	Done
4-7	9	Can you be more specific in what part of Chapter 2, Hydrology so a quicker reference can be made?	Okay
4-7	Ex 4-5	Third photo, an irrigation turn-out is a structure that delivers water to a farm, an irrigation return or wasteway returns unused irrigation water to the river.	This backwater was actually associated with an irrigation turn-out (not an irrigation return or wasteway). While it's not showing the acequia, the channel is fed by the diversion dam turnout.
4-10	Ex 4-6 & 4-7	These x-sections are shown on page 2-62. Do they need to be shown again?	We think they are helpful, as is demonstrated by comment 75 above.
4-13	5	USFS 1991 appears to be a very old reference for riparian vegetation condition.	This citation is provided because it's the only reference we found that discusses vegetation potential. We believe that it is still relevant.
4-13	23	"is" should be "are"	Okay
4-18	6	There should be consistency in listing genus species for all land predators.	Done
4-19	17-25	This is a very generalized discussion of browsing on riparian woody vegetation, more detail is suggested. Do elk deer or cattle or a combination cause the browse, who is the management agency?	It is probably a combination of all three, but as we state in this section, it is not possible to ascertain which are contributing more to the browse observed on the cottonwoods in the Upper Chama Sub-Reach (managed by the USFS as stated on page 4-19, line 2). While it is very generalized, we believe that it could be a limiting factor based upon general site observations, and therefore propose leaving this section in tact as is.
4-21	9-10	Probably important to note that no flycatchers have ever been observed along Rio Chama.	This point of this section is to say that there might be flycatchers nesting in the Lower Chama Sub-Reach but no formal flycatcher surveys have been performed because of difficult access.
Chapter 4 General Comment		Is there flycatcher habitat up tributaries to the Chama, for example does El Rito have flycatcher habitat that should be explored?	Yes, all areas in the Upper Rio Grande Management Unit, including Los Ojos, El Rito, etc., should be evaluated, but these areas were not included in our study so we have not analyzed these areas for restoration potential. We will add language in Chapter 5 below Exhibit 5-5 to make this point.

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Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
4-25		Class 1 objectives for Wild and Scenic River status appear to make more cost effective restoration difficult. However, the potential for SWIFL restoration on BLM lands at La Petaca should be considered and partnerships with user groups could be formed (such as rafting groups to ferry materials) to overcome constraints. The emphasis on protecting existing visual quality must be balanced with habitat quality and the impacts (ecological, social, recreational and visual) of retaining stands of aging non native trees.	Good points. Will modify language.
4-30	18-21	Should the A&R limit the recommendation to the Upper Chama? Can the authors look to other sections of the river to find potential restocking sites?	Yes and we have "looked at other sections." Indeed, within the Velarde Reach, as defined by our contract, there are many location where silvery minnows could be stocked. But why? In our professional opinion, there is only one of this studies' sub-reaches where a self-sustaining population can be established. For the reasons this report discusses, our analyses point to stocking in other reaches would not lead to self-sustaining silvery minnow populations, without first removing the existing irrigation diversions, where present, removing structures from the floodplain in the lower Rio Chama, and extensively re-engineering the channel in the upper Rio Grande. We did not analyze sections of the Rio Grande south of the Velarde Reach to Cochiti Reservoir, where other opportunities for self-sustaining silvery minnow populations may exist.
4-30	19-21	Is there a conflict with the previous statement, "It may have just been an insignificant portion of the population living at the edge of its range in habitat generally unsuitable for its persistence" which described the area upstream of Cochiti Reservoir, let alone the upper Chama reach. Floodplain accessibility and habitat degradation aside, the Upper Chama would be the last of the 5 sub reaches where minnow would be able to survive.	The statement in Chapter 3, page 29, has now been deleted and updated information is now provided. Regarding the comments final statement, that would have been true historically, but is no longer true due to the reasons defined in our responses to the previous comment.
4-31	1	Highly impacted by flow importations? This is an overstatement.	"highly impacted" has been replaced with "markedly altered." The substantial effects of SJC imports are described in Chapter 2.
4-31	30-34	The report should discuss this as an opportunity for restoration and introduction of RGSM.	We consider the cost of re-engineering the upper Rio Grande sub-reaches to be of very high cost with potentially minor benefit for silvery minnow. Such an investment could have potentially much greater benefit for this species in the more southern reaches of the Rio Grande. Sections 18 and 20 provides options to address issues listed here for the lower Chama. Reference to these two sections is now included.
4-32		Temperature decreases due to reservoir releases, especially during summer months is probably a bigger factor than water volumes or increases in velocity.	Since this section discusses potential effect due to flow alterations produced by El Vado, it was retiled to reflect that. Temperature alterations are discussed in Section 15.
4-34	1-8	Were the investigations of benthic macroinvertebrates and algae based on representative sampling?	No, this contract excluded the collection of new data. The statement is based on qualitative examination of the inverts on assorted cobble at 8 location, roughly following "best rock" macroinvertebrate assessment procedures developed at the University of Idaho, relative to experience from years of working in more than 30 mountain streams.
4-34	3-7	A literature reference to support this position would be helpful, could be another species.	See above comment; no suitable reference exists, observations were qualitative. The photo shows a mayfly (Heptageniidae).
4-34	11-17	Could lab experiments be set up to test both temperature and substrate size?	While such laboratory studies with silvery minnow could be conduct with cobble, Dudley and Platania (1997) already report on their association with cobble and other finer substrates. Additionally, silvery minnow successful survive and grow in in fiberglass and plastic tanks, without fine sediment. They eat the algae growth from the sides of the tanks. Swimming tests conducted by USBR/CSU show that silvery minnows have readily interact with cobble and boulders. We are not inclined to suggest that studies with cobble would be an essential research priority for silvery minnows. We do recommend additional temperature studies in Section 15.
4-34	25 -30	This discussion needs to be expanded and have literature citations to support RGSM reintroduction.	See next comment response.
4-34	32	Is highly favorable correct? The listed inundation durations for the floodplain and T2 surfaces is 6 days and 2 days respectively. With significantly colder water then the MRG, how is there a sufficient amount of time for recruitment of RGSM on floodplain habitats?	"highly" is deleted; additional discussion of floodplain inundation from Chapter 2 is inserted and a reference provided.

