RECLAMATION

Managing Water in the West

Middle Rio Grande River Maintenance Plan 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.

Middle Rio Grande River Maintenance Plan Part 1 Report

Middle Rio Grande Project, NM
Upper Colorado Region

Maintenance Plan Team

Albuquerque Area Office

Karl Martin, Manager, Technical Services Division P.E.
Robert Padilla, Supervisory Hydraulic Engineer, River Analysis Group, P.E.
Mark Nemeth, Senior Hydraulic Engineer, P.E.
Carolyn Donnelly, Hydraulic Engineer, E.I.
Valda Terauds, Hydrologist, CGWP
Tamara Massong, Hydrologist
Robert Doster, Wildlife Biologist
Michael Porter, Fishery Biologist, CFP
Candice Ford, Realty Specialist

Technical Service Center

Paula Makar, Hydraulic Engineer, P.E.
Drew Baird, Hydraulic Engineer, P.E.

U.S. Department of the Interior
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ACRONYMS AND ABBREVIATIONS

AAO	Albuquerque Area Office
Acts	Flood Control Acts of 1948(PL 80-858) and 1950 (PL 81-516)
AMAFCA	Albuquerque Metropolitan Arroyo Flood Control Authority
BEMP	Bosque Environmental Monitoring Program
BHG	Bosque Hydrology workgroup
BiOp	2003 Biological Opinion
BDANWR	Bosque del Apache National Wildlife Refuge
CEC	Categorical Exclusion Checklist
City	City of Albuquerque
CWA	Clean Water Act
Compact	Rio Grande Compact
Collaborative Program	Middle Rio Grande Endangered Species Act Collaborative Program
Corps	United States Army Corps of Engineers
DOI	Department of the Interior
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
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
MERES	Management of Exotics for Recovery of Endangered Species
Methodology	Priority Site Review Methodology
MRGCD	Middle Rio Grande Conservancy District
MRG Project	Middle Rio Grande Project
NEPA	National Environmental Policy Act
NHPA	Historic Preservation Act
NMISC	New Mexico Interstate Stream Commission
PIF	Project Initiation Form
Program	Middle Rio Grande River Maintenance Program
Reclamation	Bureau of Reclamation
RGSM	Rio Grande silvery minnow
RM	River Mile
SSCAFCA	Southern Sandoval County Arroyo Flood Control Authority
Service	United States Fish and Wildlife Service
SNWR	Sevilleta National Wildlife Refuge
SRH	Sedimentation and River Hydraulics, formerly GSTAR
SIAM	Sediment Impact Analysis Methods
SWFL	Southwestern willow flycatcher
TSC	Technical Service Center
TSD	Technical Services Division
URGWOPS	Upper Rio Grande Water Operations
WRDA	Water Resources Development Act

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1 Introduction

1.1 Vision

The vision of the Middle Rio Grande River Maintenance Plan (Maintenance Plan) is to develop a long-range plan for the Middle Rio Grande River Maintenance Program (Program) that accomplishes Middle Rio Grande Project (MRG Project) purposes in an environmentally and economically sound manner consistent with MRG Project authorization.

1.2 Authorized Maintenance Program Goals

Prior to significant anthropogenic modifications, 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 because of high water tables. This led to the Flood Control Acts (Acts) of 1948 (P.L. 80-858) and 1950 (P.L. 81-516) which established the MRG 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 MRG 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 the Endangered Species Act (ESA)-listed species within the MRG Project area**

The first four goals are from the original MRG 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 (ESA). An international treaty with the Republic of Mexico for delivery of water affects the MRG Project. The 1939 Rio Grande Compact, which regulates the distribution of Rio Grande water among the states of Colorado, New Mexico, and Texas also affects the MRG Project. Consequences of not performing essential maintenance include substantial damage to riverside facilities, loss of water, and loss of endangered species habitat. Chapter 3 provides more information on these goals and the authorizing legislation.

1.3 Maintenance Plan Approach

The Maintenance Plan is intended to help make informed decisions on future river maintenance activities and will be developed and documented in two parts. This document is the *Middle Rio Grande River Maintenance Plan Part 1 Report* and is based on existing information. It contains discussion 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 the Part 2 Report.

The Part 1 Report describes the Program and its needs and benefits. It documents the authority and necessary maintenance activities, including legal requirements, institutional constraints, water delivery issues, endangered species issues, current river and LFCC conditions, and historical changes in those conditions. It also includes how environmental laws have been integrated into river maintenance activities.

The Part 2 Report will incorporate results, as available, from new and ongoing studies to help guide Program decisions for future analyses, data collection, and maintenance practices—including environmental compliance needs. Strategies and specific methods will be described and initially evaluated for applicability by the Maintenance Plan Development Team and reviewed by an independent review panel for technical merit. The *Draft Scope of Work for Development of Middle Rio Grande River Maintenance Plan* (Martin et al. 2006) describes the roles and responsibilities of all organizational units that work on river maintenance functions. Strategies could include altering, reducing, or discontinuing current maintenance practices to better manage aggradation, degradation, high flows (within Reclamation's authorization), bank erosion, and endangered species habitat improvement.

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.

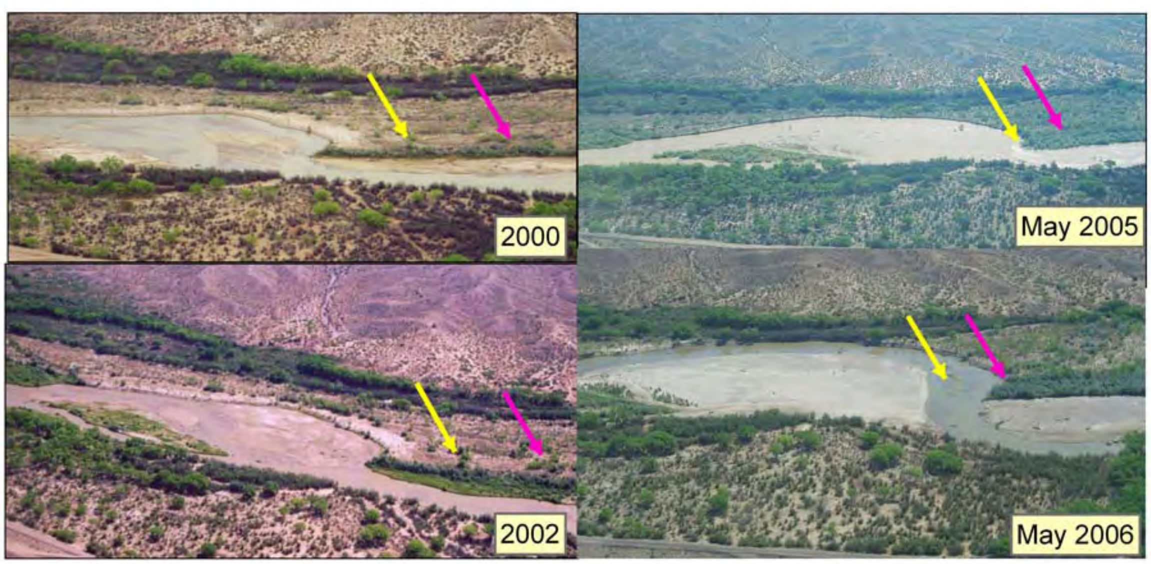

Figure 1. Rapidly migrating bend at River Mile 110. (Flow is left to right.)

To help manage this dynamic river, the Maintenance Plan is based on a systematic approach to meet the river maintenance goals listed in section 1.2. Four main steps are used to guide the Maintenance Plan development and implementation.

- **Describe and understand the river conditions**

This requires characterizing geomorphic processes and current conditions for each reach (see chapters 5-16) and then estimating likely future conditions. Also needed are descriptions of water delivery, riverside infrastructure, policy, management objectives, and land use for the Middle Rio Grande as a whole and within each reach. All of these provide a basis for assessing the river maintenance needs in each reach. The reach-based conceptual model described in section 1.4 is the method used to integrate the information described above.

- **Evaluate information needs**

Additional information needed to adequately characterize and describe existing and future Middle Rio Grande geomorphology, water delivery, infrastructure, policy, management objectives, 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**

This includes identifying, evaluating and recommending appropriate strategies and the methods to implement those strategies. Recommendations may be reach-based to provide long-term management and/or site specific to address local instabilities. 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.

- **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.

The two combined parts of the Maintenance Plan are envisioned to be an engineering and geomorphic review that can be used to readily 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.

1.4 Maintenance Plan Objectives

The 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 ESA). Potential new maintenance strategies and methods will be identified and assessed at an appraisal level for applicability.

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 (Martin et al. 2006).

Part 1—Current Maintenance Strategies & Needs

- Provide overview of MRG Project authority and Program benefits
- Review past and current maintenance methods
- Describe current and historical river and LFCC conditions/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

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 the authorized Program goals. This should reduce emergency maintenance activities where possible by using future river trends to help ensure that individual site or reach maintenance work is consistent with expected tendencies of the river. The Maintenance Plan will document guidelines for strategy and method selection for both long-term and emergency activities. The resulting Maintenance Plan will incorporate the evaluation of maintenance needs based upon estimates of future river conditions and constraints.

The Rio Grande is an evolving river system, so the Maintenance Plan is 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 reaches described in this first Maintenance Plan may change in future editions because of adjustments in river morphology and function over time. Reaches will be reevaluated based on changes in hydrology, river planform, slope, sediment size, channel capacity, biological needs, institutional needs, and other factors that may be identified in the Maintenance Plan use.

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. Timely input is needed from the Maintenance Plan Development Team and reviewers to meet this schedule. It is expected the Maintenance Plan will be reviewed for possible revision every 5–10 years or as significant changes in any of the key reach evaluation areas occur.

2 Maintenance Program

2.1 Historical Maintenance Phases

Historical river maintenance and flood control practices differ significantly from the current activities. The initial work on the MRG Project, in the 1950s and 1960s, consisted primarily of river channelization and construction of the LFCC between San Acacia Diversion Dam and Elephant Butte Reservoir (Reclamation 2003a). Authorized maintenance goals for the MRG Project are listed in section 1.3 and the roles of other agencies in section 3.1. There have been three general phases of maintenance activities.

2.1.1 Phase 1—MRG Project Inception to the Mid 1980s Maintenance Activities

There were two primary goals in the immediate post construction period. One was to maintain channelized areas in their constructed configuration through pilot channeling, floodway clearing, and jetty installation. The other was dredging above Elephant Butte Reservoir in the river and LFCC to maintain connectivity to the pool (Reclamation 2003a).

2.1.2 Phase 2—Mid 1980s to Late 1990s Maintenance Activities

In the mid 1980s, it was determined that repetitive excavation of the river to the original configuration was not cost effective. Also, jetty jack placement had lost effectiveness because of decreased sediment loads in the river, and environmental laws (NEPA, Clean Water Act [CWA]) made maintaining the historical channelization not feasible. Phase 2 maintenance activities included:

- Channel was allowed to migrate; it was no longer maintained as originally constructed.
- Bends were stabilized in areas where it was necessary to protect riverside infrastructure.
- Temporary Channels into Elephant Butte were excavated to effectively transport water through the delta which is not capable of providing a self-maintaining channel owing to the incoming sediment load and valley slope.
- Alternate bars were mowed where the channel had narrowed even further than the constructed width which occurred between the mid 1970s until the late 1990s.
- Mowing that occurred historically to maintain channel capacity was discontinued in the late 1990s because of ESA and budget concerns.

2.1.3 Phase 3—Late 1990s to the Present Maintenance Activities

Since the late 1990s, river maintenance projects have been designed using a process-based reach-wide approach that also incorporates habitat protection and enhancement. The rationale for changing maintenance practices from Phase 2 to Phase 3 was to meet ESA requirements for the Rio Grande sivery minnow (RGSM) and Southwester willow flycatcher (SWFL) , and the fact that Service would no longer provide concurrence under ESA for Phase 2 river maintenance work. The two most common maintenance issues are preventing erosion damage and ensuring effective water delivery. Updated maintenance activities to achieve this include:

- Bio-engineered bankline
- Deformable bankline
- Gradient restoration facility (GRF)
- Channel realignment
- Floodplain reconnection
- Channel widening
- Limited strategic bank stabilization
- Adaptive Management

These and other practices are included in the 2003 Biological Opinion (BiOp). Appendix A contains a list of the Reasonable and Prudent Alternatives from the BiOp. Part 2 of the

Maintenance Plan will include information about these types of maintenance practices and potential new strategies.

2.2 Decision Process for Determining River Maintenance Requirements

The decision process for identification of river maintenance projects and actions follows criteria developed to prioritize river maintenance needs (Smith 2005). 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 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

Factors that provide decision criteria for the Priority Site Review Methodology (Methodology) process include engineering analysis and judgments, river geomorphic considerations, funding considerations, environmental considerations, public involvement, political considerations, and economic considerations. The fundamental activities that support decision making on channel maintenance needs are monitoring changes in the river channel morphology, evaluating channel stability, and modeling channel and levee capacity (Smith 2005).

River maintenance needs and priorities are largely identified through the Methodology and database maintained by the Albuquerque Area Office (AAO) River Analysis Group. This documentation includes a description of the criteria and methodology used to determine river maintenance priority sites. The Methodology and database are established for assessing existing sites and identifying new site locations. The determination of the overall recommended action for a site is based on five considerations (Smith, 2005):

1. The potential mode of failure which identifies the method in which failure may occur at a given site
2. The numeric rating which evaluates nine factors and provides a numerical representation of the relative potential failure at a given location
3. The qualitative failure rating which is a descriptor based on the numeric rating value
4. A damage estimate for the site in the event of failure
5. “Other considerations” which allows for the inclusion of various operational and policy decisions by Reclamation management

The Methodology rates sites for maintenance repair to determine their relative priority to each other as well as to document decisions that are made to undertake river maintenance activities for each site. Priority sites are locations where actual river maintenance projects are identified for construction maintenance. Monitored sites are locations that have the potential of becoming future priority sites. The AAO continually updates and maintains the river maintenance database through a review process. The AAO River Analysis Group is the focal point for the priority site assessments, although interdisciplinary input from other divisions plays an important role. Decisions are based on experience and expertise in working on river systems and require an understanding of hydraulics, sediment transport, geomorphology, river engineering, and riverine and riparian biology.

Given the inherent dynamic nature of the river channel, uncontrolled tributary inflow, reach instabilities involving river bed elevation, width, and lateral migration changes, fluctuating reservoir elevations, and continued bank erosion, real time monitoring of conditions is essential for identifying river maintenance projects and activities. River monitoring and inspection is done routinely for the entire MRG Project reach through site visits to specific locations, boat trip reviews (airboat, motorboat, raft trips), aerial flights (small plane or helicopter), and observations by other agencies, Pueblos, and private landowners on the ground along the river channel and levee systems. These inspections of the Rio Grande are conducted at least annually to assess river maintenance needs and priorities and address changing river channel conditions. The frequency of these types of reviews depends largely on the hydrology associated with spring runoff and thunderstorm monsoonal flows. Monitoring and inspecting channel conditions provide a sound method for field identification of potential river maintenance projects and activities.

River analysis studies also provide the part of the basis for decisions regarding river maintenance projects and activities. 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. Long term river maintenance problems can be identified. Also, a better understanding of the physical processes and hydraulic conditions occurring can be realized that may not be apparent through monitoring and inspection.

River analysis studies are associated with:

- Evaluations of the hydraulic capacity of the river channel and levee system
- Sediment transport continuity modeling
- Modeling of hydraulic thresholds for bed and bank erosion
- Planform and channel migration modeling
- Analyses of bank erosion and erosion rates
- Geomorphic and physical process assessments

Lastly, river maintenance projects and activities are dictated based on Albuquerque Area Office (AAO) policy and priorities that may be associated with requests for work or assistance by stakeholders such as Native American Pueblos (eight located along project reach), Middle Rio Grande Conservancy District (MRGCD), U.S. Army Corps of Engineers (Corps), private landowners, New Mexico Interstate Stream Commission (NMISC), etc. 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 involve considerations for whether the work is within Reclamation's MRG Project authority (see section 1.2) and responsibility or if the work is the responsibility of others. Federal responsibilities under the 1973 ESA and an international treaty (1907) with the Republic of Mexico for delivery of water affect the project, as well as the Rio Grande Compact (1939) which regulates the distribution of Rio Grande water between the states of Colorado, New Mexico, and Texas.

For implementing decisions or river maintenance projects and activities, annual workload planning and scheduling work is conducted. Annual work load decisions and priorities are based on available annual budgets and AAO staff capabilities from the Environment Division, Socorro Field Division, and the Technical Service Division (TSD). Annual plans and schedules are prepared and reviewed by the AAO Divisions with consideration for other AAO projects and programs at the beginning of each fiscal year.

2.3 Requirements of the River Maintenance Program

In recent years, the Program has evolved to accommodate Reclamation's increased responsibility for environmental protection to comply with NEPA and the regulatory requirements resulting from the presence of endangered species. The 2003 BiOp defines these requirements. Along with these new responsibilities, Reclamation's responsibilities for erosion protection, limited flood control, and water delivery continue unabated. Most historical needs remain important in the present and have been joined by new considerations. The combination of immediate project specific requirements and long term strategies and methods requirements necessitates several components are necessary for the Program.

2.3.1 River Data Collection

Data collection occurs for two main purposes: designing projects and monitoring trends. The rate of collection is based on rate of change in different variables. Long-term data collection is necessary for monitoring changes in river bed elevation and slope, channel position, width, depth, flow velocity, sinuosity, channel capacity, and sediment (bed material and suspended sediment data). 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, and controlled aerial photography and remote sensing. 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, and topographic surveys in support of planning, design, environmental compliance, and maintenance implementation.

2.3.2 Geomorphic Analysis

Geomorphic analysis provides the underpinnings of a conceptual model of the physical channel processes at a reach scale and supports trend analysis to plan for river maintenance needs. This requires site visits to monitor channel and floodplain geomorphology on a regular basis plus analysis of the data described above. In addition, understanding the physical channel processes through detailed analysis at each priority site is necessary to plan and design maintenance activities that maximize long term sustainability while minimizing cost and future maintenance needs.

2.3.3 Hydrologic, Hydraulic and Sediment Transport Modeling

Several types of modeling are required to effectively manage the Program. The scale and intensity of the investigations ranges from basin-wide and long-term trends to smaller models on a reach/site basis as needed. Hydrologic modeling and analysis efforts are necessary to estimate flood frequency for design flows for the Rio Grande, tributaries, and structures. Hydrologic, hydraulic and sediment transport modeling 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 helps to improve designs and minimize maintenance requirements and evaluate the effects of proposed project options on channel stability and capacity.

An example of long term modeling is the SRH-1D (Sedimentation and River Hydraulics, formerly GSTAR) sediment modeling of the Temporary Channel into Elephant Butte Reservoir beginning in 2002. Temporary Channel models updated with new geometry and hydrology over the last few years have helped design and maintain more effective channels. This has been accomplished by estimating the future effects of construction, thereby guiding future maintenance plans to minimize mechanical removal of sediment. Other more detailed models can help evaluate the effects of proposed project options on river bed elevation, channel slope, and channel capacity. An example is the recent SRH-2D sediment modeling of the Drain Unit 7 priority site. Information from this study provided an envelope of likely scour and degradation to aid project planning and design.

2.3.4 Planning and Maintenance Design

Planning and Designing projects is a major component of the Program. Projects are designed using a reach-based approach that accounts for fluvial processes and works with river trends while considering the needs of endangered species. This is accomplished through engineering geomorphology, which integrates geomorphology and modeling used in channel stability trend analyses and more traditional engineering of specific project features. This component includes determining and evaluating project options and features that minimize cost, maximize sustainability, and are compatible with environmental goals and requirements. The TSD provides project maintenance design and analysis and provides maintenance implementation drawings. The multidisciplinary approach in the 2004 Memorandum of Coordination for River Maintenance and Restoration Activities for the MRG Project (Appendix B) prescribes coordination with other AAO divisions.

2.3.5 Environmental Compliance and Analysis

Each river maintenance project must comply with the CWAct, NEPA, ESA (Appendix C), and other laws included in Appendix D. In addition, archaeological clearance must be received from the New Mexico State Historic Preservation Office. Environmental compliance is obtained by Reclamation’s Environment Division. In many cases, this is a lengthy process that incurs significant cost. The 2001 and 2003 Biological Assessments (BA) were intended to obtain programmatic consultation to streamline activity specific environmental compliance. Furthermore, the required inclusion of habitat enhancement features to provide a net positive benefit to listed species has increased the time and cost required to complete projects. A viable maintenance program ensures compatibility between river maintenance and habitat restoration goals resulting in greater project benefits that meet Reclamation's purpose and mission (Reclamation 2003a). Additional information on environmental compliance requirements can be found in section 2.5.3.

2.3.6 Maintenance Implementation and Operations

Implementing river maintenance projects is a significant component of the Program. This component is the culmination of previously described efforts for data collection, analysis, modeling, planning, design, and environmental compliance. Maintenance implementation by Reclamation's Socorro Field Division provides repairs and fixes at priority sites and supports other MRG Project activities. River maintenance projects may involve river bank protection/stabilization, river bed/grade stabilization, channel and levee realignment, pilot channel excavation, sediment removal, levee repair and rehabilitation, and/or vegetation clearing and installation. Implementation maintenance is done in accordance with all project design, environmental, lands, and safety requirements. Operational considerations for the MRG Project involve the nearly 50 miles of LFCC (including its diversion headworks and outfall) and levee system.

2.3.7 Monitoring and Adaptive Management

Adaptive management is a systematic process to achieve the best decisions possible in the face of uncertainty. It requires selecting the best option (as discussed above) and monitoring the effects of the implementation. The intent is to respond in a timely manner to any concerns that may arise and provide lessons learned to projects in the future. Documentation of the project objectives, process, and predicted 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 interpretation of monitoring data, or any combination of these factors. This information is essential to improve the next project or to repeat the success.

It should also be noted that using an adaptive management approach for channel restoration in dynamic river systems often extends the time period of a project. Traditional maintenance methods rely on one construction season to be cost effective. In contrast, some channel restoration projects incorporate plans for reviews and minor work in subsequent construction seasons after the occurrence, or in the absence of significant channel forming flows. This approach works well with projects that "assist" channel responses, i.e. the Phase 3 maintenance activities.

2.3.8 Project Development Process

Several steps are necessary in the project development process. The first step is to develop preliminary project options and features. These are usually based on information available from ongoing long term reach-based analyses. Site conditions and project goals must be defined. Project specific discussion that includes authority, coordination with other projects and agency reviews, and division of work among agencies takes place here.

The next step is to evaluate project options. The advantages and disadvantages for each strategy are described at the appraisal level based upon site conditions and project goals. Feasibility of options is determined in three areas. Engineering feasibility is determined through evaluating the function, effectiveness, liability, service life, maintenance, and sustainability of an option. Environmental acceptability and benefits must be assessed. Economic feasibility consists of determining implementation and maintenance costs and service life using average unit costs. Once the “three Es” (Engineering, Environmental, and Economic) information has been established, the preferred option can be selected.

Specific environmental compliance requirements are set at this point (see sections 2.3.5, 2.5.3 and appendices A, B, C, D, and E) and the final decision on project features is made. Implementation of the preferred option provides the installation of the project features in accordance with design and environmental requirements. Implementation is not the final step, however. Completion of the project requires two more steps, monitoring and adaptive management (see section 2.3.7).

2.4 Program Capabilities

2.4.1 Albuquerque Area Office Management

The Albuquerque Area Manager and Assistant 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.

2.4.2 Technical Services Division

The TSD provides overall leadership, program management, development, and coordination of river maintenance activities with the AAO Divisions and outside stakeholders. The TSD River Analysis Group performs necessary design work and analysis of Rio Grande sediment transport and geomorphic data in support of river maintenance projects.

2.4.3 Environment Division

The Environment Division provides the necessary biological analysis for each project, which often includes developing mitigation and/or enhancement features during project design in coordination with the TSD River Analysis Group. This Division is responsible for all regulatory environmental compliance activities (See section 2.5.3).

2.4.4 Facilities and Lands Division

The Facilities staff perform dam and associated facilities site evaluations to identify safety and operation and maintenance deficiencies, conduct analyses, and recommended actions to resolve related concerns. The Facilities and Lands Division Realty staff provide the necessary lands analysis, review, approvals, licenses and/or permits needed for each project (See section 3.2).

2.4.5 Water Management Division

The Water Management Division staff is responsible for daily water operations, including management of inflows, outflows, and reservoir storage for Reclamation facilities in coordination with other Federal, State, Tribal, and local stakeholders. Water operations are guided by Rio Grande Compact (Compact) compliance, contracted water deliveries, and regulatory and environmental compliance obligations. The Program Management Group is a subgroup that provides planning support and resource management analyses for existing and new projects or operations.

2.4.6 Socorro Field Division

The Socorro Field Division performs maintenance for the Program. The Socorro Field Division has specialized capabilities involving equipment and knowledge related to accomplishing this type of construction maintenance work. These in-house capabilities allow the Program to undertake the Design-Build approach where designing, permitting, and implementing are integrated on projects. This capability allows the Program the ability to have the design and implementation maintenance personnel work together to maximize a project's value in the use of materials, construction methods, and scheduling. This approach allows flexibility in continually refining the implementation program to maximize benefits for each project. Their capability also includes the ability to provide lower level design information, specifications, and drawing preparation. Also, these capabilities allow the Program to mobilize and be on a site immediately to address emergencies along any MRG Project reach.

2.4.7 Technical Service Center

The Technical Service Center (TSC) in Denver provides specialized expertise in support of the River Maintenance Program. The primary activities include geomorphic evaluations and the modeling and analysis of river hydraulics, sediment transport, and channel migration. In particular, the TSC has performed sediment transport and geomorphic process modeling of the river channel system for both long term trends and in response to river maintenance activities and investigations of cutting edge, long term maintenance strategies and methods and their applicability to the Middle Rio Grande.

2.4.8 Integration of Division Roles and Responsibilities

The AAO and Soccoro Field Division participate on project teams to plan and implement river maintenance projects. The TSD River Analysis Group identifies annual work needs and project priorities based on periodic field reviews and analysis of existing data. In consultation with the Environment Division, Facilities and Lands Division, and Socorro Field Division; annual priority and schedule review meetings are conducted to establish near and long term priorities for river maintenance projects authorized under the MRG Project. Monthly River Scheduling meetings occur between the Area Office and Field Divisions to discuss planning, adaptive management, and implementing work on each project. At the project level, a Project Initiation Form (PIF) is prepared to ensure each project is approved by the Area Office Management and Division Managers. The PIF also identifies the project lead and project team members (see section 2.5.3).

