RECLAMATION

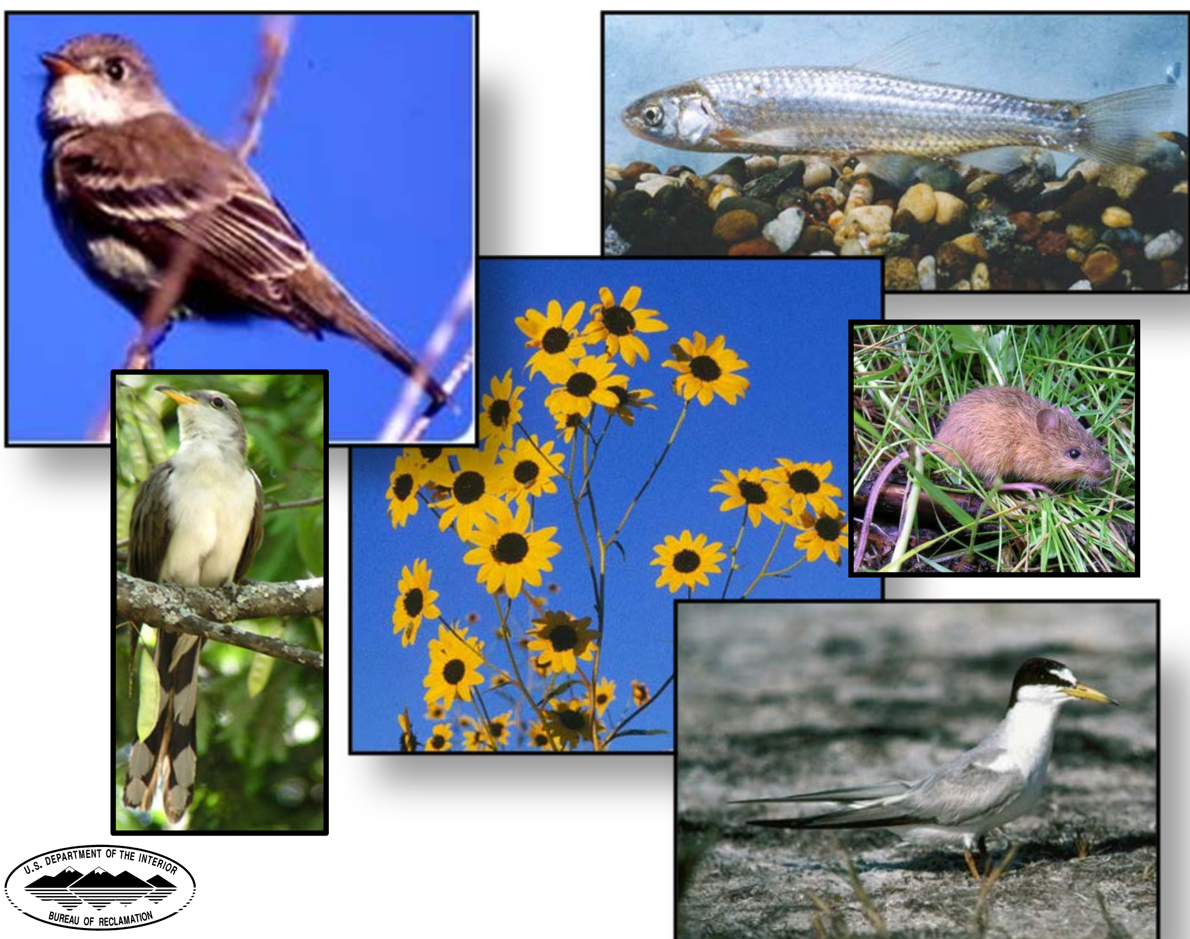
Managing Water in the West

Joint Biological Assessment

Bureau of Reclamation, Bureau of Indian Affairs, and Non-Federal Water Management and Maintenance Activities on the Middle Rio Grande, New Mexico

Appendices

Middle Rio Grande Project, New Mexico
San Juan-Chama Project, New Mexico
Upper Colorado Region



U.S. Department of the Interior
Bureau of Reclamation

August 2015

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.

The Bureau of Indian Affairs' mission is to enhance the quality of life, to promote economic opportunity, and to carry out the responsibility to protect and improve the trust assets of American Indians, Indian tribes and Alaska Natives.

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Middle Rio Grande Project, New Mexico
San Juan-Chama Project, New Mexico
Upper Colorado Region

Submitted to the U.S. Fish and Wildlife Service

Rio Grande Silvery Minnow	**Southwestern Willow Flycatcher**
Yellow-billed Cuckoo	**New Mexico Meadow Jumping Mouse**
Pecos Sunflower	**Interior Least Tern**

U.S. Department of the Interior
Bureau of Reclamation

August 2015

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APPENDIX A

RIVER MAINTENANCE PROGRAM –
DELTA CHANNEL MAINTENANCE PROJECT
BIOLOGICAL ASSESSMENT

RECLAMATION
Managing Water in the West

River Maintenance Program -- Delta Channel Maintenance Project Biological Assessment

U.S. Department of the Interior
Bureau of Reclamation
Albuquerque Area Office

July 2015

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.

Front Cover Photo Caption – Photo showing San Marcial Delta Water Conveyance Channel, looking downstream (south) from about River Mile 39 (J. Bachus photo, C. Donnelly caption, 2013).

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1.0 Background Information on the Existing Delta Channel

The Bureau of Reclamation (Reclamation) has authorization for river channel maintenance of the Rio Grande from Velarde, New Mexico, south to the headwaters of Caballo Reservoir, as specified by the Flood Control Acts of 1948 and 1950. Under this authority, Reclamation monitors priority sites along the river, which are locations where channel conditions could damage infrastructure, or impair or interrupt water delivery.

