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Managing Water in the West

Middle Rio Grande River Maintenance Plan Summary—Part 1 Report

Middle Rio Grande Project, NM
Upper Colorado Region

U.S. Department of the Interior
Bureau of Reclamation
Albuquerque Area Office, Albuquerque, New Mexico
Technical Service Center, Denver, Colorado

May 31, 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Upper Colorado Region

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Acronyms and Abbreviations

BiOp	2003 Biological Opinion
CWA	Clean Water Act
Collaborative Program	Middle Rio Grande endangered Species Act Collaborative Program
Compact	Rio Grande Compact
Corps	United States Army Corps of Engineers
ESA	Endangered Species Act
FWCA	Fish & Wildlife Coordination Act
GRF	Gradient Restoration Facility
LFCC	Low Flow Conveyance Channel
NEPA	National Environmental Policy Act
Maintenance Plan	Middle Rio Grande River Maintenance Plan
MBTA	Migratory Bird Treaty Act
MRGCD	Middle Rio Grande Conservancy District
NEPA	National Environmental Policy Act
NMISC	New Mexico Interstate Stream Commission
Program	Middle Rio Grande River Maintenance Program
Project	Middle Rio Grande Project
Reclamation	Bureau of Reclamation
RGSM	Rio Grande silvery minnow
Service	United States Fish and Wildlife Service
SRH-SIAM	Sedimentation and River Hydraulics Sediment Impact Analysis Methods
SWFL	Southwestern willow flycatcher
TSC	Technical Service Center
TSD	Technical Services Division
URGWOPS	Upper Rio Grande Water Operations

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1.0 Introduction

Prior to significant man-made modifications, much of the Middle Rio Grande was unable to transport all the sediment entering the channel, causing the riverbed to aggrade and on occasion shift across the floodplain with high flow events. This condition caused severe flooding, loss of water, damage to riverside facilities, and the loss of productive farmlands due to high water tables. This led to the Flood Control Acts of 1948 (P.L. 80-858) and 1950 (P.L. 81-516) which established the Middle Rio Grande Project (Project) and under which the Bureau of Reclamation (Reclamation) is authorized to perform maintenance of the Rio Grande channel and the Low Flow Conveyance Channel (LFCC).

The authorized maintenance goals for the Middle Rio Grande Project have evolved over time and include:

- **Provide for effective transport of water and sediment to Elephant Butte Reservoir**
- **Conserve surface water within the Middle Rio Grande Basin**
- **Protect riverside structures and facilities**
- **Reduce and/or eliminate aggradation in the Middle Rio Grande**
- **Reduce the rate of channel degradation from Cochiti Dam south to Socorro**
- **Provide habitat improvements for Endangered Species Act (ESA)-listed species within the Project area.**

The first four goals are from the original Middle Rio Grande Project authorization. The fifth goal is a result of the changing sediment regime of the river, while the sixth comes from federal responsibilities under the 1973 Endangered Species Act. An international treaty with the Republic of Mexico for delivery of water affects the Project, as does the 1939 Rio Grande Compact, which regulates the distribution of Rio Grande water among the states of Colorado, New Mexico, and Texas. Consequences of not performing essential maintenance include substantial damage to riverside facilities, loss of water, and loss of endangered species habitat. This Part 1 report summary contains discussions pertaining to the entire Maintenance Plan. This information is intended to help the reader grasp the Maintenance Plan as a whole to better understand the Part 1 Report and preview Part 2.

1.1 Purpose and Scope of the Middle Rio Grande River Maintenance Plan

The Middle Rio Grande River Maintenance Plan (Maintenance Plan) serves as a guide for Reclamation's future river maintenance activities within existing federal authorization. The Maintenance Plan supports compliance with applicable laws and regulations, including the National Environmental Policy Act (NEPA) and the Endangered Species Act. The Maintenance Plan is intended to help make informed decisions on future river maintenance program (Program) activities and is being developed and documented in two parts.

The Part 1 report describes the Program and its needs and benefits and includes a review of the Program authorization, the current conditions of the river, and how environmental laws have been integrated into river maintenance activities. It is based on existing information. The Part 2 report will incorporate available results from ongoing studies to help guide Program decisions for future analyses, data collection, and maintenance practices including environmental compliance needs. Potential new maintenance strategies and methods will be identified and assessed at an appraisal level for applicability. Strategies could include altering, reducing. or discontinuing current maintenance practices to better manage aggradation, degradation, high flows (within Reclamation's authorization), bank erosion, and to improve endangered species habitat.

The two combined parts of the Maintenance Plan are envisioned to be an engineering and geomorphic review to help implement the most cost effective and environmentally sound strategies that potentially reduce Reclamation's long-term commitment of resources. This plan for river maintenance uses and builds on information from past and ongoing studies associated with the Middle Rio Grande.

1.2 Maintenance Plan Approach

The Middle Rio Grande is a complex and changing river system which presents many maintenance challenges. For example, the rapidly migrating bend in Figure 1 is the middle bend in a series of three migrating bends. The yellow arrow points to the same cluster of trees in 2000, 2002, and 2005 which are gone by 2006. The pink arrow points to the approximate location of the 2006 bend apex in all years. This bend is only one example of a series of fast changing bends in the recently incised reach downstream of San Acacia Diversion Dam that threaten the LFCC levee to the west.

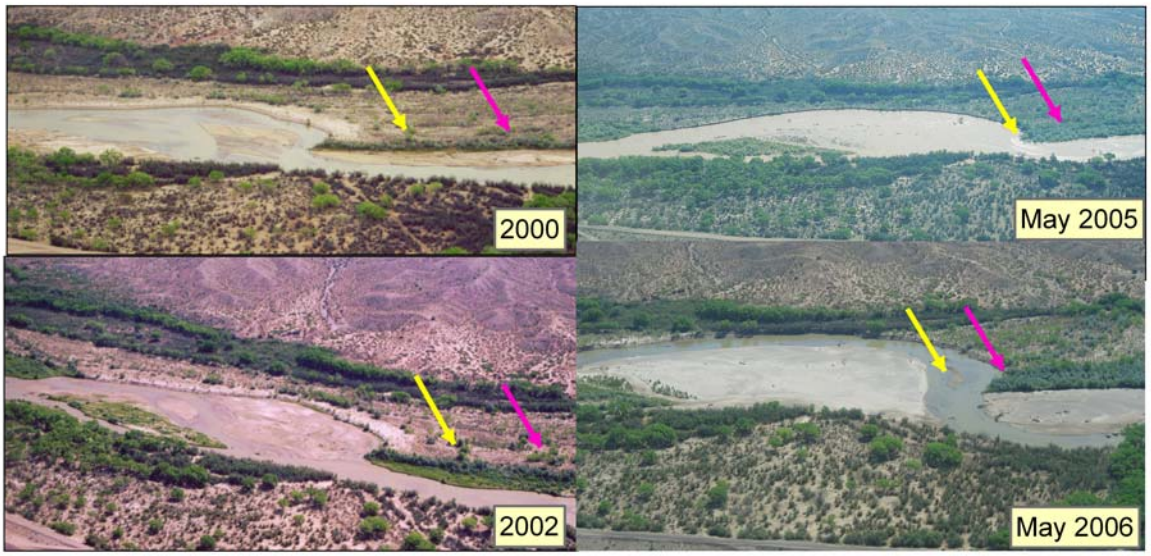

Figure 1. Rapidly migrating bend at River Mile 110. (Flow is left to right.)

To help manage this dynamic river, the Maintenance Plan is based on a systematic approach to meet the river maintenance goals listed in the Introduction. Four main steps are used to guide the Maintenance Plan's development and implementation.

- **Describe and understand the river conditions.**

A reach-based conceptual model of how the Rio Grande works is under development to help evaluate existing and proposed methods and strategies to meet Program goals. This should reduce emergency maintenance actions, where possible, by using strategies and methods that work with the expected tendencies of the river. Reaches were designated based on changes in hydrology, river planform, slope, sediment size, channel capacity, biological needs, and institutional needs.

- **Evaluate information needs.**

Additional information needed to adequately characterize and describe existing and future Middle Rio Grande geomorphology, water delivery, infrastructure, policy, and land use for river maintenance activities has begun to be identified and described. Additional information may also be needed to adequately assess proposed maintenance strategies and methods.

- **Outline a comprehensive management approach.**

The Maintenance Plan will document the strategy and methods evaluation and provide recommendations and guidelines for implementation of long-term and emergency activities. Informal coordination with key stakeholders during development will help ensure the Maintenance Plan is compatible with other plans in the basin. The resulting Maintenance Plan will incorporate the evaluation of maintenance needs based upon estimates of future river conditions and constraints.

- **Assess the strategies and methods applied.**

It is essential to incorporate feedback into implementing the Maintenance Plan. Strategies and methods used will be evaluated for applicability on a reach scale and in specific situations. The Maintenance Plan will then be updated with lessons learned about strategy and method selection and adaptive management practices in future editions.

As the Rio Grande is an evolving river system, the Maintenance Plan needs to be updateable with new information and changing conditions. Future river maintenance needs will be affected by modifications in runoff, water operations, and sediment regime; continuing channel evolution; the pace and type of maintenance activities implemented; and changing ESA and environmental needs. Trends in these variables are used to plan and prioritize maintenance activities. The Maintenance Plan is flexible enough to take advantage of advances in strategies and methods to improve river maintenance practices to manage this very dynamic river. The initial Maintenance Plan will be completed by the end of FY 2008. It is expected the Maintenance Plan will be reviewed every 5–10 years for possible revision or as significant changes in any of the key reach evaluation areas occur.

1.3 Maintenance Plan Objectives

A comprehensive, economical, effective, and ecologically sound Maintenance Plan is achieved through the following general objectives:

- Review of historical and current river conditions and maintenance practices
- Review of previous data collections and analyses
- Projections of future river conditions, trends, and priority sites
- Assessment of both short term and long term strategies
- Development of future monitoring, data collection, and analyses plans

These are further defined into specific tasks for each part of the Maintenance Plan as listed below.

Part 1—Current Maintenance Strategies & Needs

- Provide overview of Project authority and Program benefits
- Review past and current maintenance methods
- Describe current and historical river and LFCC conditions and changes and begin development of a conceptual model
- Describe river and LFCC alignment strategies downstream of San Marcial Railroad Bridge
- Describe environmental considerations for river maintenance
- Describe stakeholder needs
- Describe potential maintenance strategies

Part 2—Future Conditions & Maintenance Strategies

- Evaluate population growth, land, and water use trends
- Develop methodologies to avoid, minimize, and mitigate impacts, as well as to rehabilitate or create endangered species habitats
- Discuss land ownership and access requirements as they relate to river maintenance activities on the Middle Rio Grande
- Develop new river maintenance methods and strategies
- Use the conceptual model and hydraulic and sediment models to estimate future conditions
- Estimate future river maintenance requirements
- Describe most effective maintenance strategies and methods
- Identify preferred strategies, methods, and decision process
- Develop the Maintenance Plan and report

2.0 River Maintenance Program

2.1 Historical Program

Maintenance practices have evolved since the original Project channelization in the 1950s and 1960s. The first phase (project inception to mid-1980s) involved maintaining channelized areas in their constructed configuration through pilot channeling, floodway clearing, jetty installation, and sediment removal above Elephant Butte Reservoir. The

second phase (mid-1980s to late 1990s) involved strategic bank stabilization and excavation of temporary channels into Elephant Butte Reservoir. The river channel was no longer maintained as originally constructed and was allowed to migrate.