2.5 Environmental Compliance

2.5.1 Legal requirements

The River Maintenance Program coordinates maintenance activities and projects with the Environment Division. The project's size and environmental impacts determine 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

A description of each act can be found in Appendix D.

2.5.2 Endangered Species Act

(*from* Service and National Marine Fisheries Service 1998)

Section 7 consultations as prescribed by the Endangered Species Act are particularly important in river maintenance planning. Section 7 of the ESA provides some of the most valuable and powerful tools to conserve listed species, assist with species' recovery, and help protect critical habitat. It mandates all federal agencies to determine how to use their existing authorities to further the purposes of the ESA to aid in recovering listed species, and to address existing and potential conservation issues.

Section 7(a) (1) directs the Secretary (Secretary of the Interior/Secretary of Commerce) to review other programs administered by them and use such programs to further the purposes of the ESA. It also directs all other federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of species listed pursuant to the ESA.

This section of the ESA makes it clear that all federal agencies should participate in the conservation and recovery of threatened and endangered species. Under this provision, Federal agencies often enter into partnerships and Memoranda of Understanding with the Fish and Wildlife Service or the National Marine Fisheries Service for implementing and funding conservation agreements, management plans, and recovery plans developed for listed species.

Section 7(a) (2) states that each federal agency shall, in consultation with the Secretary, insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. In fulfilling these requirements, each agency is to use the best scientific and commercial data available. This section of the ESA sets out the consultation process, which is further implemented by regulation (50 CFR §402). By law, section 7 consultation is a cooperative effort involving affected parties engaged in analyzing effects posed by proposed activities on listed species or critical habitat(s).

2.5.2.1 Southwestern Willow Flycatcher (Endangered)

(*from* Service 2002)

The SWFL , *Empidonax traillii extimus*, is a small Neotropical migratory bird, whose nesting habitat is restricted to relatively dense growths of trees and shrubs in riparian ecosystems in the arid southwestern United States and possibly extreme northwestern Mexico. These riparian habitats are associated with rivers, swamps, and other wetlands, including lakes and reservoirs (Bent 1960). Most of these habitats are classified as wetlands in the legal sense: palustrine and lacustrine forested wetlands and scrub-shrub wetlands (Cowardin et al. 1979). Some are non-wetland riparian forests. Surface water or saturated soil are typically, but not always, present year-round or seasonally and ground water is generally at a depth of less than 2 or 3 meters (6.5 to 9 feet) within or adjacent to nesting habitat. Regardless of the plant species composition or height, occupied sites usually consist of dense vegetation in the patch interior, or an aggregate of dense patches interspersed with openings. In most cases this dense vegetation occurs within the first 3–4 m (10-13 feet) above ground. These dense patches are often interspersed with small openings, open water, or shorter/sparser vegetation, creating a mosaic that is not uniformly dense. In almost all cases, slow-moving or still surface water and/or saturated soil are present at or near breeding sites during wet or non-drought years.

Thickets of trees and shrubs used for nesting range in height from 2 to 30 m (6 to 98 feet). Lower-stature thickets (2–4 m or 6–13 feet) tend to be found at higher elevation sites, with tall stature habitats at middle and lower elevation riparian forests. Nest sites typically have dense foliage from the ground level up to approximately 4 m (13 feet) above ground, although dense foliage may exist only at the shrub level, or as a low dense canopy. Nest sites typically have a dense canopy, but nests may be placed in a tree at the edge of a habitat patch, with sparse canopy overhead. The diversity of nest site plant species may be low (e.g., monocultures of willow or tamarisk) or comparatively high. Nest site vegetation may be even- or uneven-aged, but is usually dense (Brown 1988, Whitfield 1990, Muiznieks et al. 1994, McCarthey et al. 1998, Sogge et al. 1997a, Stoleson and Finch 1999).

Historically, the SWFL nested in native vegetation such as willows, buttonbush, boxelder, and *Baccharis*, sometimes with a scattered overstory of cottonwood (Grinnell and Miller 1944, Phillips 1948, Whitmore 1977, Unitt 1987). Following modern changes in riparian plant communities, the flycatcher still nests in native vegetation where available, but also nests in thickets dominated by the non-native tamarisk and Russian olive and in habitats where native and non-native trees and shrubs are present in essentially even mixtures (Hubbard 1987, Brown 1988, Sogge et al. 1993, Muiznieks et al. 1994, Maynard 1995, Sferra et al. 1997, Sogge et al. 1997a, Paradzick et al. 1999).

Since the initial surveys of the Rio Grande Valley in the 1990s, SWFL breeding pairs have been found within the MRG Project area from Elephant Butte Reservoir upstream to the vicinity of Española. Several locations along the Rio Grande have consistently held breeding flycatchers. These areas have one or more SWFL pairs that have established a territory in an attempt to breed, with most birds returning annually. A territory is an area around a nest that is actively defended against other members of the same or different species. In some locations, these local populations appear to be expanding, with increased number of territories being detected. Some local populations have remained small (10–15 territories, or fewer) but stable. Other sites have become extirpated and no longer contain territorial flycatchers.

A final rule was published in the February 27, 1995 Federal Register to list the southwestern U.S. population of the SWFL as an endangered species under the ESA with proposed critical habitat. However, the final rule designating critical habitat for the species range-wide did not include the Rio Grande (Service 1995) at that time. A proposal to list critical habitat was published October 12, 2004 (Service 2004), with a final designation published October 19, 2005 (Service 2005a). This designation included the Middle Rio Grande. The species occurs in southern California, Arizona, New Mexico, southern portions of Nevada and Utah, western Texas, and possibly southwestern Colorado (Service 1995a). Arizona, New Mexico, and California account for the greatest number of known SWFL sites (93%) in this region and 88% of the total known territories located in 2001. Within these states, the largest known population of SWFL territories is found along the Gila River drainage while the Rio Grande in Colorado and New Mexico contribute the second largest number of territories to the overall population (Sogge et al. 2002). See Appendix C for more detailed information.

2.5.2.2 Rio Grande Silvery Minnow (Endangered)

(*from* Service, 1994)

The RGSM *(Hybognathus amarus)* is one of several species in the genus *Hybognathus* found in the United States. It is a stout silvery minnow with moderately small eyes and a small mouth (Pflieger 1975). Adults may reach 90 mm (3.5 in) in total length (Sublette et al. 1990). This species was historically one of the most abundant and widespread fishes in the Rio Grande basin, occurring from Española, New Mexico to the Gulf of Mexico (Bestgen and Platania 1991). Collection data indicate the species presently occupies about five percent of its historic range (Platania 1993). It has been completely extirpated from the Pecos River and from the Rio Grande downstream of Elephant Butte Reservoir. Currently, it is found only in a 275 km (170 mi) reach of the Middle Rio Grande, New Mexico; from Cochiti Dam to the headwaters of Elephant Butte Reservoir (Bestgen and Platania 1991). Throughout much of its historical range, decline of the RGSM may be attributed to modification of stream discharge patterns and channel desiccation by impoundments, water diversion for agriculture, and stream channelization (Bestgen and Platania 1991, Cook et al. 1992). The draft recovery plan is available for public comment: Service. 2007. Rio Grande Silvery Minnow (*Hybognathus amarus*) Recovery Plan. Albuquerque, NM.

Critical habitat for the RGSM was designated by the Service (Service 2005b) as the river corridor inside levees or within 300 feet of the river from Cochiti Reservoir to the power lines upstream of Elephant Butte Reservoir. Collaborative Program funded surveys cover the Rio Grande from Angostura Diversion Dam downstream to the power lines upstream of Elephant Butte Reservoir (Dudley and Platania 2007; Dudley et al. 2007). A survey by the Service in the Elephant Butte Reservoir Temporary Channel area has found RGSM (Porter, pers. comm.: awaiting trip report from Service). These surveys followed a change in construction to leave point bars in the Temporary Channel where possible. RGSM uses habitat at these point bars. Population increases in 2004 and 2005 throughout their current range correlated with overbank flows creating inundated habitat for recruitment (Dudley and Platania 2007). Augmentation of RGSM by the Service appears to contribute less than one percent of the population (Remshardt 2006).

There is a strong positive correlation between peak discharge and duration of high flows during the spawning season (May–June) with the RGSM mean October catch rates (Dudley and Platania 2007). This correlation supports the concept that RGSM use floodplain habitat for spawning and rearing of larval fish. Inundated point bars, islands and riparian habitats on a recurring basis appear essential for recruitment (Pease 2004). Short (< 5 days), low magnitude (<1,500 cfs) spawning pulses are ineffective for recruitment while slightly higher duration (5–7 days), moderate magnitude (2,500–3,000 cfs) flows support good recruitment. The spring runoff peak in 2005 was over 4,000 cfs for nearly two months and the 2004 peak was over 3,000 cfs for more than a week. The population survey numbers increased three orders of magnitude from October 2003 to

October 2005. Data from ongoing Reclamation electrofishing surveys from Bernalillo to Socorro provide ecological insights into habitat use (Porter and Dean 2006).

A number of biological constraints and needs have been identified that should be considered in planning and management. Each of these parameters needs to be maintained over a large enough area on an annual basis to sustain the populations of RGSM:

- Natural flow regimes
- Periodic flood events during spring and summer to initiate breeding
- Appropriate habitat for early life-history stages, including floodplain and other shallow, quiet water environments
- Suitable water quality
- Unimpeded flows to allow for movement of various life stages

These primary constituent elements of critical habitat provide for the physiological, behavioral, and ecological requirements of the RGSM.

The first element provides sufficient flows from early spring (March) to early summer (June) to trigger spawning, flows in the summer (June) and fall (October) that do not increase prolonged periods of low or no flow, and a relatively constant winter flow (November through February).

The second element provides habitat necessary for development and hatching of eggs and the survival of the species from larvae to adult. Low-velocity habitat provides food, shelter, and sites for reproduction, which are essential for the survival and reproduction of RGSM.

The third element provides appropriate silt and sand substrates, which are important in creating and maintaining appropriate habitat and life requisites such as food and cover.

The fourth element provides protection from degraded water quality conditions. When water quality conditions degrade (e.g., water temperatures are too high or dissolved oxygen concentrations are too low), RGSM are likely to be injured or die.

The last element provides for hydrologic connectivity to facilitate fish movement. This element is essential to the conservation of the species because it cannot withstand permanent drying (loss of surface flow) of long stretches of river. Dams, diversions, and river impediments can have negative impacts on the downstream movement of eggs and larvae and on the ability of subadult and adult fish to move upstream. There is no evidence to date to suggest optimal timing, periodicity, or geographic extent of upstream movement.

2.5.2.3 Bald Eagle (Removed)

The southwestern population of the bald eagle (*Haliaeetus leucocephalus*) was federally-listed as endangered in 11 March 1967 (Service 1967). The species was downlisted to threatened in 1995 and was removed from the list of threatened and endangered wildlife in 2007. Bald eagles will continue to be protected by the Bald and Golden Eagle Protection Act and the MBTA. Both acts prohibit killing, selling, or otherwise harming eagles, their nests, or eggs.

The bald eagle prefers habitat consisting of roosts over open water, such as inundated cottonwood snags. They are typically found in reservoir areas and sometimes in transit between reservoirs. Generally, bald eagle habitat spans from the south boundary of the Bosque del Apache to Caballo, although bald eagles can be found on the non-reservoir portions of the Rio Grande all winter.

2.5.2.4 Pecos Sunflower (Threatened)

Pecos sunflower (*Helianthus paradoxus*) is a wetland plant that was given threatened species status under the ESA on October 20, 1999 (64 FR 56582-56590). Critical habitat for this plant was proposed on March 27, 2006 (FR 72:14328-14366) and includes many of the marshes on the west side of the Rio Grande, and west of the drains, at La Joya State Wildlife Area. Spring seeps, or wet meadow (cienega) habitats are very rare in the dry regions of New Mexico and Texas. There is evidence these habitats have historically, and are presently, being reduced or eliminated by aquifer depletion, or severely impacted by agricultural activities and encroachment by alien plants (Poole 1992, Sivinski 1996).

2.5.2.5 Western Yellow-billed Cuckoo (Candidate)

Major declines among western populations of the Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) in the twentieth century are due to habitat loss and fragmentation, local extinctions, and low colonization rates to where it is now extremely rare in most areas (Laymon and Halterman 1989). In the Program area, the San Marcial area holds the greatest population in New Mexico in part because of the abundant riparian vegetation in the area.

2.5.2.6 Whooping Crane (Endangered)

An effort to create a wild flock with an alternate migratory route was initiated in 1975, using Sandhill Cranes (*Grus canadensis*) as “foster parents” (considered a Section 10(j) experimental population). Whooping Crane eggs were placed in the nests of Sandhill Cranes on their nesting grounds at the Grays Lake National Wildlife Refuge in Idaho. The Sandhills reared the chicks as their own, teaching them feeding habitats and ultimately a new 850-mile migratory path to the Bosque Del Apache National Wildlife Refuge (BDANWR) in New Mexico. Unfortunately, these Whooping Cranes became so accustomed to their Sandhill parents that they would not mate with other Whooping Cranes. Today, there are no Whooping Cranes left in this flock and in this area.

2.5.3 Environmental Compliance Activities and Requirements

A proposed river maintenance project is initiated when the River Analysis Group fills out a PIF and submits it to the Environment Division. The PIF provides project-related information for an upcoming proposed project. Based on the information provided within the PIF, an interdisciplinary team is defined and the anticipated level of ESA and NEPA compliance (i.e., Environmental Impact Statement (EIS), Environmental Assessment (EA), or a Categorical Exclusion Checklist (CEC)) is determined for the project. Once the PIF is finalized, it is routed and signed by the appropriate division managers and the Area Manager. Once the PIF has been approved, the proposed design and compliance work can commence along with the expenditure of project funding. See Appendix B for more information.

As the project becomes more defined, additional environmental compliance approvals necessary for the project are determined. These could include, but are not limited to: National Historic Preservation Act (NHPA) archaeological assessments, CWA Sections 404, 402 and 401 and the ESA. The Environment Division provides the necessary biological analysis for each project which often includes developing mitigation and/or enhancement features during project design in coordination with the River Analysis Group.

The Program coordinates maintenance activities and projects with the Environment Division. The project's size essentially determines the compliance level and work effort needed for successful project completion. The federal laws listed in section 2.5.1 need to be incorporated into planning maintenance activities for environmental compliance.

Recent river maintenance projects have been designed to address habitat needs 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 providing greater latitude for fluvial processes.

Figure 2. Levee setback at river mile 113/114

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.

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

Figure 3. Bioengineered bankline at La Canova

The project's size determines the work effort needed for successful project completion. Larger projects look at a broader scale, focusing on implementing improvement for an entire river reach. Medium sized projects generally focus on small reaches with a more limited scope than the large projects, but may have enough issues to warrant the preparation of an EA. Smaller sized projects focus on localized site specific needs that can generally be achieved under a CEC.

Presentations describing the proposed project are frequently made to federal and state agencies and other stakeholders to inform the public on the proposed work, i.e., the project's purpose and need, engineering design and features, environmental effects, project enhancement features/commitments, monitoring, biological data and status, etc.

Within the 2003 BiOp for water operations and river maintenance, there are 25 Conservation Recommendations listed that are intended to benefit endangered and threatened species (see Appendix A). These recommendations are specifically for the SWFL and RGSM. Conservation recommendations are discretionary agency activities that can be undertaken to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. Reclamation has undertaken several activities that follow Conservation Recommendations from the BiOp. Examples of these non-required activities include:

- Continue to work collaboratively to develop and implement a long-term plan to benefit the recovery of the RGSM and SWFL , e.g., CR-10; being done via the Middle Rio Grande Endangered Species Act Collaborative Program (Collaborative Program).

- Survey and monitor all suitable SWFL habitats throughout the action area annually This has been done each year since 1995.

- Conduct research to better understand micro- and macro-habitat characteristics of occupied SWFL habitat and methods to most successfully restore it (completed a three-year study on nest-site habitat characteristics). Work is being done via the Collaborative Program to develop effective habitat restoration techniques and locations in the Middle Rio Grande.

3 Authorization, Roles, and Activities of Reclamation and Other Agencies

3.1 Middle Rio Grande Project Authorization

The MRG Project is authorized by the Flood Control Acts of 1948 and 1950. The project authority extends from Velarde, New Mexico, to headwaters of Caballo Dam. MRG Project components are assigned to Reclamation, Corps, and MRGCD in the House Documents (see Appendix F for more information).

Responsibilities for implementation of activities are defined in a joint agreement between the Secretary of the Interior and Secretary of the Army dated July 25, 1947. Additional analysis by Lawler (*in* Reclamation 2003b) confirms that “the Albuquerque Area Office has clear authority to conduct continuing channel rectification work above Elephant Butte Reservoir”.

The major features of the MRG 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 and rehabilitation
- Establishment and maintenance of a cleared floodway and conveyance channel into Elephant Butte Reservoir

3.1.1 Reclamation Authorized Activities

The Secretaries’ agreement assigns the following activities to Reclamation:

- El Vado Reservoir improvements
- Channel rectification and maintenance
- Irrigation and drainage rehabilitation and extension

Rectification objectives include providing a stabilized channel with a nominal capacity of not less than 5,000 cfs (i.e., the mean annual flood) together with a floodway having capacity to safely pass uncontrolled flash flood flows (Reclamation 1947a). Reclamation currently provides channel capacity maintenance for discharges up to the mean annual flood event or 2-year peak. The mean annual flood varies from 5,000 cfs to 8,500 cfs depending on the reach.

Reclamation regularly maintains the levee in the San Acacia to Elephant Butte reach and in other areas may perform levee maintenance on an intermittent, occasional, or emergency basis at the request of MRGCD. Regular levee maintenance is to prevent failure caused by bank erosion at less than overbank flows.

Reclamation's river maintenance activities have evolved over time. There have been three phases of river maintenance activities since maintenance began after the completion of the original channelization. These phases of maintenance are described in section 2.1.

3.1.2 U. S. Army Corps of Engineers Authorized Activities

The Secretaries' agreement assigns the following activities to the Corps:

- Abiquiu Reservoir construction
- Jemez Canyon Reservoir construction
- New levee construction and improvement for local flood protection

3.1.3 Middle Rio Grande Conservancy District Responsibilities

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 Dam and some jetty fields).

3.2 Land Acquisition and Access

The Secretary of the Interior has, by and through the Commissioner of the Bureau of Reclamation, delegated the authority of the Regional Director to,acquire property in the name of the United States as authorized, among other things. Appendix E contains a list of authorizing legislation and other legal requirements. The acquisition of property is an obligation of the United States, and, as such, this right is strictly regulated through both the Department of the Interior and the Department of Justice. The MRG Project is, as derived from the Flood Control Act of 1948, a unique Federal reclamation project.

The Facilities and Lands Division Realty staff must be involved in all project phases regarding any planned maintenance activity on the MRG 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. This access may include purchase, easements, leases, permission, or any combination of the above.

A variety of land ownership patterns exist within the MRG Project (Table 1). These various land ownerships include Tribal/Pueblo lands, numerous Land Grants, various federal holdings, state lands, lands held by municipalities, and business and private holdings. Obtaining access from these various land owners and land management entities requires significant records research, analysis of access options, and, often, close coordination with other federal, state, county and municipal entities.

Current Albuquerque Area Office policy requires coordination with MRGCD on any operational or maintenance work within the MRG Project which may affect the interests and operations of the MRGCD.

Table 1. Summary of land ownership by reach

Reaches	Private	Municipal	Tribal/ Pueblo	BIA	Other Federal	State	River Miles Approx.	Lands Contact
Velarde to Rio Chama	X	X	X	X	X		285 to 272	ALB420
Rio Chama to Otowi*	X	X	X	X	X		272 to 258	ALB420
Cochiti to Angostura	X	X	X	X			233 to 210	ALB422
Angostura to Isleta	X	X	X	X		X	210 to 169	ALB422
Isleta to Rio Puerco	X	X	X	X			169 to 127	ALB422
Rio Puerco to San Acacia	X	X			X	X	127 to 116.2	ALB422
San Acacia to Arroyo Canas	X	X			X	X	116.2 to 95	ALB422
Arroyo Canas to San Antonio	X	X			X	X	95 to 87.1	ALB422
San Antonio to RM 78	X	X			X	X	87.1 to 78	ALB422/ ALB420
RM 78 to Elephant Butte Reservoir	X	X			X	X	78 to 50	ALB420
Elephant Butte Reservoir to Caballo Reservoir	X	X			X	X	50 to 12	ALB420
Low Flow Conveyance Channel	X	X			X	X	116.2 to 61.4	ALB422/ ALB420
*Currently no maintenance activities are performed in White Rock Canyon or Cochiti Reservoir, BIA – Bureau of Indian Affairs								

3.3 Stakeholder Responsibilities and Agency Programs

3.3.1 Reclamation Programs (in addition to River Maintenance)

3.3.1.1 Middle Rio Grande Endangered Species Act Collaborative Program

Reclamation is the agency charged with administering the Collaborative Program. The Collaborative Program includes a number of participating federal, state, tribal and stakeholders. Program Signatories to the 2006 Memorandum of Understanding included the following:Assessment Payers Association of the MRGCD; Attorney General, State of New Mexico (NM); City of Albuquerque; MRGCD; National Association of Industrial and Office Properties; New Mexico State University; NM Department of Game and Fish; NM Department of Agriculture; NM Environment Department; NMISC; Pueblo of Santa Ana; Pueblo of Santo Domingo; Rio Grande Water Rights Association; Bureau of Indian Affairs, Department of the Interior (DOI); Bureau of Reclamation, DOI; United States Department of Agriculture, Forest Service, Rocky Mountain Research Station; Corps; Service; and University of New Mexico. In 2007, Collaborative Program administrative duties continue to reside with Reclamation.

The goals of the Collaborative Program include the following:

- 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 state and federal law, including compact delivery obligations

As shown on the website <http://research.unm.edu/WaterForum/April_Sanders.pdf>, accessed 11/20/06.

Many projects are or have been sponsored by the Collaborative Program to help meet these goals. Table 2 summarizes projects by reach.

Table 2. Summary of projects by reach

Reach	Total Projects	Sponsors	Types of Projects
Velarde to Rio Chama	3	BOR, FWS, EPA, Pueblo of San Juan	Wetland creation, vegetation removal and planting, create fish habitat, expand active floodplain
Rio Chama to Otowi	2	BOR, RGR	Wetland creation, vegetation removal and planting, create habitat, expand active floodplain
Cochiti to Angostura	4	Corps, Pueblo of Cochiti, Santo Domingo Pueblo	Habitat restoration, vegetation removal and planting, underground drains
Angostura to Isleta	29	City of Albuquerque Open Space, BOR, Corps, FWS, MRGCD, ISC, Pueblo of Jemez, Pueblo of Sandia, Intel, Phillips, UNM, NM Natural Heritage Program, Habitech, Ducks Unlimited, Minimal Access Technologies, NRCS	Wetland creation, vegetation removal and planting, bank lowering, create fish habitat, reconnect abandoned channels
Isleta to Rio Puerco	5	BOR, FWS, FWP, Corps, ISC, MRGCD, Valencia County SWCD	Habitat restoration, vegetation removal and planting, jetty jack removal, reconnect channel, bank lowering
Rio Puerco to San Acacia	10	BOR, FWS, Sevilleta NWR, Corps, ISC, MRGCD	Habitat restoration, vegetation removal and planting, re-connect historical channels
San Acacia to Arroyo de las Cañas	17	Save Our Bosque Task Force, Socorro SWCD, FWS	Habitat restoration, vegetation removal and planting, create wetlands, construct firebreaks
Arroyo de las Cañas to San Antonio	1	Save Our Bosque Task Force	Vegetation removal and planting
San Antonio to River Mile 78	20	BDANWR, BOR, FWS, NAWCA	Habitat restoration, vegetation removal and planting, create wetlands, construct firebreaks
River Mile 78 to Elephant Butte Reservoir	4	BOR, BDANWR	Vegetation removal, habitat restoration, river maintenance
Elephant Butte Reservoir to Caballo Reservoir	1	BOR	River maintenance

More detailed information on individual projects and acronyms can be found in Appendix A. The flow and geomorphic needs of habitat restoration, vegetation removal, wetlands creation, floodplain reconnection, and other activities will need to be considered as proposed river maintenance activities are designed to alter river form and function.

3.3.1.2 Title XVI

Title XVI gives Reclamation general authority to conduct appraisal and feasibility studies on water reclamation and reuse projects. It also provides general authority for research and demonstration programs to test water reclamation and reuse technologies. Reclamation may also participate in construction of reuse projects after congressional authorization of the project. River maintenance activities could have an impact on some projects with Reclamation investment. Policy development is needed to better define the role of Title XVI projects in river maintenance activities.

The original Title XVI Act provided authority to participate in the design and construction of five specific projects in California and Arizona. The 1996 Title XVI Act authorized 16 additional recycling projects and 2 desalination demonstration projects. Subsequent amendments to Title XVI and other individual acts authorized nine additional construction projects. (See <http://12.46.245.173/pls/portal30/CATALOG.PROGRAM_TEXT_RPT.SHOW?p_arg_names=prog_nbr&p_arg_values=15.504> accessed 11/20/06.)

Examples of water projects under Title XVI are from Albuquerque and Santa Fe. The City of Albuquerque (City) is diverting water from the Rio Grande to augment both non-potable and potable supplies. The non-potable surface water reclamation project includes a new subsurface water diversion facility to capture San Juan-Chama water. The diversion structure is on the east bank of the Rio Grande, approximately 1,000 feet south of the bridge at Alameda Boulevard. The non-potable water reclamation project diverts water from beneath the riverbed using Ranney collectors. At full capacity, the project is expected to deliver about 2,500 acre-feet per year for turf irrigation and other non-potable purposes. Reclamation contributed 25 percent of the non-potable water reclamation project through Title XVI funding.

The City's drinking water project diverts water from the Rio Grande at the site of an inflatable dam north of Alameda Boulevard on the north side of the City of Albuquerque. The drinking water project is expected to divert the City's share of San Juan-Chama project water together with native Rio Grande water, with an expected return flow of about 50 percent at the City's South Valley Wastewater Treatment facility outfall.

The City of Santa Fe is currently preparing NEPA documents assessing the feasibility of diversion structures in the Rio Grande above Otowi. River maintenance issues associated with the Santa Fe's diversion structures are anticipated to be similar in nature to those associated with the City of Albuquerque projects. More information on these projects can be found in Appendix G.