One such priority site is the existing San Marcial Delta Water Conveyance Channel (Delta Channel, formerly known as the Temporary Channel), located within the boundaries of the Elephant Butte Reservoir between about 2002 River Mile (RM) 57.8 and the current reservoir pool. Although the 2012 RM locations have been established, the RM designations used in this document are those developed from the 2002 controlled aerial photography within the boundaries of the MRG Project to maintain consistency with previous consultations, the latest being December 22, 2014, Cons. #02ENNM00-2015-F-0103. River Mile locations are approximate and are not an exact measurement of channel distance.

Reclamation and the New Mexico Interstate Stream Commission (NMISC) have entered into a cooperative agreement for water salvage on the Rio Grande. In this agreement, Reclamation has committed to maintenance of the existing Delta Channel to facilitate delivery of water and sediment so that the NMISC can meet its water delivery obligations under the Rio Grande Compact.

This biological assessment (BA) analyzes the effects of proposed maintenance of the Delta Channel on the following listed species in the action area: the Rio Grande silvery minnow (*Hybognathus amarus*; minnow), the Southwestern willow flycatcher (*Empidonax traillii extimus*; flycatcher), the yellow-billed cuckoo (*Coccyzus americanus*; cuckoo), and the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*; mouse).

Disconnection between the Rio Grande and the active reservoir pool has been a persistent problem since the early 1950s that leads to high water loss and impacts New Mexico's Rio Grande Compact (Compact) deliveries. With channelization work during the 1950s and 1960s and subsequent maintenance in the 1970s and 1980s, followed by a period of increasing reservoir pool elevation, the river was able to maintain a connection. However, dry years in 1989 and 1990 required construction of a pilot channel in the early 1990s to maintain a connection between the river and the reservoir pool. The term "temporary channel" was used, as the pilot channels are not permanent features and serve a purpose only until the reservoir level rises. In 1998, the river once again became disconnected from the reservoir pool and design/work began on a project for a new water conveyance channel, known as the 2000 Temporary Channel. Conditions in 1998 are shown in Figure 1.

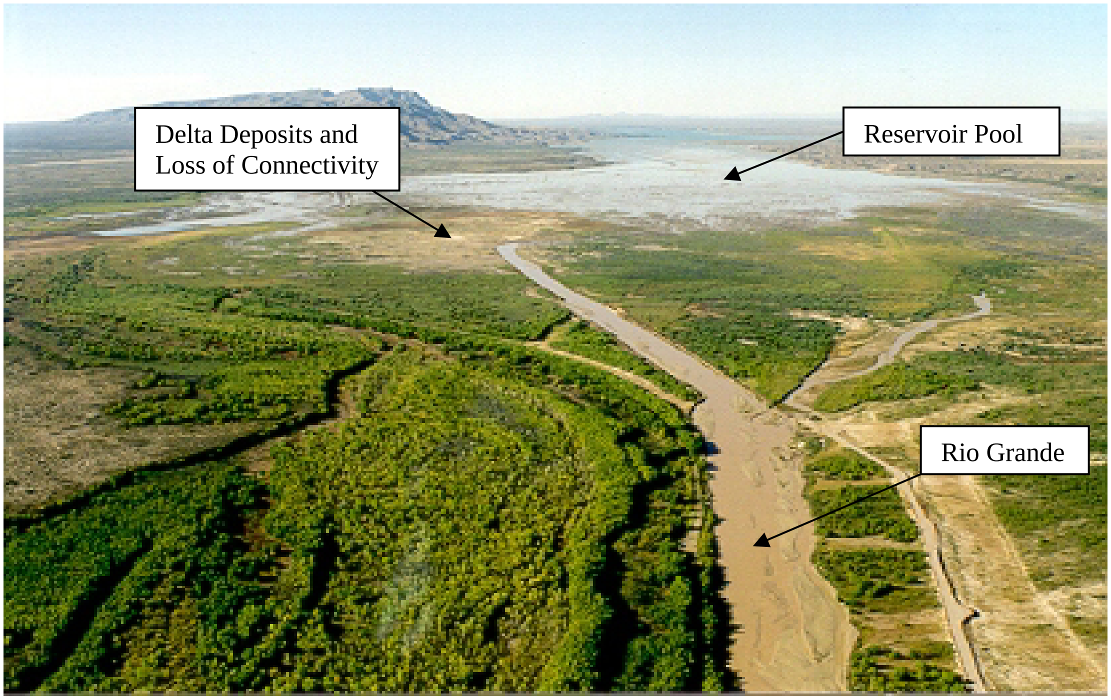


Figure 1. Photograph showing the Rio Grande's inability to maintain a channel through the sediment delta (1998)

As the reservoir has continued to recede, construction of additional Delta Channel reaches became necessary to maintain a connection between the river and reservoir pool. Table 1 defines the reaches of the Delta Channel and summarizes the original channel construction. The action area includes these reaches and extends to the active reservoir pool. The existing access road between the Delta Channel and RM 62 is also included in the action area, for maintenance purposes (as are other access roads, discussed in Section 2.1, Site Access and Staging Areas). The lateral extent of the action area is the width of the active floodplain, as bounded by levees or natural geologic formations and the access roads. While the Delta Channel starts at RM 57.8, the action area extends to RM 62 to include the maintenance of an access road in that area. The length shown for each reach is the constructed channel length, which differs slightly from the RM lengths. Figure 2 provides a graphical depiction of the reaches.