Environmental laws (e.g., Clean Water Act [CWA] and NEPA) as well as the cost effectiveness of maintaining the original channelization factored into these maintenance practices. The third phase (late 1990s to present) of maintenance practices involves a holistic process-based, reach-wide approach that also incorporates habitat protection and enhancement. These approaches entail meeting the requirements of the ESA for the Rio Grande silvery minnow (RGSM) and the southwestern willow flycatcher(SWFL). These practices are included in the 2003 Biological Opinion (BiOp). This Maintenance Plan includes these types of maintenance practices and seeks potential new strategies.

2.2 Decision Process for Determining River Maintenance Requirements

River Maintenance needs and priorities are largely identified through the Middle Rio Grande Priority Review Methodology and database. A river maintenance *priority site* is defined as a site at which one or more of the following conditions exist and could be addressed by authorized river maintenance activities:

- The continuation of current trends of channel migration or morphology will likely result in damage to riverside infrastructure within the foreseeable future
- Similar conditions have historically resulted in failures or near failures at flows less than the 2-year flood
- Existing conditions could cause significant economic loss, danger to public health and safety, or loss of water

Priority sites are ranked based upon the anticipated rate of change and the significance of the threatened riverside infrastructure relative to other priority sites. Decisions about undertaking river maintenance activities at each site are documented. Reclamation's Albuquerque Area Office continually updates and maintains the priority site databases through a review process by a Priority Site Assessment Team. Continual monitoring and inspection of channel conditions provide a sound method for field identification of river maintenance projects and activities. River Analysis studies provide additional information for evaluating the time for problem development, channel stability, and level of river maintenance that is necessary. These studies and analyses add value due to their forecasting and predictive capabilities which provides for proactive river maintenance work that addresses problems before emergencies or more costly maintenance repairs are necessary.

River maintenance project and activity decisions are also based on Area Office policy and priorities that may be associated with requests for work or assistance by our stakeholders. Reclamation management may determine that river maintenance projects and activities for assistance to stakeholders is a high priority. Decision making for river

maintenance projects and activities also involves considerations for whether the work is within Reclamation's Middle Rio Grande Project authority and responsibility or if the work is the responsibility of others.

2.3 Requirements of the River Maintenance Program

The Program has evolved to accommodate Reclamation's increased responsibility for environmental protection to comply with the NEPA and the regulatory requirements resulting from the presence of endangered species. Along with these new responsibilities, Reclamation's responsibilities for erosion protection, limited flood control, and water delivery continue unabated. The combination of immediate project-specific requirements and long term strategy and methods requirements necessitates several components for the Program.

- **River Data Collection**

Long-term data collection is necessary for monitoring changes in river bed elevation and slope, channel position, width, depth, flow velocity, sinuosity, channel capacity, sediment transport capacity, and bed material and suspended sediment loads and sizes. This type of data collection supports trend analysis and future projections of geomorphic conditions, sediment transport, and hydraulic geometry. Methods include hydrographic data collection (river cross sections, sediment sampling, gage data, Modified Einstein Procedure sediment discharge measurement, etc.), surveying, controlled aerial photography, and other remote sensing activities. These types of data also support design and analysis work for specific maintenance site projects. Individual project data collection typically involves controlled aerial photography, river cross sectional data, sediment bed material size, and topographic surveys for specific maintenance site work planning, design, environmental compliance, and maintenance implementation.

- **Geomorphic Analysis**

Geomorphic analysis provides the underpinnings of a conceptual model of the physical processes at a reach scale and supports trend analysis to plan for river maintenance needs. Detailed analysis at each priority site is necessary to plan and design maintenance strategies that maximize long-term sustainability while minimizing cost and future maintenance needs.

- **Hydrologic, Hydraulic, and Sediment Transport Modeling and Analysis**

These modeling and analysis efforts are necessary to estimate flood frequency for design flows for the Rio Grande, tributaries, and structures. They help define the necessary current and future channel capacity for the safe passage of the mean annual flood and water delivery. Hydraulic and sediment modeling of river maintenance designs and implementation maintenance helps to improve designs, minimize maintenance requirements, and evaluate the effects of proposed project options on channel stability

and capacity.

- **Planning and Maintenance Design**

Planning and designing projects are a major component of the Program. The multidisciplinary approach in the 2004 Memorandum of Coordination for River Maintenance and Restoration Activities for the Middle Rio Grande Project prescribes coordination with other divisions. See sections 2.4, 2.5, and 3.3 of this summary for more information. Projects are designed using a reach-based approach that accounts for fluvial processes and geomorphic trends while considering the needs of endangered species.

- **Environmental Compliance and Analysis**

Each river maintenance project must comply with the federal laws listed in section 2.5 of this summary. In addition, archaeological clearance must be received from the New Mexico State Historic Preservation Office. Projects are designed to have habitat enhancement features to provide a net positive benefit to listed species. A viable maintenance program ensures the compatibility between river maintenance and habitat restoration goals, resulting in greater project benefits that meet both Reclamation's purpose and mission and environmental requirements.

- **Maintenance Implementation and Operations**

Implementing river maintenance projects is a significant part of the Program and the end result of the above components. Reclamation's Socorro Field Division performs maintenance implementation. River maintenance projects may involve river bank protection/stabilization, river bed/grade stabilization, channel and levee re-alignment, pilot channel excavation, sediment removal, levee repair and rehabilitation, and/or vegetation clearing and installation. Operational considerations for the Middle Rio Grande Project involve the nearly 50 miles of the LFCC (including its diversion headworks and outfall) and levee system.

- **Monitoring and Adaptive Management**

Adaptive management is a systematic process to achieve the best decisions possible in the face of uncertainty using monitoring as an input. Documenting the project objectives, process, predicted results, and actual results is necessary to understand which activities work (or do not) and why. The *why* is important because success or failure can result from factors such as incorrect assumptions, poorly implemented designs, changing conditions at the project site, flawed monitoring, or any combination of these factors. This information is essential to improve on the next project or to repeat the success.

2.4 Program Capabilities

The Albuquerque Area Office Manager and Assistant Area Managers provide guidance and direction to the River Maintenance Program in programmatic aspects such as

Reclamation Policy, Budget Formulation, Stakeholder Collaboration, and River Maintenance work priorities. The Technical Services Division (TSD) provides overall leadership, Program management, development, and coordination of river maintenance activities. The TSD River Analysis Group performs necessary design work and analysis for river maintenance projects. The Environment Division provides the necessary biological analysis for each project, which often includes developing mitigation and/or enhancement features during project design. This Division is responsible for all regulatory environmental compliance activities. The Facilities and Lands Division Realty staff provide the necessary lands analysis, review, approval, clearances, and instruments for each project. The Water Management Division is responsible for daily water operations for Reclamation facilities in coordination with other Federal, State, Tribal, and local stakeholders. The Program Management Group is a subgroup that provides planning support and resource management analyses for existing and new projects and operations. The Socorro Field Division performs operations and maintenance functions for the river and LFCC, specializing in river maintenance and construction. The Area Office Divisions participate on project teams in planning and implementing river maintenance projects.

The Technical Service Center (TSC) in Denver provides technical support to the Program. Activities include river hydraulics, sediment transport, channel migration and geomorphic process modeling, and analysis of the river channel system for long-term trends and in response to river maintenance activities.

2.5 Environmental Compliance

The Program coordinates maintenance activities and projects with the Environment Division. The project's size and environmental impacts essentially determines the compliance level and work effort needed for successful project completion. The following federal laws need to be incorporated into planning maintenance activities for environmental compliance:

- NEPA—National Environmental Policy Act
- ESA—Endangered Species Act
- CWA—Clean Water Act
- MBTA—Migratory Bird Treaty Act
- FWCA—Fish & Wildlife Coordination Act

Recent river maintenance projects have been designed to address habitat needs (see sections 1.3 and 2.1 of this summary) as well as erosion problems. Levee setback, a method in which the levee is relocated away from the point of erosion in the channel, was used at the Santa Fe River Confluence and the San Acacia River Mile 113 and 114 priority sites (Figure 2). This technique improves habitat by increasing the area of the floodplain and provides greater latitude for fluvial processes.

Figure 2. Levee setback at River Miles 113 and 114.

The Santa Ana and La Canova priority site projects (Figure 3) included a bio-engineered bankline consisting of a rock toe and several layers of coir fabric encapsulated soil planted with native vegetation. The native vegetation provides wildlife habitat and increases soil stability as the plants mature. At Santa Ana, the rock toe of the bio-engineered bankline was sized to be mobile at very high flows, allowing the channel dimensions to naturally adjust to the hydrology with vegetation and newly established floodplain providing protection to previously threatened riverside facilities.

Bendway weirs were employed at the Bernalillo and Sandia priority sites, as well as at Williamsburg Bend, which is south of Truth or Consequences. These structures stabilize the bankline by redirecting flow and also improve fish habitat by providing diverse hydraulic conditions along the bankline.

Figure 3. Bioengineered bankline at La Canova

3.0 Roles and Activities of Reclamation and Other Agencies

3.1 Middle Rio Grande Project

The major features of the Middle Rio Grande Project are large dams to provide flood control and reduce the sediment load in the Rio Grande; Rio Grande rectification (channel reconstruction) and maintenance to reduce aggradation, improve water delivery, and protect valley infrastructure; rehabilitation of the irrigation and drainage system; levee construction or rehabilitation or both; and establishment and maintenance of a cleared floodway and conveyance channel into Elephant Butte Reservoir.

Project components are assigned to Reclamation, United States Army Corps of Engineers (Corps), and Middle Rio Grande Conservancy District (MRGCD) in the U.S. House of Representatives Documents P.L. 80-858 and P.L. 81-516, and a clarifying agreement between the Secretary of the Army and the Secretary of the Interior as follows:

- The following activities are assigned to Reclamation:
  - El Vado Reservoir improvements
  - Channel rectification and maintenance
  - Irrigation and drainage rehabilitation and extension
- The following activities are assigned to the Corps:
  - Abiquiu Reservoir construction
  - Jemez Canyon Reservoir construction
  - New levee construction and improvement for local flood protection
- The following activities are performed by MRGCD:
  - MRGCD is required to “maintain throughout the Rio Grande Conservancy District the existing levees and new levees constructed as a part of the Rio Grande floodway project”
  - MRGCD’s maintenance responsibility does not include “channel maintenance, which is considered to be a Federal responsibility”
  - Currently, MRGCD pays Reclamation to maintain reserved works (i.e., El Vado Reservoir and selected jetty installations)

3.2 Land Acquisition and Access

The Facilities and Lands Division must be involved in all project phases regarding any planned maintenance activity on the Middle Rio Grande Project. This provides a degree of assurance that Reclamation’s interests are protected through the proper acquisition and documentation of legal and physical access for planned and necessary maintenance activities.