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Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
4-35	3	Jacobi and McGuire 1992 appears old for aquatic insect work supporting current condition.	If there was a more recent reference we could include it here. However, as watershed conditions have not markedly changed between their study and present, we concluded their observations remain relevant.
4-36	31-32	Should the authors recommend conducting cold water survivability test on the RGSM facilities?	Exhibit 4-22 shows that minimum water temps, even at Alameda, reach near 0 C during some days in the winter, yet silvery minnow and other species survive this temperature in this reach. The exhibit also shows that the seasonal durations for extreme cold water temperatures for the three sites shown are not markedly different. So, we do not see the need for cold temperature survivability tests. Test to assess gamete production at cold water temperature are now recommended section.
Chapter 4 Anywhere		What is the fish community in the Chama River? Could RGSM be a member of this community based on life history, anatomy, swimming ability and ecology? Discussion would be helpful.	See Chapter 3, Section 18 of this report, plus we have added to the Exhibit 3-11 list a footnote to indicate the species found in upper Chama.
4-40	14-23	The average maximum temp listed for Above Abiquiu is less than the listed average minimum temp for Alameda. How is this "within a range of potentially acceptable to silvery minnows"?	Exhibit 4-23 was incorrectly modified during final editing for the previous draft. The table has been replaced in the revise draft to improve the presentation of the discussion points.
4-40	16	What does potentially acceptable mean. Please suggest conducting temperature analyses at a lab.	this discussion has been revised and needs for additional laboratory or in situ studies noted.
4-41	6-12	Would pebble counts help address concerns?	It is unclear how pebble counts could better convey the preponderance of cobble in the streambed of the reach better then the photo shows.
4-41	30-31	What "historic occurrence"? See quote from Row 82. Please provide a single documented RGSM on the Chama?	See Exhibit 3-10 in this report.
4-42 - 4-43	Sediment	The accuracy of the sediment section was questioned by one reviewer.	We assume this comment relates to the indirect reference to the report by Dudley and Platania; direct quotes of material are now provided.
4-43	23	Are these diversions actually fish barriers? With stocking upriver, would fish pass through the irrigation structures and move downriver? Does fragmentation have a genetic implication, suggest rewriting in a more positive context that supports restoration and 10J.	We conclude they are barriers to upstream movement, but not the downstream displacement. Additional discussion is included on how 10(j) stocking could be approached in this reach. Sections 18 and 20 of this chapter provide information on alternative related to the barriers.
4-44	6	Could active floodplains be reconstructed within the Velarde reach, economically?	Floodplain encroachment by residential structures prohibits a functionally connected floodplain in the lower Rio Chama sub-reach. Economic constrains prohibit viable floodplain connectivity of any extent in the Rio Grande sub-reaches.
4-44	16-21	If the CP move forward with a 10J population there needs to be several (multiple locations) to support resident fish – please consider rewriting the paragraph in a more positive context that support restoration and the CP and find limitations in dollars if you need to put up road blocks.	See comment at 4-43 and in text.
4-45	8-37	Listing these cost presents a predetermined position not wanting to stock RGSM within these reaches of river, placing multiple boulders below the irrigation structures may create different surface water elevations, compounded by varies discharges, this could be a budget version to establishing fish passage.	The listed cost are accurate, to the best of our information. We included the costs to provide realism to the content of the discussion, not bias. We have deleted the final sentence, which does include our professional conclusion, and our on this issue: "While they remain an option, we do not specifically recommend implementing these structures on irrigation diversions in the Velarde project area."
4-46	30-33	Overall turbidity, additionally impacted by El Vado, is significantly lower than that of the MRG. The statement "between periods of higher turbidity" is questionable. Do periods of low turbidity conditions far exceed those of high turbidity conditions?	Patterns of turbidity have not been continuously monitored in the Upper Chama sub-reach. There is little doubt that sometimes the water is very turbid in this reach, other times much less so. The phrase in question is included as a basis for a possible research hypothesis on the uncertain relationship described in this section. The sentence has been revised to, hopefully, better convey the intended meaning.
4-47	4-12	Please expand this section to support 10j and the CP and potential downlisting, implementation.	Chapter 5, Sections 4 through 6 provide specific recommendation for introducing a 10(j)(1) experimental population of silvery minnows in the Upper Chama sub-reach. This is has been added to the final section of this chapter.
4-48	11-22	Do these restoration options have the potential to support a resident population of RGSM? Could these areas be stocked from upriver? Would these objectives meet elements in the new BO? If so, please address and close this section of the document in a positive presentation that supports the CP.	We believe a self-sustaining population of silvery minnow could be restored to the upper Chama sub-reach. We believe they could be stocked near the monastery or upstream. The new BO is not even in draft, so we have no idea of its relationship to this proposal. Chapter 5 provide the information requested here. This section now concludes with a reference to that discussion.

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Section & Page #	Line #	Reviewer Comment	Parametrix Team Response
Chapter 5		What is the total acreage of recommended SWIFL restoration projects? It would be helpful to have a summary table that compared min/max recovery goals in terms of acreage with candidate and recommended projects.	The total acreage for candidate restoration sites is approximately 425 acres, although the potential habitat quality, even through restoration work is unclear. Also, the emphasis on "acres" can be misleading. For example, within the 32-acre site at Los Luceros (Velarde sub-reach) there are patches of relatively dry bosque. An emphasis on acres here to predict potential number of territories (and potential contribution to meeting recovery goals) would be misleading. We will add language below Exhibit 5-5 to address this question and to make this point.
Chapter 5		Could techniques to enhance backwaters or overbanking to benefit the RGSM be implemented on T2 surfaces in conjunction with SWIFL habitat improvements in the Upper Chama? Where?	Perhaps on some surfaces, but without a FLO2D model for this sub-reach it was not possible for us to figure out where this might yield benefits.
5-1	24-25	Can any RGSM habitat augmentation projects be recommended in conjunction with the passive restoration recommended later in the chapter in the Upper Chama Reach?	Based on our assessment of the Upper Chama, we felt that the basic elements of RGSM habitat (deep pools, overbank flooding, food resources...) may already be adequate and that no physical habitat modifications were warranted. Only recommendation is to try introducing non-essential experimental population.
5-7	7-11	Mis-indentation	Fixed, thanks.
5-41	10	Substitute include for includes.	Done
5-45 - 5-48		A very questionable suggestion. At the very least indicate 10j should go above Cochiti first to see if even those conditions can support RGSM.	We disagree. Silvery minnows appear to have lived in the upper Chama sub-reach in the past. While questions remain on whether today's genetic strains could live there, that potential requires additional research as we suggest. We were not contracted to assess habitat potentials for silvery minnows downstream from the Velarde Reach and have no basis for judging the merit of that suggestion.
5-46	7	Remove Pueblo, it is repetitive.	Done
5-47	31	100,000 to 500,000 RGSM is a wide range, how was the range determined, as well as the frequency of stocking?	Based on the number of silvery minnows being stock annually into Big Bend (500,000), we suggested that a similar annual stocking of at least 20% of that number would be appropriate and more, if available.
5-51	1	Suggest changing the title, Other Recommendations, to Data Gaps.	Okay
5-57	All	While it is important to conduct public outreach and education for the land owners along the reach corridor, there is another property right holder who was not addressed, the water rights holder. While it appears as though many of the riparian "land" owners in this area support ESA issues, the Rio Chama Acequia and the mainstem Rio Grande Acequias should also be included in this section.	Will do.
D1-D7	All	The approach to Net Depletion Analysis is questionable for two reasons. First, there is no real scientific agreement as to the difference in ET rates for native and non-native riparian vegetation in general, and in particular for saltcedar. Second, there is no depletion analysis necessary for vegetation modifications to riparian areas. The Office of the State Engineer does not require nor recognize such. If land surface elevations are lowered within riparian areas (outside the active channel), then open water evaporation rates apply for the additional time an area is inundated above pre-existing conditions. For now this is the OSE policy. This second comment has been made by the NMISC for at least the San Acacia Reach A&R and also possibly for the Isleta Reach A&R .	The purpose of the river channel vegetation restoration consumptive use study is to satisfy questions about the magnitude of the riparian depletions, not to add to scientific discussion on ET rates or for use in a water right application. This study shows that there is no significant difference in depletions between native and non-native riparian vegetation at these sites. This simplified consumptive use analysis helps understand a portion of the water budget along this reach of the Rio Grande, it is not a prediction of future hydrologic conditions. It can assist in the preparation of an environmental analysis if one were to be required for future implementation of the project. Current NMOSE policy regarding river restoration depletions is acknowledged. If at some time in the future it is recognized that the NMOSE may not have jurisdiction over the consumptive use associated with these types of river restoration activities, then a change in policy may result. If current policy were to change, water right offsets may not be required.
Overall Comment		Good description and analysis of issues related to habitat restoration for the SWIFL and RGSM. It is refreshing to see some alternative perspectives presented with the familiar ones.	Thank you!

