RECLAMATION

Managing Water in the West

Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide Executive Summary

Middle Rio Grande Project, New Mexico
Upper Colorado Region

U.S. Department of the Interior
Bureau of Reclamation

April 2012

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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.

Photo: Jonathan AuBuchon, Rio Grande near Jemez River confluence, flow approximately 3,100 cubic feet per second, April 2010.

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Acronyms and Abbreviations

AAO	Albuquerque Area Office
Compact	Rio Grande Compact
ESA	Endangered Species Act
LFCC	Low Flow Conveyance Channel
MRGCD	Middle Rio Grande Conservancy District
NEPA	National Environmental Policy Act
NMISC	New Mexico Interstate Stream Commission
Project	Middle Rio Grande Project
Reclamation	Bureau of Reclamation
RGSM	Rio Grande silvery minnow
Plan and Guide	Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide
River Maintenance Program	The Middle Rio Grande River Maintenance Program
RM	river mile
Service	U.S. Fish and Wildlife Service
SWFL	southwestern willow flycatcher
USACE	U.S. Army Corps of Engineers

Key Definitions

Goals. Goals are outcome statements that describe desired conditions on the Middle Rio Grande.

Strategies: Strategies are the basic approaches to achieving the goals on a reach-wide basis, and methods are the means to implement those strategies. The variety of river management practices considered for implementation on the Middle Rio Grande is grouped into six basic strategies.

Reach Characteristics. Reach characteristics are overall assessments of the existing conditions of a reach to provide information used in prioritizing reaches and in rating the strategy effects by reach.

Evaluation Factors. Strategy implementation effects are rated by the attributes of the three evaluation factors of Ecosystem Function, Engineering Effectiveness and Economics for each suitable strategy in each reach.

Perched Conditions. These occur when the river channel is higher than adjoining riparian areas in the floodway or land outside the levee.

Incised Conditions. These occur when the river has cut down, lowering its bed and leaving the flood plain behind as a terrace.

Contents

Table and Figure

1. Introduction

Prior to significant manmade modifications, much of the Middle Rio Grande was unable to transport all the sediment entering the channel, causing the riverbed to aggrade and, on occasion, shift across the flood plain with high-flow events. This condition caused severe flooding, loss of water, damage to riverside facilities, and the loss of productive farmlands due to high water tables. This led to the Flood Control Acts of 1948 (Public Law 80-858) and 1950 (Public Law 81-516) that established the Middle Rio Grande Project (Project) and under which the Bureau of Reclamation (Reclamation) is authorized to perform maintenance of the Rio Grande channel and the Low Flow Conveyance Channel (LFCC). An international treaty with the Republic of Mexico for water delivery affects the Project, as does the 1939 Rio Grande Interstate Compact, which regulates Rio Grande water distribution among the States of Colorado, New Mexico, and Texas. Consequences of not performing essential maintenance include substantial damage to riverside facilities, loss of water, and impacts to endangered species and their habitat.

The Middle Rio Grande River Maintenance Program (River Maintenance Program) covers 260 miles of the Rio Grande from Velarde to Caballo Reservoir. Maintenance practices continue to evolve since the original Project major channelization works constructed in the 1950–70s. These early works included the LFCC (see section 4.2 of this summary for more information). After the 1970s, the first phase (project inception to mid-1980s) of maintenance involved maintaining channelized areas in their constructed alignment through pilot channeling, floodway clearing, jetty installation, and sediment removal. The second phase (mid-1980s to late 1990s) of maintenance involved localized strategic bank protection and excavation of temporary channels into Elephant Butte Reservoir. The river channel was no longer maintained as originally constructed and was allowed to migrate until infrastructure was threatened.