3.3.1.3 Water 2025

Water 2025 is intended to focus attention on the reality that explosive population growth in western urban areas, the emerging need for water for environmental and recreational uses, and the national importance of the domestic production of food and fiber from western farms and ranches is driving major conflicts between these competing uses of water. The DOI promotes the use of four key tools:

- Conservation, efficiency, and markets
- Collaboration
- Improved technology
- Removal of institutional barriers and increase interagency cooperation

The Water 2025 efforts at the MRGCD are being funded with $3.5 million in federal money and matching funds from the MRGCD. The Water 2025 funds will used for efficiency improvements on MRGCD facilities in Sandoval, Bernalillo, Valencia, and Socorro Counties. The MRGCD non-federal matching funds include in-kind as well as cash contributions. The MRGCD has begun work on its Water 2025 plan, which is an effort to manage its resources to conserve water and create a more efficient water conveyance system with planned improvements to the District's 1,200 miles of drains, canals, and laterals. Those improvements will likely include automatic gates, water flow monitors, and the lining of ditches and canals with concrete in select locations to reduce water seepage loss. The plan might also include the construction of a siphon to convey water from the Lower San Juan Riverside Drain on the east side of the river to Drain Unit 7 on the west side and to supplement irrigation needs for the Socorro Division. The projects are scheduled to be completed by 2008.

(See <http://www.doi.gov/water2025/Water2025-Exec.htm>, accessed 11/20/06 and <http://www.mrgcd.com/?cmd=newsletters&id=21>, accessed 05/03/07.)

Impacts to river maintenance activities may include changes in seepage and flow characteristics along river sections where extensive canal lining is occurring and where siphons are installed.

3.3.2 U.S. Army Corps of Engineers

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. The Corps also issues permits for discharges of dredged or fill materials into the waters of the United States under Section 404 of the CWA, as well as permits for the transportation of dredged materials for ocean dumping under Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972.

Within the Middle Rio Grande valley, the Corps operates four flood control dams on the main stem or major tributaries. The Corps has also conducted numerous planning studies; constructed flood damage reduction projects including stream bank erosion protection, channel modification, and levee projects; constructed ecosystem restoration projects and environmental infrastructure projects, operates and maintains several recreational areas; issues regulatory permits under Section 404; and performs emergency flood-fighting operations. Corps projects include restoration efforts in the Rio Grande Bosque in Albuquerque in response to wildfires during 2003.

The Middle Rio Grande Flood Control Project was authorized by the U.S. Congress with the passage of the Water Resources Development Act (WRDA) of 1986 (Public Law 99-662). The project entails replacing existing embankments along both sides of the Rio Grande with structurally competent levees capable of containing high volume, short duration flows up to the design discharge, as well as low volume, long duration flows.

The division of shared responsibility for levee construction and maintenance is based on agreements between the Corps, MRGCD, and Reclamation. The major points of the division are:

- The Corps has authorization to replace existing embankments with levees, while the MRGCD has responsibility to maintain the levee structures both under the Flood Control Acts of 1948 and 1950 and as the local sponsor under WRDA of 1986.
- When bank erosion occurs at less than flood flows, it is Reclamation’s authorized role to perform the river maintenance work
- When levee damage occurs during flood flows then MRGCD is responsible for maintenance.

Appendices F and H provide more information on the division of shared responsibility. A discussion of existing levees, proposed levees, and other programs of interest to river maintenance can be found in Appendix I.

3.3.3 Middle Rio Grande Conservancy District

The MRGCD was created more than 80 years ago, formed under the authority of the New Mexico Conservancy Act for purposes such as irrigation and agricultural development, flood control, stream regulation, drainage, and construction and maintenance of distribution facilities for irrigation waters. It is a political subdivision of the State of New Mexico. MRGCD serves a geographic area that stretches 150 river miles from Cochiti Dam to the northern border of the BDANWR, and includes portions of Sandoval, Bernalillo, Valencia, and Socorro counties. MRGCD provides for the irrigation of approximately 70,000 acres of cropland in the Middle Rio Grande Valley.

During the 1920s and 1930s, MRGCD consolidated water rights and irrigation systems in the Middle Rio Grande valley. By the 1940s, MRGCD could not afford the necessary maintenance on much of the facilities within its boundaries.

The Acts provided MRGCD with the federal help it desperately needed to rehabilitate and modernize existing facilities. The Acts also authorized appropriations to the Corps and the Reclamation for work on the MRG Project. Under the MRG Project, Reclamation and the Corps agreed to a unified plan for control of floods and irrigation and use of water in the Middle Rio Grande basin. MRGCD is the local sponsor under the 1986 WRDA.

In 1974 (effective February 1, 1975), Reclamation transferred operation and maintenance of the MRG Project facilities back to the MRGCD. Reserved works that were excepted include El Vado Dam and Reservoir, San Acacia Diversion Dam, and certain channelization and flood protection works. Operation and maintenance of the San Acacia Diversion Dam was transferred to MRGCD effective September 1, 1977. See Appendix H for information on the division of river channel maintenance activities.

Several environmental groups challenged the alleged failure of Reclamation and the Corps to consult fully with the Service in efforts to protect the endangered RGSM and SWFL. This included potential requirements for water to sustain the species. During this time, MRGCD filed for ownership of the properties, which include key reservoirs, diversion works, water rights, and properties in the Rio Grande Valley.

In July of 2005, Judge James A. Parker ruled that the United States held title to the MRG Project works. On September 9, 2005, the MRGCD filed its notice of appeal.

Sources:

Judgment, Rio Grande Silvery Minnow, et al., vs. John W. Keys III, et al., July 2005
<http://econtent.unm.edu/cdm4/item_viewer.php?CISOROOT=/New> accessed 05/03/07
<http://libxml.unmedu/oanm/nmlcu/nmlculms252.html>
<http://www.mrgcd.com/?cmd=pages&what=About theDistrict>
<http://www.mrgcd.com/?cmd=pages&what=Mapping/GIS>

3.3.4 New Mexico Interstate Stream Commission

The NMISC has broad powers to investigate, protect, conserve, and develop New Mexico's waters including both interstate and intrastate stream systems. The eight unsalaried members of the NMISC are appointed by the Governor. The ninth member is the State Engineer who, under state law, is the secretary of the NMISC. The Director serves as the deputy state engineer. The NMISC's authority under state law includes negotiating with other states to settle interstate stream controversies. New Mexico is a party to eight interstate stream basins. To ensure basin compliance, NMISC staff analyzes, reviews, and implements projects in New Mexico and in other states and analyze streamflow, reservoir, and other data on the stream systems. The NMISC is also authorized by statute to investigate and develop the water supplies of the state and institute legal proceedings in the name of the state for planning, conservation, protection, and development of public waters. (See <http://www.ose.state.nm.us/isc_index.html>, accessed 11/20/06.)

3.3.5 Fish and Wildlife 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, conserves and restores wildlife habitat such as wetlands, and helps foreign governments with their international conservation efforts. It also oversees the Federal Aid Program that distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies. (See <http://www.fws.gov/faq/fwsfaq.html> accessed 05/03/07.)

3.3.6 Native American Pueblos

The fifteen Native American Pueblos found within the eight-county study region require special mention. The Pueblos, listed from north to south include: Ohkay Owingeh (formerly San Juan Pueblo), Santa Clara, San Ildefonso, Pojoaque, Nambe, Tesuque, Jemez, Zia, Santa Ana, Cochiti, Santo Domingo, San Felipe, Sandia, Laguna, and Isleta. Some of the Pueblos can generally be characterized as economically depressed areas with high unemployment rates and low per capita incomes. People identified as Native American represent five percent of the study area population, with Rio Arriba, Sandoval, and Socorro Counties claiming higher percentages of Native Americans. With fairly extensive land areas, many of these Pueblos rely on subsistence farming and ranching.

Indian trust assets are legal interests in property held in trust by the United States for Indian tribes or individuals. Examples of things that may be trust assets are lands, minerals, hunting and fishing rights, and water rights. The United States, with the Secretary as the trustee, holds many assets in trust for Indian Tribes or Indian individuals. This trust responsibility requires that all Federal agencies, including Reclamation, take all actions reasonably necessary to protect trust assets.

See the Pueblos and Tribes bullet in section 3.5 for more information on the direct impact to river maintenance activities.

3.3.7 Local Flood Control Authorities

3.3.7.1 Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA)

AMAFCA was created in 1963 by the New Mexico Legislature with specific responsibility for flooding problems in greater Albuquerque. AMAFCA's purposes are to prevent injury or loss of life and to eliminate or minimize property damage. AMAFCA does this by building and maintaining flood control structures which help alleviate the problem. (See <http://www.amafca.org/about.htm> accessed 11/20/06.)

3.3.7.2 Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA)

SSCAFCA is an independent corporate political body with an elected board empowered to undertake the acquisition, improvement, maintenance and operation of flood and storm water control facilities on streams and watersheds which originate on, enter, or cross the SSCAFCA's facilities. It was established by New Mexico Statute Section 72-19-1 through 72-19-103 in 1990 to provide flood protection up to the 100-year storm for the public health, safety and welfare of residents and properties within its boundaries. SSCAFCA regulates activities which may affect those facilities such as drainage control from proposed real estate development. (See <http://www.sscafca.com> accessed 11/20/06.)

3.3.8 Acequias

Acequias are both the irrigation ditches and the associated community-based water management systems that have supported historic and current land-based culture and community in New Mexico. There are over 1,000 acequias in New Mexico and many are concentrated in the historically agricultural villages of northern New Mexico. Over the years, acequias have formed regional associations and participated in the New Mexico Acequia Association to address common issues including water rights, water marketing and transfers, adjudication, and impacts of endangered species litigation. River maintenance issues with the potential to impact acequias include maintaining channel capacities that do not threaten the overtopping and destruction of relatively fragile acequia diversion structures.

3.4 Upper Rio Grande Water Operations (URGWOPS)

The Final Environmental Impact Statement (FEIS) for the Upper Rio Grande Water Operations Review (Review) was published in April 2007 (Reclamation 2007). The Review evaluated a range of water operations alternatives at ten federal facilities in the upper Rio Grande basin. The location and operating agency of each facility are identified in the FEIS. Proposed changes were limited to actions that were within current authorities . The preferred alternative, alternative E-3, suggested the following changes: 1) extend Heron Reservoir waivers to September; 2) permit storage of up to 180,000 acre-feet of native Rio Grande water in Abiquiu Reservoir; 3) increase channel capacity below Cochiti Dam to 10,000 cfs; and 4) operate the LFCC at ranges of 0 to 2,000 cfs. Reclamation actions under this alternative will be described in the Record of Decision, issued in July 2007 and include 1) extending Heron Reservoir waivers to September and 2) continued operations of the LFCC as a passive drain with zero cfs diversions from the Rio Grande. Reclamation actions are consistent with water operations activities described in the 2003 Biological Assessment and the BiOp issued by the Service on March 13, 2003.

Operational impacts to the river will include actions needed to increase and maintain the 10,000-cfs channel capacity below Cochiti. Potential changes in the timing and distribution of flows along the Rio Chama and Rio Grande resulting from storage in Abiquiu Reservoir may also affect river maintenance activities. The current condition of the LFCC precludes active diversion; therefore, it is presumed that the LFCC will operate only as a drain for the foreseeable future.

3.5 Interagency Coordination

The Program at both the programmatic and individual project level seeks to coordinate 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, landownership, 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 river maintenance responsibilities within the MRG Project reach require that Reclamation coordinate with the following agencies, programs, and entities (see sections 3.1, 3.3, and 3.5 for agency authorized activities).

- **U.S. Army Corps of Engineers**

The Program should continue regular coordination with the Corps on their Middle Rio Grande Flood Control Levee Projects (Corrales, Albuquerque, Isleta, Mountainview, and Belen Units) and the San Acacia to Bosque del Apache Flood Control Project in their various stages of planning, design, construction, and inspection. For these Corps Flood Control Projects, the physical location, design, and maintenance needs may affect the amount and type of future river maintenance projects at their location. The Program should also continue to coordinate with the Corps regarding ongoing hydrologic studies in support of design requirements for Corps Flood Control Projects. Lastly, coordination should continue with the Corps Reservoir Control during flood control operations related to spring runoff and thunderstorm runoff associated with bank erosion and channel capacity at priority site locations. Agency roles between Reclamation and the Corps for levee maintenance and prevention of levee failure due to bank erosion remain as described in section 3.1.1 and 3.1.2. Coordination should also include cooperating with the Corps related to sharing studies, analyses, and data along the Rio Grande.

- **Middle Rio Grande Conservancy District**

The Program should continue regular coordination with the MRGCD in various stages of planning, design and construction, studies, and on operations of irrigation and drainage facilities. For river maintenance projects, Reclamation continues to use the existing MRGCD levee and drain roads for access. For river maintenance construction activities, coordination occurs regarding use of water from canals and drains (e.g., dust control). Agency roles for levee maintenance and prevention of levee failure due to bank erosion remain as described in sections 3.1.1 and 3.1.3.

- **New Mexico Interstate Stream Commission**

The Program should continue regular coordination with the NMISC through the State Cooperative Program for work involving benefits from River Maintenance projects to water salvage within the Middle Rio Grande valley. This includes projects and activities involving the Elephant Butte Temporary Channel and the LFCC. Other coordination involves providing annual updates to the Engineer Advisors for the Rio Grande Compact and sharing information on other operations and studies from NMISC.

- **United States Fish and Wildlife Service**

The Program should continue regular coordination with the Service in accordance with the requirements of the 2003 BiOp in addressing the identified Reasonable and Prudent Actions and Measures for river maintenance activities (see Appendix A). The Program should also continue regular coordination on its projects and activities with the BDANWR and Sevilleta National Wildlife Refuge (SNWR). Coordination should also continue on projects and studies with the Bosque Hydrology workgroup (BHG) and Management of Exotics for Recovery of Endangered Species (MERES) program.

- **Pueblos and Tribes**

Land and water issues are critically important. 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 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. In recent years, obtaining access permission has frequently been problematic. In several cases, Pueblos have cited concerns about potential release of hydrographic or biological data under the Freedom of Information Act (FOIA) in describing their reluctance to grant access to Reclamation. In other cases, no concern has been cited, and delays may be attributable to the Pueblos' obligations to higher priority needs within their governments.

- **Local Agencies and Organizations**

The Program should continue regular coordination with local government agencies and associations (state, county, municipal), research institutions (e.g., universities), and other local entities (e.g., public and private utilities). In past coordinations with local agencies, decisions regarding river maintenance activities have been based on the philosophy that local agencies provide and perform maintenance of river protection works for their structures (e.g., bridges, diversion dams, gas pipelines, railroad crossings, bosque parks, Title XVI - Albuquerque and Santa Fe water supply projects, etc.). This includes the local vicinity of their structures both upstream and downstream. The Program should continue regular coordination with associations such as the Middle Rio Grande Floodplain Manager Association (Annual Meeting), the Save Our Bosque Task Force (monthly meetings and river and floodplain restoration planning), and the City of Albuquerque Open Space (floodplain clearing). The Program should continue to coordinate with local research institutions and their projects such as the University of New Mexico (Bosque Environmental Monitoring Program—BEMP) etc.), New Mexico Tech (Surface and Groundwater modeling and data collection), and New Mexico State University.

- **Middle Rio Grande ESA Collaborative Program**

The River Maintenance Program should continue regular coordination with the Collaborative Program staff including providing annual updates for BiOp activities. Also, the Program should continue review of planned habitat restoration, monitoring, and other riverside activities as they relate to river maintenance projects and activities.

In regard to current River Maintenance policies, river maintenance activities would <u>not</u> address:

- Providing for river-bed elevation controls (i.e., grade control) to protect subsurface diversion structures from excessive scour.
- Considering underground pipeline utility crossing protections.
- Developing future policy regarding river maintenance activities with regard to subsurface structures within or crossing the riverbed. Consideration should be given to protecting structures constructed with Reclamation funds.
- Considering increasing wastewater treatment plant discharges and their contributions to downstream river flows
- Considering environmental impacts by others to habitat and water quantity and quality.

Issues for consideration to develop future policy regarding the Program and its involvement with other agencies and stakeholders are:

- Facilities and structures that are owned, constructed, operated, and maintained by other agencies and stakeholders within the river channel and floodplain defined by the levees.
- 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 (e.g., bank-side protection of collection, treatment, and discharge facilities).
- Facilities and subsurface structures within the river channel and floodplain defined by the levees constructed with Reclamation funding (e.g., Title XVI projects).

4 River Conditions

The majority of the 270 river miles 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.

Eleven separate reaches 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. Many reaches are at different stages of evolution and each has distinct factors affecting the current geomorphology. Figure 4 gives reach locations, and Table 3 summarizes the data for many of the definition factors for each reach.

Much of the discussion in chapters 4 through 15 is based on the *Draft 2007 Geomorphic Summary of the Middle Rio Grande, Velarde to Caballo* by Massong et al. The MRG Project Histories, Review of Operations and Maintenance Reports, and other historical maintenance reports are referred to as Historical Maintenance Reports. Various data collection reports by FLO Engineering, TetraTech, BioWest, Colorado State University, Reclamation, and others are referred to as Data Collection Reports.

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 loss of active bars via vegetation encroachment. 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 sections that had extensive island stabilization and growth 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 (Leopold 1994). 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. The rapidly migrating bend in

Figure 1 provides an example. Migration and incision usually occur with the spring runoffs. Lateral migration and incision occurred with the July through October 2006 monsoon rains. These changes in the channel morphology and physical processes demonstrate the speed at which change occurs in the Middle Rio Grande 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 Elephant Butte Reservoir.

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
- Channel narrowing
- Loss of sand on the channel bed resulting in a gravel dominated bed
- Lateral channel migration

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

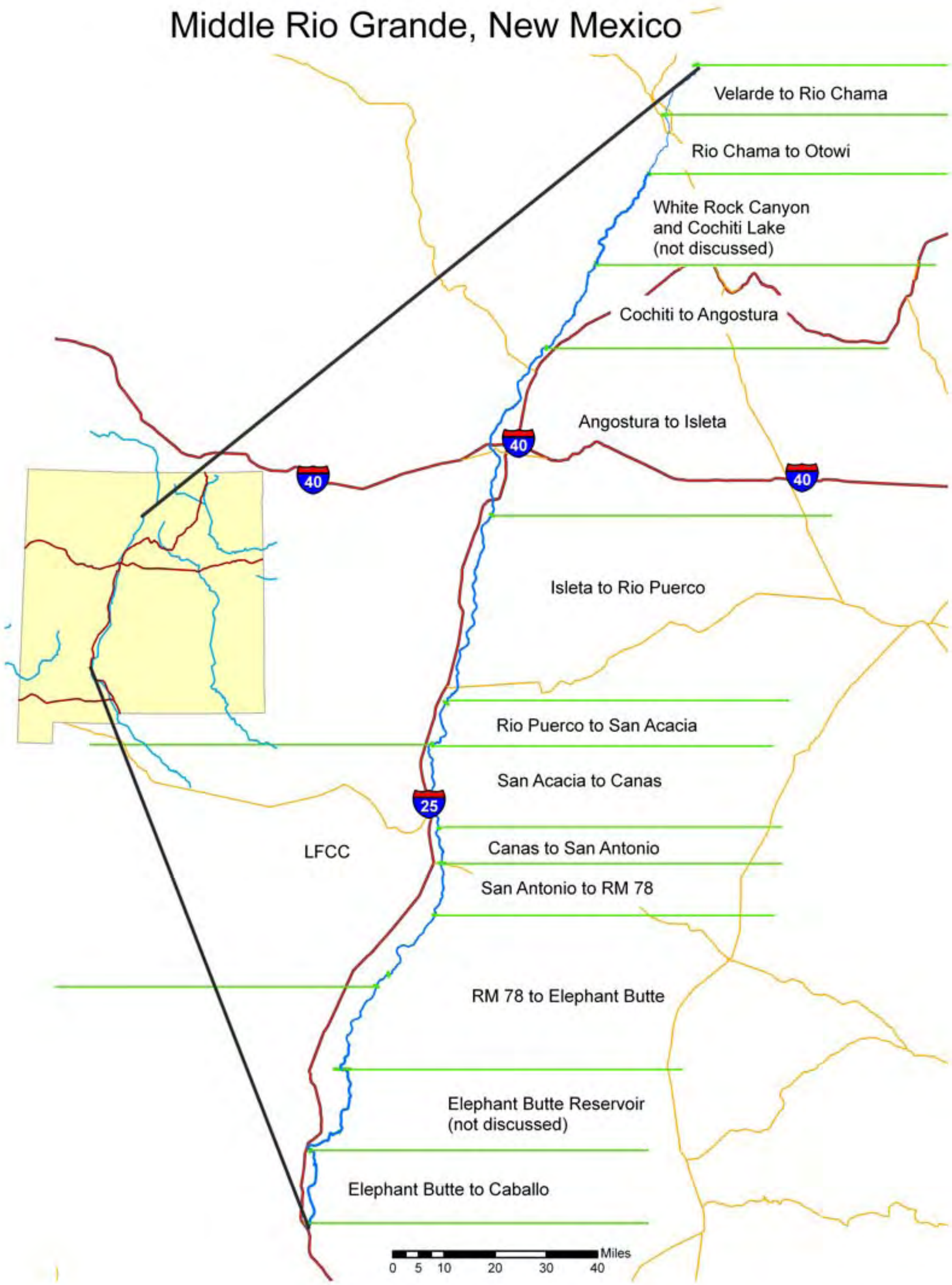

Figure 4. Location map of reaches

Table 3. Reach Characteristics

Reaches	~River Miles (RM)	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 (RM)	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 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)

4.2 Infrastructure or Maintenance Activities

Several different anthropogenic 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 MRG Project which includes channel rectification and maintenance, reservoir construction, rehabilitation of the MRGCD, and other collateral improvements. The initial work on the MRG 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 dams include Cochiti (1975) and Galisteo (1970) Dams. There are several other 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 two Federal ESA listed species in the MRG Project area. The SWFL and the RGSM are endangered. Critical habitat is designated for both of these species over much of the area under Reclamation management. Physical characteristics of each reach are a major factor in population distribution, 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 additions to maintenance projects designed to have features that provide a net positive benefit to the listed species.

The bald eagle was removed from the endangered species list in 2007 (see section 2.5.2.3).

4.4 Maintenance Needs and Strategies

The evolving river morphology is the fundamental cause of numerous river maintenance issues. In areas where there is a single thread, meandering channel; the tendency for lateral migration is greatly increased. This results 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 in chapters 5 through 16.

5 Velarde to Rio Chama (RM 285 to 272)

5.1 Geomorphology

The Velarde Reach extends upstream from the Rio Chama confluence, approximately 13 river miles to Velarde, New Mexico. A major feature of this reach is the lack of a well-formed or extensive Rio Grande floodplain and riparian zones. The numerous east-side tributaries push the Rio Grande towards the west valley wall in this reach, which is composed of large landslide deposits. Prior to these landslides, the west valley wall contained thick deposits of ancient Rio Grande sediments (cobble, gravel, and sand layers) capped by a lava flow of basalt. The large mass-wasting events created a mixture of the ancient fluvial deposits and basalt boulders, which effectively limits the area available for river migration. As a consequence, the formation of a significant Rio Grande floodplain is absent in this reach.

Historical AAO data collection reports and other sources suggest that the channel has a slightly sinuous, single channel pattern with significant bank stabilization consisting of riprap, dikes, and revetments (Oliver 2004,) to protect agricultural areas near the river. The bed is composed of gravel and small cobbles with a pool-riffle morphology; however, the pools tend to be small in size compared to the riffles (glides). Side channels are rare. The channel alignment appears fairly stable, but there is evidence that narrowing may be beginning in select locations below RM 278. There is an active bend at about RM 272.5. The riparian zone in this reach is often very small or absent; small patches have recently formed in isolated locations which provide small sections of young vegetation. The floodplain is generally disconnected, but the bed elevation is not below root depth.

The main stem has a low sand load with relatively clear water and has essentially unregulated perennial flow. Bankfull flow was not available, Reclamation is authorized to maintain a channel capacity of 5,000 cfs. The Embudo gage 2-year flow is 4,360 cfs (Bullard and Lane 1993). Tributary arroyos supply gravel on a regular basis, the largest of these is the Rio Truchas.

5.2 Infrastructure or Maintenance Activities

The most important anthropogenic influences in this reach are agriculturally based. The reach contains a series of low head dams that divert water for irrigation. Los Chicos and La Canova Diversion Dam are at the upstream end of the reach, and El Medio Diversion Dam is less than 3,000 feet downstream from these dams. Next, in order, are Garcia, Lyden, Rinconada Isla, Alcalde, El Guique, and San Juan Diversion Dams. Most of these dams are concrete/sheet-pile structures with riprap aprons, and many are in need of repair.

Large scale channelization projects in the reach from the 1930s through the 1960s were aimed at straightening and narrowing the channel. In the 1950s, Reclamation attempted to limit the river channel to a relatively narrow right-of-way intended to provide a nominal channel capacity of 5,000 cfs. That constructed alignment has not remained stable; however, and the river has begun to meander and erode adjacent land. This is a concern as irrigation canals and ditches, orchards, farm land, homes, and other buildings are quite close to the river. Several riprap revetments were constructed in the 1990s to provide bank protection. In addition, more recent bank protection projects have used bio-engineering techniques.

Two bridges span the river in this reach. It has no priority sites, but does have nine monitored sites. Two of those monitored sites are completed priority site projects.

5.3 Endangered Species

5.3.1 Southwestern Willow Flycatcher

(from Moore and Ahlers 2006b)
SWFL territories in this survey reach have declined from a high of six in 1995 to one or less between 2002 and 2006. Habitat quality in this reach has not declined greatly during this period, which suggests that the amount of available breeding habitat in this reach may be insufficient to support a viable SWFL population. Current trends seem to indicate that this population has become unsustainable. It is likely that limiting factors such as predation and brood parasitism are acting in concert with restricted amounts of available habitat to affect this local population so that it is unable to sustain itself. This local population is likely to fluctuate depending on local habitat conditions and reproductive success of nearby populations such as on the San Juan Pueblo.

The reach of the Rio Grande above Cochiti Reservoir to the Colorado state line is within the Upper Rio Grande Management Unit of the Rio Grande Recovery Unit. Within this Management Unit, the population goals are 75 SWFL territories (Service 2002). As of 2006, this recovery target has not been met (N. Baczek, pers. comm.).