Comments from the U.S. Fish & Wildlife Service; Received by Parametrix October 6, 2009 (after official review period with the Program Habitat Restoration Workgroup closed). Parametrix team responses kept very brief and highlighted in yellow.

1. Life Span (Section 3-23). The suggestion that RGSM are "increasing" in length due to habitat restoration since 2005 lacks substantiation; specific data and/or literature need to be cited. Fish of all size ranges have been documented in all sampling, not just since 2005. The Recovery Plan notes that fish up to 85 mm SL are found occasionally during routine monitoring. In addition, the abundance increase of RGSM present in the MRG can also be attributed to the ongoing augmentation efforts conducted by USFWS, NMFWCO. Augmentation efforts have been instituted since 2002 and 981,736 RGSM have been released into MRG. Cumulative effects of these releases resulted in increased numbers of RGSM collected throughout the occupied range (Remshardt 2008).

We will review and consider edits.

2. Red Shiner as surrogate for RGSM. (Section 3-32). While red shiner and RGSM do overlap in some habitat requirements, red shiners are far more general in their tolerance of habitats and have a completely different reproductive strategy. It is far more tolerant of intermittent and low stable base flows than RGSM and uses highly variable sites for egg deposition during the reproductive season, which can span between spring and fall with multiple spawning events by individual fish. It is well documented that RGSM are pelagic spawners, and they along with the other species in this reproductive guild, (speckled dace, bluntnose shiner, phantom shiner) are all extinct/extirpated from the Rio Chama.

It appears that the reviewers are misinterpreting our intentions for this section. Nonetheless, if it is this misleading we will delete.

3. Survival (3-37). No data are referenced that larger fish in collections equate to ages of 4 or 5 years. Growth is highly variable due to an array of factors and is not solely attributable to age. It has been documented that Age 0 fish can grow up to 60 mm SL in their first summer and may vary by up to 30 mm SL between sites and years (Augmentation Annual Reports). Suggestions that RGSM are "increasing" in size in recent years and represent ages up to 4 years old is just an opinion and remains unverified. This section even mentions that data to substantiate this claim are lacking.

We will review and consider appropriate edits.

4. Where do silvery minnow spawn (3-38)? The term "feeding habitat" is used within the text in association with connected flood plains. How does this term relate to young Rio Grande silvery minnow nursery areas? Is this habitat term defined in a report or publication and can it be cited here? Much of the discussion of this section ties back to speculation about spawning location and the value of connected flood plains to retention of eggs and larvae. The presentation of the concept that eggs and larvae show up in these connected habitats because they were spawned there is completely unsubstantiated and should not be included without specific data or citations.

This entire section will be revised so that this question of floodplain role in spawning is presented as alternative hypothesis**.**

5. How could silvery minnow benefit from water quality conditions that aversely [*sic*] affect other species (3-43 through 3-45). This concept is attributable to results from a laboratory study by Dr. Kevin Buhl on the potential effects of low dissolved oxygen and the report specifically states that **the evaluation relies on preliminary results that have not been reproduced or independently verified.** A personal communication from Dr. Kevin Buhl (which is available in an email) states that results are preliminary, lethal limits were not reported to the collaborative program and that more trials are needed. To use this preliminary information is inappropriate and should be first qualified with Dr. Buhl.

We will provide more recent publication citations from Dr. Buhl and/or edit section.

6. RGSM adapted to life in an isolated pool (3-43 through 3-45). While it may be true that RGSM are adapted for life in desert environments, the suggestion that a critical habitat requirement should include periods of channel drying is completely baseless. RGSM are part of a large community of riverine fishes and have never been known to "outcompete" all other species during harsh periods. Current channelization of the river leads to wholesale drying of entire reaches of river without the referenced "refugial pools" which would provide limited habitat for a severely limited number of individuals if available at all. In fact, it has been documented that during low, stable base flows which would include intermittency, RGSM become less abundant at the expense of other more tolerant species such as red shiner and fathead minnow (Hoagstrom, et al. 2008).

We will delete this section.

7. Topeka shiner as a surrogate for RGSM (section 3-43 through 3-45). Topeka shiner and RGSM do not co-occur, their life histories differ considerably and the threats to both species are widely different. The distribution of Topeka shiner is in clear prairie streams of north-central Missouri, and in Missouri River tributaries. Primary threats to Topeka shiner are sedimentation, environmental pollution from pesticides and concentrated animal feed operations, increased urbanization and competition from introduced populations of blackstripe shiner and western mosquitofish (Pflieger 1997). Streams that support Topeka shiner typically experience low base flow, and cease to flow in the dry season (Pflieger 1997). Stream flow intermittence is not a threat to Topeka shiner (stream flow intermittence does threaten RGSM), and therefore the use of this fish as a surrogate is inappropriate.

The section will be deleted.