3.3 Interagency Coordination

The Program at both the programmatic and individual project level coordinates with stakeholders on the variety of technical issues that can affect Program activities. The degree and type of coordination varies depending on the nature of the river maintenance

project, the extent of river affected, land ownership, permitting needs, and environmental compliance issues. Coordination efforts are dynamic and ongoing and the details vary by project and agency. The involvement in coordination efforts also varies with Reclamation's priorities as an agency. Reclamation's authorized river maintenance activities within the Project area require that Reclamation coordinate with agencies, programs, and entities identified as stakeholders. Major examples are listed below:

- **Reclamation Programs**

Reclamation is the agency charged with administering the Middle Rio Grande Endangered Species Act Collaborative Program (Collaborative Program). The Collaborative Program is a congressionally sponsored program which includes a number of participating federal, state, and tribal agencies and other stakeholders. The goals of the Collaborative Program include:

- Protect and improve the status of listed species in the Middle Rio Grande with emphasis on RGSM and SWFL

- Simultaneously protect existing and future water uses by evaluating and developing mechanisms for making water available for ESA purposes while protecting existing uses

- Achieve these objectives while complying with Federal and State law, including compact delivery obligations

Other programs include Water 2025, which aims to reduce conflict between competing water uses, and Title XVI, where Reclamation may conduct feasibility studies on and contribute matching funds for water reclamation and reuse projects. Water operations is another Reclamation function that affects the quantity and timing of river flows. (See section 3.4 of this summary.)

- **Corps Programs**

The Corps is authorized to carry out civil works water resources projects for navigation, flood damage reduction, and ecosystem restoration, as well as storm damage reduction, hydroelectric power, environmental infrastructure, recreation, and water supply. Under its Regulatory Program, the Corps and the Secretary of the Army must approve plans for the construction of any dam or dike across any navigable water of the United States.

Within the Middle Rio Grande valley, the Corps operates four flood control dams on the main stem or major tributaries. The Corps also conducts planning studies; constructs flood damage reduction projects including stream bank erosion protection, channel modification, and levee projects; and issues regulatory permits under Section 404 of the Clean Water Act.

- **MRGCD Programs**

MRGCD was created for such purposes as irrigation and agricultural development, flood control, stream regulation, drainage, and construction and maintenance of distribution facilities for irrigation waters. MRGCD has responsibility to maintain levee structures both under the Flood Control Acts of 1948 and 1950, and as the local sponsor under the Water Resources Development Act of 1986.

- **New Mexico Interstate Stream Commission (NMISC)**

The NMISC has broad powers to investigate, protect, conserve, and develop New Mexico's waters including both interstate and intrastate stream systems. New Mexico is a party to eight interstate stream basins and authority includes negotiating with other states to settle interstate stream controversies.

- **United States Fish and Wildlife Service (Service)**

The Service's mission is, working with others, to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Among its key functions, the Service enforces federal wildlife laws, protects endangered species, manages migratory birds, restores nationally significant fisheries, and conserves and restores wildlife habitat such as wetlands.

- **Pueblos and Tribes**

The river has special cultural and religious significance that should be considered when undertaking river management activities including considerations for maintaining water quality appropriate for ceremonial use. The Pueblos are also engaged in improving riparian habitats along the river corridor. With respect to water use decisions, the Pueblos may significantly affect irrigation water management, as they hold priority water rights. Reclamation cannot collect data or perform river maintenance work on Pueblo lands without obtaining permission from the Pueblo's government.

Indian trust assets are legal interests in property held in trust by the United States for Indian tribes or individuals. This trust responsibility requires that all Federal agencies, including Reclamation, take all actions reasonably necessary to protect trust assets.

- **Local Agencies and Organizations**

Local agencies and organizations include flood control authorities, acequias, and groups such as Save Our Bosque.

3.4 Upper Rio Grande Water Operations (URGWOPS)

The Final Environmental Impact Statement for the Upper Rio Grande Water Operations Review was published in April 2007. The location and operating agency of each facility are identified in the FEIS. The preferred alternative includes:

1) Considering Heron Reservoir waivers to September

2) Considering up to 180,000 acre-feet of conservation water storage in Abiquiu Reservoir
3) 1,800 cfs safe channel capacity below Abiquiu Dam
4) 10,000 cfs safe channel capacity below Cochiti Dam
5) Continued operations of the LFCC as a passive drain with zero cfs diversions from the Rio Grande.

Reclamation issued a Record of Decision in July 2007 implementing Heron Reservoir waivers and operation of the LFCC as a drain.

River maintenance activities that alleviate or eliminate discharge bottlenecks and facilitate higher peak releases from Cochiti Dam are beneficial to SWFL, RGSM, and bald eagles. Although it is impossible to remove all constraints at once, incremental increases in peak discharges from Cochiti Dam can be realized if Reclamation's river maintenance program continues to identify and resolve potential constraints though a priority-based management strategy. Conversely, Reclamation's river maintenance program should not allow local river conditions to deteriorate to the point that reservoir releases are further reduced.

4.0 River Conditions

Much of the 270-mile-long of Middle Rio Grande river channel (Velarde to Caballo) is no longer flooding and aggrading, but the channel is evolving at a rapid rate with incision and narrowing. Figure 4 shows the eleven separate reaches that have been defined to facilitate selection of maintenance strategies and methods. Reach definition is based on differences in hydrology, river planform, slope, sediment size, channel capacity, biological needs, institutional needs, and other factors. Table 1 summarizes the factors for each reach and helps illustrate the wide variety of reach conditions. Many reaches are at different stages of evolution and each has distinct factors affecting the current geomorphology.

4.1 Geomorphology

In recent times (late 1990s to 2005), the Rio Grande watershed has been in a regional drought. This major reduction in water supply and peak flows caused the river to narrow, mostly through the colonization of active bars with vegetation. In 2005, the spring snowmelt runoff was above normal but found a river with stable bars and banklines. The Rio Grande has responded to this in a variety of ways; in those sections that had extensive island growth and stabilization during the drought, the river has narrowed, deepened, and abandoned all but a single dominant channel. This narrowing may indicate a future increase in river maintenance sites because of the long recognized relationship of meander wavelength generally equal to 10–14 times channel width. In other words, the number of meander bends per river mile increases with decreasing channel width and thereby increases the number of potential maintenance sites.

In areas where a single channel already existed and bank-attached bars had stabilized with vegetation, the channel has begun to migrate, especially where incision is deep enough to allow flow beneath the bankline root zone. Lateral migration and incision

occurred with the July through October 2006 monsoon rains, which usually occur with the spring runoffs. These changes in the channel morphology and physical processes demonstrate the speed at which change occurs in the MRG and help explain the rapid increase of river maintenance sites of concern throughout the management area. Along with these highly visible changes, the bed sediments are coarsening throughout most of the watershed, thereby changing the governing processes for sediment transport and contributing to bank erosion and meander development and other in-channel processes. This complex and changing river system presents many maintenance challenges. At this time, maintenance activities are not performed in White Rock Canyon reach and the Elephant Butte Reservoir.