5.3.2 Rio Grande Silvery Minnow

The RGSM is believed to have been extirpated upstream of Cochiti Lake in the 1980s. Channel incision leading to a loss of nursery habitat and subsequent isolation from populations downstream of Cochiti Lake are probable contributors to extirpation. Successful reintroduction upstream of Cochiti Lake would depend on identifying potential nursery habitat and evaluating trends in hydrology. The current river channel morphology, coarse substrate, and regulated hydrology may limit availability of nursery habitat and constrain re-introduction efforts. This is a cold-water reach with low conductivity and turbidity. Some tributary streams that enter this section can introduce high sediment loads during storm events. There are point discharges from wastewater effluent, but the water quality of the reach is most influenced by non-point sources. (Service 2007)

5.4 Maintenance Needs and Strategies

This reach has an approximate length of 13 miles and must safely convey 5,000 cfs. The 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 the 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 with SRH–Meander, formerly GSTAR-M.

It would be desirable to increase the width of the floodplain and riparian corridor in this reach. Progress on this issue is difficult because most of the land is privately owned, with active farmland near the channel. If the landowners were encouraged to help establish a riparian buffer, another agency such as the NMISC, the Natural Resources Conservation Service, acequia commissions, or the Corps would have to support a program.

6 Rio Chama to Otowi (RM 272 to 258)

6.1 Geomorphology

Managing peak flows on the Rio Chama (Abiquiu Dam) for flood control at Española, New Mexico, has reduced the peak flow hydrology of this 14 mile long reach. The reach is perennial with summer and fall flows that are higher than natural due to increased reservoir releases, including releases from the San Juan-Chama Project. The bankfull flow should be recalculated, but the 2-year flow at the Otowi gage is 8,050 cfs. There are three major tributaries, the Rio Chama, the Santa Cruz River, and the Pojoaque River.

Although the dams on the Rio Chama have also reduced the supply of sand-sized sediment, the reduction does not appear significant as the channel bed material seems to have always been fairly coarse. Gravel mining has occurred at several locations within this reach, but appears to be less prevalent; several headcuts and bed lowering events have been linked with gravel mining activities in this area (TetraTech 2002). Bed slope appears stable near the Vigiles diversion structure but lateral migration is possible (Makar and Bauer 2004). A moderate amount of incision exists (4–5 feet) and appears to have a low probability of increased incision (Massong and AuBuchon 2005). Sedimentation and River Hydraulics Sediment Impact Analysis Methods (SRH-SIAM) modeling would help confirm the assumed small probability of increased incision. Unlike the Velarde to Rio Chama reach, the western valley wall is composed of relatively undisturbed ancient Rio Grande sediments and there is a relatively large floodplain throughout most of this reach. The channel planform is a slightly sinuous single channel with sections of migrating bends and double channels. Other than sections with active bends, the bankline throughout this reach appears relatively stable. The active bends will likely evolve into double channels through point bar cutoffs and reduce migration. Further analysis is needed to confirm this assumption.

The channel dimensions are relatively stable with only a minor amount of narrowing in recent times where riparian vegetation is encroaching on the active channel. As the active bends migrate, sediment deposits on the inside of the bend, creating a point bar; these point bars provide new habitat areas for both riparian and aquatic species. Older sections of the point bars are becoming vegetated, creating a mosaic of different vegetation age classes. The active areas of the point bars are providing areas of shallow flow at nearly all discharges. During high flows, these point bars, as well as the islands associated with the split channels become inundated creating small, isolated patches of floodplain habitat.

6.2 Infrastructure or Maintenance Activities

Agriculture is significant to river maintenance activities in this reach, particularly in the upper portion, but less so than in the previous reach. The river also flows through the town of Española and three Native American Pueblos. Four bridges cross the Rio Grande in this reach, including three within about a mile and a half in Española.

An extensive channelization project in the 1950s was aimed at creating a single thread channel, limited to a much narrower floodplain (Figure 5 and Figure 6). Earthwork, jetty jacks, and vegetation clearing were all used to that end. The relatively straight channel in the upper portion of the reach indicates that those efforts were mostly successful, but the sinuous channel in the lower portion of the reach indicates a higher potential for lateral migration.

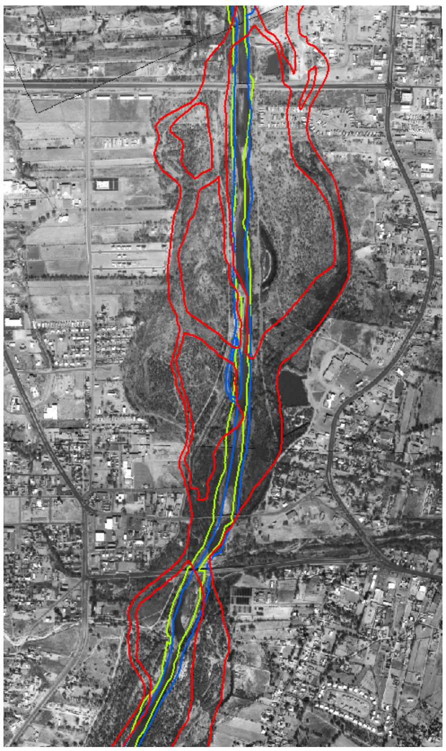

Figure 5. Upper Portion of Rio Chama to Otowi Reach, within the town of Espanola, showing straight channel and narrow floodplain (2001 Aerial Photo)

In the early 1990s, several bank protection projects, such as the Vigil Ditch and Santa Clara Pueblo projects, were constructed in the reach. These projects used riprap revetments and spur dikes to prevent bank erosion. River maintenance was recently completed at one priority site, the San Ildefonso Pond. The reach has nine monitored sites.

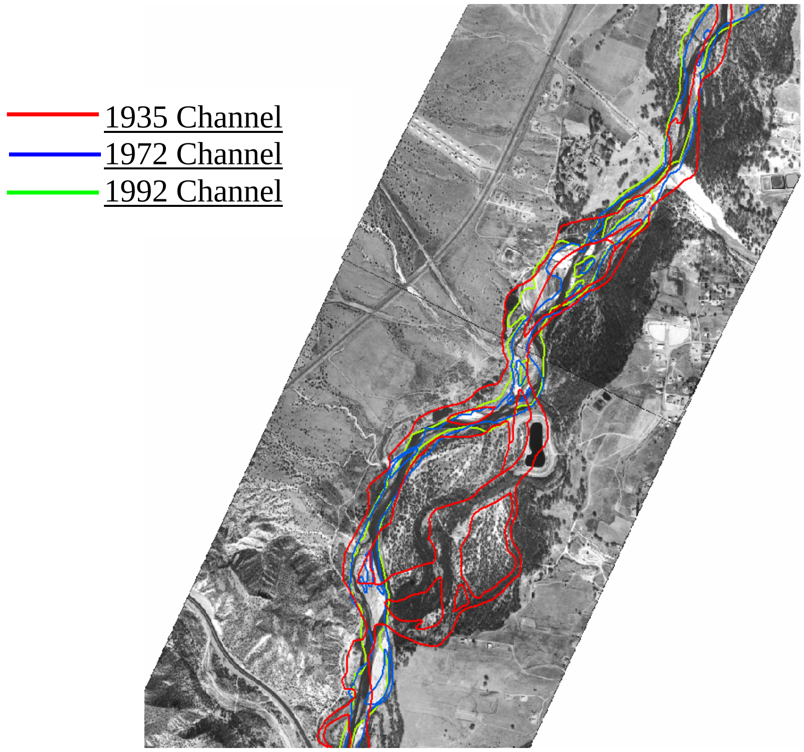

Figure 6. Lower Portion of Rio Chama to Otowi Reach, on San Ildefonso Pueblo, Showing Relatively Sinuous Channel (2001 Aerial Photo)

6.3 Endangered Species

6.3.1 Southwestern Willow Flycatcher

A data gap exists for this reach, primarily because most of the lands involved are tribal lands. The Ohkay Owingeh Pueblo does have a small SWFL population that consists of 10 territories as of 2005 (N. Baczek, pers. comm.). Surveys for SWFLs were conducted in 2005 immediately downstream of Otowi on Santa Fe National Forest lands (Koronkiewicz and Rhodes 2005). This survey detected several SWFLs in migration and a possible pair near the upper end of Cochiti Reservoir, though no nesting was found.

6.3.2 Rio Grande Silvery Minnow

The RGSM is believed to have been extirpated upstream of Cochiti Lake in the 1980s. Channel incision leading to a loss of nursery habitat and subsequent isolation from populations downstream of Cochiti Lake are probable contributors to extirpation. Successful reintroduction upstream of Cochiti Lake would depend on identifying potential nursery habitat and evaluating trends in hydrology. The current river channel morphology, coarse substrate, and regulated hydrology may limit availability of nursery habitat and constrain re-introduction efforts. This is a cold-water reach with low conductivity and turbidity. Some tributary streams that enter this section can introduce high sediment loads during storm events. There are point discharges from wastewater effluent, but the water quality of the reach is most influenced by non-point sources. (Service 2007).

6.4 Maintenance Needs and Strategies

This reach has an approximate length of 14 miles. The bed consists of gravel and cobbles, with some sand supplied from the Rio Chama. Discharge in this reach is significantly higher than in the reach upstream, owing to input from the Rio Chama. The main river maintenance need is to address channel migration in isolated areas. The reach is highly channelized and incised, but the channel has not historically been prone to extensive lateral erosion. In most areas, the width has been relatively constant in recent years, though 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 to increase SWFL habitat and to provide a buffer for lateral migration. Some SWFL are present in the reach, though there are no known RGSM.

Within the boundary of Ohkay Owingeh there was extensive gravel mining in the 1980s, which resulted in the bed of the river being lowered about 5 feet; channel instability in this area was increased. 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 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 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.

Both Santa Fe and Espanola have plans for in-river diversion structures: Reclamation should consider whether it will create a vertical migration control policy for river maintenance to protect Title XVI investments for in-river subsurface infrastructure.

7 Cochiti to Angostura (RM 233 to 210)

7.1 Geomorphology

After operations began at Cochiti Dam in 1973, the channel bed immediately began to erode and coarsen (Lagasse, 1980). According to USGS water quality data, the dam releases relatively clear water with about a 60 percent reduction as compared to pre-dam sediment supply. This set of processes has continued to the present (Massong 2004). The larger grain size that emerged very quickly after 1973 retarded incision, such that the floodplain, although quickly abandoned, is not more than six feet higher than the current channel elevation (Massong 2004, Massong et al. 2006), except for a few sites on San Felipe Pueblo where banks are closer to eight feet tall. There are anecdotal reports from Cochiti Pueblo of a number of historical “crossing fords” with coarse gravel/cobble beds. Several large tributaries deliver coarse grain sizes to the Rio Grande here, such as the Galisteo River and the Arroyo Tonque. Data indicate that the grain size is continuing to increase; in some sections, small cobbles line the river channel. Additional incision is not likely.

Similar to the upstream reaches, here the Rio Grande is slightly confined on the west by geologic features (volcanic vents and bedrock) and by the prograding sedimentary fans/deposits on the east side that push the river towards the west valley wall. As a consequence, the Rio Grande valley is relatively narrow in this section of the Middle Rio Grande. As in the Rio Chama to Otowi Reach, the current channel planform is varied with sections that are mostly straight to slightly sinuous channels interspersed with meanders, double channels, and abandoned channels. The point bars that formed in association with the meander bends vegetated quickly but are still inundated during high flows. Most of these planforms are surprisingly stable, the majority of the migrating bends are moving very slowly and tend to be moving downstream rather than laterally. This trend is expected to continue, creating a more stable channel. The tall banks in the San Felipe Pueblo area are an exception and are experiencing significant migration at some sites.

The banklines are typically densely vegetated and mostly stable (not eroding). As found upstream, the channel morphology is that of a pool-riffle. However, the pools are infrequent and poorly formed while the riffles are widespread and well formed. Historically the channel was wide (1500+ feet), but the channel has narrowed to an apparently stable size of approximately 250-300 feet. The average width of the active channel in 1992 was 275 feet, in 2002 230 feet, and in 2006 260 feet after the high flows of 2005.

The low peak flows between 1997 and 2002 facilitated island and vegetation growth, resulting in narrower widths in the 2002 photography. The 2006 photography shows the channel widened to near the 1992 average. Here, the relatively large 2005 peak of 6,670 cfs is the probable cause. Schembera (1963) estimated the channel forming flow for this reach is 6,000 cfs. Analysis of the channel widths from the 1997 photography and SRH-SIAM modeling would help refine the stable width and channel forming flow assumptions. The 2-year peak flow at the San Felipe gage varies from 4,040 to 5,650 cfs (Bullard and Lane 1993, MEI 2002, Waltermeyer and Raff 2004), depending on the assumptions used for different hydrology studies. The bankfull flow of 9,000 cfs has changed little since 1992. This may not be adequate for the URGWOPS preferred alternative which assumes a 10,000 cfs capacity (section 3.4). This reach is perennial and the hydrograph timing is similar to the natural one but peaks are reduced to meet safe channel capacity downstream.

This reach of 23 river miles is almost entirely Pueblo-owned, with infrastructure close to the river, including drains, irrigation canals, and roads. Water temperature is cold, owing to releases at Cochiti, but does warm up downstream. Evolution of habitat is similar to that in the next upstream reach. However, this reach appears just a little more stable, which translates into smaller, more isolated patches of evolving habitats.

7.2 Infrastructure or Maintenance Activities

From Cochiti to Angostura, the Rio Grande flows mostly through Pueblo land. The reach is dominated by the two dams that bound it: Cochiti Dam on the upstream end, and Angostura Diversion Dam on the downstream end. Early maintenance activity included channelization and construction of a levee system in the 1930s. As the 1962 channel in Figure 7 shows, the river migrated beyond the channelization, but the levees were effective in preventing further lateral erosion. By the 1950s, the river was a wide, shallow channel extending from levee to levee, often at a higher elevation than the floodplain outside of the levees (Massong 2005a).

In response to this and to continued flooding in the entire Middle Rio Grande, Congress authorized river modifications to control sedimentation and flooding. The authorization included more channelization, the use of Kellner jetty jacks, and several large dams, two of which are in this reach. Galisteo Dam is on the ephemeral Galisteo Creek, approximately 12 miles upstream from its confluence with the Rio Grande. This is a dry dam, and its effect on the sediment supply to the river is not great (Massong 2005a).

The other dam, Cochiti, is an earth-filled embankment on the main stem with a crest length of over five miles and a height of 250 feet above the river bed. It was built downstream of the old Cochiti Diversion Dam and began operations in 1973. Operational procedure is to release all native water inflow up to a channel capacity of 7,000 cfs, as measured at the Albuquerque gauge. (See <http://www.fws.gov/southwest/mrgbi/Resources/Dams/index.html#cochiti>.) The dam has effectively reduced flood peaks, with no flow greater than 10,000 cfs recorded at the San Felipe gauge since 1967. It should be noted that the URGWOPS goal for channel capacity is up to 10,000 cfs. The volume of water passing the gauge, however, has increased since the dam began operations with the addition of San Juan-Chama water. The suspended sediment load, which began declining in 1958, saw a dramatic decrease in 1973, when Cochiti began operations. In response, the bed has coarsened as far downstream as Bernalillo (Massong 2005a). Since construction, the dam has raised the downstream ground water table, water-logging downstream farmlands in Cochiti Pueblo.

Angostura Diversion Dam is a low-head dam that diverts up to 650 cfs for irrigation. It was constructed in 1934, and was rehabilitated in 1958 (Reclamation 1981).

In addition to the channelization work performed in the 1950s, several projects were completed in the early 1990s. The Santo Domingo river maintenance project consisted of curve shaping and strategic riprap bank protection. A similar project at San Felipe Pueblo consisted of earthwork and riprap bank protection.

Three bridges span the river in this reach. Currently, there are 15 priority sites, with the majority located on Pueblo of San Felipe land. There are also 10 monitored sites, of which two are completed priority sites.

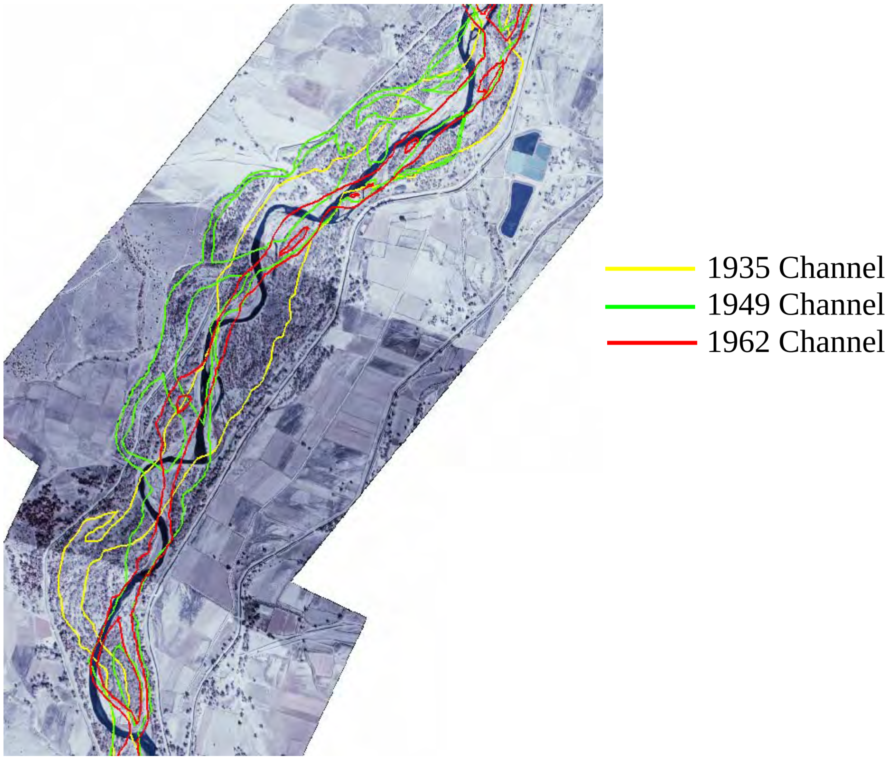

Figure 7. Portion of Cochiti to Angostura Reach, on Santo Domingo Pueblo, Showing Narrowing (2006 Aerial Photo)

7.3 Endangered Species

7.3.1 Southwestern Willow Flycatcher

As in the previous reach, most of the lands in this area are tribal lands. Many of the tribes conduct their own surveys for SWFLs but the results of those surveys are typically confidential.

The Collaborative Program is funding a number of habitat restoration projects in this reach aimed at removal of exotic vegetation (saltcedar and Russian olive, primarily) and subsequent restoration with native vegetation (cottonwood and willows) to benefit the SWFL and RGSM. In summer 2006, a single territorial male SWFL was sighted in a habitat restoration site on Sana Ana Pueblo (B. Bader, pers. comm.) suggesting that habitat restoration efforts in this reach have potential to successfully attract SWFLs.

7.3.2 Rio Grande Silvery Minnow

Due to access restrictions, the RGSM has not been documented in the Cochiti Reach since 1995 (Platania and Dudley 2003a). Surveys by Pueblos are not known to have documented RGSM in the past ten years.

Reclamation is not required by the 2003 BiOp to implement fish passage at Angostura Diversion Dam and currently has no plans to do so at this diversion dam. Availability of nursery habitat will limit populations in the Cochiti to Angostura Reach. RGSM appear to have a low dispersal rate and may be very slow to take advantage of new habitat upstream of the diversion dam. Ninety-five percent of RGSM are recaptured within five miles of the release site. Releasing RGSM near potential spawning and nursery areas such as arroyo confluences may improve recruitment.

The loss of floodplain connectivity and nursery habitats essential for recruitment of larval and juvenile RGSM probably contributed to extirpation of the species in this reach. Channel incision and a truncated spring hydrograph reduce the frequency of floodplain inundation, especially during drought years. Near average hydrographs in 2004 and 2005 resulted in a three-order of magnitude increase in fall RGSM collections over two years. Recently, Santo Domingo Pueblo has constructed high flow channels and embayments for RGSM nursery habitat areas at various spring flows. San Felipe Pueblo has funding for possible riverine habitat restoration projects. River maintenance projects in the reach include habitat features for RGSM spawning to the extent possible while achieving project needs to protect infrastructure.

Reclamation is continuing nursery habitat studies to monitor constructed habitat features and document parameters for RGSM nursery habitat. There has been considerable sculpting of islands and bars to create nursery habitat, but conditions have not been suitable to verify their effectiveness.

7.3.3 Other Species

Some Western Yellow-billed Cuckoos, an ESA candidate species, are present in this reach. Further data collection and observations would be necessary to determine the extent of the presence of the species.

7.4 Maintenance Needs and Strategies

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 armored and is still coarsening as time progresses. 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. Sediment deposition at tributary confluences can act as a bed control and cause erosion of the bankline opposite the tributary. 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. Reconnecting the currently incised channel to the floodplain 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, to the extent that upland vegetation can be observed growing at the top of the channel bankline.

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 reduce their available pasture and farmland. It might be worthwhile to discuss the possible use of pastureland that could be encouraged on the inside of meander bends. Land access issues exist with Pueblos in this reach, so in-depth coordination is often required.

A grade control structure or gradient restoration facility (GRF) on the Pueblo of Santa Ana was completed in 2002. This GRF was designed to halt channel incision, provide fish passage by RGSM, avoid flanking caused by channel migration, and reconnect the river with the abandoned floodplain. Design of future similar structures should meet these same objectives.

Many of the river maintenance problems of this reach might be improved if the 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 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 very 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.

8 Angostura to Isleta (RM 210 to 169)

8.1 Geomorphology

The conversion to a gravel bed and narrow, single-thread channel planform (called the transition) that began near Cochiti Dam is now located within this reach. In the early 1990s, the transition zone appeared to be located near the City of Bernalillo, New Mexico (Ortiz 2003). Since that time, the transition has moved downstream and in 2006 was located within the Albuquerque city limits (Bauer 2004a, Bauer 2004b, Bauer 2006). As a consequence of this transition zone, this reach is subdivided into three subreaches based on the location of the conversion to gravel bed: Post-Transition Subreach (Angostura Diversion Dam to Corrales), Transition Subreach (Corrales to Bridge Street Bridge), and Pre-Transition Subreach (Bridge Street Bridge to Isleta Diversion Dam).

This is a perennial reach with a similar peak hydrograph to the Cochiti to Angostura reach, but with irrigation diversions and inflows. The 2-year event at the Albuquerque gage ranges from 3,761 cfs to 5,410 cfs (Bullard and Lane 1993, MEI 2002, Waltermeyer and Raff 2004) depending on which hydrology study is used. Channel capacity to the terrace is estimated at 10,000 cfs, a result of degradation since 1962. More incision is possible (Massong 2005a, Massong 2005b). Sediment modeling and analysis using Reclamation's suite of SRH models would help estimate future incision amounts and lateral migration potential. Major tributaries are the Jemez River, Arroyo de la Baranca, Harvey Jones Channel/Arroyo de los Montoyas, AMAFCA North and South, and Arroyo Calabacillas; all of which supply sand and larger sized sediments. It should be noted that most of these tributaries have sediment detention facilities.

Post-Transition Subreach (Angostura Diversion Dam to Corrales)

Through most of the 20th century, these 11 miles of river were a sand-bedded section of the Rio Grande, which was aggrading before Cochiti Dam began operations. As a result of the aggradation, the floodplain within the levees became higher than the floodplain outside the levee system and is very fine grained. This elevated floodplain/channel is most noticeable near the Highway 550 Bridge crossing in Bernalillo, New Mexico. Part of the reason for the rapid aggradation was the influx of sediment from the Jemez River, the largest tributary in this reach which is located just downstream from Angostura Diversion Dam. This tributary was once a very large supplier of mostly fine sediments (Rittenhouse 1944).

Jemez Canyon Dam was completed in 1953 on the Jemez River several miles above the mouth. The purpose of the dam was to reduce both flood peaks and the sediment load reaching the Rio Grande. The operating procedure bypasses all native inflows up to 7,000 cfs. In 2001, the sediment pool was evacuated and the dam has not stored water since; see section 8.2 for additional information. (See <http://www.fws.gov/southwest/mrgbi/Resources/Dams/index.html#jemez>,)This bypass helps keep water in the Rio Grande to improve habitat for the endangered Rio Grande RGSM during drought years. The effect of this sediment pool modification still needs to be assessed, but it is logical to assume that the sand supply will be increased. Bank heights through most of this reach are higher than those found upstream. Unlike upstream in the Cochiti to Angostura Reach, bed degradation proceeded faster than the channel bed coarsening, thus allowing more degradation.

A major feature of this reach is a much broader historical floodplain than that found upstream. Also, an extensive series of mid-channel bars emerged in the 1990s and now act as high-flow floodplain surfaces which have narrowed the active channel.

Between the Angostura Diversion Dam and Arroyo de los Montoyas/Harvey Jones Channel in Corrales, the channel bed has already degraded and coarsened, but at different times. Near Angostura Diversion Dam, the incision and planform conversion occurred first, probably between the late 1980s to early 1990s, while changes just recently occurred near Corrales (2000–2005). The transition included:

- Channel bed incision began in the 1980s and the bed has continued to degrade through the 1990s as part of the transition. Channel incision has abandoned the historical floodplain, which is now a terrace.
- A coarsening of the bed material from sand bed to gravel bed began in the 1990s. Currently the grain size is coarse gravel to cobble in the upstream half of the reach, and grades down to medium gravel near Corrales.

- Planform conversion occurred in the late 1990s. The current planform is that of a single, deep thalweg, especially during low flows, with high flow channels becoming inundated only when river flows are near the 2-year return event or greater.
- Medial bars (islands) were transitory prior to the late 1990s transition period; post-transition, the bars are relatively stable and now partially vegetated. Some of these surfaces inundate during high flows. The islands are storing a significant amount of sand that would have been available for reworking by the river.
- The 2005 peak flows also widened this subreach more than ten percent, mainly by reworking some of the island sediments.

The thalweg is alternating between the banklines and is developing a series of migrating bends. At present, the bank height is generally tall enough for the river's thalweg to intersect the bankline beneath the root zone of the riparian vegetation. An analysis of the migration potential of active bends would be useful for maintenance planning.

During the 1990s, vegetation began growing on numerous bars; these surfaces are both islands and bank attached bars. These features provide small patches of young vegetation and small patches of floodplain, which add to both riparian habitat and in-channel habitat. The migrating bends are also creating small point bars, which will evolve in the same manner as the islands, vegetating and becoming small areas of floodplain. Although these small habitat features exist in this section, the channel is coarsening, becoming narrower and deeper, and the historical floodplain is becoming more isolated from normal river flows. Neither the main channel nor the historical floodplain are providing quality habitat. If channel migration continues, both the riparian and channel habitat will likely improve. The migrating planform exchanges the tall, relatively undesirable terrace habitat for new point bar habitat that is better connected to the river channel.