Table 1. Summary of Delta Channel Reaches

Project Reach	**Construction**	**Length**	**Start**	**End**
Upper	2000 to 2004	7.0 miles	RM 57.8	RM 51.2 Nogal Canyon
Middle	2003 to 2004	11.1 Miles	RM 51.2 Nogal Canyon	RM 40.7 d/s of Narrows
Lower	Started 2005	2.7 miles to date	RM 40.7 d/s of Narrows	Reservoir pool
d/s = downstream				

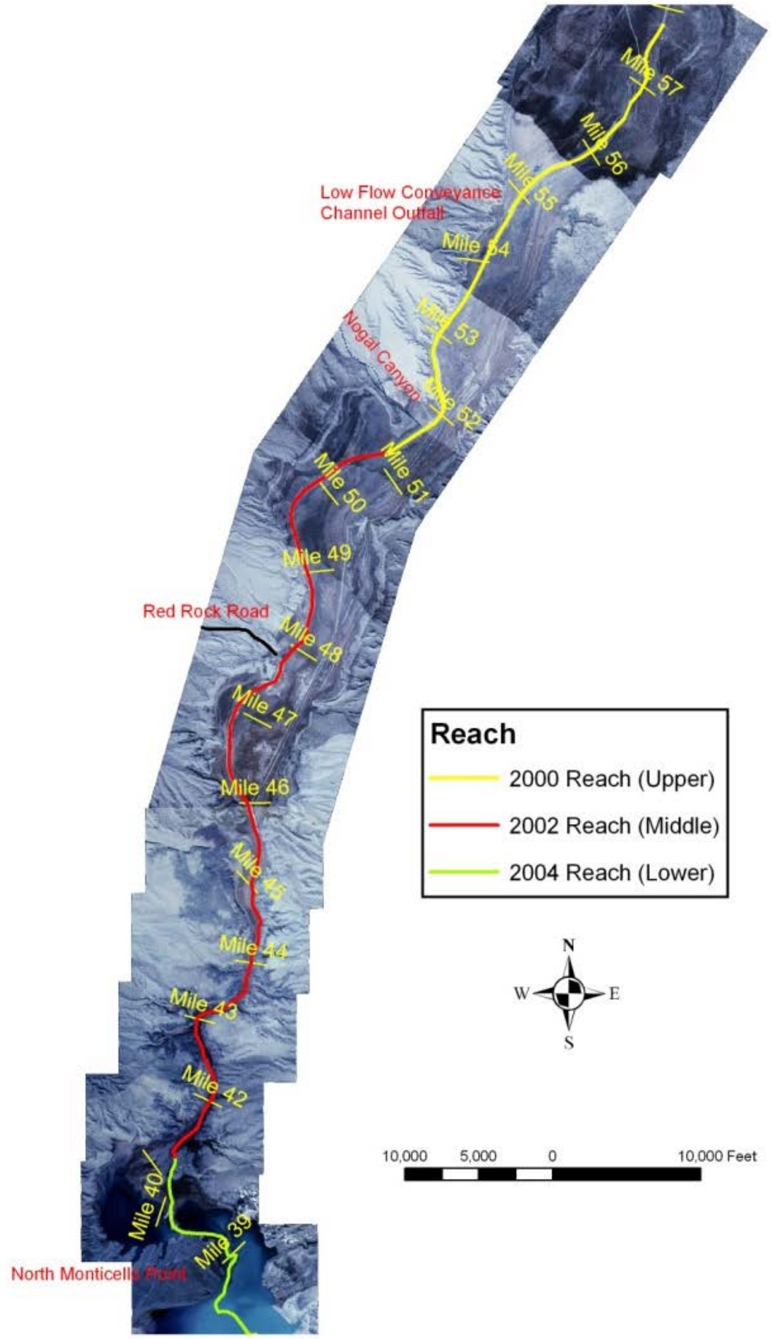


Figure 2. Delta Channel Reaches

The efforts to maintain the Delta Channel through the headwaters of the reservoir have provided significant water delivery benefits. Dry conditions since 1996, especially during 2002, 2003, 2011, 2012, and 2013 led to annual flow volumes that were significantly less than the long-term average. During periods of 2012, river flows recorded at the San Marcial USGS gage were at or below 10 cubic feet per second (cfs). Even during these low flow periods (2011-2013), water was being delivered to Elephant Butte Reservoir due to the Delta Channel. It is highly unlikely that these flows would have made it to the active reservoir pool without the continued maintenance of the Delta Channel.

1.1 Upper Reach (River Mile 57.8 to 51.2)

Since the construction of the Upper Reach, the Delta Channel has changed over time. Figure 3 and Figure 4 show two existing cross-sections surveyed in 2010 within the Upper Reach that are good representations of the existing conditions within the reach. Additional cross-sections showing variability over time can be seen in Reclamation's Geomorphic Assessment of the Rio Grande Upstream of Elephant Butte Reservoir (Holste 2013).