8. Section 3-49 through 3-50. Rio Grande silvery minnow habitat requirements are generally well known. Dudley and Platania (1997) reported that RGSM are found in low-medium velocity water over silt (sometimes sand) substrate, utilizing debris piles, pool and backwater habitats. Habitat use also changed by length class with smaller fish using shallow, low velocity water, and larger fish moving into swifter and deeper water. In the river reach between Angostura

diversion dam and Isleta diversion dam RGSM was collected less often than expected over gravel, indicating avoidance for that substrate. The argument presented that RGSM are associated with fine sediments (silt and sand) only because their true preference is for low velocity waters, and fine substrates occur there by default is overly simplistic and ignores available reports and peer-reviewed literature. By the same logic someone could argue the opposite- that RGSM do not prefer low velocity habitat, the fish really prefers silt and sand, and low velocity water co-occurs in the same area only by default.

We do not agree with the commenter's perspective regarding velocity vs. Substrate. We will revise some language but the overall concept will be left in tact.

9. Upper Chama Sub-Reach as favorable (4-34). RGSM were never documented anywhere upstream of present day Abiquiu Lake, and sand substrate, along with overbank flooding alone does not provide "favorable" conditions for a RGSM population. Sublette et al. (1990) stated RGSM occurred in the Rio Grande downstream from Velarde and in the Chama River (a tributary of the Rio Grande) **downstream of Abiquiu**. The Upper Chama Sub-reach can be considered similar the Rio Grande reach above Cochiti Reservoir. Stream reach length (less than 100 kilometers), water temperature (lower than in current distribution), stream reach gradient (a steep gradient would transport eggs and larvae into downstream reservoir), and a cool or cold water fish assemblage, all indicative that the Upper Chama Sub-Reach is highly unfavorable to reintroduction of RGSM.

We agree that we should not be so casual about implying the upper chama subreach should be considered for 10j population. This entire section will be revised and we will soften our position considerably. We do not feel strongly that the upper chama subreach has good potential for rgsm reintroduction, more so that further study is needed to take a strong position one way or another. We will elaborate on this in the final report.

10. Water Quality (4-35). The statement that "toxic waste discharges have not resulted in a recorded fish kill involving any species in the MRG" is simply wrong. Several events have been recorded in the MRG that have resulted in fish kills in the MRG (Joel Lusk, USFWS personal communication). In fact, a laboratory study where RGSM were exposed to AMAFCA storm water resulted in a 70 to 90% kill of RGSM (Joel Lusk, USFWS personal communication).

We are unaware of any scientific publications that support fws comment.

11. Where do silvery minnow spawn (3-38 and 3-39)? "Actual spawning locations for silvery minnow remain a point of *active speculation"*. This sentence best summarizes what is known about the location of RGSM spawning. There is chronic and persistent speculation without reproducible evidence to test any hypothesis put forth on this issue. The answer to the question in this report is equally speculative, and lacks any scientific backing through peer reviewed citations. However, we do know that from previous egg monitoring efforts at San Marcial in channel spawning occurs and this is supported by the presence of drifting eggs at lower flows that did not inundate or connect with flood plain environments.

We will consider editing this section, but we disagree with the general premise, as is suggested in this comment, that there is no room for alternative hypotheses in a planning and recommendations report and that only peer-reviewed literature should be cited.

12. Where do silvery minnow spawn (3-41)? It is mentioned that “it is more plausible that silvery minnow spawned in these backwater and floodplain habitats.” Where is the report, publication or data to support this statement? This statement is pure speculation. Rio Grande silvery minnow are pelagic spawners that produce thousands of semibuoyant, non-adhesive eggs that passively drift downstream while developing (Platania and Altenbach 1998). While it is possible that limited spawning in flowing areas of flood plain habitats likely occurs, main channel spawning is well documented and flood plain habitats are primarily available to eggs and larvae at high spring flows.

This will be addressed further in the final report.

13. Water Temps (4-40). Significant differences between the “above Abiquiu” temperatures and Alameda Bridge indicate that RGSM growth and even spawning and recruitment would be limited at best. Temps never exceed the 25 degree range above Abiquiu, which as detailed in Platania (2000), is optimal range for growth and recruitment. In fact, the current temps found near the Alameda Bridge, may be comparable to historic temperatures in the upper Rio Grande near Espanola before impoundment and limnetic reservoir releases decreased temperatures significantly. Temperature effects by impoundments effectively moved the upstream-most range of RGSM to somewhere downstream of Cochiti Reservoir.

This will be addressed further in the final report

14. Does channel substrate limit silvery minnow populations in the upper Chama sub-reach (4-41)? “*The preference of silvery minnow for habitats with fine textured bed materials has not been demonstrated in modern studies*”. This sentence is incorrect and either chooses to ignore or misrepresent previous study of RGSM habitat preferences. Dudley and Platania (1997) found (as stated earlier) that RGSM is associated with fine textured sediments and low-medium velocity habitats **and that in the Angostura reach RGSM were found less often than expected over larger diameter sediments such as gravel**.

Again, we do not agree with the FWS comment regarding velocity vs. Substrate. We will revise some language but the overall concept will be left in tact.

15. Is reach length and habitat fragmentation between irrigation diversions necessarily a limitation to silvery minnow viability? (4-43). The importance to pelagic, broadcast spawning fish, of a contiguous, unfragmented reach of river greater than 100 kilometers is well established. Studies (not arguments) have shown that fragmentation, in hand with river channelization and habitat degradation have resulted in extinctions, local extirpations and dramatic declines in distribution of native pelagic spawning cyprinids (Dudley and Platania 2007). In rivers with segments greater than 100 kilometers (such as the middle Pecos River in New Mexico) native pelagic spawning minnows have survived with more intact distributions and have experienced less extirpations and extinctions (Hoagstom and Brooks 2005; Hoagstrom et al 2008). This restoration analysis speculates that floodplain connectivity is important for retention of pelagic eggs and larvae. Undoubtedly, a wide river channel with a range of depths and velocities helped to slow downstream transport time of eggs and larvae. But the role of inundated floodplain in retaining eggs and larvae is remains speculative and untested,

particularly in regards to low-flow years where the flood plain is not inundated yet Rio Grande silvery minnow reproduce and recruit (see annual monitoring data by Dudley and Platania). The upper Chama sub-reach proposed for reintroduction is ca. 13.6 miles (21.8 kilometers) in length and does not appear suitable for Rio Grande silvery minnow, if we consider where the species remains

This section will be revised per FWS comments

16. Do any of the project sub-areas have potential for sustaining experimental re-introductions of silvery minnow (5-45 through 5-46)? The recommendation that an experimental population of Rio Grande silvery minnow be reintroduced into upper Chama sub-reach is not supported with the available science. The river reach length is short (21.8 kilometers), substrate is large (gravel, cobble and boulder), and the water temperature is too cool (on average, 5 degrees C less than the most northerly waters that support a RGSM population). The downstream impacts of El Vado Dam to the fish assemblage illustrates this well. Warm water, pelagic spawning cyprinids no longer persist in the study area.
The documentation of RGSM in the far upstream reach in the Rio Chama by Ohkay Owingeh tribal members is anecdotal (i.e., pre-dam) and remains unverified. To base a management recommendation on anecdotal information is not scientific, especially since the river ecosystem has been altered (e.g., post-dam) after this apparent observation, and present day habitat conditions are unsuitable to support RGSM (see line item #8).