Transition Reach (Corrales to Bridge Street Bridge)

This 17.5-mile portion of the Angostura-Isleta reach is transitioning from a sand-bedded channel with a braided planform to gravel bed with a single dominant channel. The degree of transition lessens downstream toward Bridge Street. This change in planform has caused a rapid decrease in wetted width and a deep thalweg, but migration is generally absent thus far and little widening occurred during the 2005 peak flows. Islands and bank-attached bars are now vegetating and still mostly connected to the river channel.However, due to surface deposits during the last high flows in spring 2005, these bars and islands are requiring higher runoff events to inundate. Dense vegetation anchors these features and they are highly resistant to river erosion, often forcing the river to flow around them even during the high flows which inundate their surfaces. Common features throughout this sub-reach include:

- Channel bed incision and the historical floodplain is abandoned (began 1980s–1990s)
- Gravel deposition within the active channel
- Some level of planform transition which initially includes the growth of islands, abandonment of side channels and then the formation of a single, relatively deep channel

At present, the channel bed has incised 3–5 feet, from pre-transition elevations and the historical floodplain has become disconnected from high river flows, even the 2-year event. The City of Albuquerque Ranney collector wells were constructed to be 25 feet below grade in 2006.

The major feature of the fully transitioned channel is that the full-channel width has a gravel bed, with or without coarse grained riffles. Sand dunes may temporarily cover the gravel but are transient in nature. At present, this reach is still dominantly sand; however, gravel is systematically depositing within the active channel, indicating the transition is in progress. Gravel deposits were first sampled near I-40 in 2004, and observed at Bridge Street in 2004. The process of gravel bed transition occurs in several steps:

- The first location where gravel is often found during transition is at the head of islands and along the sides of the islands.
- Next, these patches along the islands grow upstream, which creates small riffle-like features that remain sand-free.
- The riffle-like deposits continue to grow, until they reach another riffle-like deposit, an island bankline, or the channel's bankline. At that time, these gravel deposits become more like a traditional riffle.
- After the riffles have formed, the channel between the riffles coarsens until the channel bed is fully gravel-bedded.
- In this section and throughout much of the Rio Grande, sand dunes are often present and are transported over the more stable gravel layer.

Full conversion of this reach could happen as quickly as the next large spring runoff if the gravel supply from upstream sources is sufficient. More likely though, is that the upstream portion of the reach, which is closer to full conversion, would switch sooner than the downstream portion. At present, the in-channel features are widely variable and have been considered good habitat. The continued evolution would likely decrease this habitat value. The riparian habitat is similar to the upstream section that is already past this transition; the historical floodplain is already abandoned with a mature vegetation complex. The only locations with new or young vegetation growth are on the islands and bank attached bars. These areas are relatively small, but have the potential for high quality riparian habitat.

Pre-Transition Reach (Bridge Street Bridge to Isleta Diversion Dam)

The Rio Grande downstream from Bridge Street to Isleta Diversion Dam (12 miles) is similar to the historical Rio Grande descriptions: it still has a sand bed with migrating macro-dunes and dune fields. Investigations of the shear stresses present would help determine what is necessary to keep the channel bed and bars active. Sampling in 2006 and observations during the 2007 profile data collection found gravel downstream to the I-25 Bridge, although it was not large or exposed in significant layers. During low flows, the dunes become inactive, but vegetation does not establish as they reactivate when flows increase and gravel deposition is not present in measurable amounts. The floodplain is inundated during high flows and the channel planform and width are relatively stable. The planform is low-flow braided with a relatively shallow thalweg that changes to a single, fairly uniform channel during high flows. Islands and bank-attached bars are mostly absent. The bed elevation is mostly stable to slightly decreasing (slightly incising). Banklines are relatively stable, with no priority sites within this sub-reach.

As the channel still exhibits historical river conditions, the channel habitat has a large amount of complexity within the braided planform and active floodplain. Sand supply is key to maintaining the braided planform. Once the upstream reaches fully convert to gravel or upstream bars and islands store sand causing diminished supply, the transition could be quick. The riparian habitat may not be considered as good as the in-channel habitat, as the floodplain contains mostly mature vegetation. Areas with new riparian growth are rare and isolated. Eventually, the transition zone will impact this reach as it continues to migrate downstream. As a consequence, this reach will evolve in the same manner as discussed in the upstream subreaches.

8.2 Infrastructure or Maintenance Activities

Agriculture was once important in the reach from Angostura to Isleta Diversion Dam, but the greatest influence is now urbanization. Two diversion dams set the limits for the reach:

- Upstream, Angostura, completed in 1934 and rehabilitated in 1958, diverts up to 650 cfs for irrigation.
- Downstream, Isleta Diversion Dam, completed in 1934 and rehabilitated in 1955, diverts up to 1,070 cfs for irrigation

(Reclamation 1981).

Just as in the upstream Cochiti to Angostura reach, initial efforts at channelization in the 1930s consisted of excavating a relatively narrow floodway, in the same general location as the river, and constructing spoil levees (Figure 8). This was in response to bed aggradation and flooding. After the channelization, however, both continued to be problems, and the river bed was often higher than the ground outside the levees.

Flooding outside of the levees led to two Congressional authorizations, in 1948 and 1950, for additional river modifications. The authorized work included channelization, placement of Kellner jetty jacks, and construction of engineered levees in the Albuquerque area. Jetty jacks were often placed in-channel, and have effectively deepened and narrowed the river channel. Engineered levees were constructed on the east side of the river from just upstream of the southern boundary of Sandia Pueblo to the current outfall of the AMAFCA South Diversion Channel. On the west side of the river, the engineered levee begins just upstream of Central Avenue and also ends near the South Diversion Channel Outlet (see Appendix I).

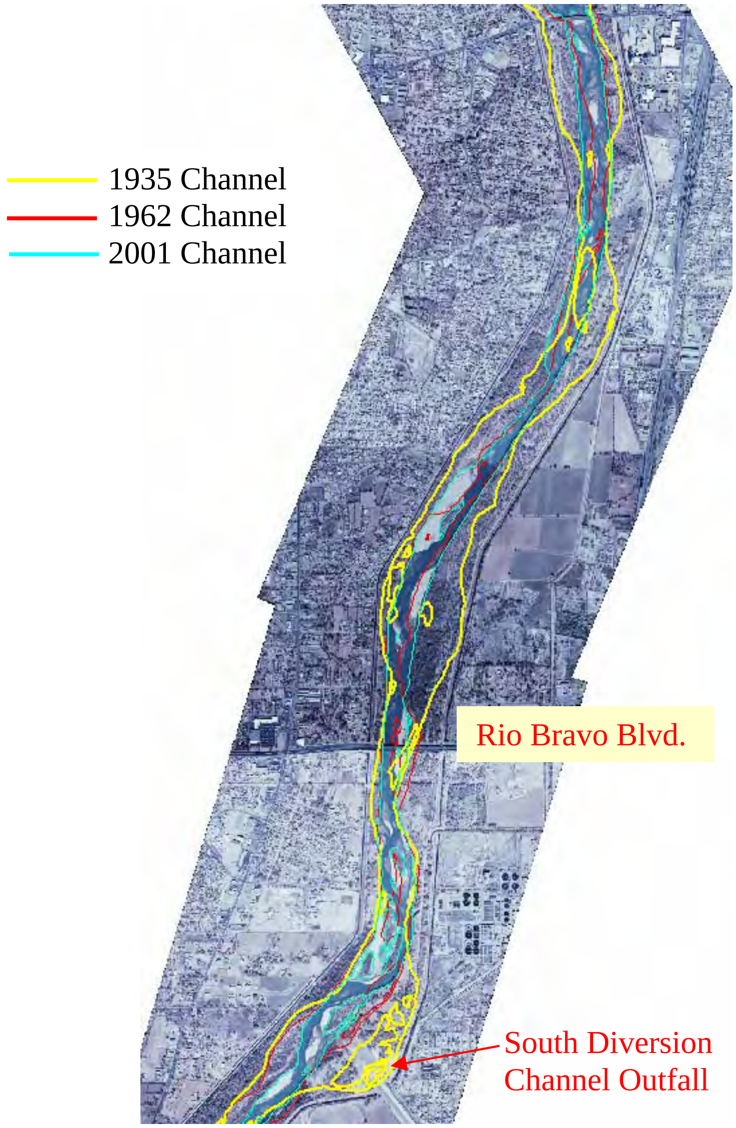

Figure 8. Portion of Angostura to Isleta Reach, Showing More Narrow Channel in Same Alignment (2006 Aerial Photo)

Jemez Canyon Dam began operation in October 1953 to regulate flows on the Jemez River for flood control and sediment retention. The closure of Jemez Canyon Dam reduced the sediment supply to the Rio Grande, particularly to this reach (Corps 1994). In 1986, the sediment retention pool was expanded to include the entire unused capacity of the allocated sediment space to further improve trap efficiency of the reservoir. The water for this expansion (up to a maximum sediment retention pool capacity of 24,425 acre-feet) was obtained through exchange for water currently at the San Juan-Chama Project leased from the City of Albuquerque by the NMISC. The pool was created and maintained by capturing native water from the Rio Jemez in the reservoir and replacing that water to the Rio Grande by releasing San Juan-Chama Project water from upstream storage, usually during the spring runoff period. Thus, a pool had existed without interruption at Jemez Canyon Reservoir since 1979. The sediment trapping in the pool further reduced the downstream sediment supply.

The Corps and the NMISC storage agreement expired on December 31, 2000; the original expiration date. The NMISC decided not to extend the agreement for sediment pool storage, citing significantly increased demands on available water in the region, its increasing cost, and the need for increased sediment loading to the currently degrading Rio Grande channel as factors in this decision. A partial evacuation of the pool began on September 20, 2000. The pool at Jemez Canyon Reservoir was finally evacuated by October 2001 (Corps 2003) and has not stored water since.

Three large storm water collection systems outfall to the river in this reach. The first is SSCAFCA's Harvey Jones Channel which collects flows from Montoyas Arroyo and the City of Rio Rancho, and outfalls into a large detention basin near RM 198. The basin is intended to reduce the amount of sediment reaching the river. AMAFCA has two large outfalls in the reach. The North Diversion Channel collects runoff from the highly urbanized northeast portion of Albuquerque and outfalls into a large detention basin near RM 194. The South Diversion Channel conveys flow from Tijeras Arroyo and urban runoff from the southeast portion of Albuquerque, and outfalls into a detention basin near RM 178. Both basins reduce the amount of sediment transported to the river. In addition, there are numerous smaller outfalls for both urban runoff and ephemeral flows in the reach, both with and without detention basins. Both SSCAFCA and AMAFCA may perform periodic maintenance on their off-channel facilities, but neither has authority to work in the floodway.

Another sign of the reach's urban character are some of the City of Albuquerque's facilities. The City of Albuquerque Wastewater Treatment Plant's outfall, near RM 177.5, contributes an average flow of 80 cfs to the river <http://pubs.usgs.gov/circ/2002/circ1222/pdf/chap4.pdf>.The City has also recently installed a low-head inflatable dam, just south of the Alameda Bridge, which will be used to divert water as part of the City's drinking water project.

In recent years, the reach has seen numerous habitat restoration projects. These projects have ranged from non-native vegetation and jetty jack removal, to construction intended to increase channel complexity. One large project was undertaken jointly by the City of Albuquerque and the Corps, and included construction of wetlands adjacent to the river. Another wetlands area, the San Antonio Oxbow, is maintained by the City of Albuquerque. It was disconnected from the river as part of channelization work in the mid 1950s.

There are 11 bridges in this reach, including seven within a 14-mile-reach where the river passes through Albuquerque. There is one priority site, Corrales Siphon, which is scheduled to go to implementation in the spring of 2008. There are also eight monitored sites, which include the Bernalillo and Sandia sites currently under implementation and the completed Santa Ana site.

8.3 Endangered Species

8.3.1 Southwestern Willow Flycatcher

This reach is not often surveyed for SWFLs, except for project-specific purposes, because it is believed that there are no breeding populations of SWFLs in this reach. Much of the habitat is cottonwood gallery forest with saltcedar and Russian olive understory. Many areas have had understory removal (also known as “fuel reduction”) for fire prevention. Such clearing has increased the area of unsuitable habitat for SWFLs in this reach.

Several Collaborative Program restoration projects are active within this reach. Most of the projects are aimed at providing in-stream habitat features for Rio Grande RGSM, but some native vegetation planting for SWFLs may occur in the near future.

8.3.2 Rio Grande Silvery Minnow

Islands in this reach are still well-connected floodplain, but lowering bank edges might allow more natural recruitment of vegetation. This would require large quantities of excavation. The City of Albuquerque intends to start using its 48,200 acre-foot annual allocation of San Juan-Chama Project water in 2008, so this water will no longer be available for the supplemental water program. The NMISC is using island destabilization as a major habitat restoration technique. They will be monitoring their projects to document techniques that produce effective RGSM habitat. Island lowering/destabilization can provide nursery habitat areas at various spring flows.

Availability of nursery habitat will limit populations in the Cochiti to Angostura Reach. RGSM appear to have a low dispersal rate and may be very slow to take advantage of new habitat upstream of the diversion dam. Ninety-five percent of RGSMs are recaptured within five miles of the release site. Releasing RGSM near potential spawning and nursery areas such as arroyo confluences may improve recruitment.

The reduction of floodplain connectivity and nursery habitats essential for the survival of larval and juvenile RGSM have increased population decline in this reach following years of low spring runoff. For 2007 geometry, recruitment occurs at flows exceeding 2,000 cfs that continue for at least five to seven days. Channel incision and a truncated spring hydrograph reduce the frequency of floodplain inundation, especially during drought years. Near average hydrographs in 2004 and 2005 resulted in a three-order of magnitude increase in fall RGSM collections over the two years. Recently Santo Domingo Pueblo has constructed high-flow channels and embayments for silvery minnow nursery habitat areas at various spring flows. San Felipe Pueblo has funding for possible riverine habitat restoration projects. River maintenance projects in the reach include habitat features for RGSM spawning to the extent possible while achieving project needs to protect infrastructure.

Reclamation is continuing nursery habitat studies to monitor constructed habitat features and document parameters for RGSM nursery habitat. There has been considerable sculpting of islands and bars to create nursery habitat but conditions have not been suitable to verify their effectiveness. Data to assist in designing more effective nursery habitats includes minimum area, baseline and inundation flow levels, feature orientation to flow, and recruitment per unit area. Water temperatures in this reach do not appear limiting for spawning or recruitment. Low water temperatures caused by reservoir releases may limit RGSM annual growth relative to other reaches. Doctoral research at the University of New Mexico suggests that RGSM may be omnivorous. Citations are pending.

8.3.3 Other Species

Some Western Yellow-billed Cuckoos, an ESA candidate species, are present in this reach. Further data collection and observations would be necessary to determine the extent of the presence of the species.

8.4 Maintenance Needs and Strategies

This reach has an approximate length of 40 miles. Bed material grain size has been continuously increasing (Bauer 2004a, Bauer 2004b, Bauer 2006). The upstream portion of the reach has a predominantly gravel bed, while the downstream portion remains sand-bedded. There is a potential for incision because upstream sediment loads have decreased and there are few tributaries in the reach. Field observations indicate incision could be as much as five feet over the next decade. The incision is causing the floodplain to be disconnected; if the bed incises to below the vegetation root level (about five more feet), lateral migration may start. Sediment modeling using Reclamations suite of SRH 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 root level is at an appropriate elevation to help resist lateral erosion. This would allow for the creation of a floodplain buffer to protect riverside facilities. Installing grade controls could also achieve this result, though costs, maintenance needs, and other morphological effects would need to be carefully considered. 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 significantly narrowed, and the transition from a wide, braided planform to a narrower, meandering channel is slowly proceeding downstream. 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.

Future river maintenance needs will involve protecting the levees from migration as the planform transition continues to extend further downstream. Geomorphic analysis and SRH-Meander modeling would help estimate the approximate number and timing of new priority site development in this reach. At many locations, moderate flows do more damage because flow is directed against banks, whereas higher flows straighten out, resulting in less erosion of the banks. The reach is mostly urban and has little room for levee setback.

9 Isleta to Rio Puerco (RM 169 to 127)

9.1 Geomorphology

This 43-mile reach is typically described as one of the most stable reaches on the Rio Grande. Until very recently, it remained sand-bedded with a connected floodplain and a mostly braided morphology. The channel width varied less than other reaches; channelization and bank stabilization efforts in the 1950s resulted in an initial large-scale reduction in width between 1949 and 1962 <u>but with long-term width stabilization until</u>

2001. A significant amount of narrowing occurred between 2001 and 2002 which coincides with the formation of numerous islands and vegetated sand bars. Since 2002, the channel has begun shifting towards a single-thread planform, with the islands becoming bank attached (see Figure 9). The unvegetated portion of the channel has decreased significantly and a more sinuous low flow channel is forming. Despite relatively stable bed elevations, the reach has seen significant amounts of vegetation growth on bars and islands in the past few years which stabilized these features. In the 2007 thalweg profile data, there is an area of flatter slope from State Highway 309 in Belen to upstream of US Highway 60. The reach downstream to the Rio Puerco is a bit steeper. Identifying the stable slope using SRH-SIAM with the current bed material and the narrowed channel geometry would help determine whether the bed elevations will remain stable or if incision is likely to instigate lateral migration.

Although it has often been considered stable, several changes have been occurring that may indicate that this reach is rapidly destabilizing. The changes can be grouped:

- **Planform**

  After 2001, macro-dunes in the Belen reach became less active and woody vegetation started growing on them during abnormally low water years. This bar stabilization process created numerous islands that effectively reduced the channel width and concentrated the low and moderate flows into only two or three small channels. Of note in Figure 9 is the dramatic increase in the size of the islands in five years between 2001 and 2006.

  In 2004, a moderate spring runoff year, channel filling was evident in many of the side channels; this marked the beginning of conversion from low-flow channels to moderate or even high flow channels. Through the 2005 runoff cycle, the islands remained stable and resisted overbank erosion. Additional vertical accretion and channel filling was observed. A dominant thalweg developed during the 2005 spring runoff event. In addition, the continuation of side channel filling produced numerous high flow channels.

  After 2005, field observations indicate that some of the side channels are starting to become vegetated. The current planform is best described as a single-threaded channel at low flows, but becoming an anastomosing or island-braided planform at higher flows in some sections (when the side channels become active), or with wider overbank flows in the areas where the bars and islands are attached to the banks.

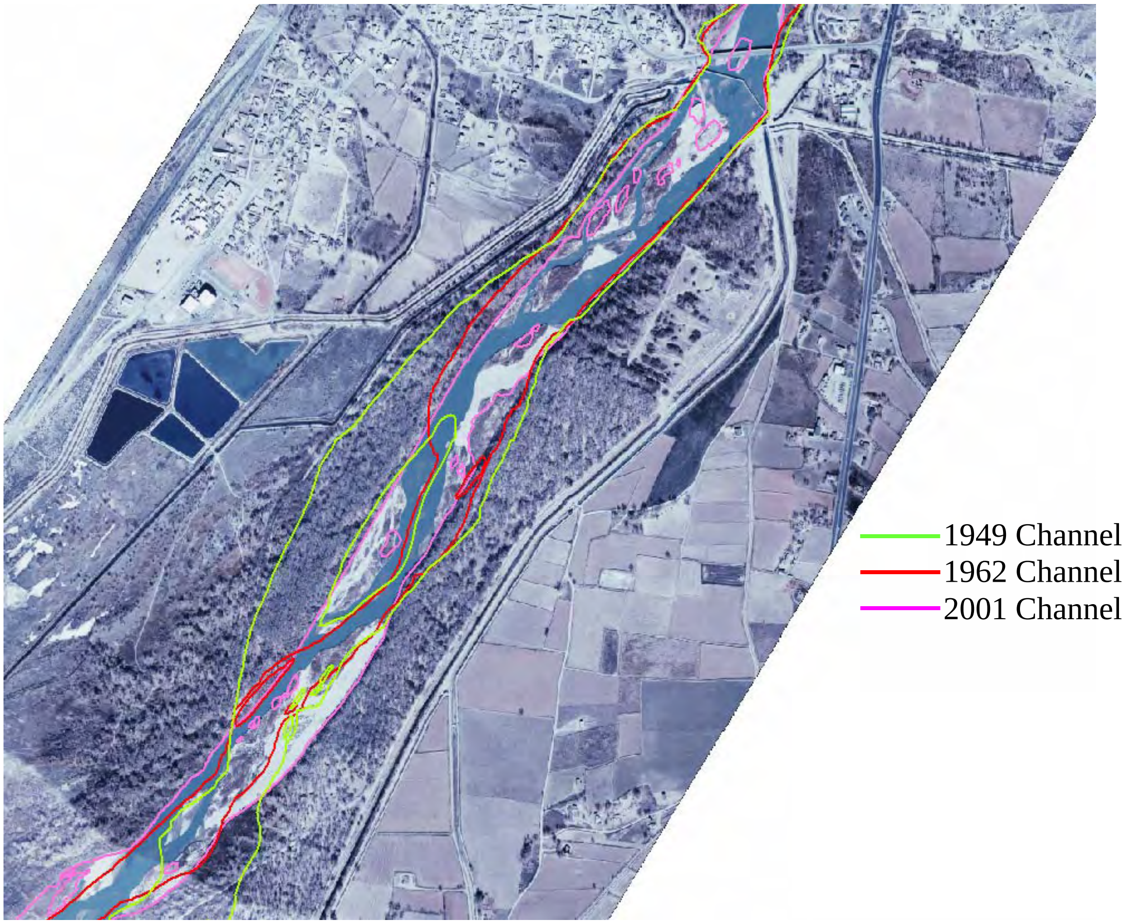

Figure 9. Isleta to Rio Puerco Reach, Downstream from Isleta Diversion Dam (2006 Aerial Photo)

- **Floodplain**

  In 2005, much of the historical floodplain was significantly inundated during the spring runoff. Most of the islands and bars were also inundated. After runoff ended, field observations indicate significant vertical accretion occurred on the bars, islands and floodplains (especially near areas of flowing water). Field observations in 2007 show increased bank heights, such that higher flows, about 5,000 cfs rather than about 3,000 cfs, are now required to cause overbank flooding on these surfaces.

- **Sediment Composition**

  Prior to 2005, only minor amounts of gravel were observed in this reach, and the locations appeared random. After the 2005 runoff, gravel deposits have been found systematically at the head of islands/side channels and in long patches within the high-flow side channels, and at the side channel outlets between islands. Currently, the historical banklines in this reach are stable as they are near the high water mark and are densely vegetated. Numerous jetty jack lines also add to bankline protection. In the future, channel capacity may decrease, as the side channels continue to fill and become vegetated. The planform will likely continue to evolve into a slightly sinuous, single channel.

As the banks increase in height, the slightly sinuous pattern that currently exists could cause some bank erosion, but large migrating bends are unlikely as the channel slope is relatively low. New floodplain is forming on bars and islands and quickly becoming vegetated. Riverine habitat is shrinking as the channel incises, narrows, and the bars become vegetated and stable. However, the new floodplains provide small isolated pockets of good habitat for both riparian and in-channel species.

The bankfull flow of 7,000 cfs has changed little between 1992 and 2002, but it may be changing because of factors discussed above. This is below the 10,000-cfs capacity of the URGWOPS EIS preferred alternative. The Bernardo gage 2-year flow varies from 3,670 cfs to 5,790 cfs (Bullard and Lane 1993, MEI 2002, Waltermeyer and Raff 2004). This reach is not perennial and reflects the highly managed flows. Several riverside drains return flow to the river. Water quality is lower than in the upstream reaches. This difference is dominated by nonpoint sources.

For in-channel habitat, this reach is expected to continue to narrow through the abandonment of side channels, and the main channel is expected to incise, eventually containing larger flows and abandoning the current floodplain. All of these changes reduce space for aquatic habitat. However, as these riverine features evolve, new vegetation will emerge, thus providing new riparian and new floodplain features, which may provide new bird and other riparian habitats.

9.2 Infrastructure or Maintenance Activities

This reach is bracketed by the Isleta Diversion Dam upstream and the confluence with the Rio Puerco downstream. Isleta Dam was completed in 1934, rehabilitated in 1955, and diverts flows up to 1,070 cfs for agricultural use (Reclamation 1981). Like the upstream reaches, this reach was channelized in the 1950s through excavation of a pilot channel and constructing a spoil levee, placement of Kellner jetty jacks, and vegetation clearing in the floodplain. In response, the channel narrowed between 1949 and 1962, but channel planform remained relatively stable until 2002 (see section 9.1).

There are five bridges and two aerial gas lines crossing the Rio Grande in this reach. Some habitat restoration took place in the Los Lunas area in 2002, including jetty jack removal, lowering the adjacent floodplain, and re-establishing native vegetation <http://www.usbr.gov/uc/albuq/envdocs/techreports/geo-techRep/Geomorph-LosLunas.pdf>. There are currently no priority sites in this reach, although there are four monitored sites.

9.3 Endangered Species

9.3.1 Southwestern Willow Flycatcher

Isleta Pueblo has had a small breeding population of SWFLs for several years. Located downstream of the Isleta Diversion Dam, there were eight territories in 2006 (N. Baczek, pers. comm.)

Six SWFL territories have been documented in this reach since in was first surveyed in 2002 (Moore and Ahlers 2006). With the exception of a breeding pair in 2005, all have been either unpaired male territories or late migrants that were considered territorial due to their date of detection. Suitable SWFL habitat within this reach is limited. The majority of habitat consists of sparse, decadent saltcedar and Russian olive. Cottonwoods and grassy meadows are also interspersed throughout this reach. There are occasional stands of native willows adjacent to the river, most often mixed with Russian olive or saltcedar, which is where the SWFL territory was documented in 2006. This reach also receives very little overbank flooding, with the exception of a few areas. Small patches of habitat continue to improve in quality, particularly in areas where restoration projects have occurred and/or natural recruitment of native willows has occurred. Considering the habitat available and the presence of source populations on the Pueblo of Isleta and in the Sevilleta/La Joya reach, this reach has the potential for colonization by SWFLs in the near future.

9.3.2 Rio Grande Silvery Minnow

In 2007, the level of floodplain connectivity provides RGSM nursery habitat at flows above 1500–2000 cfs. This reach is subject to widespread intermittency in a dry year depending on the summer monsoon season. There is potential for maintaining small sub-populations near drain outfalls. RGSM may also use the irrigation drains as temporary refugia during river drying. The drains are also used by centrarchids (predator fish like crappies and bluegills), increasing predation pressure on RGSM.