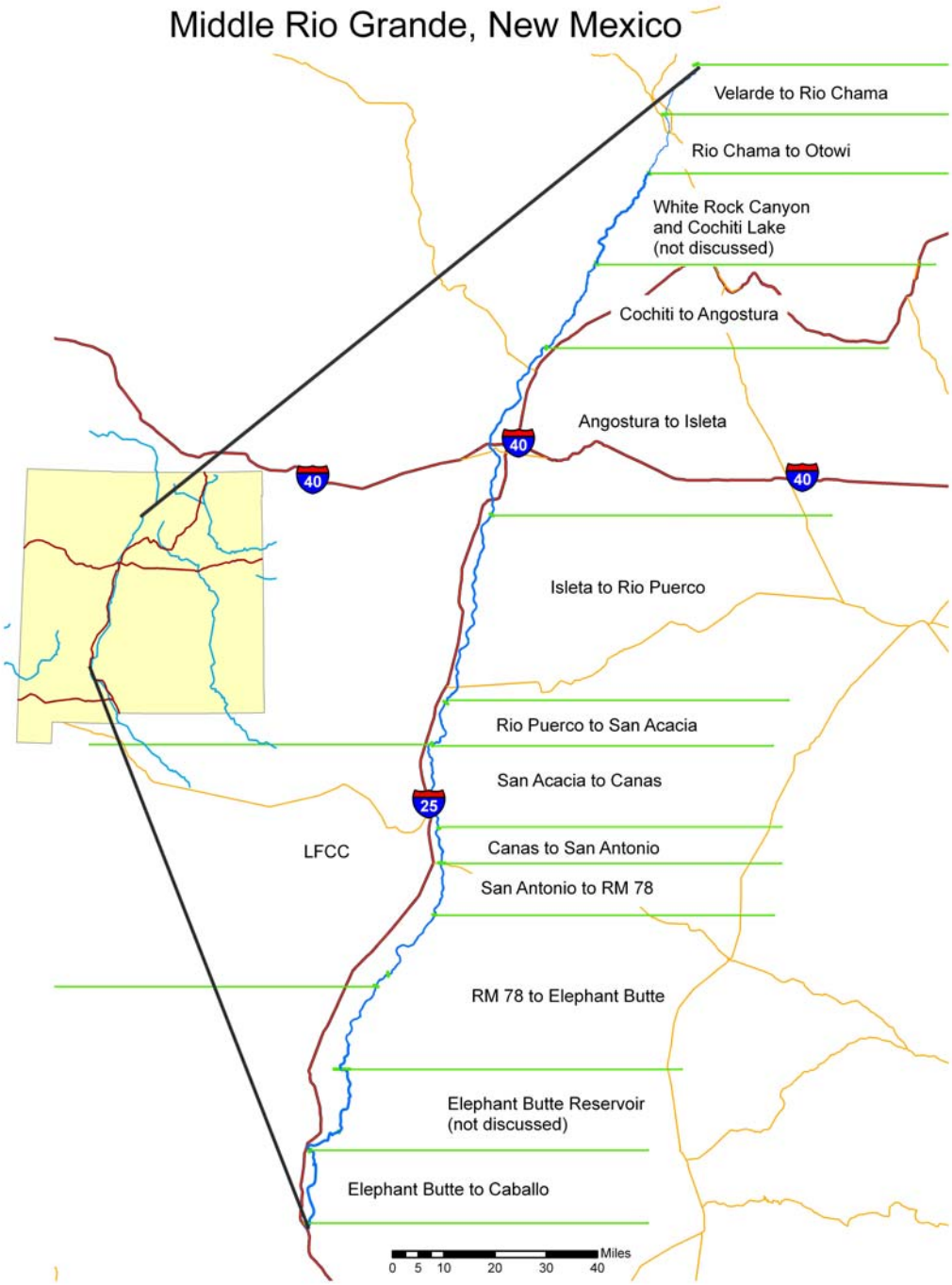

Figure 4. Reach Locations

Table 1 Reach Characteristics

Reaches	~River Miles	Ave width (feet)	Planform	Bed material type	Vertical	SWFL/ RGSM	Existing Trend	Maintenance Options
Velarde to Rio Chama	285 to 272	210[a]	Low sinuosity, single channel	Gravel & small cobble	Low incision	SWFL - low recruitment	Little change	Widen riparian corridor
Rio Chama to Otowi	272 to 258	370[a]	Low sinuosity, single channel	Gravel & coarse sand	Moderate incision	migrating SWFL	Some active bends	Widen riparian corridor Monitor bends Discourage gravel mining
Cochiti to Angostura	233 to 210	260[b]	Moderate sinuosity, single channel, with islands	Gravel & small cobble	Moderate incision, currently stable	migrating SWFL	Lateral erosion, several bankline erosion sites	Lower terraces Bank stabilization
Angostura to Isleta	210 to 169	440[b]	Transition from wide braided to single channel	Sand changing to gravel	Moderate incision – greater upstream	Recruitment: SWFL none RGSM at >2000 cfs	Continued incision, narrowing, & coarsening	Monitor bends Lower terraces Bank stabilization Grade control Island destabilization
Isleta to Rio Puerco	169 to 127	380[b]	Braided but narrowing	Sand	Low incision increasing to high downstream	Recruitment: SWFL low RGSM at >1500 cfs	Potential to become unstable	Monitor Grade control now?
Rio Puerco to San Acacia	127 to 116.2	245[b]	Single thread with few islands, narrowing	Bimodal gravel & sand	Entrenched with low bank height	Recruitment: SWFL good RGSM low at >2000 cfs	Potential for migration	Monitor Changes in San Acacia operations
San Acacia to Arroyo Canas	116.2 to 95	310[b]	Single channel -low to moderate sinuosity	Bimodal gravel & sand	High incision, decreasing downstream	migrating SWFL RGSM low recruitment at > 1000 cfs	Large rapidly migrating bends	Levee setback Direct river to east Constructed logjams Terrace lowering

Reaches	~River Miles	Ave width (feet)	Planform	Bed material type	Vertical	SWFL/ RGSM	Existing Trend	Maintenance Options
Arroyo Canas to San Antonio	95 to 87.1	375 [b]	Becoming single threaded	Sand	No recent incision	Good RGSM recruitment at >1000 cfs	Fairly stable	Monitor
San Antonio to RM 78	87.1 to 78	295 [b]	Braided but narrowing	Sand	Slightly aggrading	Recruitment: SWFL low RGSM good (with pumping)	Continued narrowing	Monitor Proactive grade control?
RM 78 to Elephant Butte Reservoir*	78 to 50	140 [b]	Narrow single thread	Sand	Generally aggrading	Recruitment: Good SWFL Poor RGSM habitat	Recent headcut & lateral migration	Temporary channel Realign river to west
Elephant Butte to Caballo Reservoirs	50 to 12	130[c]	Narrow single thread with some split channel sections	Mostly sand	Slightly incised	None	Fairly stable	Continue current strategies
Low Flow Conveyance Channel	116.2 to 61.4	N/A	Constructed canal	Sand bed, riprap side slopes	LFCC bed stable and usually below river at lower end	SWFL and RGSM dependent on LFCC water	LFCC could be reconnected to river due to headcut	No changes –passive drain Reconstruct outfall Realign with river to west

a Bankfull width from 2001 Biological Assessment, b Measured from 2006 aerial photography, c Measured from 2002 aerial photography
* Poor RGSM habitat in RM 78 to 60, fair habitat in Temporary Channel (RM 60 to 50 if point bars not removed)

There are many processes that control changes on the Rio Grande, but four major processes stand out among the changes throughout the Middle Rio Grande:

- Floodplain conversion to terraces
- Active channel narrowing
- Loss of sand on the channel bed resulting in a gravel-dominated bed
- Lateral channel migration

Although recently developed islands and bars are inundated during high flows, the loss of main channel width and the large historical floodplain system indicates a major change in governing processes for the river system. Together, incision, channel migration, planform conversion, and river bed coarsening to gravel are rapidly changing the Rio Grande channel and requiring renewed consideration about appropriate management strategies.

4.2 Infrastructure or Maintenance Activities

Several different man-made influences are present on the Middle Rio Grande. Large scale channelization and irrigation projects began in the 1930s. Most significant are the results of the comprehensive plan for the Middle Rio Grande Project which includes channel rectification and maintenance, reservoir construction, rehabilitation of the MRGCD infrastructure, and other collateral improvements. The initial work on the Project, in the 1950s and 1960s, consisted primarily of river channelization, levee improvements, construction of the LFCC between San Acacia Diversion Dam and Elephant Butte Reservoir, and construction or rehabilitation of Platoro, El Vado, Jemez Canyon, Angostura, Isleta, and San Acacia Dams. Earlier dam construction includes Elephant Butte (1916) and Caballo (1938) dams; later dam construction includes Cochiti (1975) and Galisteo (1970) Dams. There are several diversion dams present in the Velarde to Rio Chama and Rio Chama to Otowi reaches.

Agriculture (including irrigation infrastructure) is present near much of the river as are populated areas (both cities and Pueblos) which were originally located to be near water. Several bank protection projects have been constructed to protect these locations and/or the levees that shield them. These include placement of Kellner jetty jacks, riprap, and most recently using techniques such as bioengineered banklines, flow redirection, and grade control.

4.3 Endangered Species

There are three federal ESA-listed species in the Project area. Two are endangered, the SWFL and the RGSM. Critical habitat is designated for both of these species over much of the area under Reclamation management. Effective August 8, 2007, the bald eagle is removed from the list of threatened and endangered wildlife. While ESA protections are no longer extended to the bald eagle, the species is still afforded protection by the Bald and Golden Eagle Protection Act as well as the Migratory Bird Treaty Act. Physical characteristics of each reach are a major factor in population distribution of the endangered species, but other factors like site fidelity for the SWFL and dispersion rates for the RGSM are also determinants. Habitat improvement occurs through projects

designed for that purpose and through adding features to maintenance projects to provide a net positive benefit to the listed species.

4.4 Maintenance Needs and Strategies

The evolving river morphology is the fundamental cause of numerous river maintenance concerns. In areas where there is a single thread, meandering channel; the tendency for lateral migration is greatly increased, resulting in increased erosional damage to levees and other riverside facilities. The channel narrowing and incision increases average velocity and depth, accelerates bank and toe erosion, and decreases available habitat for endangered species. The benefits of river maintenance include water salvage, effective water delivery to Elephant Butte Reservoir, flood protection, and infrastructure maintenance to protect critical riverside facilities and property. Specific maintenance needs and strategies for each reach are discussed below.

4.4.1 Velarde to Rio Chama Confluence (RM 285 to 272)

This reach has an approximate length of 13 miles and Reclamation is authorized to maintain a channel capacity of 5,000 cfs. The river bed is primarily gravel and cobbles. The reach is generally straight, with extensive historical channelization and bank stabilization. Reclamation monitors and maintains previously placed riprap, dikes, and revetments, with the intent of preventing damage to riverside infrastructure, including eight existing diversion dams. There are some sites in the reach where bank migration could damage irrigation canals and ditches. This potential could be assessed through geomorphic analysis and planform migration modeling.

It would be desirable to increase the width of the floodplain and riparian corridor in this reach, although little progress on this issue is likely to occur because most of the land is privately owned, with active farmland and irrigation infrastructure near the channel. If the landowners were encouraged to help establish a riparian buffer, another agency such as the State of New Mexico, the Natural Resources Conservation Service, acequia commissions, or the Corps would have to oversee the project. SWFL are present in this reach, but no recruitment has been observed recently.

4.4.2 Rio Chama Confluence to Otowi (RM 272 to 258)

This reach has an approximate length of 14 miles. The bed consists of gravel and cobbles, with some sand supplied from the Rio Chama and ephemeral tributaries. Discharge in this reach is significantly higher than in the reach upstream, owing to input from the Rio Chama (including San Juan-Chama water). The main river maintenance need is addressing channel migration in isolated areas. The reach is highly channelized and there are areas of incision, but it has not historically been prone to extensive lateral erosion. In most areas, the width has been relatively constant in recent years, although there are areas where riparian vegetation is encroaching on the active channel. Some portions of the reach are bordered by agricultural and residential development, whereas in other areas the bosque remains in place. If possible, it would be desirable to increase the width of the floodplain and riparian corridor in the Española area (Figure 5). This would allow more space for channel migration and could benefit SWFL. Some SWFL are present in the reach; however, there are no known RGSM.

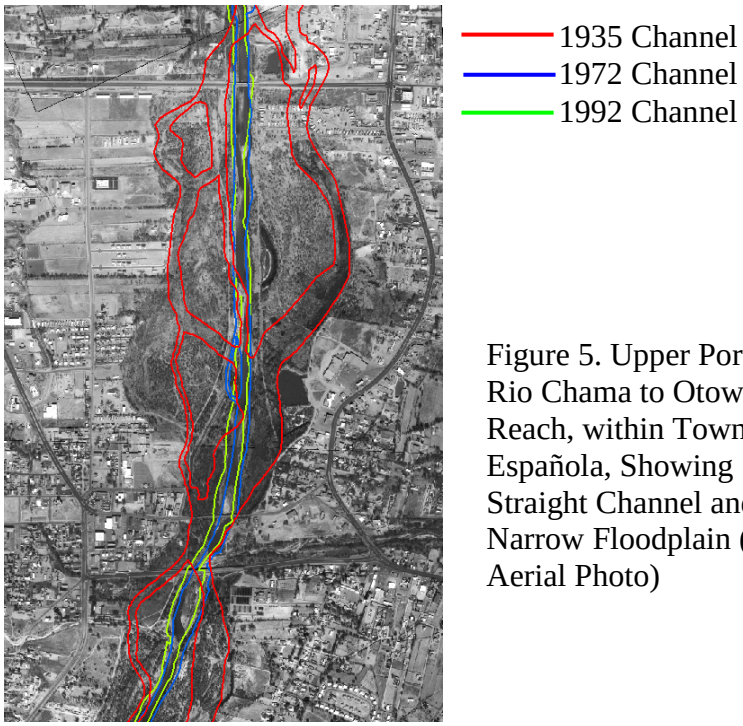

Figure 5. Upper Portion of Rio Chama to Otowi Reach, within Town of Española, Showing Straight Channel and Narrow Floodplain (2001 Aerial Photo)

Within the boundary of Ohkay Owingeh (formerly San Juan Pueblo), there was extensive gravel mining in the 1980s, which resulted in the bed of the river being lowered about five feet and increased channel instability in this area. The resulting bed degradation has progressed upstream since the conclusion of gravel mining operations. The San Ildefonso and Pojoaque Rivers also have geomorphic effects attributable to gravel mining. Future gravel mining in or near the river channel should be discouraged because of its deleterious effect on channel stability.