Reclamation's increased responsibility for environmental protection involving the Federal National Environmental Policy Act (NEPA) (1969), Clean Water Act (1972), and Endangered Species Act (ESA) (1973) and the listing of two endangered species in the early 1990s led to the third phase (late 1990s to present) of maintenance. This third phase of maintenance involves a holistic process-based, reach-wide approach that also incorporates habitat protection and enhancement. Along with these newer responsibilities for environmental protection, Reclamation's responsibilities for erosion protection, limited flood control, and water delivery continue unabated. Adaptive management has become a part of river maintenance, and this will continue in the future.

The combination of immediate project-specific and long-term strategic requirements necessitates the following components for the River Maintenance Program.

- Trend Monitoring through
  - Data Collection and Analysis
  - Geomorphic Analysis
  - Hydrologic, Hydraulic, and Sediment Transport Modeling and Analysis
- Initial Project Investigation and Assessment
- Alternative Development, Evaluation, and Selection
- Design and Project Description
- Environmental Compliance
- Construction and Maintenance
- Monitoring and Adaptive Management

2. River Maintenance Program Comprehensive Plan and Guide Purpose and Scope

The Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide (Plan and Guide) provides guidance for Reclamation's future river maintenance activities within existing Federal authorization. The Plan and Guide supports compliance with applicable laws and regulations, including NEPA and the ESA. The Plan and Guide is intended to help make informed decisions on future River Maintenance Program activities. The Plan and Guide are developed and documented in two separate reports. These two reports document a comprehensive guideline for the River Maintenance Program and its direction for future efforts. Future efforts under the guidelines will include feasibility assessments of reach-based strategies, developing project design and implementation considerations for strategies, and planning for future analyses, data collection, and updates.

The first report describes the River Maintenance Program and its needs and benefits and includes a review of the River Maintenance Program authorization, the current conditions of the river, and how environmental laws have been integrated into river maintenance activities. The second report incorporates current studies and their findings for guidance on future analyses, data collection needs, and maintenance practices. Potential new maintenance strategies with suitable methods identified are evaluated at an appraisal level.

The two combined parts of the Plan and Guide are an enhanced, contemporary review that helps achieve the best long-term goals and strategies for the Middle Rio Grande River Maintenance Program. They create a framework for evaluating

the Middle Rio Grande as a whole and by reaches. This comprehensive and new approach to addressing river system needs is evident throughout. The Plan and Guide's new methodology is most strongly reflected in the new goals, strategies, and the strategy assessments for each of the reaches. The Plan and Guide's newer framework includes identifying and rating significant reach characteristics and a systematic geomorphic, engineering effectiveness, ecosystem function, and economics analysis of potential maintenance strategies on a reach basis. It also is important to note that the strategies formulated and their assessments in this plan are supported by state-of-the-science/practice literature reviews, sediment transport and hydraulic modeling, and geomorphic modeling and assessment. Suites of corresponding applicable methods for meeting each strategy's intent are described. Use of water operations as a river maintenance strategy or method is not part of the scope of this report. However, it should be noted that the reductions in peaks, increased low-flow duration, and reduced sediment supply have disrupted the historical geomorphic pattern.

Strong consideration was given to the current and future geomorphic processes and trends occurring in the Middle Rio Grande for the current flow and sediment regimes. Future river maintenance strategy implementation is planned to be as compatible as possible with these geomorphic processes and trends as well as the ecosystem function needs identified in this Plan and Guide. This robust approach seeks to understand and treat the causes of channel instability rather than the trending symptoms as much as is practical. The best available tools related to predicting the future channel conditions and needs through sediment transport and hydraulic and geomorphic modeling and assessments are used in this Plan and Guide. Analyses with these tools are at appropriate levels given the scope and scale of the Plan and Guide.