See response to Comment 9.

Summary

The justification for the reintroduction of Rio Grande silvery minnow into the Velarde Reach of the Rio Grande is poorly developed and requires significant revisions for future consideration of the proposed action. The poor scientific justification that appears to have been developed from a faulty review of the literature and extensive use of unreported and/or unpublished data. We suggest a complete re-thinking and re-writing of the sections regarding Rio Grande silvery minnow. Finally and as a point of procedure, the authors do not acknowledge the required consultation process (i.e., government to government consultation) that must be initiated with all Rio Grande pueblos residing below the Upper Chama Sub Reach.

COMMENTS BY FISH & WILDLIFE SERVICE RECEIVED BY PARAMETRIX APRIL 22, 2010. RESPONSES TO THESE COMMENTS WERE OUTSIDE THE SCOPE OF THIS CONTRACT.

FWS Comment 1; Section & Page #: General

We are submitting more comments on the revised Restoration Analysis and Recommendations for the Velarde Reach of the Middle Rio Grande, NM. We continued to find significant issues with the sections on Rio Grande silvery minnow biology, Restoration Issues and Opportunities, and Recommendations. The comments that we provided are submitted in the hope that these recommendations will have the greatest support from the current Rio Grande silvery minnow knowledge base. Unfortunately, what we found in the Recommendations report was based more on speculation than fact, and we advise caution in the use of these recommendations with respect to reintroducing silvery minnow into the upper Chama sub-reach.

Response 1:

This final report does not recommend experimental reintroductions into the Upper Rio Chama Sub-Reach (see Chapter 5). The recommendations are that more study would be needed before this area could be considered for experimental reintroduction, if at all. The report also defines other reaches in the study area where the potential for establishing a viable silvery minnow population is minimal, both due to the channelized condition of the river and reach fragmentation. The responses we provide below are submitted with the hope that those responsible for managing the MRG, with the goal to enhance habitat conditions for silvery minnow, will obtain an improved understanding of the best available science and current information limitations regarding the habitat and biological requirements for this species. Indeed, studies needed to collect new data regarding various species-habitat relations along the MRG have not been completed. Therefore, the discussion we present often builds from information available for other similar species, limited unpublished observation from the field, discussion with other members of the Rio Grande fisheries biology community, and logical scientific inference. As such this report includes the presentation of various hypothesis to be tested to further our understanding of the species biology and habitat. Indeed, the scientific method and the Program's developing adaptive management depend on recurring cycles of hypothesis formation, data collection, analysis and hypothesis updating. As such, we disagree with the FWS direction to delete much of the presented discussion we include in the report related to the hypotheses regarding habitat relationships and biological relationships for silvery minnow. We provide additional details on the bases for this general response throughout the following specific responses, as well as information on the implications of hypotheses themselves, which would have been excessive to include within the original text.

FWS Comment 2; Section & Page #: General

The substrate (gravel, cobble and boulder), cold water temperatures compared to occupied reaches, lack of historic collections, the fact that silvery minnow in the Rio Grande upstream of Cochiti and in the Rio Chama were most likely on the edge of their natural ranges, and short distance of the upper Chama sub reach are all reasons to be highly skeptical about the possibilities of silvery minnow persisting in this river reach if reintroduction occurred there. Because of the poorly defended and capricious rejection of peer reviewed science, misuse of scientific literature, consistent reliance on untested hypotheses, and repeated speculation found in this report we advise caution in using the recommendations in this analysis for reintroduction of silvery minnow into the upper Chama subreach.

Response 2:

There is no recommendation in this report for reintroducing silvery minnows to the Upper Chama Subreach. Many sections of the report individually address the potential for conditions to limit silvery minnow sustainability in the upper Chama subreach, some of this information is also highlighted below. However, we are less conclusive in our report than the FWS about rejecting outright the Upper Chama Subreach as having some potential until some existing data gaps are filled (see Chapter 5).

FWS Comment 3; Section & Page #: General

Recovery of the minnow is dependent on establishing populations in the historical range of the species and FWS priorities will focus in that range.

Response 3:

We agree that FWS should place priority on the more recent historical range of the species. However, available information, as compiled and highlighted in this report, cannot conclude the upper Chama subreach above the Abiquiu Lake as being outside of this historical range occupied by silvery minnow. Historical fish collections do not exist. We do not advocate in this report that the upper Chama subreach should be their first or even a high priority reach for introducing this species, but until some important data gaps are filled, this area should not be conclusively ruled out.

FWS Comment 4; Section & Page #: General

It is a significant improvement and they did a good job of addressing most of the original comments, but the main recommendation for RGSM is flawed. Regardless of the relative lack of effort in the late 1800's, the suggestion that the area upstream of Abiquiu has potential for reintroduction seems ridiculous when they were not even known from there.

Response 4:

Thank you for the positive comment. Also, see responses to Comments 2 and 3 above.

FWS Comment 5; Section & Page #: General

In the biology section on the minnow, there are many references to older versions of the minnow recovery plan. These could be corrected to bring the document up to date. At least including the correct recovery criteria from the 2010 plan would be beneficial.

Response 5:

At the time the report was finalized, the 2010 version of the recovery plan was still in draft and not appropriate to cite. Revising the report to now include this update is out of scope for this project.

FWS Comment 6; Section & Page #: General

Also, it is stated that designated critical habitat for silvery minnow excludes Pueblo lands. I looked at the Federal Register notice and not all Pueblo lands are excluded, only: Isleta, Santa Ana, Sandia, and Santo Domingo. So, Cochiti Pueblo and San Felipe Pueblo lands are designated.

Response 6:

We concur and page 3-45 of the final report states, "With the exception of Cochiti and San Felipe Pueblos, Pueblo lands downstream of Cochiti Dam are excluded from the critical habitat designation (FWS, 2003b)."

FWS Comment 7; Section & Page #: 3-24, 14. Life Span.

The life span of silvery minnow is generally known, but currently poorly quantified. Based on the best available science, age structure is dominated by age 0 and age 1 fish with a small percentage of age 2+ fish in the population. Cowley et al 2006 provided ages for 13 non-randomly selected silvery minnow, and ages derived from scale annuli counts were not independently verified. The small sample size, nonrandom representation of the population and lack of independent verification diminishes the importance of the observations reported in Cowley et al 2006, and should be used only with caution. Though there are several observations of longer life spans in hatchery raised silvery minnow these observations do not relate to wild fish, and are not relevant.