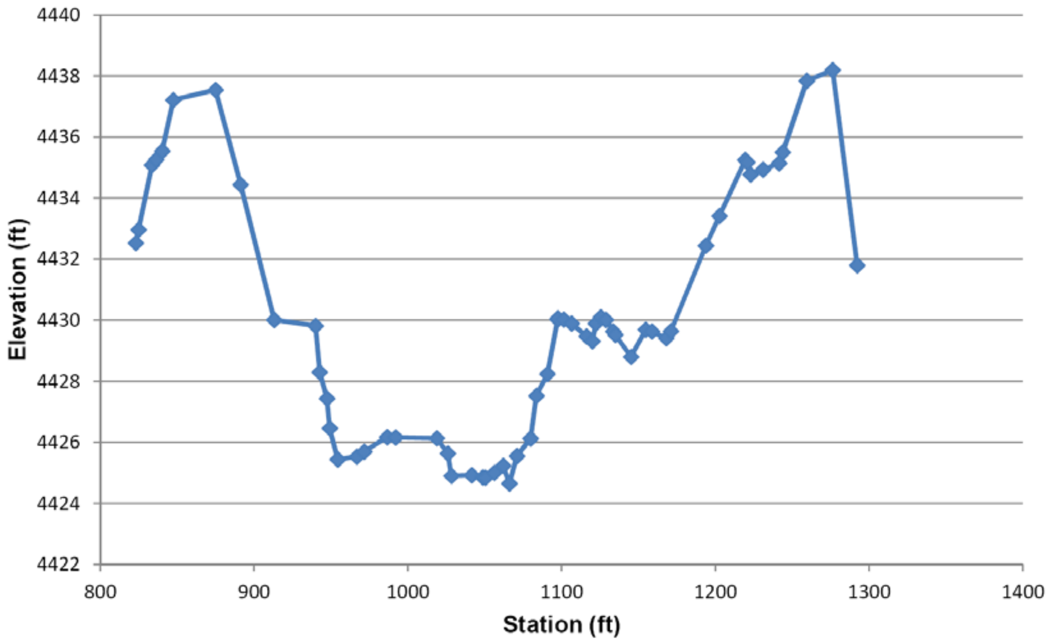


Figure 3. EB 30.6 (approx. RM 56) Cross Section (2010)

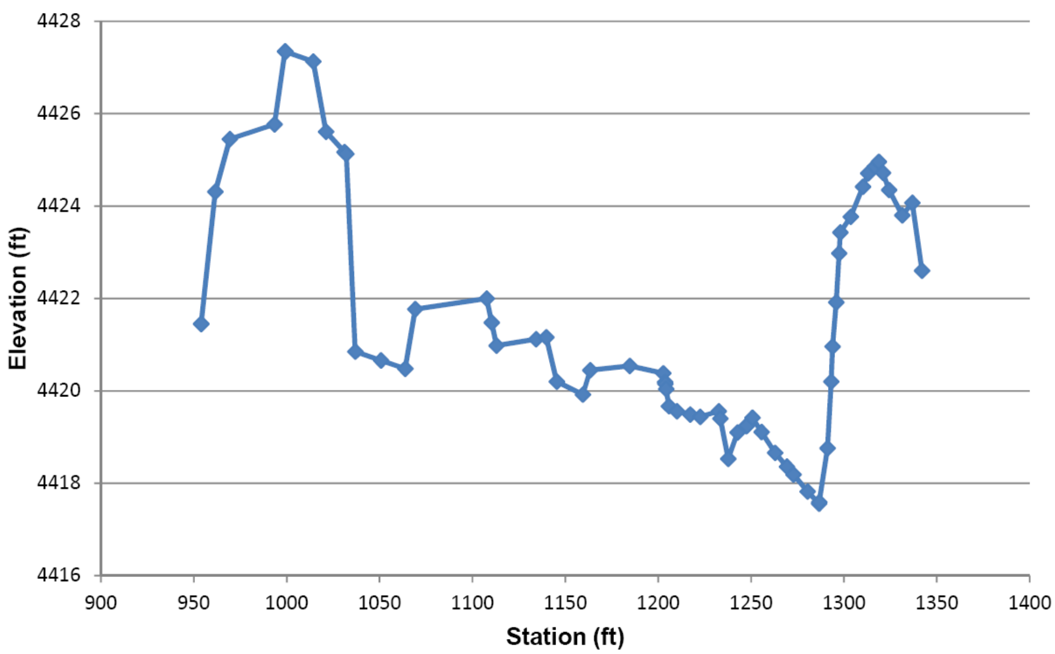


Figure 4. EB 34.8 (approx. RM 53.5) Cross Section (2010)

The cross-sections show the variability of the channel section through the Upper Reach. The existing maximum construction footprint (measured from outside toes of the berm slopes) within the Upper Reach is 590 feet and the existing minimum is 210 feet, both measured from the outside toes of the berm slopes. The channel bed through the Upper Reach has developed from a uniform section to a more natural channel bed. The development of a natural channel bed allows hydraulic properties such as width, depth, and velocity to vary throughout the reach at different flow regimes. Sinuosity of the existing Delta Channel in this reach was 1.07 in 2006; channel maintenance has intentionally sustained that sinuosity (1.08 in 2011, computed in the conventional manner of channel length divided by valley length using 2011 NAIP New Mexico aerial photography).

Hydraulic modeling of the Upper Reach was done using GPS cross section data collected during 2010. Cross sections were analyzed to determine the hydraulic capacity of each cross section. Results from the hydraulic model revealed that some cross sections within the Upper Reach had a hydraulic capacity greater than 5,000 cfs; however, given the geotechnical soil stability of the material present, it is highly unlikely that channel berms would withstand flows in excess of 5,000 cfs. Table 2 shows capacity analysis results for the existing Delta Channel within the Upper Reach.

Table 2. Existing Upper Reach Channel Capacity (2010)

Minimum	**Maximum**	**Reach Weighted Average**
3,300 cfs	5,000 cfs	4,502 cfs

1.2 Middle Reach (RM 51.2 to 40.7)

The overall footprint within the Middle Reach remains relatively the same; however, the channel bed has changed over time from a constructed uniform section to a varying geometry (low flow sinuous inner channel with alternate bars). Figure 5 and Figure 6 show two existing cross-sections surveyed in 2010 within the Middle Reach that are good representations of the existing channel conditions within the reach. Additional cross-sections showing variability over time can be seen in Holste (2013). In the Narrows (defined as the narrow section within the Delta Channel that extends from RM 46 to RM 42), the river has eroded much of the berm material away and substantially widened the originally constructed Delta Channel. In this reach the berm has not been reconstructed, as discharge is confined by the natural narrow valley and the berm is not needed to provide the desired conveyance capacity.