3. Roles and Activities of Reclamation and Other Agencies

3.1 Middle Rio Grande Project

The major features of the Middle Rio Grande Project are large dams to provide flood control and reduce the sediment load in the Rio Grande; Rio Grande rectification (channel improvement) and maintenance to reduce aggradation, improve water delivery, and protect valley infrastructure; rehabilitation of the irrigation and drainage system; levee construction or rehabilitation or both; and establishment and maintenance of a floodway and conveyance channel into Elephant Butte Reservoir. Project components are assigned to Reclamation, United States Army Corps of Engineers (USACE), and Middle Rio Grande Conservancy District (MRGCD) as follows:

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

3.2 Interagency Coordination

The River Maintenance Program at both the programmatic and individual project levels coordinates with stakeholders on the variety of technical issues that can affect River Maintenance Program activities. The degree and type of coordination varies depending on the nature of the river maintenance project, the extent of river affected, land ownership, permitting needs, and environmental compliance issues. Coordination efforts are dynamic and ongoing, and vary by project and stakeholder. The involvement in coordination efforts also varies with Reclamation's priorities as an agency. Reclamation's authorized river maintenance activities within the Project area require that Reclamation coordinate with agencies, programs, and entities identified as stakeholders. Major examples are listed below:

- **Other Reclamation Programs**
  Reclamation has several programs and functions that can affect River Maintenance decisions. These include the Middle Rio Grande Endangered Species Act Collaborative Program, Native American Water Rights Settlements, Title XIV, other facilities operation and maintenance, and water operations.

- **USACE Programs**
  USACE 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 and issues regulatory permits under Section 404 of the Clean Water Act.

- **MRGCD Programs**
  MRGCD was created for such purposes as irrigation and agricultural development, flood control, stream regulation, drainage, and construction and maintenance of distribution facilities for irrigation waters.

- **New Mexico Interstate Stream Commission (NMISC)**
  The NMISC has broad powers to investigate, protect, conserve, and develop New Mexico's waters including both interstate and intrastate stream systems.

- **United States Fish and Wildlife Service (Service)**
  The Service's mission is: working with others, to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

- **Pueblos and Tribes**
  The river has special cultural and religious significance that should be considered when undertaking river management activities. The pueblos hold priority water rights, and Reclamation cannot collect data or perform river maintenance work on pueblo lands without obtaining permission.

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

4. River Conditions

Much of the 270-mile-long Middle Rio Grande river channel (Velarde to Caballo) is no longer flooding and aggrading, but the channel is evolving at a rapid rate with incision and narrowing. Figure 1 shows the 11 separate reaches that have been defined to facilitate selection of maintenance strategies and methods. Reach definition is based on differences in hydrology, river planform, slope, sediment size, channel capacity, biological needs, institutional needs, and other factors. Many reaches are at different stages of evolution, and each has distinct factors affecting the current geomorphology. At this time, maintenance activities are not performed in White Rock Canyon reach and the Elephant Butte Reservoir reach because these areas do not have current Reclamation jurisdiction and needs.