Response 7:

The potential maximum life span has been "quantified" to be at least 7 years in captivity; because these individuals were terminated, we don't know how much longer they could have lived (K. Buhl, personal communication, 2010). It is true that the ages of most wild silvery minnows from the middle Rio Grande are commonly stated as being age 0 and 1 fish, with a small percentage of age 2+ fish. But it is unknown and inappropriate to conclude that the potential life span of most silvery minnows is naturally limited to 1 to 2 year. This hypothesis has not been fully assessed for modern times and data are lacking to make a conclusion regarding historical populations. It is important to recognizing that the results presented by Cowley et al. (2006) represent only a limited population; however, this information can be used to help define hypothesized historical age relationships for silvery minnow in the wild. Unfortunately, ages for most silvery minnows captured from the MRG are based on their length; age to length relationships can differ widely north to south along the MRG due to the effects of seasonal water temperature differences on maximum growth rates. Laboratory-based age information is relevant as it indicates the maximum potential life length that silvery minnows might have in the wild under an improved habitat quality. For example, larger silvery minnows have the potential to produce many more eggs compared to smaller individuals, increasing their population recruitment potentials in the wild. The laboratory results also indicate that silvery minnows have evolved the potential for a life span much beyond that generally known from field collections. Such a wide discrepancy in reported ages from the field vs. the lab point to a series of open research questions that could be very important in helping direct habitat restoration efforts for silvery minnows: Specifically, why are the older silvery minnows not being captured in collections from the middle Rio Grande? Is this because they are not there? Or, is it because they are being missed by the current collection techniques? (Differences in potential capture efficiencies for progressively older age classes have not been assessed for the currently used sampling techniques; as is discussed in the text, silvery minnow have relatively high burst swimming rates and larger silvery minnows could evade capture by these techniques.) Then, if they are not persent, how can habitat restoration efforts better enhance their survival potentials and prolong their average lifespan? Should projects be targeted, for example, to extend the longitudinal connectivity up and down the MRG? Or, should projects be targeted to increase the lateral connectivity of the river into the floodplain? Such questions should be carefully formed into hypotheses and tested.

FWS Comment 8; Section & Page #: 3-24, 14. Recruitment

The personal communication from M Porter represents a statement based on an untested hypothesis, is only an opinion, and should be removed. Dudley and Platania (2007a) provided data on flows needed to ensure recruitment; their citation is the proper one to use.

Response 8:

We view the discussion presenting reasonable hypotheses from field observations related to this species as potentially contributing to enhancing recovery potential for the species. Beyond the information from Porter, we also summarize in the report that, "Data published by Dudley and Platania (2007c) indicate that silvery minnow recruitment is significantly improved when peak flows at Albuquerque exceed approximately 4,000 cfs and flows greater than 3,000 cfs are sustained for more than 30 days." We also state that, "For example, the relatively high monsoonal runoff flows during the summer of 2006 did not appear to produce significant silvery minnow recruitment in the Middle Rio Grande (Dudley and Platania, 2007a)."

FWS Comment 9; Section & Page #: 3-25, 14 Egg characteristics.

Information on silvery minnow egg characteristics are not provided in this section. Instead we are provided cursory, and speculative information on silvery minnow spawning behavior. The section of this paragraph beginning with "Alternatively, eggs may be spawned within inundated floodplains...", is not supported by data, represents an untested hypothesis, and should be removed.

Response 9:

The section in question cites Dudley and Platania (1999) and BOR and USACE (2003) as follows: "Spawning silvery minnows broadcast eggs (i.e., pelagic release) that are slightly negatively buoyant and are kept in suspension by minor currents, including those generated by winds (Dudley and Platania, 1999). These eggs may be spawned into water columns of the channel if that is the only aquatic habitat available. Alternatively, eggs may be spawned within inundated floodplains, backwaters, and vegetated shorelines whenever such habitats are available. When these eggs are released or are washed into floodplains, minimal downstream displacement of eggs and developing larvae occurs (BOR and USACE, 2003)."

FWS Comment 10; Section & Page #: 3-26 – 3-27, 14. Why were silvery minnow listed as endangered?

There are several recent peer reviewed publications on silvery minnow displacement by plains minnow (Moyer et al, 2005 Genetic and ecological dynamics of species replacement in an arid-land river system. Molecular Ecology: 14, 4 pages 1263-1273) and Hoagstrom et al 2010 (IN PRESS). Rapid species replacements between fishes of the North American plains: a case history from the Pecos River. Aquatic Invasions. Hoagstrom et al 2010 is available upon request.

Response 10:

We agree these citations have interesting data and observations, but the authors felt they actually contribute more detail than required for the very general introduction that was our goal for the discussion presented.

FWS Comment 11; Section & Page #: 3-29, 17. Silvery minnow distribution

The inclusion of the anecdotal observation of silvery minnow in the Rio Grande and Rio Chama by members of Ohkay Owingeh Pueblo is inappropriate. These observations cannot be verified, and identification of silvery minnow requires specific knowledge of morphological characters. Any observation by a lay person that is not backed up with specimens should not be included as evidence that silvery minnow once occupied this river section.

Response 11:

We included the information that was supplied by natural resource managers from Ohkay Owingeh Pueblo (a co-signatory to the ESA Collaborative Program) to our team to allow the readers of our report to learn about the Pueblo's perspective.

FWS Comment 12; Section & Page #: 3-33, 19. Where do silvery minnow feed?

The authors state that algae and diatoms need gravel, cobble or woody debris as attachment sites, and these substrates are lacking in the MRG. These ideas (opinions?) presented in this section are not supported by citation of reports or peer reviewed research. Without citation they should be removed.

Response 12:

The report states: "Benthic algae and diatoms, as well as the other microbial and small invertebrate communities they attract, grow best in rivers where there are relatively stable substrates that can be used for attached growth. Common examples of stable substrates in rivers and streams include gravel, cobble, and woody debris. Many of these substrates can also provide locations for attachment or accumulation of drifting leaf litter and fine detritus. All such accumulations can be important sources of food for silvery minnows." This information is commonly available from most text books on aquatic ecology and we did not see the need to include source citation for this information.

FWS Comment 13; Section & Page #: 3-33, 19. Where do silvery minnow feed?

Sublette et al 1990 is incorrectly cited. Sublette et al never states that the shovel nose sturgeon, Rio Grande sucker, blue sucker, and gray redhorse no longer persist in the MRG because of the lack of gravel. The presence of blue sucker and gray redhorse in the Rio Grande are known only from archaeological digs, and there is no data available on the distribution within the MRG or habitat associations of these species. These large river fish do not persist in the Rio Grande of NM most likely because of river fragmentation, dewatering etc, not because gravel is lacking.