The Collaborative Program has funded the Corps to study fish passage alternatives at Isleta Diversion Dam. The hope is that fish passage can be achieved by modifying the operations of the dam gates and that no new infrastructure will need to be constructed. The study report is undergoing revision.

The Collaborative Program is funding habitat enhancement at three MRGCD drain outfalls in the Los Chaves-Peralta sections of the reach. Cottonwood snags will be anchored into the banks with the goal of creating scour pools that can be kept perennially wet. MRGCD will attempt to allow a leakage of approximately 1–4 cfs at the enhanced drain outfalls to maintain a perennial refuge for the RGSM. Monitoring for this project has also been funded through the Collaborative Program. This project might help SWIFL too. During certain times of the year, these pools will probably fill in with sediment as was observed in August, 2006 at the cottonwood snags installed below Bridge Boulevard (pers. comm. by Tamara Massong, Gary Dean, Charles Fischer, and Kathy Dickinson).

9.3.3 Other Species

Some Western Yellow-billed Cuckoos, an ESA candidate species, are present in this reach, but not in large numbers. Further data collection and observations would be necessary to determine the extent of the presence of the species.

9.4 Maintenance Needs and Strategies

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. 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 root zone, which is probably 2 to 3 additional feet lower. 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 converts to a single thread and begins to migrate laterally. Consequently, morphological monitoring is particularly important in this reach.

There is uncertainty in this reach 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, 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. Potential concerns with this strategy include increased deposition in Elephant Butte Reservoir and a short-term increase in sand bed character with a more rapid eventual conversion to gravel bed.

10 Rio Puerco to San Acacia (RM 127 to 116.2)

10.1 Geomorphology

The 2-year flow at San Acacia varies from 3,600 cfs to 9,100 cfs (Bullard and Lane 1993, MEI 2002, Waltermeyer and Raff 2004) and is significantly affected by diversions to the LFCC and the time period analyzed. The range of the 2-year flow is a function of the needs of the different hydrologic studies. A summary of the studies would be useful to understand the differences and apply the correct flow for a particular analysis. The high flow should be more reflective of inflows from the larger tributaries of the Rio Puerco, Rio Salado, Salas Arroyo, and Arroyo Las Alamos without diversions to the LFCC and so is difficult to define for this reach. This reach is not perennial, but flow from spring runoff and thunderstorms often maintains flow.

Presumably due to a basin-wide reduction in sand supply, gravel has become a large component of the bed material in this reach, especially downstream from the Rio Salado confluence. The Rio Salado, in the last few decades, has added large amounts of coarse material and appears to be acting as a significant grade control with a flatter slope upstream and much steeper downstream. The Salado fan is relatively erosion resistant and pushes the river up against the very resistant ancient terrace on the left bank. Downstream of the Rio Salado, the bed material is bimodal with sand dunes sporadically covering a gravel bed (Bauer and Hilldale 2004). A large delta stabilized by vegetation has formed upstream from San Acacia diversion dam, reducing channel width and potentially stabilizing the planform. Channel migration has been rapid in areas immediately upstream of the San Acacia Diversion dam (Figure 10).

A series of terraces and abandoned floodplains line the Rio Grande, a result of the Socorro Magma Body uplift and incision through the tremendous historical Rio Puerco deposits. Smaller, inset floodplains appear to be continuously developing as the river abandons older surfaces, creating an entrenched river system with low bank heights (Massong et al. 2006). There is fairly dynamic flood plain development along the banklines, but not widespread lateral migration. There is much less island development in this 10 mile reach than immediately upstream. The habitat value is significant in this reach.

10.2 Infrastructure or Maintenance Activities

This reach is defined by the Rio Puerco confluence upstream, and the San Acacia Diversion Dam downstream. The dam was constructed in 1934 and rehabilitated in 1957. It diverts up to 283 cfs for irrigation (Reclamation 1981).

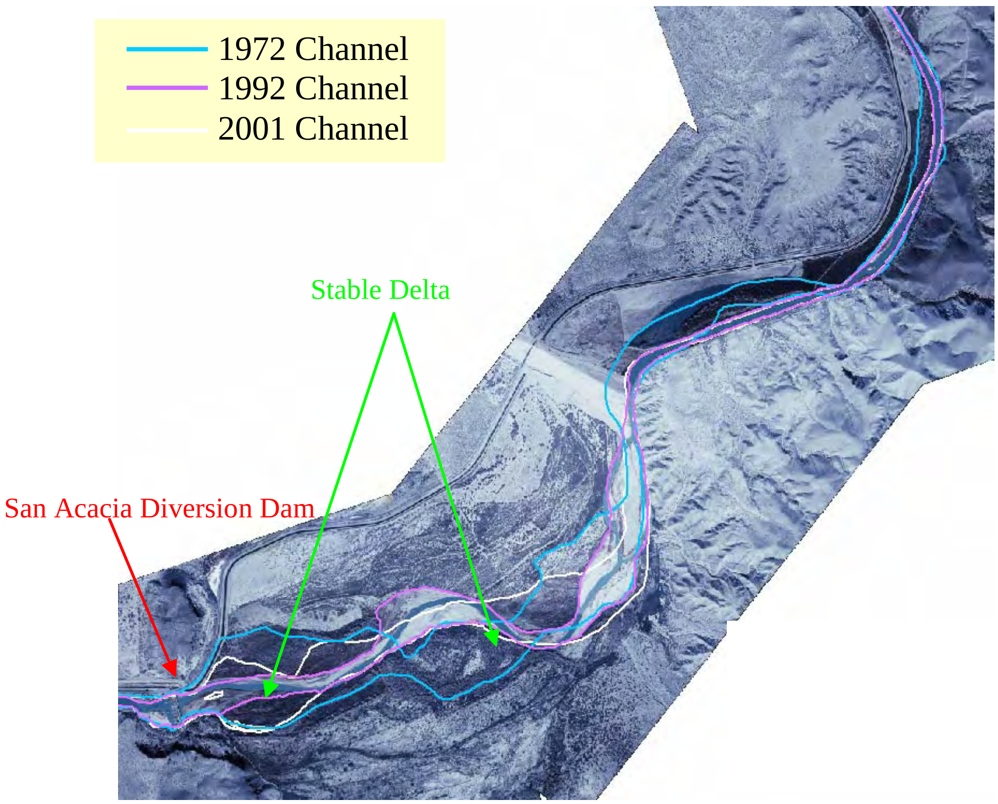

Figure 10. Isleta to San Acacia Reach, Upstream from San Acacia Diversion Dam (2006 Aerial Photo)

As in the upstream reaches, significant channelization work took place in the early 1950s. The work consisted of excavating a narrower channel within the floodway, constructing spoil levees, placing Kellner jetty jacks, and clearing vegetation in the floodplain. To protect adjacent irrigation facilities, the river was again limited to a narrower floodplain between 1962 and 1972. The channel itself then narrowed significantly between 1972 and 1992. The planform has remained stable since then, except between the confluence of the Rio Salado and near San Acacia Diversion Dam, which is less than two miles (see section 10.1).

There are no bridges in this reach, which has little development. The reach has one priority site and two monitored sites.

10.3 Endangered Species

10.3.1 Southwestern Willow Flycatcher

(*from* Moore and Ahlers 2006)

SWFLs in the Rio Puerco to San Acacia reach were first documented in 1999, and territory numbers increased through 2002. Since then, territory numbers have remained relatively constant. In 2006, numbers increased slightly. Habitat in the areas around La Joya Wildife Area has improved to the point that possible dispersing SWFLs from SNWR establish territories here. The fact that several territories (and pairs) have established in these sites reinforces the fact that this habitat is suitable and is likely to continue to be occupied by breeding SWFLs.

Habitat within the other occupied sites in this reach has not changed significantly over the past five years. The fact that territory numbers are slowly increasing suggests that recruitment or immigration, not habitat, limits the productivity of this reach. There is still ample suitable habitat within this reach for additional SWFLs to occupy, and it is expected that SWFLs in this reach will continue to increase in number until the habitat is no longer suitable, available, or some other limiting factor impacts population growth.

Population expansion within this reach is also of significant interest due to the type of habitat present. Mature saltcedar and Russian olive dominate the majority of occupied sites in this reach. Overbank flooding is rare, especially in times of drought. However, the proximity to water, the density and vertical stratification of vegetation, and scattered patches of native vegetation seem to make certain sites attractive to breeding SWFLs.

10.3.2 Rio Grande Silvery Minnow

RGSM are present in this reach, but have limited nursery habitat. In 2007, there is low recruitment at flows exceeding 2000 cfs. Two projects could have a significant effect on minnow population:

- The fish passage project at San Acacia Diversion Dam (see section 10.4)
- A proposed inverted siphon immediately downstream of the Rio Puerco. The inverted siphon would take Lower San Juan Riverside drain water that currently flows into the Rio Grande and move it to the Drain Unit 7 Extension. Studies are ongoing to determine benefits and consequences of this proposed project.

10.3.3 Other Species

Pecos Sunflower are present in areas up and out of the riparian zone. River maintenance activities should have little impact to sunflower. Yellow-billed cuckoos also present, though populations are not as large as they are farther south.

10.4 Maintenance Needs and Strategies

This reach has an approximate length of 10 miles. Incision has occurred here historically, but not recently; bank height is generally low. The Rio Salado fan acts as major grade control; downstream of Rio Salado confluence there has been significant planform change 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). There are also several areas where priority sites could develop quickly if the channel begins to migrate laterally. Investigations of bank stability would be very useful to further define the likelihood of channel migration.

A large quantity of sediment has accumulated upstream of San Acacia Diversion Dam. This sediment may be a contributing factor to the Drain Unit 7 river maintenance site, but also may be reducing the likelihood of lateral migration. Further data collection and analysis would help define the role of the delta deposits. Improvements to the operation of the dam could reduce this sediment deposition and help prevent future problems. Additionally, a fish passage project for San Acacia Diversion Dam is currently in the design state, with implementation likely to begin sometime between 2008 and 2011.

11 San Acacia to Arroyo Cañas (RM 116.2 to 95)

11.1 Geomorphology

Channel incision downstream of San Acacia Diversion Dam has been rapid, with at least 12 feet in the past 60 years (Reclamation 2003c, Massong 2005c, Bauer 2006, Bauer 2004a, Bauer and Hilldale 2004); 8–10 feet of that after 1988. Significant degradation is progressing south to below Escondida. The degradation decreases to less than two feet near Arroyo de las Cañas, which appears to be acting as a grade control (Massong et al. 2006, Reclamation 2003c, Klawon and Makar 2002). As the terraces are quite tall, the high water mark is often well below the root zone of the riparian vegetation and coupled with the dominantly sandy bank composition, the banks are generally susceptible to riverine erosion. Point bar growth is rampant as the banklines migrate. These point bars act as new floodplain surfaces and create shallow, wetted surfaces at nearly all flows. The older sections of the point bars are becoming vegetated, creating new riparian vegetation. Old riparian zones that are located on top of the abandoned floodplains (now terraces) are being eroded by the migrating bends. Although the channel location is moving, channel area and width appear to be remaining fairly constant since the large reductions that occurred between the 1992 and 2002 photography.

Planforms in this 21-mile-long reach range from the single, slightly sinuous channel close to the dam to advanced bends, some with a well developed cutoff channel that has captured the main flow. The first two miles are fairly stable in planform with the narrow width influenced by the geologic constriction of the valley and channelization (Oliver 2004). Downstream, the alternating thalweg that began forming in the late 1990s has become the dominant morphology, creating numerous rapidly migrating bends with increased sinuosity (Massong 2005c, Massong and Makar 2006, Massong et al. 2006). Several series of very large bends have formed throughout this reach; some are migrating towards riverside facilities (i.e., levees, canals). Portions of the narrowed and straightened channel cross the historical braid plain which is indicative of continued instabilities. The levee setback constructed at San Lorenzo Arroyo and one planned for

River Mile 111 provide areas for lateral migration and new habitat formation (section 11.4).

The channel bed is dominated by gravel, even though sand dunes often cover the gravel layer. Several arroyos have been reconnected to the Rio Grande by vegetation removal, which increased sediment supply, but vegetation is reestablishing in some areas. At nearly all of the tributary junctions, fans have developed which partially cover the Rio Grande's bed with gravel-sized and larger sediment and sometimes create grade-control in the channel's slope (Bauer 2006). Major tributaries include San Lorenzo Arroyo, Arroyo Alamillo, Arroyo de la Parida, and the North Socorro Diversion Channel.

The 2-year flood peak at the San Acacia gage varies from 3,600 to 9,100 cfs as discussed in section 10.1. Bankfull discharge in this reach is at least 10,000 cfs, an increase since 1992 because of channel degradation. Other studies (Reclamation 2003c) estimate up to 30,000 cfs hydraulic capacity. Flow that high would likely start incision again, which would additionally increase the conveyance capacity. This reach is not perennial, but flow is often maintained by monsoon storms. Water diversions in this reach include the Socorro Main Canal (current) and the LFCC (historical). See section 11.2 for more information.

11.2 Infrastructure or Maintenance Activities

This reach is bounded by the San Acacia Diversion Dam upstream and the ephemeral Arroyo de las Cañas downstream. The dam was constructed in 1934 to divert a maximum of 283 cfs for irrigation. It was rehabilitated in 1957 (Reclamation 1981). The reach is dominated by agriculture, although the City of Socorro has stormwater runoff facilities that outfall in the reach.

The LFCC is an important feature and begins at the San Acacia Diversion Dam. The LFCC was constructed in the 1950s. Its purpose was to reduce water loss due to evaporation, by conveying Rio Grande water in a narrower, deeper channel, rather than in the wider and shallower floodway. It began operation in 1959 and was used to convey flows up to 2000 cfs until 1981. Since 1981, it has only been used as a drain and to return irrigation flows to the river (Makar and Strand 2003).

The location of the LFCC outfall has varied depending on the location of the Elephant Butte Reservoir pool, but it is currently located downstream of this reach, near River Mile 55. An outfall that was used for test operations was constructed near River Mile 104.5 is located within this reach and just upstream of the Escondida Bridge. This outfall has not been used in over four years.

A spoil levee was built during construction of the LFCC and has successfully constrained flows. The levee is on the west side of the river, between the LFCC and the river. It constrains the river on the west (Makar and Strand 2003). In addition, large-scale channelization took place in the early 1950s. Work included straightening and deepening the channel, as well as vegetation clearing and placing Kellner jetty jacks. Approximately two miles of Floodway in the Escondida area were narrowed and straightened (Figure 11).

The North Socorro Diversion Channel outfalls to the Rio Grande at a detention basin near River Mile 103. This channel conveys ephemeral flows from a large watershed consisting of largely undeveloped land on the west side of the river. The detention basin acts to reduce the amount of sediment reaching the river.

There is one bridge in this reach. There are two priority sites and five monitored sites, including one completed priority site.

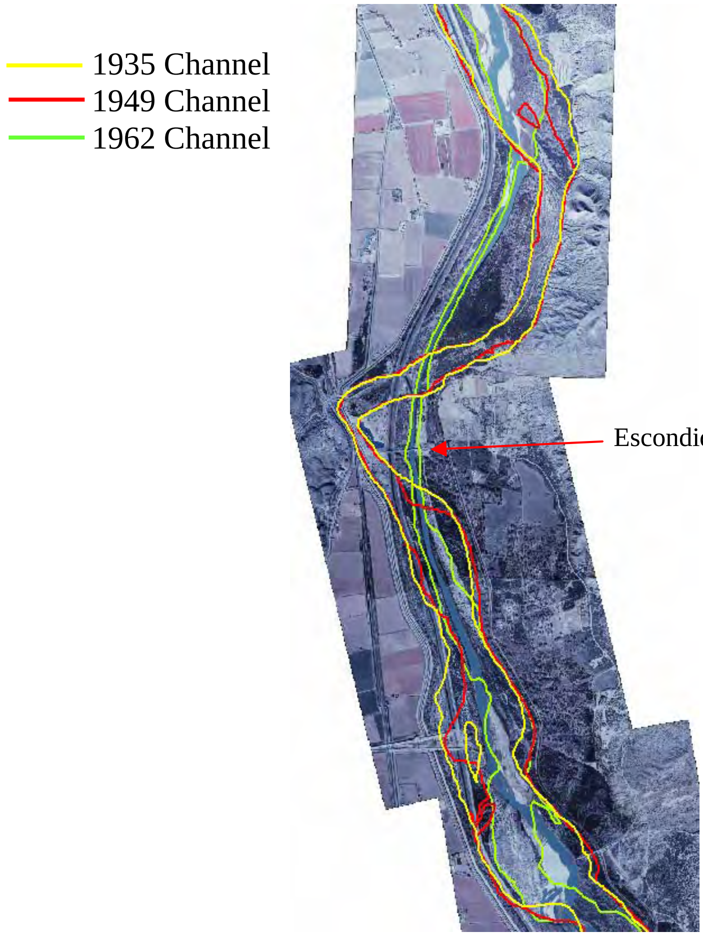

Figure 11. San Acacia to Arroyo de las Cañas Reach, Channelization Near the Escondida Bridge (2006 Aerial Photo)

11.3 Endangered Species

11.3.1 Southwestern Willow Flycatcher

(*from* Moore and Ahlers 2006b)

Habitat between San Acacia and Escondida is dominated by dry, decadent exotic vegetation in the form of saltcedar and Russian olive with an occasional cottonwood overstory. Quality SWFL habitat within this reach is very limited and composed of small patches of native vegetation along the river channel. This reach did get limited overbank flooding during the summers of 2005 and 2006, which is rare for this location. The flooding that occurred should benefit the habitat in certain areas. However, with the limited suitability of habitat in this reach, no territories or nesting SWFLs have been documented in this reach in the eight years Reclamation has been surveying it.

Habitat between Escondida and San Antonio, is very similar . Most of the habitat is sparse exotic vegetation in the form of saltcedar and Russian olive with an occasional overstory of cottonwood. Some suitable SWFL habitat exists or is forming adjacent to the river and on recently formed riverbars. However, this reach of the river seldom receives any overbank flooding and the water table has lowered in recent years so the patches of native vegetation are drying out and dying. Resident SWFLs were documented in this reach for the first time in 2002. Four territories were located early in the survey season. Because of the date of their discovery, these birds were treated as residents. Birds documented between June 10 and July 21 are typically considered resident SWFLs. It is likely that these birds were late migrants because of the habitat they were detected in and they were only detected once early in the season. In 2006, one SWFL was located on June 28 (within the “resident period”), but was not found on subsequent surveys. Although it is treated as a resident, it was likely a late migrant or non-territorial male.

11.3.2 Rio Grande Silvery Minnow

The RGSM has fluctuating populations in this reach responding to floodplain inundation and intermittent flows during the summer. This upper portion of the reach has less floodplain connectivity and remains wet longer into the summer because of its proximity to San Acacia Diversion Dam. Point bars with riparian buffer are probably the most common nursery areas. Stone toes of 2"–4" river rock and bioblocks with vegetation plantings could be used to stabilize the point bar edges. The slope should be gradual to allow habitat at lower flows. Natural sand levees may develop over time and increase the flows needed for inundation. Nursery habitat and water are the limiting factors. During spring runoff in 2007, RGSM eggs were found in the North Socorro Diversion Channel upstream of its outfall.

Intermittent flows downstream of San Acacia have split the RGSM population into two sub-populations upstream and downstream of BDANWR. The reach downstream of BDANWR is maintained by pumping water from the LFCC into the river channel.

11.3.3 Other Species

Some Western Yellow-billed Cuckoos, an ESA candidate species, are present in this reach. Further data collection and observations would be necessary to determine the extent of the presence of the species.

11.4 Maintenance Needs and Strategies

This reach has an approximate length of 21 miles. Near San Acacia Diversion Dam, the bed is basically 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 (RM 95) has been 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 single-thread channel may cause significant problems because the levee crosses the historical river channel (braid plain); historical channelization included large meander bend cutoffs. The area between Arroyo Alamillo and Escondida is less stable because of planform changes. The most common river maintenance issue in this reach is that meander bends can develop and migrate into the LFCC 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. However, there are small, inset floodplains developing on the 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 SWFLs, may benefit from the dense vegetation that should continue to develop there.

A large levee setback project to address potential levee erosion at River Miles 113 and 114 was completed in 2007; a similar project at River Mile 111 is scheduled to begin in 2008. Determination of the eventual meander belt width—in the absence of 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.

12 Arroyo Cañas to San Antonio (RM 95 to 87.1)

12.1 Geomorphology

This reach of 8 river miles represents a relatively stable stretch of river which is located between significant degradation upstream and aggradation downstream. In the last several years, channel width has decreased, which can be attributed to vegetation growth on islands and bars during the recent drought cycle. Planform characteristics within this reach were relatively stable. However, with the development and stabilization of the bars and islands, the remaining active channel area is concentrating flow, similar to the process found in the Belen Reach but at a smaller scale. AAO data collection reports suggest that the channel's grain size is mostly sand (Bauer 2006, Bauer 2004a), and the bed elevation remains stable. The location of greatest bed stability appears to be at the upstream end of the reach (Makar and Strand 2002, Makar and Strand 2003). The floodplain throughout this reach is active and begins to inundate at moderate sized flows (4,000 cfs). Two-year flows vary between 3,600 and 9,100 cfs (see section 10.1 for more information).

Currently, the channel alignment, the banklines, and bed in this reach are mostly stable; however, a slightly meandering thalweg pattern is beginning to form. Although individual migrating bends may form in this reach, numerous migrating bends are unlikely since bank height is low. The planform stability of this reach is unknown, and it is uncertain whether conversion to a narrower, meandering planform is imminent.

Further geomorphic analysis at the level of most other reaches could help identify this. There has been recent narrowing in the Bosquecito area through new island and bar development with areas of attachment. These changes suggest that a narrower channel with the potential accompanying changes in meander wavelength, increases in bed material size, and bank height seen upstream may occur here sooner rather than later.

For in-channel habitat, this reach may continue to narrow and possibly incise as the thalweg becomes more concentrated into an ever smaller active channel, reducing space for aquatic habitat. However, new riparian areas will develop, which may provide new bird and other riparian habitats.

12.2 Infrastructure or Maintenance Activities

This reach extends from the Arroyo de las Cañas upstream to the Highway 380 Bridge in San Antonio, New Mexico. The reach is predominantly agricultural. The LFCC, which begins in the next upstream reach, continues through this reach (see Chapter 16 for more detailed information). During construction of the LFCC in the 1950s, a spoil levee was also built on the west side of the river, between the LFCC and the river.

The area was channelized in the 1950s. The channel was straightened and deepened, vegetation was cleared, and Kellner jetty jacks were placed. This work was not entirely successful, but the levee on the west has effectively constrained flows. Today, the channel is relatively wide, with the exception of a stretch that begins about two miles upstream from the Highway 380 Bridge (Figure 12). This appears to be the result of channelization before 1935. The channel alignment, as well as the bed elevation, has been relatively stable since the 1930s and is expected to remain so in the short term.

Brown Arroyo outfalls to a detention basin on the west side of the river at River Mile 94. This facility is intended to reduce the amount of sediment reaching the river from this stormwater conveyance. The arroyo transports flows from a large, mostly undeveloped watershed.

The only bridge in this reach is the Highway 380 Bridge at the reach's downstream terminus. It contains no priority sites and a single monitored site.

12.3 Endangered Species

12.3.1 Southwestern Willow Flycatcher

Conditions and status of the SWFL for this reach are described in section 11.3.1

12.3.2 Rio Grande Silvery Minnow

The RGSM has better recruitment in this reach due to more floodplain connectivity at lower magnitude spring flows (field observations show 1,000 cfs in 2007). Nursery habitat strategies described in previous sections should be used in this reach to help continue habitat availability. Incision would decrease the habitat value of this reach.

12.3.3 Other Species

Some Western Yellow-billed Cuckoos, which are ESA candidate species, are present in this reach. Further data collection and observations would be necessary to determine the extent of the presence of the species should it be ESA listed.

12.4 Maintenance Needs and Strategies

This reach has an approximate length of 8 miles. The bed elevation has been stable since the 1930s and is expected to remain stable in the short term (10 years). Lessons learned from other reaches should be considered in evaluating conditions of this reach.