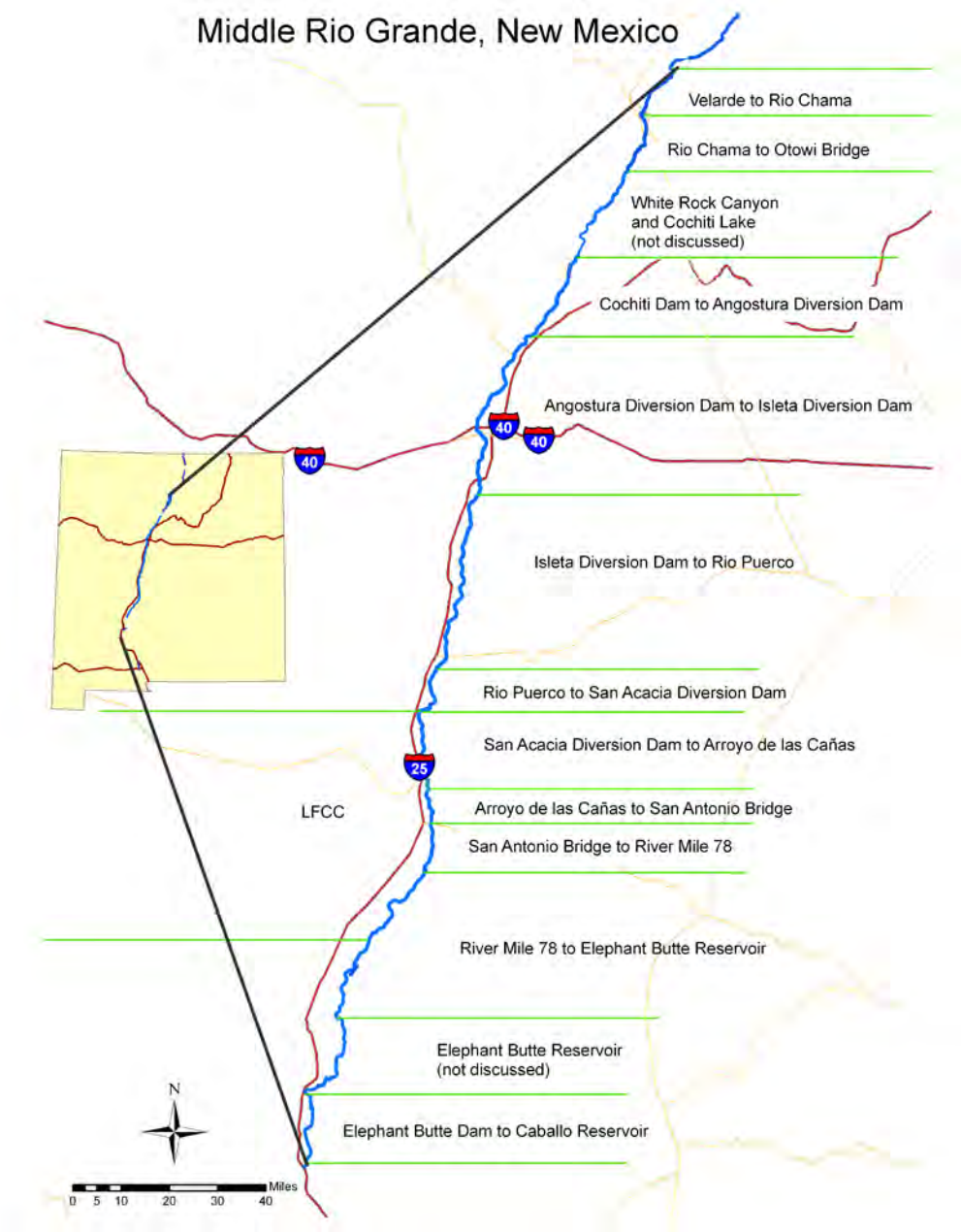

Figure 1. Reach locations. Reaches not discussed are White Rock Canyon and Cochiti Lake and Elephant Butte Reservoir.

4.1 River Geomorphology

In recent times (late 1990s to current), the Rio Grande watershed has been in a regional drought. This major reduction in water supply and peak flows caused the river to narrow, mostly through the colonization of active bars and banklines with

vegetation. In 2005, the spring snowmelt runoff was above normal but found a river with stable bars and banklines. The Rio Grande has responded to this in a variety of ways; in those sections that had extensive island growth and stabilization during the drought, the river has narrowed, deepened, and abandoned all but a single, dominant channel. This narrowing may indicate a future increase in river maintenance sites because the number of meander bends per river mile generally increases with decreasing channel width and, thereby, increases the number of potential maintenance sites.

In areas where a single channel already existed and bank-attached bars had stabilized with vegetation, the channel has begun to migrate, especially where incision is deep enough to allow flow beneath the bankline root zone. Lateral migration and incision occurred with the July–October 2006 monsoon rains; usually this occurs with the spring runoffs. These changes in the channel morphology and physical processes demonstrate the speed at which change can occur 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 study reach, thereby changing the governing processes for sediment transport and contributing to bank erosion and meander development.