Response 13:

The report states (on page 3-34, not 3-33, as indicated in this comment): "Historically, reaches of gravel channel appear to have been once common in the MRG channel (Nelson et al., 1914). The gravel stream bed helped to support the historical presence in the MRG of various native gravel spawning fish, including shovelnose sturgeon (*Scaphirhynchus platorynchus*), Rio Grande sucker (*Catostomus [Pantosteus] plebeius*), blue sucker (*Cycleptus elongates*), gray redhorse (*Moxostoma congestum*), and others (Sublette et al., 1990)." The citation was used only to compile a list of gravel spawners that one existed in the Rio Grande in NM, presented in Fishes of New Mexico. We did not think it necessary to state in the text that, that without a far amount of gravel in the river, there could not have been such a diverse collection of gravel spawning fish. If the presence of a gravel bed limits the distribution of silvery minnow, then their distribution should have been historically limited when these gravel spawners were important components of the Rio Grande ecosystem. We provide no discussion on why the gravel spawners are no longer present. We can conclude, however, that increasing agriculture and other watershed developments, which commonly increase the amount of fine sediment in river beds, cannot be discounted outright as not affecting the bed character and population persistence potentials for gravel spawning species.

FWS Comment 14; Section & Page #: 3-34, 19. Where do silvery minnow feed?

The authors state that algae and diatoms grow on stable sandbed habitats in the Rio Grande (directly contradicting the earlier claim that these organisms need gravel, cobble and woody debris for attachment substrate) and do not provide citation for this claim. Please provide citation.

Response 14:

See response to comment 13 above.

FWS Comment 15; Section & Page #: 3-33-3-36, 19. Where do silvery minnow feed?

Most ideas presented about silvery minnow feeding sites lack citation. This is most likely due to the fact that there have not been field investigations on this topic. As such, this entire section should be removed, because it is almost entirely speculation.

Response 15:

We have addressed this issue in our response to comment 13, above. As that responses indicated, pages 3-25 and 3-26 includes citations to studies and other information characterizing food and feeding habitats of silvery minnow.

FWS Comment 16; Section & Page #: 3-36, 20. Post-spawn silvery minnow survival

This section is also highly speculative, includes very few citations and should be reduced in length to include only information that can be supported with data.

Response 16:

This section is intended to be speculative. It lays out in detail a hypothetical cause for the apparent high rate of mortality in older silvery minnows. As noted above in our response to comment 8, the question of why there are not higher percentages of older silvery minnows in the MRG is a concern affecting the recovery of silvery minnow. If a failure to capture the older silvery minnow is not the reason why their numbers are limited in the present day catches, then determining why they these numbers have declined is a critical concern. This discussion lays out a scenario and hypothetically cause/effect relationships. No other hypotheses have been presented that can account for the loss off older silvery minnows, if that is indeed occurring.

FWS Comment 17; Section & Page #: 3-38, 20. Post-spawn silvery minnow survival

"The early death of silvery minnow apparently is not necessarily, and may not always have been, the norm." Really? The authors cite life spans of hatchery and laboratory raised fish (K Buhl, USGS) and 13 nonrandomly sampled silvery minnow (Cowley et al 2006) to support this claim. For the reasons already stated, this is a highly speculative claim.

Response 17:

See response to comment 16, above. Defining the cause(s) and providing corrective actions to address the general absence of older silvery minnow in modern day collections, and apparently the river are important research questions that could enlighten plans and designs for recovery .

FWS Comment 18; Section & Page #: 3-38, 21. Where do silvery minnow spawn?

Data (direct, quantifiable observations of silvery minnow spawning events in the wild that can be replicated) on location of silvery minnow spawning and silvery minnow spawning behavior in the wild is completely lacking. Therefore this entire section is based on speculation, and should be removed. Again, the authors present "alternate hypotheses" and "others have surmised" on silvery minnow spawning behavior and locations. Recommendations should rely on data, not speculation.

Response 18:

This comment suggests the deletion of discussion related to important questions on silvery minnow survival and considerations on how we might best enhance their spawning success. We do agree that information on silvery minnow spawning in the wild is, in essence, "completely lacking." Therefore, appropriate actions to enhance the recovery of silvery minnow through enhancing their spawning (and population recruitment) success must be based on strategies extrapolated from hypothesized relationships, as is also done in the 2010 restoration plan for this species.

FWS Comment 19; Section & Page #: 3-24, 22. Water temp effects on silvery minnow development.

The claim that 'silvery minnow survive over winter water temperatures of near freezing" is not relevant to the topic of development of silvery minnow larvae and post larvae. The issue is growth of recently spawned larval fish at lower spring time temperatures in the upper Rio Grande and Chama River compared to the MRG, not over winter survival.

Response 19:

The report states, "While these data are very useful in gaining a better understanding of water temperature relationships for silvery minnows, a limitation of this study is that it terminated while the larval silvery minnow were still developing in three of the exposure conditions (Platania, 2000). Since silvery minnows survive over winter temperatures in MRG waters near freezing (32ºF, 0ºC) and gametes must be developing during this period, an improved understanding of their cold-water physiology would greatly aid in understanding their reproductive physiological requirements at low temperatures. Therefore, it is suggested that additional studies of lower temperature exposures be completed to more clearly define lower temperature conditions that influence silvery minnow spawning and larval development." The title of this section is, "How does water temperature affect the early development, survival, and growth rates for silvery minnows?" Its purpose is to present a summary of the study cited above; the concern regarding older fish presented in the comment was not addressed in the Platania (2000), therefore we did not address it is this section. Pages 4-42 to 4-46 provide additional discussion in the report regarding water temperature relationships for other silvery minnow life stages, addressing this part of the comment.

FWS Comment 20; Section & Page #: 3-42, 23.Silvery minnow adverse water quality

The discussion of Dr Buhl's laboratory studies of silvery minnow' tolerance of low dissolved oxygen and high temperature is not relevant to introduction of silvery minnow into the upper Rio Grande and Chama River, because water temperatures in this reach are lower, and the river is perennial. With this knowledge (that is presented in this report) why is this section included? Silvery minnow would not encounter these extremes if they were introduced into any river section of the upper Rio Grande or Chama River.

Response 20:

The discussion is included to provide the reader a complete understanding of the biology of the silvery minnow. The discussion also contributes to establishing the historical basis that floodplains and stranding on floodplains were potentially, critical habitat components for silvery minnows. The existence of connected floodplains in the upper Chama subreach above Abiquiu Lake is one of features of habitat that could help promote the persistence of silvery minnows potentially introduced into this reach. As such, we will retain the section as presented.

FWS Comment 21; Section & Page #: 3-42, 26. Do silvery minnow require sand and silt substrates?