Erosion protection was planned for the east bankline of the Rio Grande near the Ohkay Owingeh fishing ponds, but the channel shifted away from the ponds in 2005 and thick vegetation developed along the bankline, eliminating the immediate need for the work. This area will be monitored. An erosion control project near the Pueblo of San Ildefonso fishing pond was completed in May 2007; the work involved installing buried rock vanes to deter migration of the channel toward the pond. Extensive bank erosion was observed during the 2005 spring runoff in the channel upstream of the pond.

4.4.3 Cochiti Dam to Angostura Diversion Dam (RM 233 to 210)

This reach has an approximate length of 23 miles. The bed is primarily gravel and cobbles at the upstream end, with the grain size gradually decreasing as the distance from Cochiti Dam increases. The bed is covered with a thin armor veneer and is still coarsening. This reach has the highest concentration of river maintenance sites anywhere on the Middle Rio Grande. Within the boundaries of the Pueblo of San Felipe alone, there are nine sites where river maintenance work is planned. A large project that involved placing riprap along several bends was completed on the Pueblo of Santo Domingo in the 1990s.

The channel in this reach is incised, and the reach is probably the most sinuous portion of the Middle Rio Grande (Figure 6). Sediment deposition at tributary confluences can act as a bed control and cause erosion of the bankline opposite the tributary. Localized bank erosion is fairly common in the reach, particularly in the downstream portion. The main river maintenance need is protecting the levee, irrigation infrastructure, and roads from lateral migration of the channel. Reconnection of the currently incised channel to the floodplain through terrace or island lowering would provide habitat benefits, as well as encourage growth of vegetation that would tend to stabilize the planform. Projects including revegetation should probably include fencing, since many of the Pueblos allow livestock grazing in the bosque. Degradation of the bed has led to almost complete disconnection of the floodplain.

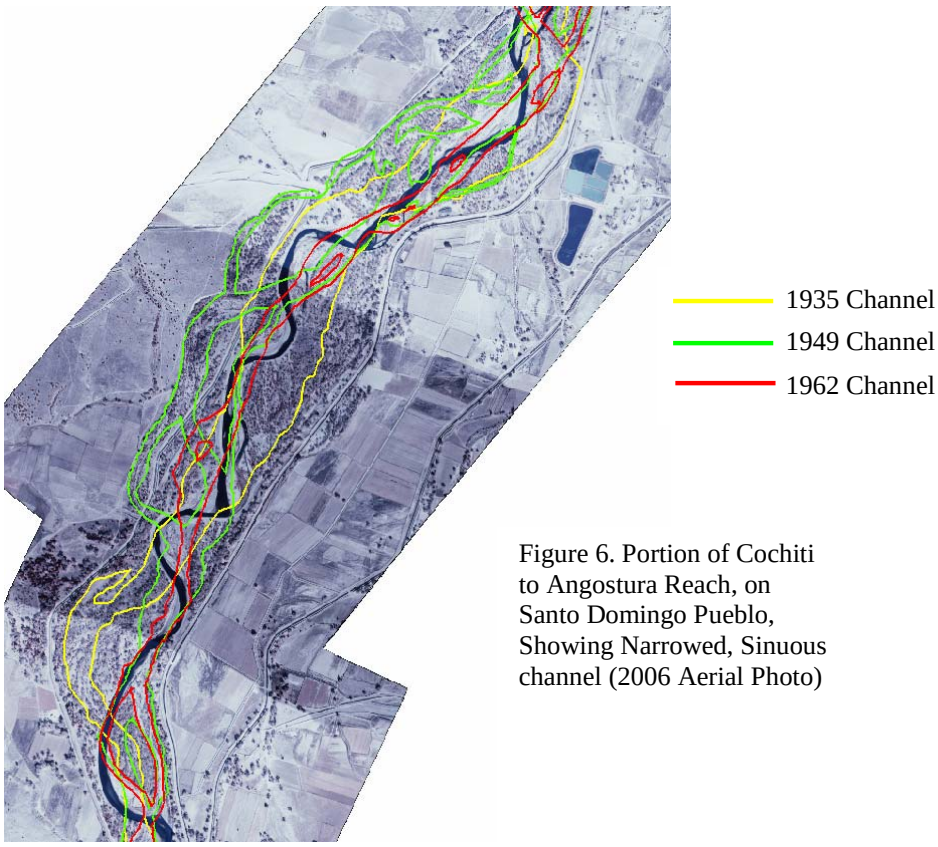

Figure 6. Portion of Cochiti to Angostura Reach, on Santo Domingo Pueblo, Showing Narrowed, Sinuous channel (2006 Aerial Photo)

In general, there is not much room to move infrastructure away from the river, owing to the proximity of mesas and active farmland. Additionally, the Pueblos that own the land may be unlikely to approve levee setback projects that affect cultural sites or reduce their available agricultural lands.

Many of the river maintenance problems in this reach might be improved if the sand-sized sediment load of the Rio Grande was increased. This could be accomplished by finding a way to bypass sediment through or around Cochiti Dam. This possibility is only in conceptual stages; no specific plan for a Cochiti sediment bypass has been proposed. Sediment modeling with SRH-SIAM (Sedimentation and River Hydraulics-Sediment Impact Analysis Methods) would help define the quantities needed, but additional analysis is necessary to understand the probable benefits and consequences of such an

idea. This concept would need to be carefully evaluated prior to implementation. For example, the rate of storage capacity loss in Elephant Butte Reservoir could be increased and current sediment research indicates that adding sand-sized sediment to a gravel-cobble system could locally increase sediment transport capacity.

4.4.4 Angostura Diversion Dam to Isleta Diversion Dam (RM 210 to 169)

This reach has an approximate length of 40 miles. Bed material grain size has been continuously increasing since the closure of Cochiti and Jemez Canyon Dams. The upstream portion of the reach has a predominantly gravel bed, while the downstream portion remains sand-bedded. The potential for incision is a concern because upstream sediment loads have decreased and there are few tributaries in the reach. Incision could be as much as five feet over the next decade. The incision is causing floodplain disconnection; if the bed incises to below the vegetation root level (about five feet), lateral migration may start. Sediment modeling using Reclamation's suite of SRH (formerly GSTAR) models could better define the timeframe and likelihood. Each model is designed for analysis at various levels of detail and uses different temporal and spatial scales.

Terrace lowering and floodplain reconnection would stabilize the channel by ensuring that the vegetation root level is at an appropriate elevation to help resist lateral erosion. Installation of grade controls such as a Gradient Restoration Facility (GRF) or constructed cobble riffles could also achieve this result; though costs, maintenance needs, and other morphological effects would need to be carefully considered. A GRF on the Pueblo of Santa Ana was completed in 2002. This GRF was designed to slightly raise the channel bed, provide fish passage for RGSM, avoid flanking caused by channel migration, and reconnect the river with the abandoned floodplain. Design of any future similar structures should follow these same objectives. SWFL migrate through this reach. Sediment augmentation, such as by a Cochiti Dam sediment bypass, could also be beneficial to this reach.

The upstream portion of the reach (Angostura to the Harvey Jones Channel) has narrowed significantly, and the transition from a wide, braided planform to a narrower, meandering channel is slowly proceeding downstream (Figure 7). The downstream portion of the channel, which has not yet completed the transition, has finer gravel, fewer arroyos, more degradation, and a flatter slope than the upstream portion. SWFL are present, but there has not been documented recruitment. RGSM has mixed nursery habitat and recruitment occurs at flows exceeding 2,000 cfs.

Future river maintenance needs will involve protecting the levees from migration as the planform transition continues to extend further downstream. At many sites, moderate flows do more damage because the main flow direction is towards the banks. Higher flows tend to straighten out, resulting in less erosion of the banks. The reach is mostly urban and has little room for levee setback.

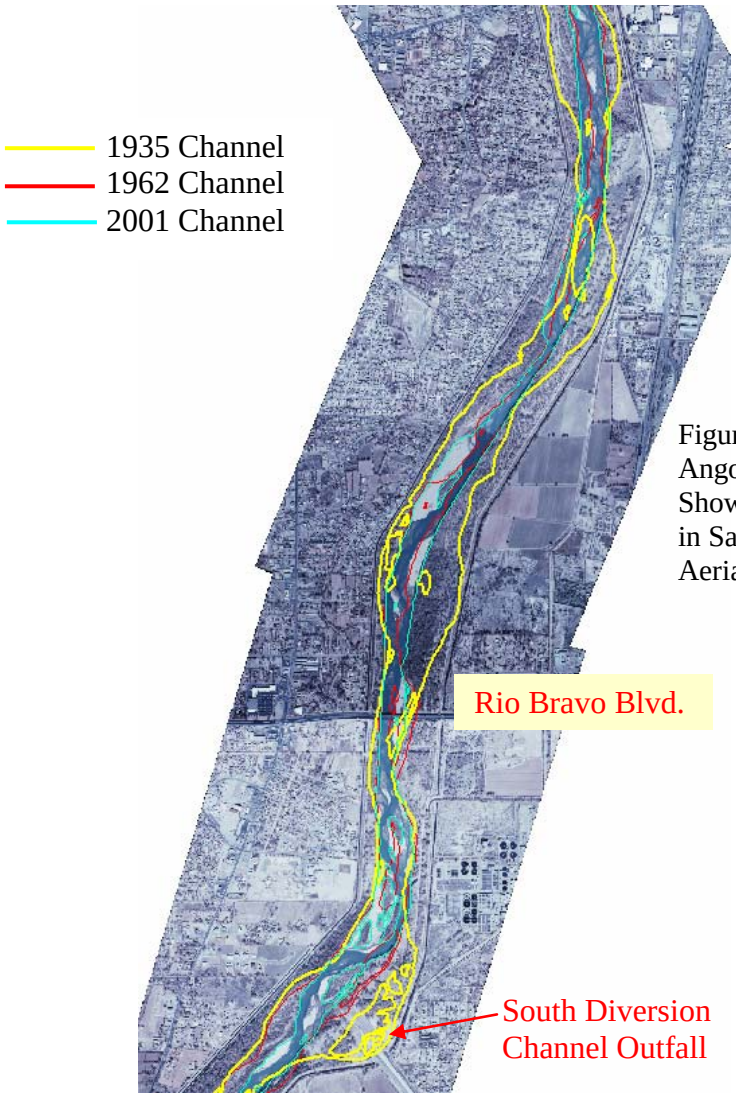

Figure 7. Portion of Angostura to Isleta Reach, Showing Narrower Channel in Same Alignment (2006 Aerial Photo)

4.4.5 Isleta Diversion Dam to Rio Puerco Confluence (RM169 to 127)

This reach has an approximate length of 43 miles. Significant narrowing of the formerly wide, braided channel has occurred in recent years. Sand deposition in side channels and narrowing caused by vegetation growth has significantly changed the planform, creating a focused thalweg that encourages rapid incision (Figure 8). This change will likely affect the current state of low incision. Many islands have evolved from stabilized medial bars and had vertical accretion during the 2005 spring runoff. Moderate flow may become a significant cause of erosion if the channel incises below the vegetation root zone, which would be 2 to 3 additional feet lower than the current bed elevation. The channel planform transition increases the potential for lateral migration and can reduce channel capacity. There are no river maintenance sites in this reach now, but many could develop quickly if the channel fully converts to a single thread and begins to migrate laterally and/or continues to incise. Consequently, morphological monitoring is particularly important in this reach.