The reach from San Antonio downstream has been very active in recent years. In the lower portion of the reach, there has been degradation due to the low pool elevation of Elephant Butte Reservoir with some temporary local degradation downstream of plug areas due to the sediment supply being stored in the plug area. The degradation has increased the channel capacity under the San Marcial railroad bridge crossing. Also, riparian habitat and endangered species are effected by degradation with a lowered local water table and loss of flood plain connectivity. Plugs have formed in several locations resulting in flooding, increased risk to infrastructure, and possible losses in water delivery; with terrestrial endangered species nesting at one plug location and nearby upstream areas. This complex and changing river system presents many maintenance challenges.

4.2 Low Flow Conveyance Channel

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

Elephant Butte Reservoir storage increased in the early to mid-1980s, inundating and burying the last 15 miles of the LFCC with sediment. The LFCC currently provides valley drainage benefits, water for pumping to benefit the Rio Grande silvery minnow (RGSM), and supplemental irrigation water supplies to the Bosque del Apache National Wildlife Refuge and irrigators of the MRGCD. Various LFCC rehabilitation or relocation strategies that potentially would increase water deliveries to Elephant Butte Reservoir are presented in the first report.

5. Plan and Guide Steps

The Plan and Guide is a comprehensive re-evaluation of the River Maintenance Program as a whole and defines a new framework to assess the channel and flood plain on a reach basis through a series of steps. It does not select a strategy for implementation, nor does it identify specific locations or methods for future maintenance work. It uses existing data and new analysis results to rate strategies by Engineering Effectiveness, Ecosystem Function, and Economics Evaluation Factors. The Plan and Guide does not consider water operations as a maintenance strategy because this is outside the scope of the River Maintenance Program authorization. The most consistent level of data and analysis available across the major divisions of the entire study reach is used and, thus, may not use the most detailed information in a reach. Once policy decisions are made on the reach priorities and the recommended strategies, the future processes of feasibility analysis, strategy selection, and design for implementation can take place with more detailed information.

5.1 Maintenance Goals

Step 1: Assess and redefine River Maintenance Goals to reflect the evolution of practices of river engineering and management and the changing river conditions within the context of the Middle Rio Grande Project authorization. The updated goals are:

- Support Channel Sustainability
- Protect Riverside Infrastructure and Resources
- Be Ecosystem Compatible
- Provide Effective Water Delivery

5.2 Maintenance Strategies and Methods

Step 2: The first component of this step examined the available information to define a set of geomorphic trends of importance to river maintenance and analyzed the reaches based on the observed trends. These trends are:

- Channel narrowing
- Vegetation encroachment
- Incision or channel bed degradation
- Increased bank height
- Bank erosion
- Coarsening of bed material
- Aggradation
- Channel plugging with sediment
- Perched channel conditions

The fundamental cause of channel and flood plain adjustments that generate these trends is an imbalance between sediment transport capacity and sediment supply. Changes in this balance are driven by changes in flow and sediment supply magnitude, duration, and frequency. System controls that influence the effects of the drivers include bank and bed stability, downstream base level, flood plain lateral confinement, and flood plain connectivity. For each reach trend, the interrelationship with sediment transport capacity and sediment supply are explained. The underlying river system drivers and controls are identified to complete this Step's first component.

Step 2's second component formulated holistic reach scale strategies to address these trends. These strategies are:

- *Promote Elevation Stability* – Reduce or prevent channel incision and degradation to maintain bed elevation and connectivity. This strategy also could minimize aggradation where appropriate but would be implemented through complementary strategies (see section 3.3.1 of the main report).

- *Promote Alignment Stability* – Allow the river channel to adjust horizontally while monitoring bank line movement. When the safety or integrity of riverside facilities and structures is likely to be compromised within the next few years, then bank protection measures are provided to protect infrastructure.