The existing maximum construction footprint within the Middle Reach is 407 feet, while the minimum construction footprint is 232 feet. The channel bed through the Middle Reach has developed from a uniform section to a more natural channel bed. The development of a natural channel bed allows hydraulic properties such was width, depth, and velocity to vary throughout the reach at different flow regimes. Sinuosity of the constructed Delta Channel in this reach is 1.08, computed in the conventional manner of channel length divided by valley length using 2011 NAIP New Mexico aerial photography. However, valley conditions in this reach are somewhat unique, and for comparison, the sinuosity was also computed based on channel length divided by the straight line distance from start to end of the reach. That sinuosity is 1.17.

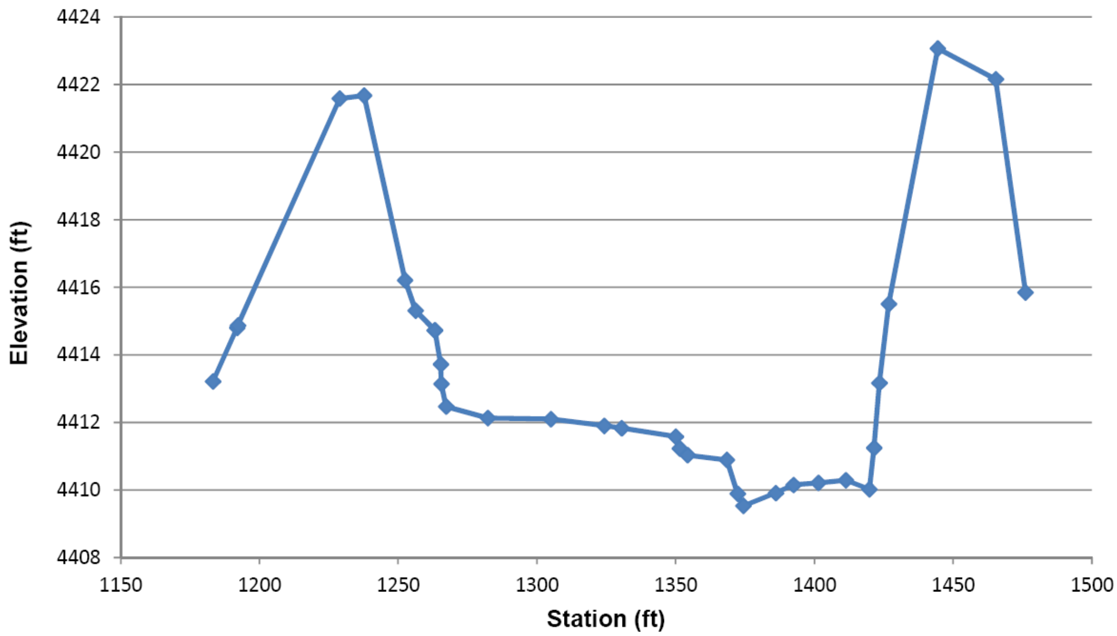


Figure 5. EB 39.3 (approx. RM 50) Cross Section (2010)

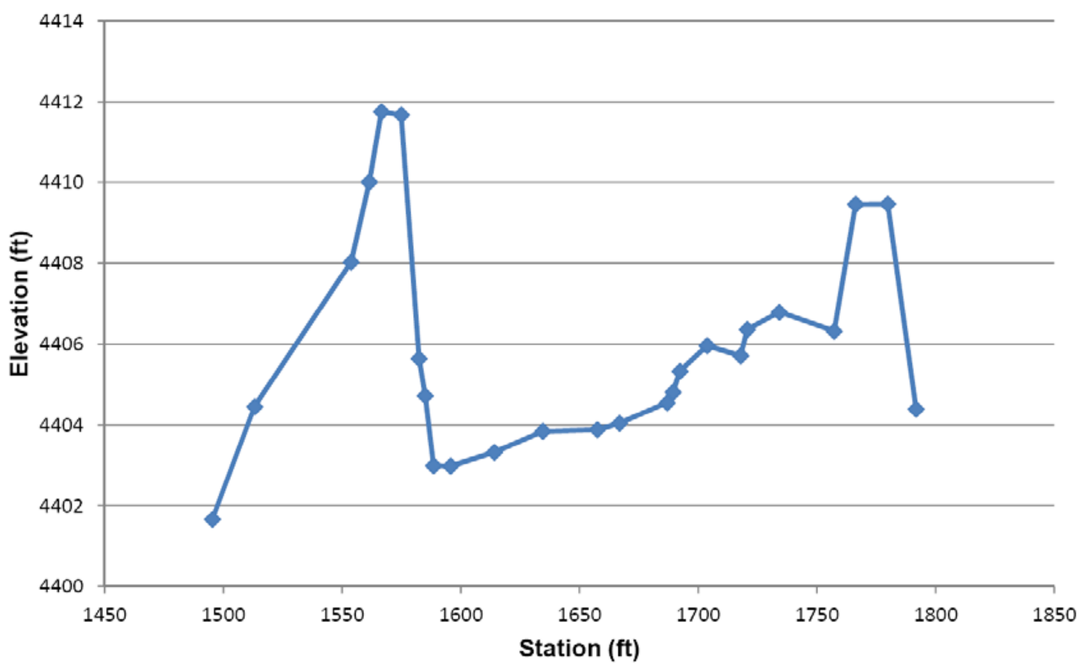


Figure 6. EB 44 (approx. RM 48) Cross Section (2010)