For this reach, there is uncertainty about whether it would be more efficient and cost effective to attempt to maintain bed elevation and floodplain connection now (such as by grade control structures, constructed cobble riffles, etc.) or to attempt to restore conditions in the future, after the bed has degraded. Further geomorphic analysis and SRH-SIAM modeling, and possibly local SRH-2D sediment modeling should be employed to help make this important decision. Another strategy to consider is vegetation removal to reactivate bars and islands. The resulting destabilized sediment could also be pushed into the channel. The reactivation could temporarily improve both RGSM and SWFL habitat with careful planning. Currently there is low SWFL recruitment and RGSM has successful spawning at flows greater than 1,500 cfs.

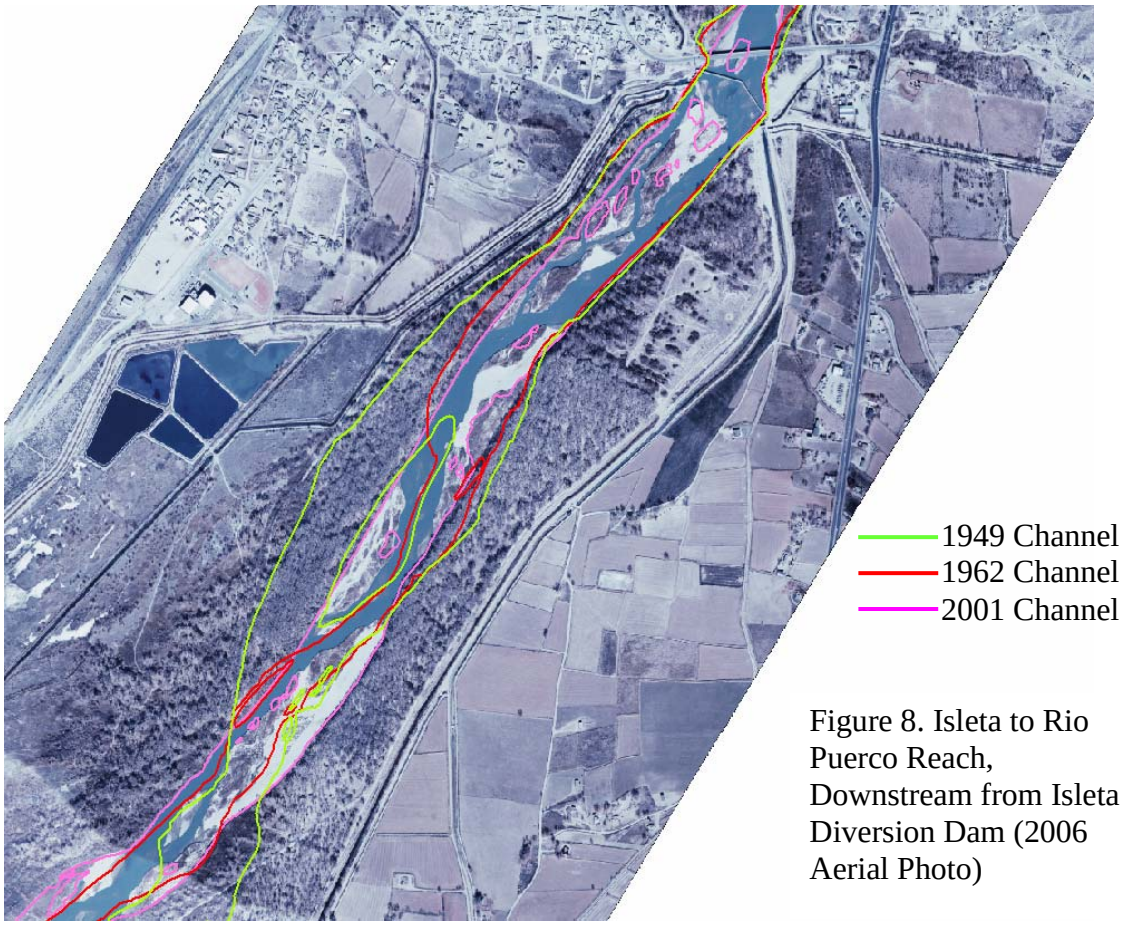

Figure 8. Isleta to Rio Puerco Reach, Downstream from Isleta Diversion Dam (2006 Aerial Photo)

4.4.6 Rio Puerco Confluence to San Acacia Diversion Dam (RM 127 to 116.2)

This reach has an approximate length of 10 miles. Although incision has occurred here historically, recent inset floodplain formation means many active bank heights are generally low. The Rio Salado fan acts as major grade control. Downstream of Rio Salado confluence, the planform has changed significantly in recent years with some incision also occurring. The main river maintenance issue is potential damage to the levee

on the west side (along Drain Unit 7 as shown in Figure 9). There are also several areas where priority sites could develop quickly if the channel begins to migrate laterally.

A large delta stabilized by vegetation has formed upstream from San Acacia Diversion Dam. The resulting narrowed channel is a contributing factor to the Drain Unit 7 river priority site. The TSC recently completed a SRH-2D sediment model of this area to provide more precise scour depths for design to potentially reduce project costs. Improvements to the operation of the dam might reduce this sediment deposition and prevent future problems. Additionally, a fish passage project for San Acacia Diversion Dam is currently in the planning and design phase, with implementation likely to begin between 2008 and 2011. There is good recruitment for SWFL and low recruitment for RGSM at flows exceeding 2,000 cfs in this reach.

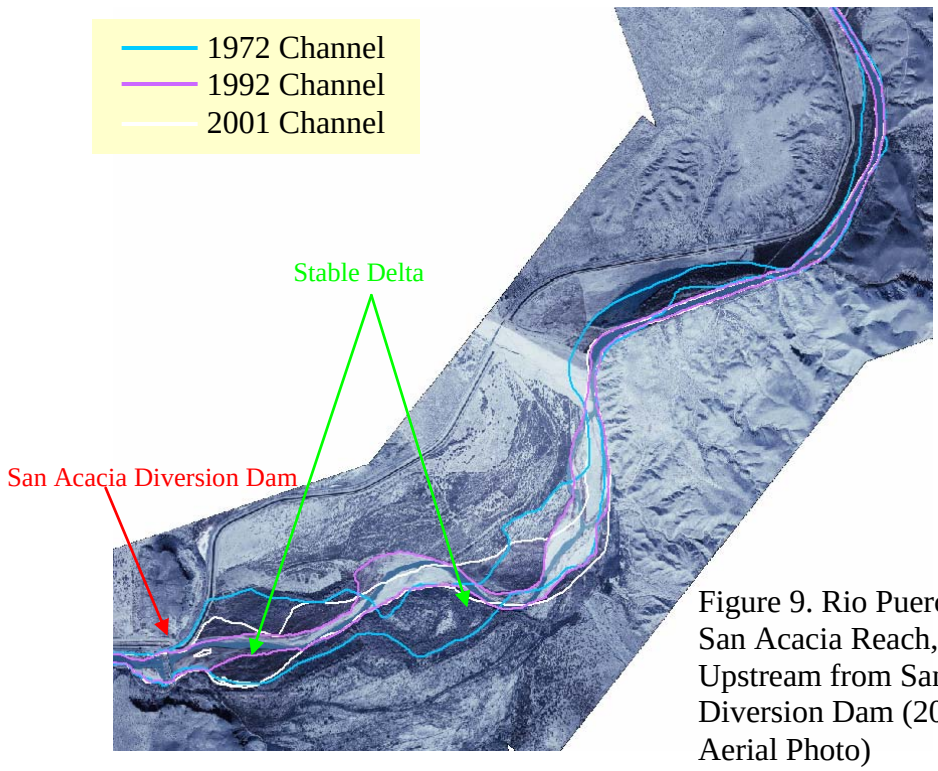

Figure 9. Rio Puerco to San Acacia Reach, Upstream from San Acacia Diversion Dam (2006 Aerial Photo)

4.4.7 San Acacia Diversion Dam to Arroyo de las Cañas (RM 116.2 to 95)

This reach has an approximate length of 21 miles. Near San Acacia Diversion Dam, the bed is armored and has undergone at least 12 feet of degradation since the 1930s, which is far below the vegetation root depth; this degradation is progressing downstream. The bed elevation near the Arroyo de las Cañas confluence is relatively stable. Coarse sediment deposited by arroyos locally increases bed material size and holds the bed elevation in steps. Bank erosion in this reach occurs at moderate and high flows because of the sandy banks and the incision that extends below the root zone. Bend series migrate both downstream and laterally. The conversion to a single-thread channel causes

problems because the levee crosses the historical river channel (braid plain), thus making it more likely for the river to re-occupy these areas and impact the levee.. The historical channelization included large meander bend cutoffs. The area between Arroyo Alamillo and Escondida is less stable because of planform changes and channelization prior to 1962. Approximately two miles of floodway in the Escondida area were narrowed and straightened (Figure 10). The most common river maintenance issue in this reach is development of meander bends that can migrate into the levee on the west side of the channel. The floodplain is disconnected from the river by an elevation of as much as 10–12 feet in some areas, but there are small inset floodplains developing on newly-formed point bars. These recently developed floodplains provide habitat as well as local bank stability. RGSM has low recruitment at 1,000 cfs on these bars but increases as flows increase. Migrating SWFL may benefit from the dense native vegetation that should continue to develop there.