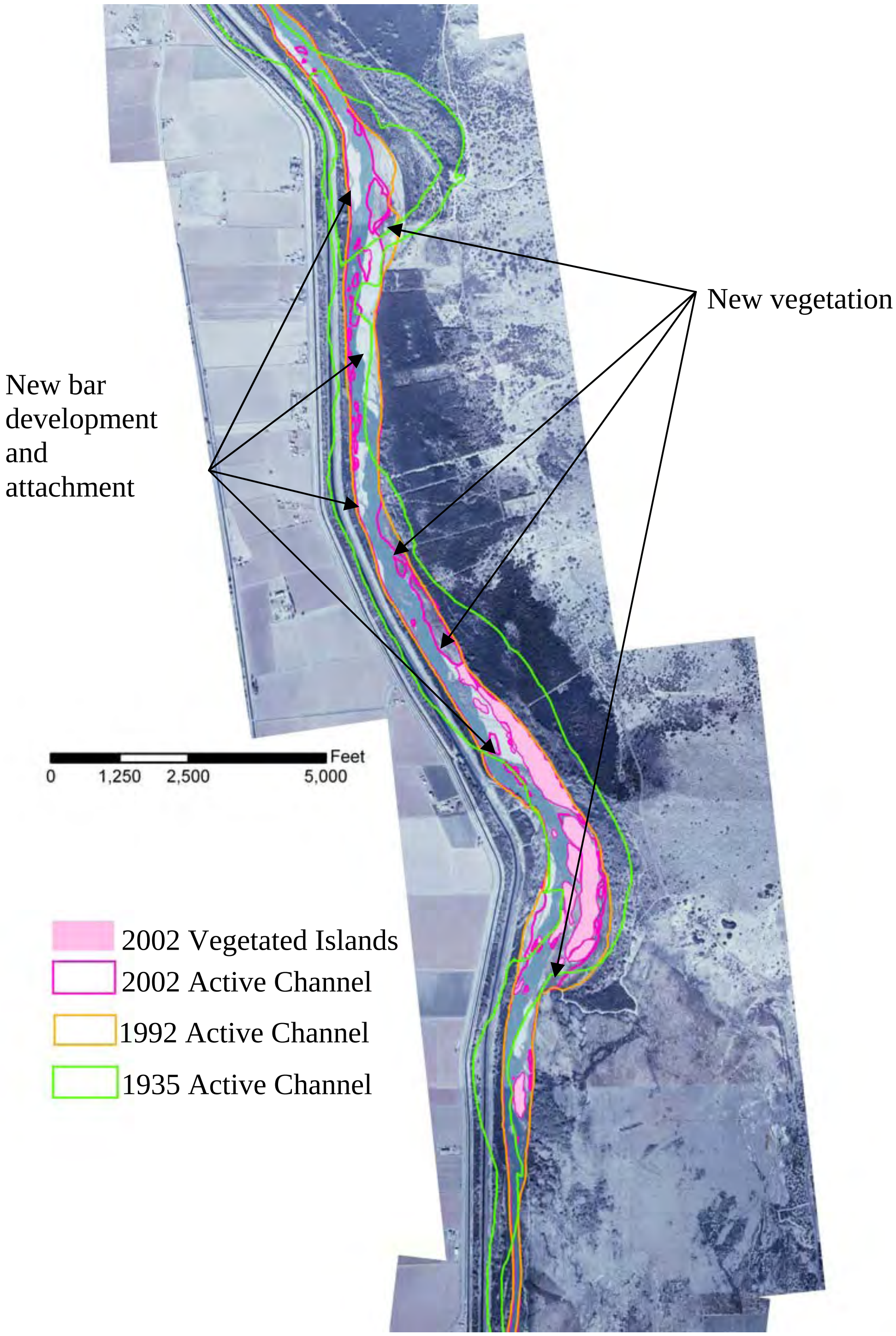

Figure 12. Arroyo de las Cañas to San Antonio Reach, Upstream of Highway 380 (2006 Aerial Photo)

13 San Antonio to RM 78 (RM 87.1 to 78)

13.1 Geomorphology

This reach (9 river miles) is and has been gradually aggrading since the 1930s. Bank heights are low and the floodplain along with recently formed islands are flood prone at relatively low flows (3,000 cfs). The amount of aggradation increases in the downstream direction. Although all of the Rio Grande has been narrowing since historical times (1918), this section of river has always been among the widest. It has maintained its wide, braided, shallow planform with a sand bed better than any other section on the Rio Grande. Several factors give possible insight into this reach's resistance to significant change:

- This reach is slightly aggradational with sand still being delivered to this reach. A high sediment load is needed to maintain the braided planform. This aggradation has persisted beyond that of all the other reaches in the Middle Rio Grande.
- Channel slope lessens slightly in this reach.
- The valley width is very wide in this reach.
- This reach receives water and sediment from numerous tributaries that are not controlled for flood or sediment production, allowing for a more natural hydrograph and sediment supply than found in the upstream reaches.
- There has been less channel maintenance work in this reach because it is not as directly influenced by Elephant Butte Reservoir. This is part of the transition reach between San Acacia and the reservoir.
- The width constriction and slope changes near RM 78 may be acting to limit sediment transport.

During the recent drought cycle, mid-channel bars isolated from the low flows become vegetated. In 2005, many of the side channels filled-in, became vegetated and are now attaching the islands to the banks. High flows in both 2005 and 2006 have not been able to erode these features; in fact, the main channel rapidly decreased in width and now snakes around these stable features, similar to that seen near Belen.

In locations where the channel was straightened by cutting pilot channels through the floodplains, the channel width is significantly narrower. The bank material in these locations is likely more resistant to erosion than elsewhere due to a higher cohesiveness more consistent with floodplain deposition.

With the extensive formation of vegetated islands and bars, less wetted channel area is available for aquatic species; the island growth trend is likely to continue in this reach. These islands/bars are very stable and force the main channel to flow around them forming a deeper more concentrated main channel to convey the in-channel flows. The likely evolution of this reach is that a single dominant channel will emerge, with the rest of the current active channel becoming vegetated floodplain. Although these newly formed surfaces easily flood, so does the historical floodplain, therefore, these features only add to the abundant floodplain habitat already available in this reach. These new riparian areas provide young vegetation that is close to the river's edge and may improve avian habitats.

One additional concern for this reach is the possible upstream migration of the Elephant Butte Reservoir headcut (see section 14.1). At present, the headcut appears to have transitioned to the preexisting river bed elevations and slope below the Tiffany Plug area. The effect of the headcut continuing upstream would be temporary bed degradation, probably less than 3 vertical feet of scour. Degradation in this reach will result in higher river flows required to inundate the floodplain. The degradation may continue until the reservoir fills again. Assuming sediment supply remains higher than transport capacity, aggradation would likely ensue but even then it is difficult to predict the timing and magnitude of adjustment after the reservoir fills.

Hydrology is similar to the next upstream reach (section 12.1) but with additional ephemeral tributary inflows. During periods of low flow, this reach frequently dries and rewets.

13.2 Infrastructure or Maintenance Activities

This reach is defined by the Highway 380 Bridge upstream and RM 78, within the BDANWR, downstream. The Refuge's northern boundary is near RM 84, and it occupies six of the nine miles that make up this reach. The LFCC and the concurrently constructed spoil levee, which were built in the 1950s, continue through this reach. For more information on the LFCC, see Chapter 16. The spoil levee is on the west side of the river, between the LFCC and the river, and constrains river flows to the west (Makar and Strand 2003). The North Boundary Pump Site, located at BDANWR's north boundary, pumps water from the LFCC to the floodway during dry years. This is intended to keep water flowing in the river to help protect the endangered RGSM.

The only bridge in the reach is the Highway 380 Bridge at the upstream boundary. There is one priority site in this reach, which addresses levee capacity in the downstream portion of the reach, where the river bed has aggraded and is often perched above the adjacent floodplain. There are no monitored sites.

13.3 Endangered Species

13.3.1 Southwestern Willow Flycatcher

(*from* Moore and Ahlers 2006b)

Four SWFL territories were documented in the Tiffany area of this reach in 2006. The reduction in territories from three in 2002 and 2003 to zero in 2005 indicated that SWFLs were not able to persist due to a lack of suitable habitat. The reestablishment of territories in 2006 suggests that there is some suitable habitat developing. Monitoring this reach is warranted to determine if this trend continues and if SWFL numbers in this reach increase as habitat matures to suitability.

13.3.2 Rio Grande Silvery Minnow

This reach has generally good floodplain connectivity for nursery habitat. Most of the reach is managed by BDANWR. Plans to create an avulsion to east at the north boundary are suspended because of Service concerns about young-of-year RGSM becoming trapped on the floodplain (a small number compared to those returning to the river) and NMISC concerns over depletions with channel lengthening. Inlets have been constructed to create nursery habitat, but were rapidly filled in or eroded.

13.4 Maintenance Needs and Strategies

This reach has an approximate length of nine miles. The river has a slightly aggrading bed and cohesive overbank lenses. Bed elevation is fairly stable, and connection to the floodplain begins at 2,000–3,000 cfs. However, the channel planform is narrowing rapidly with vegetation encroachment in some areas because of low flows and new island development.

Currently, there is some concern about a headcut moving upstream through the reach due to base level lowering resulting from the more that 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 to determine stable slope and channel geometry would further reduce this uncertainty.

Lowering of 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, however, induce occupation of other suitable sites and cause formation of new habitat. New habitat would come about through 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 it is advisable to engage in proactive action (potentially including both implementation and water operations options) to prevent future problems.

14 15 RM 78 to Elephant Butte Reservoir (RM 78 to 50)

14.1 Geomorphology

This reach has two subreaches, the river channel subreach above the full pool elevation of Elephant Butte Reservoir (RM 78 to 59) and the Temporary Channel subreach (RM 59 to 50) from there to the head of the drawdown pool of Elephant Butte. Reclamation maintains the Temporary Channel to RM 50 and NMISC from there downstream. Because of the variation in pool elevation, Reclamation’s maintenance reach may be 19 to 28 miles long. Much of the reach has been channelized through cohesive materials and remains narrow.

Prior to 2005, the river channel was rapidly aggrading, with about 15 feet in the last 30 years at San Marcial Railroad Bridge. The location of aggradation is strongly influenced by reservoir stage. In 2003, a large headcut (>10 feet in vertical elevation) was identified within the upper section of Elephant Butte Reservoir full pool reservation. In 2005, the headcut migrated upstream with spring runoff. The headcut appears to have divided into several smaller headcuts that may now be located throughout the reach. The most upstream portion of the headcut has tapered out in the upstream portion of this reach near Tiffany. It is unknown whether the smaller headcuts will continue to migrate upstream but recent (2006 and 2007) profiles show little movement.

Subsequent bed degradation in 2005 from the headcut caused significant bed elevation lowering (degradation) throughout this reach which adversely affects aquatic and riparian species alike. This degradation varies, with the greatest amount at the downstream end of the reach, greater than 10 feet, to 3–4 feet at the upstream end of the reach. Regardless of the exact amount, degradation has resulted in abandonment of most of the floodplain in this reach. Owing to rapid base level lowering and subsequent water table elevation lowering, especially at the downstream end of the reach, riparian vegetation is being stressed with some mortality occurring. As this reach is normally rapidly aggrading, the incision is presumed to be temporary; based on recent historical aggradation rates, once the sedimentation processes returns, the channel could fill to 2003 elevations within 10–15 years. However, additional headcuts migrating into this reach from the Reservoir would extend this timeframe. SRH-1D modeling of a rise in Reservoir stage could help pin down the timeframe.

Along with the rapid bed degradation, several bends within this reach have begun to migrate. The two most notable locations are at RM 60 and at the Fort Craig pumping station; in both locations, river flows intersect the bank material below the root zone and are causing erosion. Erosion at both sites began at existing bends but has evolved and created new bends. On the inside of each of the migrating bends, large point bars have developed. The recognition of this sediment deposition is important, as it indicates that the channel has formed a prominent thalweg which is located at or near the eroding bankline (across from the sediment deposition). This thalweg development indicates a shift from a uniform bed depth to that of varying depth. Channel migration is a recent process and is associated with the lowered base-level elevation of the reservoir. The incised channel allows bank erosion to occur under the riparian root mass. This type of erosion can be expected as long as the bed elevation continues to be lower than the vegetation roots.

Although this reach has changed significantly within the last few years, the channel alignment at a broad scale remains stable. This reach was always the narrowest and least variable based on historical photo reviews. Much of this reach was relocated when the river channel was moved to the east side of the valley during LFCC construction. Although a major threat just a couple of years ago, channel avulsion is not likely until the channel bed aggrades back to elevations similar to that measured in 2003; right now the river is the lowest valley elevation through most of this reach. Grain size continues to be sand but appears to be coarsening from fine to medium sand (Bauer 2006). This shift could have significant implications to sediment transport and indicates a shift in the overall sediment load. This material is also more consistent with sand found in the upstream channel.

The main portion of the Temporary Channel (upstream of the Narrows) has started to evolve since it was first constructed in 2001-2004. In 2006, RGSM were found throughout this part of the channel. As long as the reservoir pool does not fill over this channel, it will continue to evolve. A slight meander pattern is beginning to set up and is likely to progress; however, vegetation growth along the channel could stifle this planform development. The meandering pattern adds complexity to the channel through the development of inset point bars (shallow surfaces within the main channel) and a deeper thalweg which alternates between banklines.

The longer the reservoir pool stays low with a steep upstream slope and a sediment transport capacity higher than load, the more likelihood that additional headcuts will form and migrate upstream. These headcuts will increase channel capacity within the constructed channel, while lowering the water table. The incision and lowered water table are two important changes in this reach that affect habitat conditions. The incision and deepening thalweg has obvious consequences for aquatic species, as the channel area has decreased, but more importantly the shallow flow areas are disappearing. Also, the once well connected floodplain is now abandoned. The lowered water table is already affecting the riparian vegetation; stress and mortality of the riparian vegetation has obvious negative implications for SWFL habitat. These conditions are expected to exist until the reach resumes its aggradational processes and aggrades to a level at which the floodplain becomes active again.

14.2 Infrastructure or Maintenance Activities

This reach extends from River Mile 78 upstream to Elephant Butte Reservoir downstream. Storage for the reservoir began in 1915; the full pool elevation of 4407 feet extends upstream to RM 62 (Reclamation 1981). The dam supplies water for irrigation and power generation and also reduces flood peaks and sediment to areas downstream.

The first four miles of this reach are within the BDANWR. The Bosque del Apache/Tiffany levee (RM 84–74), is monitored, as the river bed is often above the adjacent floodplain in this area when the reservoir pool elevation is high. Aggradation continues to be a problem downstream, and the San Marcial levee priority site (RM 74–60.8) was established because of concerns for levee capacity.

With the exception of the area that is within the BDANWR above RM 80, there was extensive channelization work and floodway clearing in the 1950s (Makar and Strand 2003). In addition, the LFCC was constructed during this time, as detailed in chapter 16. During the LFCC construction, the floodway was moved to the east side of the river valley (Makar and Strand 2003). Figure 13 shows this change.

The location of the LFCC outfall has varied depending on reservoir pool elevation, but was at RM 54.7 in 2007. The downstream portion of the LFCC is not well-defined, and there are numerous adjacent marshes.

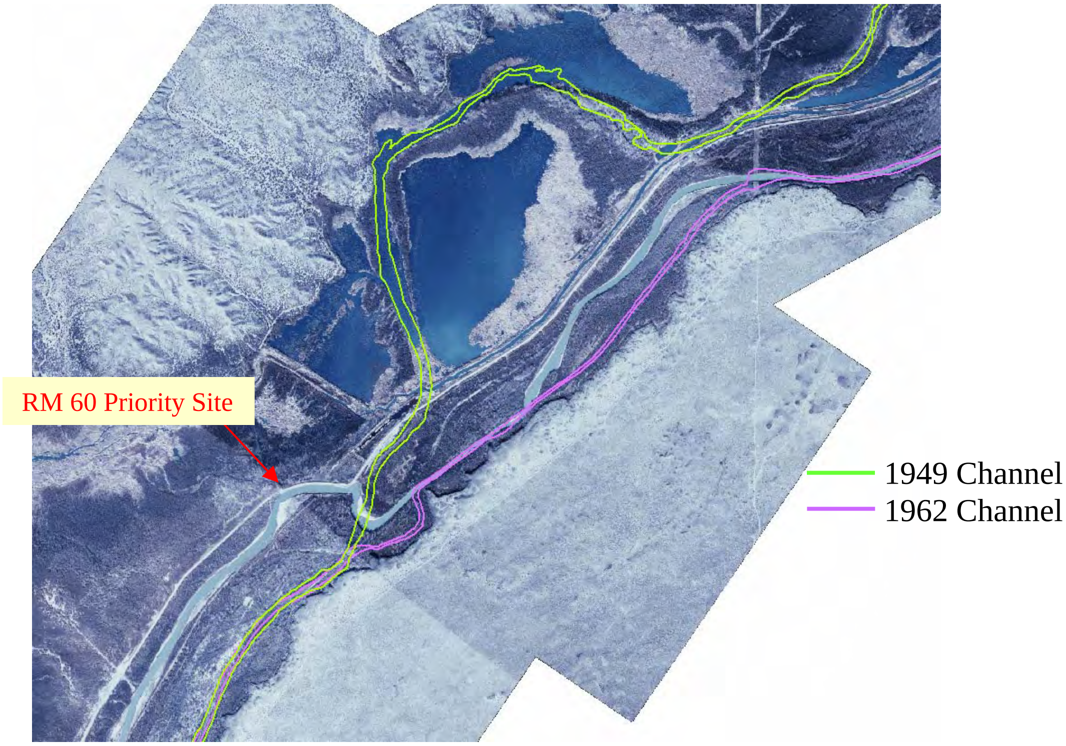

Figure 13. RM 78 to Elephant Butte reach, Near River Mile 60 (2006 Aerial Photo)

A sediment plug formed in the area between RM 74 and RM 70 in 1991, 1995, and 2005. This area, the Tiffany Sediment Plug, is designated as a priority site. In 1991, the Tiffany levee also breached during the time the plug was in place. In all cases, a pilot channel was excavated to return flow to the floodway. The channel remains extremely narrow in this area.

The San Marcial Railroad Bridge is located at RM 68.6. The current bridge was constructed in 1930, and is skewed significantly with respect to the direction of flow. Attesting to the aggradational trend in the reach, the tracks are now more than 20 feet higher than they were on the original bridge in 1920. Even so, the limited channel capacity under the bridge often controls flood releases from Cochiti Dam <http://wrri.nmsu.edu/publish/watcon/proc44/gorbach.pdf>. According to recent hydraulic modeling, the low chord was at or just above the water surface at flows in the range of 2,000–5,000 cfs before the 2005 runoff. The berm that the track is on also directs overbank flows back into the channel. Reconstruction of the San Marcial railroad bridge is an element of the Biological Opinion that, in addition to completion of Corps levee projects, would support the increased channel capacity of 10,000 cfs below Cochiti. Reconstruction plans include relocation of the railroad track and bridge downstream of its current location. The planned bridge crossing will be more perpendicular to the channel alignment (at a less skewed angle).

The Fort Craig pump site is located at RM 64. During dry years, water is pumped from the LFCC to the floodway. The intent is to keep water flowing in the river to protect the endangered RGSM. Just upstream from the pump site is one of two priority sites in this reach concerned with migrating bends.

Although a straight floodway was constructed next to the east mesa as part of the LFCC construction, at some point between 1985 and 1992, two bends—the Fort Craig Bend and River Mile 60—developed and the river diverted to the west (Massong 2006b). Both are currently priority sites. At River Mile 60, Massong (2006b) reports that Reclamation redirected the main channel into the old LFCC alignment between 1991 and 1993. In addition, the old floodway along the east mesa was mechanically blocked, and has since filled in with sediment and become vegetated. These changes can be seen in Figure 13 above, when the location of the 1962 channel is compared with that shown in the 2006 photo. The Fort Craig Bend appears to be the result of a minor avulsion.

Another priority site is the Elephant Butte Temporary Channel (RM 58–51). Since 1991, three Temporary Channels have been constructed to re-connect the river and the reservoir pool to maintain water delivery to the reservoir. Temporary channel construction is in response to the decreasing reservoir pool elevation. When the reservoir level is low, the Bureau of Land Management allows grazing in the Temporary Channel area from October to May.

As this Temporary Channel subreach is within the Elephant Butte Reservoir pool area, it has experienced periods of substantial and rapid aggradation. At the upstream end of the narrows (upper portion of the reservoir), the bed elevation has risen about 40 feet since 1915. The most sustained period of near maximum reservoir storage occurred in 1980s through the mid-1990s. The reservoir pool elevation started decreasing in 1999, moving the head of the reservoir pool downstream of the Narrows in 2002. This rapid lake recession disconnected the river from the lake, such that a channel had to be excavated through the reservoir sediments. Over 20 miles of channel have been constructed since the late 1990s. The length constructed by year is listed below:

- End of the 1990s—1.9 miles
- 2000—0.9 miles
- 2001—2.2 miles
- 2002—2.2 miles
- 2003—4.9 miles
- 2004—6.8 miles
- 2005—1.0 mile

This reach is quite remote; the only bridge across the river is the railroad bridge, and access to the east side of the river is very limited. Because of the fluctuating reservoir levels and the history of human action, its maintenance needs are complex. There are six priority sites in the reach, addressing four different river maintenance problems (levee capacity, bank erosion/migration, sediment plug formation, and maintaining channel connection to the reservoir pool).

14.3 Endangered Species

14.3.1 Southwestern Willow Flycatcher

(*from* Moore and Ahlers 2006b)

SWFLs surveys have been conducted in this reach since 1994. Since 1995, SWFL territories and available habitat below the railroad bridge have increased greatly. During the 2000 season, a concentration of breeding SWFLs developed within the LF-17 and LF-17a sites (refer to Moore and Ahlers 2006b for a description of these sites). This increase in SWFL population in the "core" areas is likely a result of a consistent water supply provided by the LFCC outfall and the emergence of maturing native vegetation within the receding headwater area of Elephant Butte Reservoir, contributing to high levels of reproductive recruitment in the population. As the reservoir continued to recede during the following years and native vegetation became established, the population of SWFLs expanded in number and extent to inhabit suitable habitat from LF-17a and LF-17 downstream to DL-07 and DL-09. This expansion was facilitated by a number of factors including an increase in available nesting habitat, high survival rates experience by both adults and fledglings, and consistently high rates of pair nesting success. This population continues to expand, which implies that quality habitat is not limiting the local population's growth.

In the future, as the dynamics of the reservoir cause water levels to rise and fall, it is likely that breeding habitat will continue to be created and destroyed. It is this type of dynamic system that SWFLs depend on for breeding habitat. From year to year there may be net gains and losses of habitat, but as a whole this population should persist and be a valuable source population for the surrounding areas into the foreseeable future.

14.3.2 Rio Grande Silvery Minnow

The number of RGSM in 2003 was low in this reach, due to the poor habitat in the narrow and incised channel. RGSM were occasionally found where the channel widened out and flow velocities are reduced. High dispersal rates and population numbers occurred in 2004 and 2005 both upstream downstream of the Tiffany sediment plug where floodplain connectivity existed. The floodplain from River Mile 60 to San Marcial Railroad Bridge has been abandoned due to degradation. One to two feet of degradation upstream of the Tiffany sediment plug has also occurred, but the floodplain remains wet from upstream overbank flows.

RGSM have been found at the LFCC outfall and downstream in the Temporary Channel. RGSM benefit from maintenance activities that do not remove the point bars that develop in the Temporary Channel. Section 7 consultation is likely soon because of the Temporary Channel population.

14.3.3 Other Species

The largest population of Western Yellow-billed Cuckoos in New Mexico, an ESA candidate species, occurs in the San Marcial area. Cuckoos appear to prefer Goodding's willows in association with a taller cottonwood canopy. Population estimates were started by Reclamation in 2006.

14.4 Maintenance Needs and Strategies

The length of this reach varies with changes in the pool elevation of Elephant Butte Reservoir. Much of the reach was previously channelized through cohesive 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 long term aggradation will continue to occur. Aggradation within the floodway causes continual problems with flood 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 issue. 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 trade off 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. Bank erosion and lateral migration could cause the levee to fail through bank erosion 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 stakeholding agencies. Costs associated with damages from uncontrolled avulsion are unknown.

The continual aggradation in this reach causes several other maintenance problems. Most notably, Reclamation and the NMISC 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 SRH-1D sediment modeling by the TSC has helped in planning river maintenance to ensure this connection. A partnership among the hydrologic community stakeholders to create a water budget estimating water salvage and delivery benefits of the LFCC and Temporary Channel would be useful in selection of maintenance strategies for this reach. Analysis has not been conducted to determine how much of the river flow would make it to the reservoir through groundwater flow if the Temporary Channel did not exist. In the later 1940s, surface flows did not form a channel to the reservoir due to aggradation and vegetation growth.

Another aggradational problem is the formation of a sediment plug at the north end of Black Mesa. A sediment plug can form in this area because of a constriction in the river channel that 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. Reclamation is currently in the formative stages of developing a long term solution; options may include channel reconstruction or realignment.

15 Elephant Butte Reservoir to Caballo Reservoir (RM 50 to 12)

15.1 Geomorphology

The Rio Grande between Elephant Butte Dam and Caballo Reservoir is extensively controlled in terms of regulated river flows and sections of the river bed elevation. The 2-year flow at the Below Elephant Butte gage is 2,470 cfs (Bullard and Lane 1993). All of the upstream sediment supply for this reach is stored in Elephant Butte Reservoir, such that released water is clear and cold. Local tributaries (Arroyo Cuchillo Arroyo Negro, Mescal Arroyo, and Arroyo Hondo) contribute to this reach flow infrequently but can deliver copious amounts of coarse and fine sediments. As an apparent result of the low sediment supply, the channel appears to be slightly incised.

The bankline is stable throughout the reach; only some of the banks are lined with riprap. As this reach is so controlled and has been since 1917 when Elephant Butte Dam began operations, it is not likely to evolve significantly in the future. The current availability and type of habitat is likely stable unless manipulated by humans.

15.2 Infrastructure or Maintenance Activities

This reach is defined by two large dams: Elephant Butte at its upstream end and Caballo at its downstream end. Elephant Butte began storing water in 1915 and has a full pool elevation of 4407 feet. Caballo Dam was completed in 1938, in part to replace storage capacity lost at Elephant Butte due to siltation. It has a maximum water surface elevation of 4182 feet <http://www.usbr.gov/dataweb/dams/nm00131.htm>. Caballo acts to reduce downstream flood peaks and to divert water for irrigation, and is also used to meet annual treaty deliveries of water to Mexico. A biological opinion issued by the Service in 1991 states that a minimum fisheries pool of 25,000 acre-feet must be maintained in the reservoir <http://www.fws.gov/southwest/mrgbi/Resources/Dams/index.html#caballo>.

One bridge crosses the river in this reach. There is one priority site, Truth or Consequences RM 24 to 22, which is concerned with maintaining the 5000 cfs channel capacity.

15.3 Endangered Species

15.3.1 Southwestern Willow Flycatcher

This reach of the Rio Grande is mostly channelized and receives annual mechanical maintenance and has a fair amount of adjacent urban area, so it does not host any populations of SWFL.

15.3.2 Rio Grande Silvery Minnow

There are no RGSM present in this reach.

15.4 Maintenance Needs and Strategies

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 to natural hot springs, so 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 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.

16 Low Flow Conveyance Channel (RM 116.2 to 61.4)

The LFCC was constructed by Reclamation in the 1950s to aid the State of New Mexico in delivering waters obligated to Texas under the Rio Grande Compact (Compact). The channel also served to improve agricultural drainage and to supplement irrigation water supplies to both the BDANWR as well as irrigators of the MRGCD. The riprap-lined channel currently parallels an approximately 56-mile reach of the Rio Grande from San Acacia to about RM 60. The LFCC currently collects river seepage and irrigation surface and subsurface return flows. Historically, the LFCC conveyed up to 2,000 cfs (with appreciably lower evapotranspiration rates than the Rio Grande) to Elephant Butte Reservoir and has been credited with assisting New Mexico to significantly decrease its Compact compliance deficit. However, the usefulness of the LFCC was limited due to increased storage in Elephant Butte Reservoir in the early to mid-1980s that buried the last 15 miles of the channel and the outfall (where the LFCC drains into the Rio Grande). The LFCC currently functions only as a passive drain for seepage and irrigation return flows.

This chapter includes a description of the past and current conditions of the LFCC, past maintenance, operations and water delivery benefits, environmental conditions and associated endangered species issues, and institutional interests and issues. Options for potential realignment and rehabilitation, various operational scenarios, and potential future maintenance needs are also given. Potential realignment includes the general consideration for realigning the LFCC and river channel downstream of the San Marcial Railroad Bridge.

16.1 Reach Conditions

See Chapter 14—RM 78 to Elephant Butte Reservoir for additional information.