Hydraulic modeling of the Middle Reach was done using GPS cross section data collected during 2010. Cross sections were analyzed to determine the hydraulic capacity of each cross section. Results from the hydraulic model revealed that some cross sections within the Middle Reach had a hydraulic capacity greater than 4,000 cfs; however, given the geotechnical soil stability of the material present, it is highly unlikely that channel berms would withstand flows in excess 4,000 cfs. Therefore, 4,000 cfs has been set as the maximum. Portions of the Middle Reach from EB-43 to EB-46 have been observed to breach at flows less than 1,000 cfs; therefore, the cross section channel capacities within this range were set to 1,000 cfs. Naturally occurring breaches often remain open for a period of several months, providing overbanking flow to the adjacent floodplain. Such breaches are typically not viewed as emergencies and usually not repaired immediately for a variety of reasons, such as flows may be too high to safely work in the river, spawning is occurring, and to avoid disturbance to nesting migratory birds. The flows from the breaches return to the Delta Channel at a downstream location. Table 3 shows capacity analysis results for the existing Delta Channel within the Middle Reach.

Table 3. Existing Middle Reach Channel Capacity

Minimum	Maximum	Reach Weighted Average
1,000 cfs	4,000 cfs	3,371 cfs

1.3 Lower Reach (RM 40.7 to active reservoir pool)

The length of the Delta Channel within this reach varies from year to year, according to reservoir levels. As reservoir levels rise, some or all of this reach will become inundated and portions of the constructed channel may be obliterated, resulting in a need for reconstruction after the reservoir recedes again. This reach was constructed with an excavated channel width averaging 50 to 75 feet, plus embankment berms on each side providing a maximum total channel width of approximately 150 feet, and a construction footprint of approximately 250 feet. Figure 7 shows the design cross section for this reach of the Delta Channel. Cross sections have not been collected within the Lower Reach because it has usually been inundated by the reservoir pool; therefore, the design cross section is shown here instead of an actual cross-section.

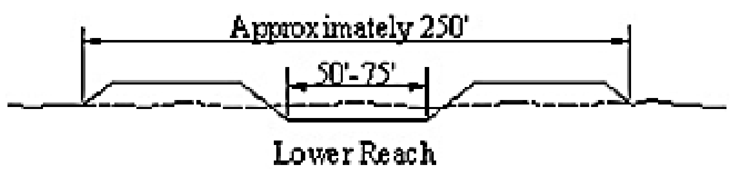


Figure 7. Lower Reach Cross Section Design

2.0 Proposed Action

The proposed action is to maintain the existing, man-made Delta Channel which delivers Rio Grande water to Elephant Butte Reservoir. In order to accomplish this goal, actions such as sediment removal, berm repair, and maintenance of site access and staging areas will be needed. Table 4 summarizes the work windows for the proposed activities for any year covered by this BA.

2.1 Action Area

The project area is the immediate area involved in the proposed action, while the action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR 402.02). The action area is shown in Figure 8.

The action area includes the Delta Channel from RM 57.8 down to the reservoir pool (~RM 34 as of October 2014) and the project-related access roads, staging areas, and equipment launching areas within the action area boundary (~293 $miles^2$) shown in Figure 8. Delta Channel sediment removal is covered by current Army Corps of Engineers Clean Water Act section 404 and 401 permits. Regional General Permits have also been secured.

Table 4. Summary of work windows for Delta Channel maintenance activities with associated conditions

Activity	Work window	Conditions
Delta Channel maintenance	No work between April 15 and September 1	Coordinate with U.S. Fish and Wildlife Service (Service) if emergency maintenance is needed during the no-work window
Access road maintenance (except for mowing and herbicide application)	May occur throughout the year	
Vegetation control (mowing and herbicide application)	No work between April 15 and September 1	If vegetation control should be needed between April 15 and September 1, migratory bird surveys will be conducted prior to activities and no mowing or herbicide treatment will occur within a 0.25 mile buffer of any nests found.
Staging area maintenance (including mowing and herbicide application)	No work between April 15 and September 1	Coordinate with Service if emergency maintenance is needed during the no-work window
Equipment launching site maintenance	No work between April 15 and September 1	Coordinate with Service if emergency maintenance is needed during the no-work window. When work is scheduled between September 1 and October 31 at equipment launching sites, they will be surveyed for suitable mouse habitat by Reclamation biologists prior to maintenance activities. If suitable habitat is found, Reclamation will coordinate with the Service prior to work.

Equipment launching site maintenance at Pete Well (Site #6 in Figure 8)	No work between April 15 and September 1; if suitable mouse habitat is found in spring 2015, then no work between September 1 and October 31	
Pumping from the Delta Channel for dust abatement	No pumping from the river between April 15 and September 1	Coordinate with the Service if pumping is needed after September 1 and before the end of irrigation season (October 31)

2.2 Site Access and Staging Areas

Access for maintenance of the three reaches of the existing Delta Channel will be on existing roads. These are public roads, constructed or improved during original construction of the Delta Channel. While the Delta Channel begins at RM 57.8, the proposed action includes maintenance of the portion of the access road between RM 58 and RM 62 (Figure 8). Maintenance will be performed annually on the roads, which will consist of: 1) smoothing of the road surface with a road grader and potential addition of gravel or Delta Channel sediment for re-surfacing; 2) repair of washout areas using a road grader, when needed; and 3) routine vegetation control along the road shoulders for safety, to a maximum distance of 10 feet from each road shoulder, which will consist of mowing and herbicide treatment. Herbicides will be used to reduce costs associated with mowing and may be applied using low pressure spray rigs mounted to OHVs, spray bars on trucks and trailers, or backpack sprayers (for spot applications). Table 5 shows the Service-approved herbicides that may be applied and the most encompassing buffers for the species covered in this BA from White (2007). These buffers will be followed during implementation of the proposed action. None of these herbicides are classified by the Environmental Protection Agency as "Restricted Use Products."