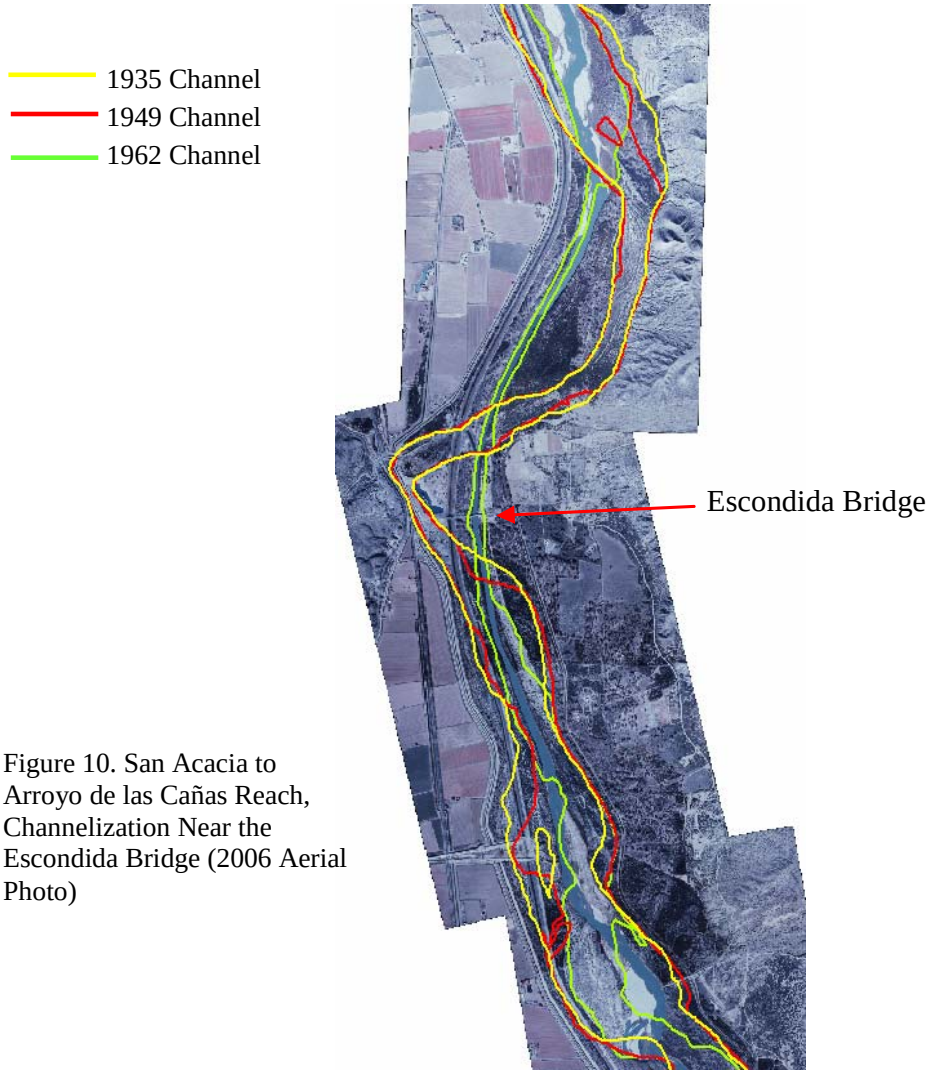

Figure 10. San Acacia to Arroyo de las Cañas Reach, Channelization Near the Escondida Bridge (2006 Aerial Photo)

A large levee setback project to address potential levee erosion at River Miles 113 and 114 (Figure 2), was completed in 2007. A similar project at River Mile 111(see cover photo) is scheduled to begin in 2008. Determination of the eventual meander belt width

through geomorphic analysis and planform migration modeling—in the absence anthropogenic intervention—would assist in identifying sites where the levee is likely to be endangered in the future. Sediment modeling could also be of benefit. Ideas for possible protection of the levee in this reach include moving the river to the east, constructing logjams, levee setbacks, bendway weirs, and lowering east-side terraces.

4.4.8 Arroyo de las Cañas to San Antonio (RM 95 to 87.1)

This reach has an approximate length of 8 miles. The channel was straightened and deepened, vegetation was cleared, and Kellner jetty jacks were placed in the 1950s. Today, the channel is relatively wide, with the exception of a stretch that begins about two miles upstream from the Highway 380 Bridge. There is new island and bar development and attachment in the widest areas of the reach (Figure 11). These changes mean a narrower channel with the potential accompanying changes in meander wavelength, increases in bed material size, and bank height may occur sooner rather than later. The channel alignment has been relatively stable since the 1930s. As well as the bed elevation and is expected to remain so in the short term.

Currently the reach has good RGSM nursery habitat and recruitment at flows exceeding 1,000 cfs. The new island and bar development could reduce the quality and quantity of habitat if the river incises. SWFL migrate through this reach. Lessons learned from other reaches should be considered in evaluating conditions of this reach.

4.4.9 San Antonio to River Mile 78 (RM 87.1 to 78)

This reach has an approximate length of 9 miles. The river has a slightly aggrading bed and clay overbank lenses. Bed elevation is fairly stable, and connection to the majority of the floodplain begins at 2,000 to 3,000 cfs. However, in some areas the channel planform is narrowing rapidly with vegetation encroachment because of extended periods of low flows and new island development. RGSM have good nursery habitat and recruitment at flows exceeding 1,000 cfs at these locations. Pumping from the LFCC is required to keep the river wet in most years.

Currently, there is some concern about a headcut moving upstream through the reach due to base level lowering as a result of the more than 80-foot drop in pool elevation of Elephant Butte Reservoir between 2000 and 2006. The pool has receded more than 20 river miles in that same time period. Reach profiles surveyed in 2004 and 2006 indicate the likelihood of the headcut continuing upstream of about RM 70 may be lower than originally considered. New SRH-SIAM and ongoing SRH-1D temporary channel modeling (see section 4.4.10) to determine stable slope and channel geometry would further reduce this uncertainty.

Lowering the water table (which potentially could occur through upstream migration of the headcut or avulsion of the river into a lower elevation portion of the valley) could have an immediate harmful effect on SWFL habitat by drying currently used nesting areas. This could induce occupation of other suitable sites and cause new habitat formation in other sites due to vegetation of new sand bars formed by the evolving river. Bank erosion and lateral migration may also be beginning; however, there are currently no sites in this reach where river maintenance is planned. Planning for this reach should

address whether or not proactive activities are advisable (potentially including both construction and water operations options) to prevent future problems.

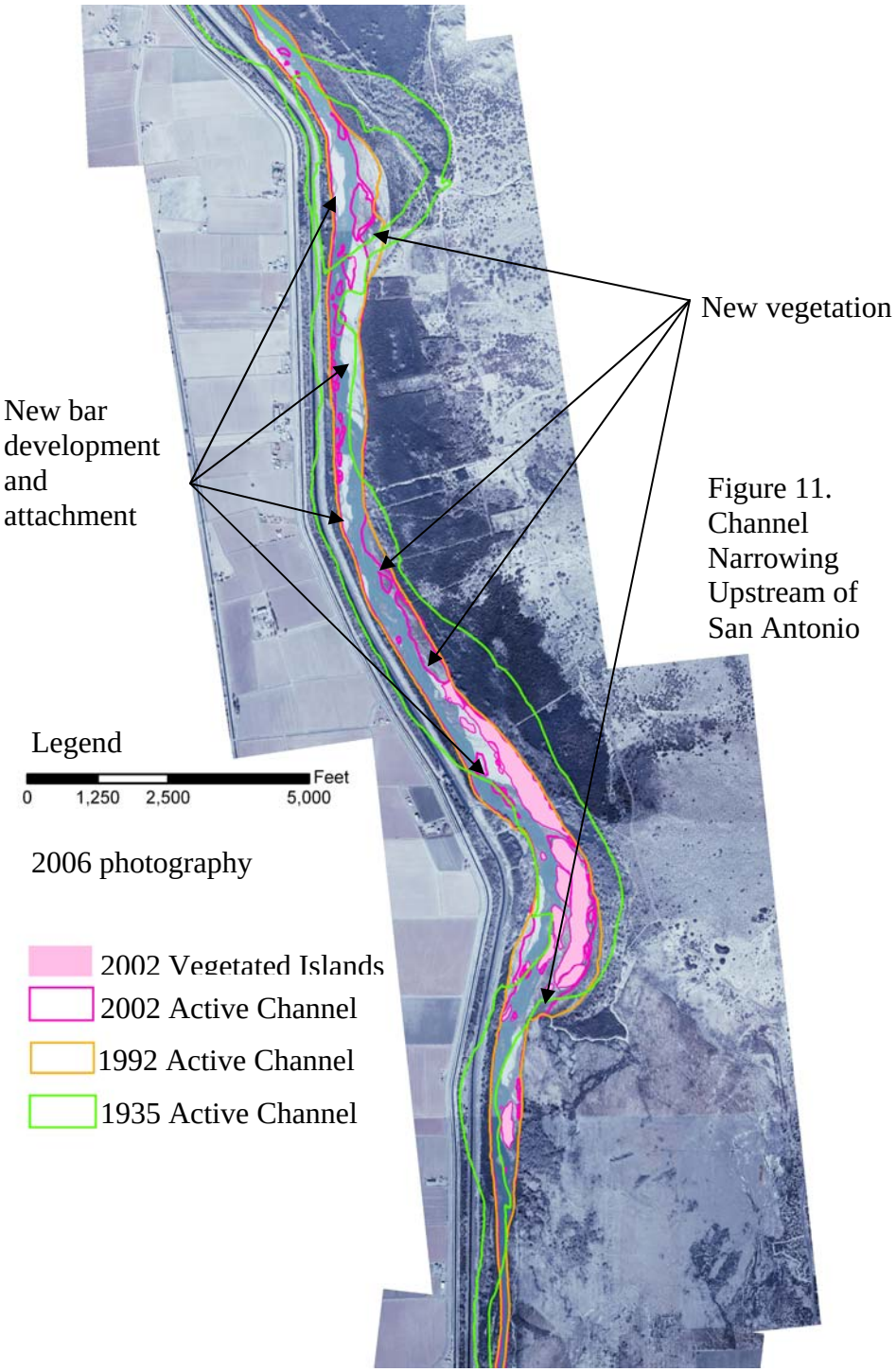

Figure 11. Channel Narrowing Upstream of San Antonio

4.4.10 River Mile 78 to Elephant Butte Reservoir (RM78 to 50)

The length of this reach varies with changes in the pool elevation of Elephant Butte Reservoir. Much of the reach was previously channelized through clay material and remains narrow. Rapid aggradation can occur during high flow periods, with the location of aggradation greatly influenced by reservoir stage. Levees confine the floodway to the eastern third of the valley. The condition of this reach is dynamic, but aggradation will continue to occur over the long term. Aggradation within the floodway causes continual problems with channel capacity; levees are periodically raised but have reached elevations where further raising has become impractical in many locations. If the levees continue to be raised, the width of the floodway will be further reduced, exacerbating problems with capacity. The existing practice of levee raising is not sustainable over the long term.