- *Reconstruct and Maintain Channel Capacity* – Address reductions in channel capacity. Capacity can be reduced through processes such as aggradation, island and bar deposition/colonization, formation of channel

plugs, large sediment deposits at the mouths of ephemeral tributaries, and natural channel relocation (avulsions).

- *Increase Available Area to the River* – Increase the available area for the river to establish a wider channel, migrate laterally, and/or develop new flood plains. This reduces the potential that riverside infrastructure is endangered from river bank erosion.

- *Rehabilitate Channel and Flood Plain* – Reconnect abandoned flood plains to allow for overbanking flow and/or creation of new flood plains. This could stabilize the channel by reducing sediment transport capacity to be nearer the sediment supply, reducing main channel velocity and creating areas of slower velocity at high flows.

- *Manage Sediment* – Aid in balancing sediment transport capacity with available sediment supply within a reach. A likely consequence of adding sediment to upstream reaches is increased deposition in downstream reaches. Likewise, the effect of reducing sediment supply may be downstream channel degradation or incision.

These reach-based strategies are intended to help to integrate more completely the physical processes occurring on the Middle Rio Grande with river maintenance. Each strategy has different methods for its implementation, geomorphic responses, and effects upon the balance between sediment supply and transport capacity and river maintenance goals. Each reach generally has multiple constraints and importance involving water delivery, protection of riverside infrastructure, local variations in geology, and endangered species habitat.

An extensive literature review of methods (including state-of-the-art practices) that can be used to implement strategies is found in appendix A. Appendix A includes descriptions of the general range of application; method objectives and benefits, features, common modes and failures, common countermeasures if needed, advantages and disadvantages, geomorphic response, ecological benefits and effects, requirements, level of reliability, potential issues during construction, design criteria, peak flow criteria, durability, and project life.

In this report, the terms “maintenance” or “river maintenance” is synonymous with river restoration/rehabilitation, bank protection/stabilization, and other methods. The applicable methods for the Middle Rio Grande are organized below into generalized groupings of methods or categories with similar features and objectives:

- Infrastructure relocation or setback
- Channel modification
- Bank protection/stabilization
- Cross channel (river spanning) features

- Conservation easements
- Change sediment supply
- Habitat improvements and mitigation

Each of these categories contains multiple methods, and combining methods can provide a means to meet multiple objectives for a strategy. Methods are the means to implement a strategy or strategies. Each strategy contains many potential methods, and strategies and methods must satisfy the Middle Rio Grande Project authorization and environmental requirements.

5.3 Strategy Assessment

This section summarizes the approach used to describe the reaches and analyzes the strategies as documented in appendices B and C and as is described in steps 3–7. Two listed federally endangered species are used to assess the habitat value and need and ecosystem function: Southwestern willow flycatcher (SWFL) and RGSM. Both of these species have evolved in the Rio Grande system and require a properly functioning river and flood plain to thrive. The riparian obligate species (SWFL) and lotic species (RGSM) are assumed to represent the needs of other species that occupy the river system at this appraisal level of analysis.

Step 3: Modeled, analyzed, and developed the expected future condition of each reach. Indicators are defined to assess changes in reach conditions due to strategy implementation. Where data were available, several types of analyses are performed, as documented in appendix B. Sediment modeling to determine long-term reach equilibrium conditions for channel slope adjustment (i.e., vertical or lateral) plus hydraulic modeling and meander belt analysis generated the indicator results that are used in the reach strategy evaluation.

Step 4: Defined reach characteristics that are critical to Reclamation's Middle Rio Grande Project mission. Reach characteristics describe existing conditions and the significance of a reach. This information determines the suitability of a strategy to address reach trends within Reclamation's authorized mission. Reach characteristics defined are:

- Channel Instability (rated in terms of instability, see section 4.4.1 of the main report)
- Water Delivery Impact (rated in terms of importance, see section 4.4.2 of the main report)
- Infrastructure, Public Health, and Safety (rated in terms of importance, see section 4.4.3 of the main report)

- Habitat Value and Need (rated in terms of importance, see section 4.4.4 of the main report)

Each reach characteristic above involves information and attributes/values that are used to develop a rating of high, medium, or low. The ratings are comparative between each of the reaches. Thus, a rating of "low" indicates that a reach characteristic may be less of a consideration when addressing maintenance needs in that reach as compared to other reaches.