Table 5. Aquatic and terrestrial buffers from White (2007)

Product Name (Active Ingredient)	Animal Ecotoxicity Class*	Aquatic Buffer Spot Application	Aquatic Buffer Mechanized Application	Terrestrial Buffer Spot Application	Terrestrial Buffer Mechanized Application
Agri-Dex (§)	1, 1, 1	10 feet	50 feet	0 feet	30 feet
AquaMaster® (glyphosate)	0, 0, 0	0 feet	0 feet	0 feet	0 feet
Garlon 3A™ (triclopyr)	0, 1e, 1e	10 feet	50 feet	0 feet	30 feet
Garlon 4™ (triclopyr)	2, 0, 1	20 feet	100 feet	10 feet	60 feet
Habitat© (imazapyr)	0, 0, 0	0 feet	0 feet	0 feet	0 feet
Polaris© (imazapyr)	0, 0, 0	0 feet	0 feet	0 feet	0 feet

Rodeo® (glyphosate)	0, 0, 0	0 feet	0 feet	0 feet	0 feet
Telar™ (chlorsulfuron)	0, 1e, 1e	10 feet	50 feet	0 feet	30 feet
Buffers were developed using recommendations from White (2007). These are the most encompassing buffers based on the species covered in this BA. Since the New Mexico meadow jumping mouse was not listed when these recommendations were developed, the protection measures for the Hualapai Mexican vole and the Mount Graham red squirrel from the Small Mammal ecotoxicity group were used to determine buffer distances. *-Animal ecotoxicity classes from White (2007) (warm water fish, small avian, small mammal): 0 = practically non-toxic, 1 = slightly to moderately toxic, 2 = highly toxic, 3 = very highly toxic; e = eye irritation rating §-Nonionic, crop oil concentrate surfactant containing heavy range paraffinic oil, polyol fatty acid esters, and polyethoxylated derivatives thereof					

The nonionic, ether-based surfactant, Chemsurf 90, or similar, nonionic, ether-based surfactant, may also be added to the above herbicides to achieve desired application characteristics (as per label directions). When used according to label directions, surfactants enhance the effectiveness of the herbicide by decreasing surface tension which increases coverage of the treated vegetation. More effective treatments would ideally result in fewer herbicide applications. When adding a surfactant to an herbicide, buffer distances for the most encompassing ecotoxicity rating will be followed (e.g. if the herbicide's rating is 0 but the surfactant's rating is 1, the buffer for a 1 rating should be used).

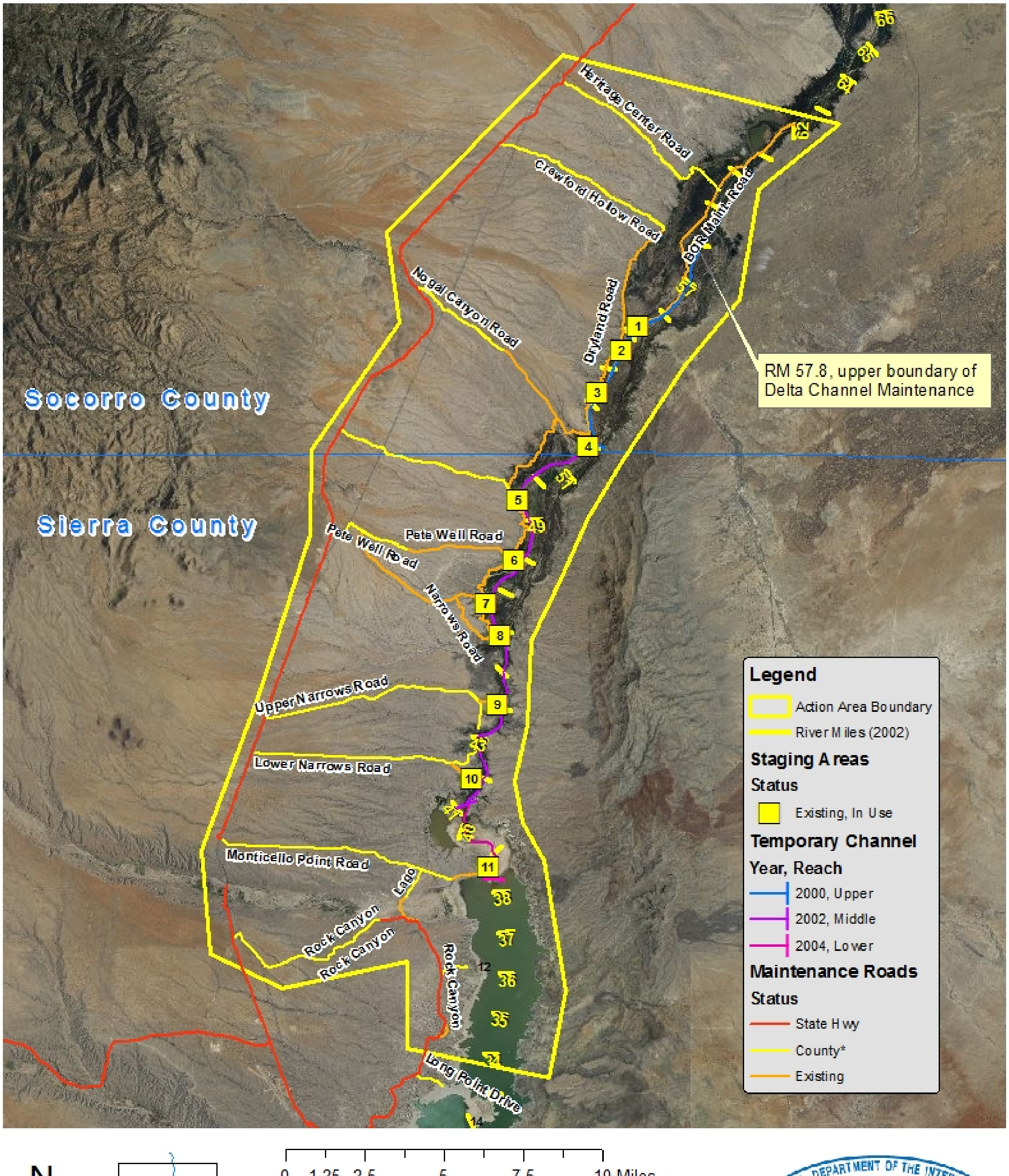
Treatments will be conducted by trained and approved personnel and will not take place when winds exceed 10 miles per hour or when rain is forecasted for the local area within 48 hours of application. Care will be taken when mixing or applying any herbicide to avoid runoff onto the ground or into the water, and application will be in accordance with label directions.