Planning efforts to move the river to the west side of the valley have previously been undertaken. Work on this potential project is stalled because of its high cost (over $20 million), combined with multiple environmental, legal, and political issues. A headcut that has recently progressed upstream and tapered out has lowered channel elevations, temporarily reducing the urgency of the levee elevation and flood capacity condition. The current headcut—and future headcuts if the reservoir elevation remains low—has the potential to disconnect the channel from the floodplain and lower the water table, which would cause a widespread loss of important habitat for the SWFL. The increased channel capacity may allow higher flow releases from Cochiti which should result in increased habitat benefits in upstream reaches. The tradeoff between the loss of this habitat and the benefits of higher flow releases should be considered in maintenance strategies for this reach.

Currently, the elevation of the channel bed and LFCC are about equal near Fort Craig. A series of bends that portend extensive lateral migration is setting up in the floodway (Figure 12). Bank erosion and lateral migration could cause the levee to fail in this area, which would cause the river to avulse to the lower side of the valley. This would address the long term issue with levee raising but would raise short term issues including loss of SWFL habitat, difficulty of maintenance access to the Temporary Channel, and reduced water deliveries. These issues are of great concern for several stakeholder agencies. Costs associated with damages from an uncontrolled avulsion are unknown.

The continual aggradation in this reach causes several other maintenance problems. Most notably, Reclamation and the Interstate Stream Commission of the State of New Mexico have expended considerable effort to maintain the Elephant Butte Temporary Channel from RM 60 downstream, which ensures continuous surface water flow to the pool of Elephant Butte Reservoir. Without continual excavation, sediment will deposit at the upstream end of the reservoir, and the channel will not flow all the way to the reservoir pool. Ongoing 1D sediment modeling by the TSC has helped in planning river maintenance to maintain this connection. A partnership among the hydrologic community stakeholders to create a water budget estimating water salvage and delivery benefits of the LFCC and the Temporary Channel would be useful in the selection of maintenance strategies for this reach. RGSM are present in the Temporary Channel and benefit from maintenance activities that do not remove the point bars that develop in this channel.

Another aggradational condition is the formation of river sediment plugs at the north end of Black Mesa. A sediment plug can form in this area because a constriction in the river channel causes a sudden increase in the proportion of flow that goes overbank during spring runoff periods. The decrease in flow in the main channel reduces the sediment transport capacity, causing sediment to deposit in the main channel and completely fill it. Three sediment plugs have formed near Black Mesa since 1990. Reclamation has excavated pilot channels through the plugs to reestablish the channel, but nothing has been done to prevent the problem from recurring, though Reclamation is currently in the formative stages of developing a long-term solution. A sediment plug model has been developed to help predict and evaluate potential solutions.

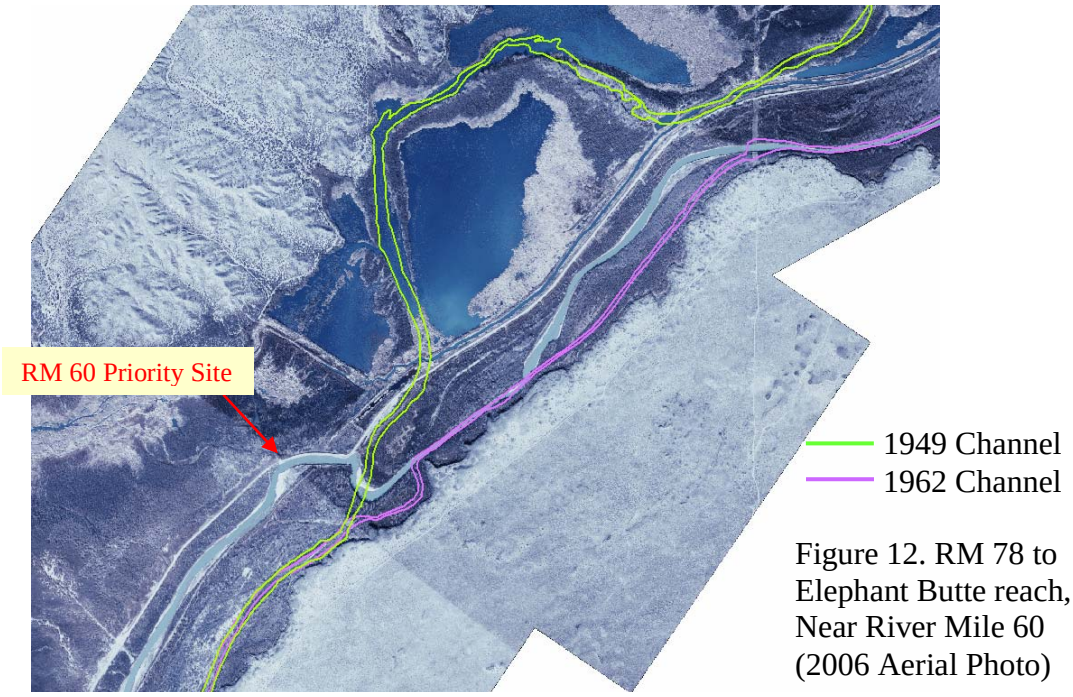

Figure 12. RM 78 to Elephant Butte reach, Near River Mile 60 (2006 Aerial Photo)

4.4.11 Elephant Butte Dam to Caballo Reservoir (RM 50 to 12)

This reach has an approximate length of 15 miles. Reclamation is authorized to maintain a channel capacity of 5,000 cfs. In 1985, Reclamation channelized this reach, lowering the bed. The 1985 channel work decreased flow from natural hot springs. Thus, Reclamation constructs a temporary dike during the winter (when flow is shut off) to raise the stage in the river, which increases hot springs flow. Sediment accumulates continually, particularly at the confluences of Cuchillo Negro Arroyo, Mescal Arroyo, Arroyo Hondo, and Palomas Arroyo. Reclamation annually excavates the sediment deposits to restore the 5,000-cfs channel capacity. Occasionally, Reclamation places riprap bank protection for property developed before 1985 in Truth or Consequences and Williamsburg. No SWFL or RGSM are known in this reach.

5.0 Low Flow Conveyance Channel

5.1 Reach Conditions

The LFCC was constructed by Reclamation in the 1950s to aid the State of New Mexico in delivery of water obligated to Texas under the Rio Grande Compact (Compact). Prior to LFCC construction, the channel into Elephant Butte Reservoir was obstructed with sediment and vegetation such that no surface flows entered the reservoir, resulting in an estimated water loss of 140,000 acre-feet per year. Historically, the LFCC conveyed up to 2,000 cfs to Elephant Butte Reservoir, saving considerable amounts of water that would have been lost to evapotranspiration. The LFCC has been credited with assisting New Mexico to significantly decrease its Compact compliance deficit (which was 325,000 acre-ft in 1951). Average annual water salvage ranged from 35,000 to 66,000 acre-feet during full operation.

Elephant Butte Reservoir storage increased in the early to mid-1980s, inundating and burying the last 15 miles of the channel with sediment. As a result, the channel was shortened to 58 miles. The LFCC currently provides valley drainage benefits, water for pumping to benefit the RGSM, and supplemental irrigation water supplies to the Bosque del Apache National Wildlife Refuge and irrigators of the Middle Rio Grande Conservancy District. Various rehabilitation or relocation strategies would potentially increase water deliveries to Elephant Butte Reservoir, a primary interest of the Compact states.

The river and LFCC are in the originally constructed alignment from downstream of the San Marcial Railroad Bridge to about River Mile 60. After 2001, the Rio Grande has been reconnected through the delta via the Temporary Channel. By 2006, Elephant Butte Reservoir stage has receded to below the Narrows to near RM 40. During the spring runoff of 2005, the channel incised so far that the LFCC can now be reconnected to the river at the current outfall location. Given the current Elephant Butte pool elevation, maintaining the river and LFCC in the current alignment may be possible for a number of years. Eventually, however, the stage in Elephant Butte Reservoir will increase, causing sediment deposition in the river channel and once again preventing the LFCC from being connected to the river. This aggradation will also again cause levee capacity reductions and loss of flow capacity under the San Marcial Railroad Bridge. The current levee and LFCC location limit river flows and reservoir delta sediment deposits to about a third of the floodplain for 10 miles downstream of the San Marcial Railroad Bridge. This location is not sustainable over the long term because the practical limit of the levee height has been reached in most areas. At some time in the future, the river will overtop the levee and move to the west side of the valley unless the river is relocated first (see discussion in section 4.4.10 for more information on realignment). Deliberately realigning the river downstream of the San Marcial Railroad Bridge would significantly reduce water loss and adverse impacts to the SWFL habitat, as compared to an uncontrolled avulsion resulting from levee failure during a high flow event.

5.2 Future Maintenance Needs for LFCC Strategies

Potential future strategies for the LFCC include:

1) No changes to the current infrastructure and operations
2) Reconstructing the LFCC outfall to the river at various locations with several possible operational scenarios
3) Realigning the river and LFCC to the west side of the valley downstream of the San Marcial Railroad Bridge

An outfall for the LFCC could be reconstructed near River Mile 60. Alternately, the LFCC could be rehabilitated from River Mile 60 downstream to the Narrows of Elephant Butte, which was the end of the channel as it was originally constructed. Another option is establishing a new outfall near Ft. Craig or San Marcial which would join the river and LFCC into a single channel. In this option, an additional, smaller channel would be needed to maintain flows to the currently occupied SWFL habitat area south and west of River Mile 60.

All three strategies include the goals of maximizing water delivery and enhancing the SWFL habitat. For all options, maintenance needs include levee repair, excavation of a surface water channel to the Elephant Butte Reservoir pool via sediment removal, side slope mowing, riprap replacement, and berm road grading. Additional maintenance needs as a result of strategies 2 and 3 include sediment removal from the outfall, as well as inspection and maintenance of arroyo crossings and diversion structures on the new portions of the LFCC.

Several items of information and analysis are needed for evaluating potential LFCC outfall locations, realignments, and operations:

- Updating the hydrologic analysis to determine how much surface water inflow to Elephant Butte comes from the LFCC under the current operations
- Obtaining the report documenting the results of the water salvage estimates made by NMISC for various operational scenarios
- Evaluating existing topography, and conduct a current condition assessment of arroyo crossing and diversion structures
- Conducting hydraulic and sediment transport modeling to determine the most cost effective, environmentally sound alternatives while maximizing benefits

6.0 New and Emerging Issues

There are several issues for which consideration is necessary to develop future policy on Program and its involvement with other agencies and stakeholders. Specifically, policies are needed to address the following:

- River channel bank erosion and lateral migration into facilities owned by other agencies and stakeholders within the river channel and floodplain defined by the levees constructed with Reclamation funding (e.g., title XVI projects)
- Potential impacts of the court decision that Reclamation owns MRGCD facilities
- Feasibility of tradeoffs in the needs of the endangered species SWFL and RGSM
- Possible realignment of the Rio Grande and LFCC south of San Marcial, as well as development of future operational scenarios for the river and LFCC that address concerns about long term viability of the current system, conveyance efficiency, and endangered species habitat in this area