This entire section is representative of a common thread in this report of questionable reasoning. For example, quotes are provided from earlier research of habitat use of silvery minnow, this research showed that silvery minnow changed habitat use seasonally and based on life stage, a fact common within many habitat studies of fishes, and that a commonality of habitat studies is that silvery minnow are associated with low to medium velocity water over silt, sand and gravel. The authors of this report embrace the established knowledge that silvery minnow are associated with low velocity habitats, but reject the established knowledge that silvery minnow also require silt, sand and gravel substrates. The reasoning for this rejection are poorly defended (silvery minnow increased capture frequency over silt and sand substrates can be explained by probabilistic reasons), and show the capricious way the authors deal with established knowledge, accepting only that which supports the arguments presented.

Response 21:

Much of this section draws on information presented in the same reports often cited to claim that silvery minnow requires silt and fine sand substrate. Indeed, from the text of our report, "We suggest that it is reasonable to conclude that silvery minnow do prefer low velocity habitats to enhance their survival potentials. Such habitats, in fact, are commonly favored by most or perhaps all stream and river species of fish and invertebrates ...." But due to the correlation between low water velocity, shallow water depth, and fine sediment, backed by information provided in the citations in this section, we are much less convinced that fine sediment or shallow water depth are equally important. Therefore, as the section concludes, "We also suggest that it is reasonable to hypothesize that silvery minnows do not require fine textured bottom sediment for their survival." Since the reach of the Chama upstream of Abiquiu Lake has limited fines in the bed, we conclude that this section includes an important discussion point on fine sediment.

FWS Comment 22; Section & Page #: 3-38, 7

I disagree with several statements in this paragraph regarding macroinvertebrate density and size. The authors' statement of "a relatively low density of benthic macroinvertebrates" following qualitative "best rock" observations is premature. Please be aware that the time of year these observations were made (mid-summer) is the time of year when most aquatic macroinvertebrates are in the adult/egg/very early instar phases of their life cycles. For this reason, it should not be surprising to not encounter high numbers of large-instar larvae when examining cobbles. Additionally, picking up cobbles is an incomplete and biased sampling methodology. While some macroinvertebrates cling to cobbles in lotic-erosional habitats, many more are likely to be found inhabiting the interstitial spaces where detritus accumulates and sheering flows are absent. The authors did well to clearly state that their methods were qualitative, but these caveats should be acknowledged. Finally, it is stated that few macroinvertebrates were observed that were greater than 0.5 inches in length. The authors don't explain why this number is significant and only allude that the small size of macroinvertebrates observed suggests suppressed benthic productivity. This is misleading and confusing.

Response 22:

We do agree with the main point of this comment, that the information on the invertebrate community dynamics along this reach of the Chama are poorly characterized, and our brief visit along the river also provided an inadequate snapshot of these conditions. Our field observations and their interpretation are presented with recommendation for further study. The final conclusion of importance that we present in this section states: "In summary, if silvery minnow introduction to this sub-reach were seriously considered, we suggest pre-introduction studies would be necessary to assess the potential impacts of summer boating releases on potential displacement of silvery minnows and on benthic productivity."

FWS Comment 23; Section & Page #: 4-38, Reach Length

$v = Q/A$. Is the assumption that doubling a wetted cross section would result in halving potential downstream displacement distance of silvery minnow egg and larvae based on a study? The transport distance of particles in a river is obviously more complex than what is stated. If the majority of eggs and larvae are located in the thalweg (an observation made during silvery minnow egg collections in recent years by Chris Altenbach, formerly Albuquerque Biological Park fish curator) then this assumption is wrong, because most eggs would be transported rapidly downstream, especially in a narrow, 13 mile river section.

Response 23:

Flow of particles in river channel is more complex than the simple relationship indicates, as discussed in the report. We have not previously seen the unpublished observations from Altenbach. Nevertheless, the section and its conclusion are appropriate as written: "Clearly more study would be required to validate these hypotheses, but until performed, we cannot conclude that reach length is a critical limiting factor for silvery minnow in the Upper Chama Sub-Reach."

FWS Comment 24; Section & Page #: 4-41, Reach Length

Again the authors are ignoring the best available science by stating that "we cannot conclude that reach length is critical limiting factor for silvery minnow" Peer reviewed research (Dudley and Platania 2007) has shown that reach length is **one of the most critically limiting factors for persistence of broadcast (pelagic) spawning cyprinids in modified rivers**.

Response 24:

Dudley and Platania (2007) provide some of the available, but not necessarily all of the "best available science." Specifically, as they acknowledge, their analysis and presentation is incomplete. They "acknowledged that physical habitat restoration (e.g., destabilizing banks and reconnecting rivers with floodplains) 'would likely decrease the transport distance of ichthyoplankton [i.e., silvery minnow larvae in the water column, clarification added], further studies will be required to determine how much drift distance would be reduced as a function of flow or habitat modification.'" Some such studies have been completed, as indicated our report's text, which support hypotheses that differ from those presented in Dudley and Platania (2007). These results are reflected in the discussion presented the report. While this information has not yet been published in the literature, it is available in the reports cited and through personal communication with the authors. It is important, here, to recognize that the publication by Dudley and Platania (2007a) is an extended discussion and set of analyses based on one set of possible hypotheses related to the basis for the spawning strategy evolved by silvery minnow. It is one set of many interesting hypotheses being considered. Their discussion does not build from observed drift distances for actual silvery minnow eggs. Instead, it builds from some of the bead drift studies conducted along the MRG. Results from other studies are available that are not included in their discussion. For example, cited reports available from Reclamation tend to point to conclusions different from those of Dudley and Platania (2007a). Of particular importance, while there have been many collections of silvery minnow eggs in the channel, silvery minnow have never been observed spawning in the wild, as emphasized in comment 19, above. Additionally, the hypotheses developed and described by Dudley and Platania (2007) include the requirement that silvery minnow have the inherent tendency and ability to move upstream following their long-distance downstream displacement of eggs and larva after spawning. While the information we summarize in the report on swimming ability indicates they do have the ability, available information does not support the hypothesis that this species has the tendency. For example, a recent report from the FWS to the Program describes that less than a half percent of the tagged silvery minnows released completed fish passage, either from upstream or downstream release sites, through the fish passage facility around the City of Albuquerque's water diversion; one would expect a much greater passage based on random occurrences only. The very low percentages in the reported numbers would more support the conclusion that silvery minnow have a marked tendency to stay more or less where they are. Thus, these data provide support for potentially rejecting the hypothesis of Dudley and Platania (2007a); but this dataset has limitations. So, additional research continues to be needed to evaluate among the available hypotheses. Our intent in the report's discussion is to provide a complete set of available information and hypotheses for the reader.