16.1.1 Past and Current Physical Conditions

16.1.1.1 Background and General Infrastructure Characteristics

The combination of flooding effects followed by the onset of drought in the mid-1940s resulted in the river between the southern boundary of BDANWR and Elephant Butte Reservoir becoming fully blocked in many places with sediment and dense vegetation (Reclamation 2000). Surface waters did not flow in a channel to the Elephant Butte Reservoir pool during this time. The clogged river channel caused water to spread over large areas and either evaporate or be transpired by vegetation. Depletion of water in this reach was estimated to be more than 140,000 acre-feet annually during this time (Reclamation 1952).

To address these needs, Reclamation constructed the LFCC from 1951 to 1959. The LFCC was originally constructed from San Acacia Diversion Dam to the Narrows of Elephant Butte, a distance of about 70 miles. At the outfall location (where the LFCC enters the Rio Grande channel), mechanical removal of sediment deposits was necessary on a continuing basis to maintain channel capacity. Riprap was placed to protect the banks at various locations throughout the 70 miles and where the channel crossed under other infrastructure. Small Kellner jetty jacks were used to control bank erosion in selected areas. After LFCC construction, the reservoir elevation remained below the Narrows until 1979, when the reservoir began to fill. As a result of the increased reservoir water surface elevation and delta sediment deposits, the lower 15 miles of the LFCC was buried. The LFCC was shortened to a length of 54.7 miles to the outfall location at about RM 60. During the period of time between 1981 and 1987, the LFCC was rehabilitated with riprap side slopes.

The original purposes of the LFCC were to convey water efficiently to Elephant Butte Reservoir, to maintain effective valley drainage, and to manage sediment. A number of concerns related to the physical channel system have emerged in recent years. During the high reservoir storage period from 1979 to the late 1990s, sediment deposited upstream of the reservoir pool and elevated the river channel bed. This stressed the levees that protect the LFCC from flooding. The levee has been raised significantly to maintain flow capacity in the river channel. During this same period, the hydraulic capacity of the San Marcial Railroad Bridge has been severely reduced. Several times the capacity was 2,000 cfs or less, restricting releases from Cochiti Dam.

In the early 2000s, the reservoir pool dropped to below the Narrows. Owing to this drop in base level, the main channel of the Rio Grande has incised and disconnected the river from its floodplain. The LFCC can be operated currently as a drainage facility, but diversions at San Acacia Diversion Dam are not possible due to sediment deposition and other LFCC Reach impediments described below. Only with extensive rehabilitation to the LFCC Reach, could the gates be operated at San Acacia Diversion Dam. Outfall channels and associated infrastructure into the river could be constructed at different locations including Fort Craig, RM 60, Elephant Butte Range Line (RL) 32, or the Narrows. The current outfall is located near RM 55. The NMISC is interested in maximizing water delivered to Elephant Butte, especially if they develop a future accrued debit under the Rio Grande Compact.

16.1.1.2 Operations and Water Delivery Benefits

In 1951, New Mexico's accrued water debit under the Rio Grande Compact was 325,000 acre-feet (Reclamation 2000). One of the significant causes for this large accrued debit was the inability of the channel in the headwaters of Elephant Butte Reservoir to effectively pass flows as described in section 16.1.1.1. When the LFCC began operating in 1960, diversions were made from the Rio Grande for all flows up to 2,000 cfs. When main stem flows exceeded 2,000 cfs, the difference remained in the river, passing through the gates at San Acacia Diversion Dam. During the 1960s and 1970s, most of the river was diverted into the LFCC at San Acacia Diversion Dam for delivery to Elephant Butte Reservoir. A large portion of New Mexico's accrued debit was eliminated during this period of time. Average annual water salvage during this period was estimated to be 66,000 acre-feet (Reclamation 2000).

Elephant Butte Reservoir filled to near capacity in 1982 and 1984. A physical spill (where water was released from the dam to prevent overtopping) occurred at Elephant Butte Reservoir in 1985. This erased the rest of New Mexico's accrued Compact debit. Diversion capacity for the LFCC was reduced during this time due to sediment deposits in the newly constructed outfall. This was a result of the high reservoir stage, low valley slope and incoming sediment supply. Sediment deposition at the LFCC outfall near RM 60 may have also been exacerbated by a widened channel section at that Temporary Outfall. Since 1984, the LFCC has only been operated a few times. Notable among these operations was the experimental operations conducted from San Acacia Diversion Dam and downstream for about 10 miles. Experimental operations began in the late 1990s ending in the early 2000s. These operations were part if a study to determine the most effective LFCC design configuration for water and sediment transport.

Since 1984, the LFCC has provided four important functions. First, because the LFCC is usually the lowest point in the valley, it collects subsurface drainage water, irrigation return flows, and ephemeral storm runoff. Second, the LFCC delivers the drainage and return flows downstream to RM 60 with minimum evaporation and seepage losses. Third, the channel furnishes a water source for diversion by MRGCD and the BDANWR. Fourth, the LFCC intercepts water seeping from the river channel and prevents those waters from raising the valley's water table. (In some areas of the Socorro Valley, the land surface is near or below the same elevation as the river bed.) More recently, the LFCC provides a water source for the SWFL wetland complex downstream and to the west of RM 60. It also provides water which is pumped into the Rio Grande during low flow periods to help preserve populations of the RGSM.

16.1.2 Endangered Species

16.1.2.1 Southwestern Willow Flycatcher

No SWFLs occur on the LFCC, but as much as 90 percent of the SWFL population in Elephant Butte is directly tied to the water that flows west from the LFCC below the 1830 berm. This water supports that wetlands and associated riparian bosque used by the SWFLs. As long as the water surface elevation of Elephant Butte Reservoir is low, the LFCC water is very important for supporting this SWFL habitat.

16.1.2.2 Rio Grande Silvery Minnow

Few RGSM occur in the LFCC due to the prismatic channel configuration which results in higher flow velocities as well as the preponderance of predators (such as bass) in the LFCC. It is an important water source for pumping to maintain a wet channel in the Rio Grande and to convey more water to the Temporary Channel where new populations of RGSM have been found.

16.1.2.3 Other Species

Some Western Yellow-billed Cuckoos, an ESA candidate species, are present in this LFCC flow area. Further data collection and observations would be necessary to determine the extent of the presence of the species.

16.1.2.4 Pumping and the LFCC

Water is pumped from the LFCC to the Rio Grande in four locations. Listed from upstream to downstream, they are Neil Cupp (RM 90), the North Bosque del Apache (RM 84), the South Bosque Del Apache (RM 74), and the Fort Craig (RM 64) pumping stations. LFCC water is pumped into Rio Grande channel to keep the channel wet to provide habitat for RGSM.

Pumping too much water in an untimely manner from the LFCC can cause these areas of the LFCC to dry up. This can be detrimental to the SWFL located in the upper portion of Elephant Butte, who rely on water for nest initiation and placement. A balance needs to be achieved between managing LFCC water for both SWFL and RGSM.

16.1.3 Institutional Issues

Reclamation constructed, maintains and operates the LFCC. NMISC has expressed interest in restoring operations of the LFCC. They have partnered with Reclamation to construct a Temporary Channel in the river to partially restore an efficient conveyance through the delta that currently forms the upper reach of Elephant Butte Reservoir. The LFCC provides water delivery benefits to NMISC through either operations or as a passive drain. MRGCD uses the LFCC for irrigation return flows and diversions. The BDANWR uses the LFCC for a water supply. Reclamation has full access to all channel berm roads and the LFCC levee roads.

16.1.4 Other Considerations

Environmental considerations associated with the reaches below San Acacia (chapters 11–14) hold true for any activities contemplated for LFCC restoration or realignment. The area supports RGSM and SWFL habitats and currently the LFCC supports locally important wetland complexes.

The impacts of alternate water operations scenarios, including explicit analysis of water operations at 0, 500, 1,000, and 2,000 cfs diversions, were evaluated in the Upper Rio

Grande Water Operations Review and EIS (EIS) (Reclamation 2007). While Compact deliveries were maximized at 2,000 cfs diversions, undesirable environmental impacts were identified at this level of diversion. At 1,000 cfs diversions, evapotranspiration losses were unacceptably large. At 500 cfs, Compact delivery benefits were still realized, while minimizing environmental impacts. These operational scenarios remain to be coupled with a physical rehabilitation or realignment plan for the LFCC. Thus, the Reclamation action resulting from the EIS will be to maintain the status quo of operating the LFCC as a passive drain and return flow conveyance until decisions are made about future infrastructure needs.

16.2 Maintenance Needs for LFCC Strategies and Operational Scenarios

Potential future general strategies for the LFCC include:

1. No changes to the current infrastructure and operations
2. Reconstruction of the LFCC outfall to the river at various locations
3. Realignment of the river and LFCC to the west side of the valley downstream of the San Marcial Railroad Bridge

The realignment strategy could incorporate any of the LFCC outfall reconstruction options. All three of these general strategies have several possible operational scenarios. Operations scenarios that include diversions would require rehabilitation of the entire LFCC. Any outfall reconstruction, realignment, and operational changes will include the goals of enhancing the SWFL habitat and ecosystem while maximizing water delivery at the lowest cost.

16.2.1 Current Strategy

Currently, the old LFCC channel outfall near RM 60 is filled with sediment and a road crossing blocks the outfall to the Rio Grande. LFCC waters flow though a series of breaches in the west berm road into the Quates Canyon wetland and the SWFL wetland area to the west and south of RM 60. LFCC flows enter the Rio Grande downstream of the wetland area at RL 32. As described above in section 16.1.1.2, the LFCC currently receives ephemeral tributary inflow, irrigation return flows, acts as a shallow ground water drain, and provides water supply for MRGCD, the Bosque del Apache National Wildlife Refuge, and the RGSM and SWFL .

Maintenance needs include potential sediment removal from the outfall at RL 32, inspection and maintenance of an arroyo crossing and diversion structure, sideslope mowing, riprap replacement, and berm road grading.

16.2.2 Outfall Reconstruction Strategy

A LFCC outfall could be reconstructed at several locations with various operation scenarios. A relatively smaller channel would need to be provided to maintain flows for the viability of the SWFL area on the west side of the valley south of RM 60. For the case of diversions into the LFCC under the URGWOPS EIS preferred alternative, maintenance needs for the LFCC include sediment removal from outfall, arroyo crossing and diversion structure inspection and maintenance, sideslope mowing, riprap replacement, and berm road grading. Table 4 is a summary of activities associated with each potential LFCC outfall rehabilitation location.

16.2.2.1 Potential Outfall Reconstruction Strategy Maintenance Activities

This section contains a description of the rehabilitation and maintenance activities in table 4 listed by corresponding number.

San Lorenzo Arroyo Crossing

1) Increase the LFCC capacity under the San Lorenzo Arroyo from 500 to 2,000 cfs. This involves increasing the culvert capacity to accommodate full operations of the head gates at San Acacia Diversion Dam.

Escondida Reach

2) Rehabilitate LFCC at Escondida by removing the test operations facilities and check structures, including removing the plug and slide gate in the LFCC, plug or remove the culverts through the levee, and fill in the channel to the river. These facilities were established as part of the test operation facilities and would need to be removed to operate the head gates at San Acacia Diversion Dam.

San Acacia Reach

3) Increase the height of the LFCC bank protection riprap to accommodate 2,000 cfs. During the implementation of the Levee Setback Project at RMs 114 and 113, the LFCC was relocated and riprap bank protection was provided to the 500 cfs water surface elevation. Given the uncertainty of future surface water diversions of the LFCC above drainage and irrigation return flows, riprap protection was provided for 500 cfs instead of the fully operational level of 2,000 cfs. Should full operations of the head gates at San Acacia Diversion Dam be reintroduced, the height of the riprap protection should be increased to reflect an operation level of 2,000 cfs.

Fort Craig to RM 60 Reach

4) Repair the berm road between Fort Craig Bridge on the west side of the LFCC for access to the Temporary Channel and LFCC outfall. The berm road would need to be passable to vehicle traffic to provide access for future Temporary Channel maintenance activities. Culverts (gated or ungated) or other flow structure would need to be placed in the berm road to maintain flows for the wetland and SWFL habitat area to the west and south of RM 60. When Elephant Butte filled to capacity during the early 1980s, the west side berm roads breached and the existing outfall location above RM 60 was plugged. A road was constructed across the top of the outfall plug.

RM 60

5) Remove the plug and road crossing across the LFCC at RM 60. The purpose of the road crossing was described in item 4 above and would need to be removed and riprap placed along the bank line to prevent erosion.

San Marcial to RM 60 Reach

6) Use the LFCC discharges to move the sediment currently deposited in the LFCC. During the time when the reservoir was filling and before a plug was placed at the current

outfall location, sediment deposited in the LFCC for several miles upstream of RM 60. These sediments need to be removed to reestablish the LFCC capacity. The majority of LFCC flow would transport the sediment into Elephant Butte Reservoir, while a portion of the LFCC flows could be temporarily pumped into the wetlands area (see item 8).

7) Rehabilitate LFCC from Station 1800 (RM 60) to the Narrows of Elephant Butte Reservoir, along the west side of the valley, and around the SWFL area. This activity includes rehabilitating the LFCC from the current outfall location to the Narrows of Elephant Butte, the original location and length established in the 1950s.

8) Place check structure and turn out facilities upstream of Station 1800 to keep some flows in the SWFL wetland area west and south of the LFCC. The type and size of structure would be determined based upon whether the LFCC would be operated under current operational strategies or whether flows would be diverted into the LFCC through the head works gates at San Acacia Diversion Dam.

9) Place facilities downstream of the SWFL wetland area west and south of Station 1800 so that wetland discharges flow back into the LFCC. This location could be downstream of the SWFL habitat area and upstream of RL 32 or at RM 32. A channel could be excavated to more effectively convey flows to the Rio Grande Channel to maximize the effectiveness of water delivery discharges from the SWFL wetland area.

10) The amount of discharge would be determined based upon the increased channel capacity realized by sediment removal upstream of the current outfall location and to allow river flows to meet the 2003 BiOp flow criteria below San Acacia Diversion Dam.

16.2.2.2 Unique Characteristics of Establishing a LFCC Outfall Location Downstream of San Marcial or near Fort Craig.

An outfall for the LFCC can be established near Fort Craig or downstream of San Marcial by either moving the river to the west side of the valley or by placing culverts through the levee and connecting the LFCC to the river with the river remaining in the current alignment. If the LFCC were connected to the river in its current alignment via a culvert under the levee, the current LFCC channel could be used to provide flows for the SWFL wetland complex. This would require a bifurcation structure and a culvert under the levee. The culvert under the levee would need a gate to prevent peak river flows from entering the LFCC, filling it with sediment and overtopping flows which would damage the berm roads and the LFCC. Moving the river to the west would involve constructing a drainage channel and a protecting levee on the west side of the valley to provide flows for the SWFL wetland complex.

Table 4. Reconstructed LFCC Outfall Strategies

Rehabilitation/Realignment/Maintenance Strategies and Operational Scenarios	Establish LFCC Outfall at Fort Craig or San Marcial		Establish LFCC Outfall at Station 1800 (RM 60)		Establish LFCC Outfall at RM 46 (Narrows of Elephant Butte Reservoir)	
	Current Operational Scenario	Operational Scenario Diversions At San Acacia Diversion Dam	Current Operational Scenario	Operational Scenario Diversions At San Acacia Diversion Dam	Current Operational Scenario	Operational Scenario Diversions at San Acacia Diversion Dam
1. Increase the LFCC capacity under the San Lorenzo Arroyo from 500 to 2,000 cfs (Rehabilitation)		X		X		X
2. Rehabilitate LFCC Near Escondida (Rehabilitation)		X		X		X
3. Increase the height of the LFCC bank protection riprap to accommodate 2,000 cfs where the LFCC was relocated near RM 114 (Rehabilitation)		X		X		X
4. Repair Berm Road on the West side of the LFCC between Fort Craig Bridge and RM 60 (Rehabilitation)			X	X	X	X
5. Remove Plug and Road crossing across LFCC at Sta. 1800 (Rehabilitation)	X	X	X	X		
6. Remove the sediment currently deposited in the LFCC upstream of RM60 (could be done using flows in the LFCC). (Rehabilitation)		X		X		X
7. Rehabilitate LFCC from RM 60 to the Narrows of Elephant Butte Reservoir (RM 46) (Rehabilitation)					X	X

Rehabilitation/Realignment/Maintenance Strategies and Operational Scenarios	LFCC Outfall at Fort Craig or San Marcial		LFCC Outfall at Station 1800 (RM 60)		LFCC Outfall at RM 46 (Narrows of Elephant Butte Reservoir)	
	Current Operational Scenario	Operational Scenario Diversions At San Acacia Diversion Dam	Current Operational Scenario	Operational Diversions At San Acacia Diversion Dam Scenario	Current Operational Scenario	Operational Diversions at San Acacia Diversion Dam Scenario
8. Place check structure and turn out facility upstream of RM 60 to use to keep some flows in the SWFL wetland area west and south of the LFCC. (Facilities would be different for the Fort Craig Outfall alternative than the other two outfall locations-See section 16.2.2.2 Operational and Rehabilitation)	X	X	X	X	X	X
9. Place facilities downstream of the SWFL wetland area west and south of the LFCC so that wetland discharges flow back into the LFCC (Operational and Rehabilitation)					X	X
10. Peak amount of discharge would be determined based upon the amount of sediment removed and to allow river flows to meet the 2003 BiOp flow criteria below San Acacia Diversion Dam (Operational and Rehabilitation)		X		X		X
Note: 1) All items with an "X" in the box would need to be accomplished before either of the two operational scenarios can be implemented; 2) No rehabilitation or realignment activities are required for the current condition to continue (see section 15.2.1.1).						

16.2.2.3 Outfall Reconstruction Operational Scenarios

There are two main operational scenarios: divert flow into the LFCC or continue operation as a passive drain. The first requires diversion of river flows into the LFCC through the head gates at San Acacia Diversion Dam. Operation of the gates must be such that the amount of river flow meets the 2003 BiOp flow criteria below San Acacia Diversion Dam as well as not exceeding the maximum LFCC capacity, which depends on the amount of sediment removed upstream of RM 60. Rehabilitation of the LFCC would be required for this scenario (Potential Operational Scenario).

The second or current LFCC operations scenario collects irrigation return flows, arroyo inflows, and shallow groundwater drain waters and has outfall flows split between the river and the wetland area (Current Operational Scenario). There are additional options for each scenario discussed below.

16.2.2.3.1 Pump the LFCC to Augment River Flows (Current Operational Scenario)

Only a brief description of this item will be contained in the River Maintenance Plan, as the existing pumping activities are largely accomplished outside of the Program. The LFCC is checked to raise the LFCC water surface elevation and flow depth to increase the amount of pumping. Permanent pumping locations could be planned and constructed that may reduce long-term costs. In this scenario, the LFCC is supplied waters from irrigation return flows, arroyo inflows, and shallow ground water drainage inflows. Consideration may be given to strategically diverting water into the LFCC during low flow periods and pumping at additional locations to provide habitat in selected reaches to take advantage of the greater water transport ability of the LFCC above the Rio Grande Channel.

16.2.2.3.2 Plug the LFCC and pump the entire channel to the River near San Marcial RR Bridge (Potential Operational Scenario)

This would involve placing a berm across the LFCC, and continuously pumping flows to the river channel. This would result in a single river channel below San Marcial Railroad Bridge, with a channel in the far west portion of the valley to convey waters to supply the SWFL wetland complex south and west of RM 60. The full time pumping required for this alternative would have significant operational costs.

16.2.3 Realignment Strategy

The river and LFCC are in the originally constructed alignment downstream of the San Marcial RR Bridge to about RM 60. Since 2001, the Elephant Butte Reservoir pool has receded to below the Narrows. As the reservoir receded, the Rio Grande channel has been reconnected to the channel in the Narrows by excavating through the delta sediment deposits. During the spring runoff of 2005, the channel incised so that the LFCC can now be reconnected to the river at the current outfall location near RM 60. Given the current Elephant Butte stage, maintaining the river and LFCC in the existing alignment may be possible for a number of years. At some time in the future, the stage in Elephant Butte Reservoir will increase, causing sediment deposition in the river channel. The increased bed elevation will cause a loss of channel and levee capacity, as well as a loss of hydraulic capacity under the San Marcial Railroad Bridge. Levee elevations have already reached the maximum practical height in many areas. The bed elevation, as well as the capacity of the channel and bridge, depends upon the reservoir stage and the location of recent delta sediment deposits. The current river channel location limits river flows and reservoir delta sediment deposits to about one third of the floodplain for 10 miles downstream of San Marcial Railroad Bridge. This condition is not sustainable over the long term because the practical limit of the levee height has been reached in most areas. Eventually, the river will overtop the levee and move to the west side of the valley unless the river is realigned first.

Moving the river to the west side in a staged and planned manner will provide for the greatest water salvage. Depending upon the location of levee failure, there could be a loss of valley drainage, flooding of infrastructure, and loss of critical riparian and SWFL wetland habitat. Realigning the river will re-initiate floodplain fluvial processes in the Elephant Butte Delta and create additional sediment storage area. This will reduce the long term rate of river bed rise and reduce long term levee maintenance. There are congressional authority and Departmental policy issues to resolve. The NMISC desires a 2,000-cfs LFCC below San Marcial Railroad Bridge. All work would be within the Elephant Butte Reservation Boundary. Preservation and improvement of the SWFL wetland complex west and south of RM 60 will be needed. The realignment strategy could incorporate any of the LFCC outfall reconstruction options (see section 16.2.2). Cost, funding and feasibility will all be factors in any plan. Two potential specific options are discussed below

16.2.3.1 Realign the River and LFCC downstream of the San Marcial Railroad Bridge

This activity would involve realigning the LFCC and protecting levee to the far west side of the valley just downstream of the San Marcial RR Bridge. The current levee could be breached just downstream of the bridge and a pilot channel created for the river that extends to about RM 60. Here, the river would be connected to the existing channel alignment to prevent sediment deposition in the SWFL wetland complex west and south of RM 60. Facilities would also need to be provided to maintain flows in the SWFL wetland complex. The size of the LFCC would be determined based upon whether the current operations would continue or diversions made into the channel through the headworks at San Acacia Diversion Dam.

Future maintenance in the river channel is similar or the same as the RM 78 to Elephant Butte Reach and includes Temporary Channel maintenance and realignment of the Temporary Channel depending upon the location of delta sediment deposits. Levee-road grading and mowing for safe vehicle use would also be needed. LFCC maintenance needs would be the same as in section 16.2.2.

16.2.3.2 Realign the river and LFCC in the Fort Craig area

This activity would involve realigning the LFCC and the protecting levee to the far west side of the valley in the Fort Craig area. The current levee could be breached near Fort Craig and a pilot channel created for the river that extends to about RM 60. Here, the river would be connected to the existing channel alignment to prevent sediment deposition in the SWFL wetland complex west and south of RM 60. Facilities would also need to be provided to maintain flows in the SWFL wetland complex.

Future maintenance in the river channel would be the same as described in section 16.2.3.1. LFCC maintenance needs would be the same as in section 16.2.2.

16.2.3.3 Description of Realignment Operational Strategies

Current LFCC operations with irrigation return flows, arroyo inflows, and shallow groundwater drain waters, with flows split between the river and the wetland area could continue. Diversions of river flows into the LFCC through the head gates at San Acacia Diversion Dam, and operations of the gates would need to be such that the amount of river flows meets the 2003 Biological Opinion flow criteria below San Acacia Diversion Dam as well as the capacity of the new outfall. Future maintenance in the river channel would be the same as described in section 16.2.3.1. LFCC maintenance needs would be the same as in section 16.2.2.

16.3 Information and Analysis Needs

Several items of information and analysis are needed to properly evaluate potential outfall locations and operations of the LFCC and alternatives involving the realignment of the river and LFCC:

- Updating the hydrologic analysis at the San Marcial River and Low Flow Conveyance Channel Gages to determine how much inflow to Elephant Butte comes from the LFCC when it acts as an irrigation return canal and passive shallow groundwater drain.

- Obtaining the Surface and Groundwater modeling report by the NMISC documenting the results of the Water Salvage Estimates for various operational scenarios and their limitations. Conduct a current condition assessment of the arroyo crossing and diversion structures.

- Evaluating existing topography.

- Conducting hydraulic and sediment transport modeling to determine the most cost effective, environmentally-sound alternatives while maximizing benefits.

16.4 Conclusions

Maintaining and improving the future viability and success of the SWFL area to the west and south of RM 60 will be needed to meet ESA compliance for any Federal actions. In addition to SWFL wetland considerations, other environmental conditions will need to be address as described above. Continued access for maintenance of the Temporary Channel downstream of RM 60 will need to be a part of any outfall reconstruction or realignment activity. The amount of water salvage benefit depends upon the physical location of the LFCC and the operational scenario selected. It is recommended that the amount of water salvage for each proposed activity be carefully evaluated using the best available data and state of the art methods. The various strategies given above have a wide range of implementation costs that affect project feasibility.

Interagency support, and a decision by Reclamation to pursue activities, will be necessary to accomplish any changes to the LFCC outfall location, length, and operations. Department policy, regulations, and existing congressional authorizations will need to be reviewed as part of developing future plans.

The following are summary conclusions statements for conditions at the head waters of Elephant Butte Reservoir.

- This reach is in a continual dynamic state depending upon Elephant Butte Reservoir stage and the location of the delta sediment deposits.
- There will be long term sediment deposition in the reservoir delta.
- The channel is not self maintaining in the delta of Elephant Butte Reservoir, because the sediment load is to large for the hydrology and valley slope.
- Due to the current low Elephant Butte reservoir stage and the Temporary Channel, the LFCC outfall at RM 60 could be re-established.
- At RM 60 there has been enough river bed degradation for the LFCC to outfall into the river without pumping. This means that flows in the LFCC could remove significant amounts of the sediments deposited in the reach upstream of RM 60 if an outfall was reconstructed. Full rehabilitation may require some strategic sediment removal.
- Changing the operations of the LFCC from the current operations is difficult, and requires a lot of political will and additional funding beyond the current annual river maintenance appropriations.
- The LFCC could continue to act as a passive drain under the current operations scenario or the gates at San Acacia Diversion dam could be opened if ESA compliance could be obtained. Preservation and continued viability of the current wetlands occupied by SWFL would be necessary for any future operations affecting flows into the wetland. Operations at San Acacia Diversion dam would need to be in compliance with the March 2003 Biological Opinion criteria below San Acacia Diversion Dam.
- A policy decision is needed concerning 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.

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