Step 5: Estimated the geomorphic effects of strategy implementation. These geomorphic effects are based on indicator modeling results, implementation method category effects, historical trends and geomorphic outcomes, and professional (scientific and engineering) judgment. The effects are discussed as reach-wide changes from baseline (existing) conditions.

Step 6: Developed and scored evaluation factors for the suitable strategies. The three evaluation factors used in this analysis are:

- Engineering Effectiveness Evaluation Factor (see section 4.7.1 of the main report)

- Ecosystem Function Evaluation Factor (see section 4.7.2 of the main report)

- Economics Evaluation Factor (in terms of implementation costs only) (see section 4.7.3 of the main report)

Attributes for the evaluation factors above were defined to focus the assessment on the principal components of each. These attributes are rated using indicator modeling results, historical trends, geomorphic outcomes, and professional (scientific and engineering) judgment. The rated attributes are then combined into a scoring table for each evaluation factor. The Engineering Effectiveness Evaluation Factor has two subevaluation factors: Strategy Performance and River Maintenance Function. Strategy Performance helps describe the qualities of a strategy that determine implementability and how well a strategy will work. River Maintenance Function helps describe the degree a strategy meets the River Maintenance Program purposes with respect to water delivery, hydraulic capacity, and public health and safety. The Ecosystem Function Evaluation Factor has two subevaluation factors grouped by the two representative species: SWFL for riparian and RGSM for aquatic considerations. The scoring results from the Engineering Effectiveness and Ecosystem Function evaluation factors for each strategy in each reach are termed "effectiveness scores."

The Economics Evaluation Factor involved cost criteria derived from a multiday workshop to develop appraisal level unit costs per river mile to estimate strategy implementation costs. Other attributes of the Economics Evaluation Factor depend on experiential professional judgment for their ratings. The effectiveness scores for Engineering Effectiveness and Ecosystem Function evaluation factors

were divided by the Economics Evaluation Factor (cost score) to provide information on which strategies should be more economical, provide better maintenance performance and function, reduce negative environmental effects, and/or have increased environmental benefits, resulting in greater overall effectiveness than current practices.

Step 7: Used the strategy assessment results and reach characteristics to recommend strategies for further study, which will help guide future maintenance decisions. These decisions include selecting the sequence for future reach feasibility analyses and the potential application of reach-wide strategies.

6. Recommendations

The Middle Rio Grande Comprehensive Maintenance Plan and Guide has created a new framework for considering the Middle Rio Grande as a whole at the appraisal level; and, in the process, several new assessment tools were developed. It provides a systematic geomorphic, engineering, ecosystem function, and economic analysis of all the Middle Rio Grande reaches with their corresponding characteristics. Table 1 summarizes the recommendations for each strategy by reach (see section 4.8 in the main report for more information).

External stakeholder and resource management agency understanding of this Plan and Guide is a key ingredient for long term success. Developing an effective communication plan and conducting workshops to present the Plan and Guide and to receive and discuss comments will aid in developing stakeholder understanding. As much as is practical, comments and feedback from stakeholders should be incorporated into future strategy analysis and maintenance planning.

Since the Plan and Guide is a living document and part of the path towards more effective river management, the following recommendations have been made in regard to the use of the Plan and Guide:

- **Information Needs** (see section 16.2.2 in the main report for more information): It is recommended that plans for data collection and analysis to fill in the gaps identified be formulated and implemented. Information needs are both project-based and system-wide and may overlap. Periodically updating the Middle Rio Grande Maintenance and Restoration Methods Appendix will help ensure that the Albuquerque Area Office (AAO) is using state-of-the-art methods.

- **Reach Prioritization** (see section 16.2.3 in the main report for more information): In addition to other constraints and priorities, it is recommended that AAO decisionmakers and stakeholders should, in defining the priority of the reach-based assessments, consider channel instability, water delivery impact, infrastructure public health and safety,

Table 1. Strategy Recommendations

Reach	Promote Elevation Stability Strategy Results	Promote Alignment Stability Strategy Results	Reconstruct/ Maintain Channel Capacity Strategy Results	Increase Available Area to the River Strategy Results	Rehabilitate Channel and Flood Plain Strategy Results	Manage Sediment Strategy Results
Velarde to Rio Chama	Not suitable	Further study	Not suitable	Further study	No further study	Not suitable
Rio Chama to Otowi Bridge	No further study	Further study	Not suitable	Further study	No further study	Not suitable
Cochiti Dam to Angostura Diversion Dam	Further study	Further study	Not suitable	Further study	No further study	Not suitable
Angostura Diversion Dam to Isleta Diversion Dam	Further study	Further study	Not suitable	Not suitable	Further study	Further study
Isleta Diversion Dam to Rio Puerco	Further study	Not suitable	No further study	Further study	Further study	Further study
Rio Puerco to San Acacia Diversion Dam	Not suitable[1]	Further study	Not suitable	Further study	Further study	Not suitable
San Acacia Diversion Dam to Arroyo de las Cañas	Further study	Further study	Not suitable	Further study	Further study	No further study
Arroyo de las Cañas to San Antonio Bridge	Not suitable[1]	Not suitable	Further study	Not suitable	Not suitable	Further study
San Antonio Bridge to River Mile 78	Not suitable[1]	Not suitable	Further study	Further study	Not suitable	Further study
River Mile 78 to Elephant Butte Reservoir	Not suitable[1]	Not suitable	Further study	Further study	Not suitable	Further study
Elephant Butte Dam to Caballo Reservoir	Not suitable[1]	Further study	Further study	Not suitable	Not suitable	No further study

[1] These reaches are expected to aggrade in the future and complementary strategies are used to promote elevation stability under aggrading conditions.

and habitat value and need, along with the effectiveness cost assessment. These reach considerations should also factor into long term decision making guided by this Plan and Guide. These key program elements were developed as part of the Plan and Guide to strike a balance among updated river maintenance goals.

- **Reach Strategy Feasibility Assessment** (see section 16.2.4 in the main report for more information): Reach-based strategy feasibility, preliminary design, and evaluation are recommended to select preferred strategies. Strategies also will need further evaluation to determine the levels of compliance under the environmental and lands approval processes if implemented. The strategy rating system developed in this report might be used in its current form or altered as part of reach strategy feasibility assessment. It is recommended that AAO decisionmakers use the findings in this report to determine which strategies should be advanced in the reach strategy feasibility evaluation. It is envisioned that after reach strategy feasibility is completed, planning, implementation, and adaptive management can occur.

- **System-wide Assessments** (see section 16.2.6 in the main report for more information): Given the dynamic nature of the Middle Rio Grande, changes to morphology and ecology occur over time. Significant changes in flow and sediment loads and/or anthropogenic constraints, other large-scale project implementations, and habitat and species conditions could trigger a re-evaluation of the system approach presented herein. Monitoring of the trends listed in section 5.2 is essential to identifying changes in the system early. It is recommended that any updates should evaluate channel instability, water delivery impact, infrastructure health and safety, and habitat value and need. Updates also may be needed to account for changes to the status of endangered species that redefine critical habitat or to add new endangered species.

These recommendations are not necessarily sequential, and more work is needed to align and integrate current program activities and the eventual long-term implementation considerations of this Plan and Guide. Over time, future reach and strategy feasibility assessments will increase the long-term effectiveness of the Middle Rio Grande River Maintenance Program and help to select more sustainable maintenance strategies for each reach.