Road maintenance such as grading and washout repair may be performed throughout the year to maintain safe access to and from the river. Vegetation control is not planned to occur between April 15 and September 1. If vegetation control should be needed between April 15 and September 1, migratory bird surveys will be conducted prior to activities and no mowing or herbicide treatment will occur within a 0.25 mile buffer of any nests found.

Eleven existing staging areas, constructed during original Delta Channel construction, will also be used for future maintenance operations. Staging areas are leveled areas where equipment, materials, and temporary fuel tanks are stored. Spill prevention measures are provided for the fuel tanks. Maintenance of staging areas may also include vegetation control consisting of mowing and/or herbicide treatment. Vegetation control may be needed on the staging areas and to a maximum distance of 10 feet from the perimeter. Herbicides will be used to minimize annual mowing needs and may be applied using low pressure spray rigs mounted to OHVs, trucks and trailers with spray bars, or backpack sprayers (for spot applications). Table 5 shows the Service-approved herbicides that may be applied and the most encompassing buffers for the species covered in this BA from White (2007). Figure 8 shows all access roads and staging areas.

Staging areas are located near equipment launching sites which are side channels leading to the Delta Channel where amphibious excavators, fuel transporters, or airboats can be launched to complete work in the Delta Channel. These side channels are maintained to allow the safe entry of excavators, fuel transporters, and airboats into the Delta Channel and they were originally constructed so that minnows and other fish would not get trapped due to drying. Maintenance includes removal of sediment and vegetation using an amphibious excavator. Removed sediment and vegetation is used to repair berms along the Delta Channel. The amphibious excavators move slowly at an average speed of two miles per hour (mph) and the fuel transporter moves at about ten mph along the channel. Maintenance of equipment launching sites will be performed by excavators immediately preceding work in the adjacent section of the Delta Channel. When work is scheduled between September 1 and October 31 at equipment launching sites, they will be surveyed for suitable mouse habitat by Reclamation biologists prior to maintenance activities. If suitable habitat is found, Reclamation will coordinate with the Service prior to work.

No construction of new access roads, staging areas, or equipment launching sites are planned at this time; if they should become needed, Reclamation will coordinate with the Service prior to any construction activity.



Prepared by Brian Hobbs, US Bureau of Reclamation
11 September 2014
NAIP Imagery 2011

Figure 8. Delta Channel Site Access and Staging Areas

2.3 Maintaining Existing Delta Channel (approximately 20.8 miles)

Delta Channel maintenance activities will include management of sediment accumulation, berm repair, and management of vegetation within the channel. Any of these maintenance activities may be necessary depending on what needs to be done to achieve the desired channel characteristics. Work may be done from September 1 to April 15. Project activities will begin at the reservoir pool (~RM 34 as of October 2014), depending on the condition of the channel and whether work needs to be done, and then will proceed upstream. When working in the channel, crews will work upstream at a maximum of approximately 0.5 miles per day.

2.3.1. Upper Reach (River Mile 57.8 to 51.2): Maintenance of the Delta Channel in this section will focus on maintaining existing berms, management of sediment accumulation, and the management of vegetation growth within the channel cross section to maintain a target conveyance capacity equal to 5,000 cfs. The existing low flow thalweg in this reach will remain, allowing low flows to meander within the boundaries of the channel. Disturbance during maintenance activities will be confined within the existing construction footprint.

Naturally occurring breaches may remain open for a period of several months, providing overbanking flow to the adjacent floodplain. Such breaches are typically not viewed as emergencies and will usually not be repaired immediately for a variety of reasons, such as flows may be too high to safely work in the river, spawning is occurring, and to avoid disturbance to nesting migratory birds. The flows from the breaches return to the Delta Channel at a downstream location.

Delta Channel maintenance will include removal of sediment from the Low Flow Conveyance Channel (LFCC) outfall area (west side of Delta Channel just below RM 55), to allow LFCC discharge to enter the Delta Channel. Approximately 850 feet downstream of the LFCC outfall is a constructed feature referred to as the wing wall, which was originally built to collect excess LFCC discharge and direct it back into the river. The wing wall extends from the Delta Channel to the west, approximately 1,300 feet. In the past, maintenance of the wing wall included periodic removal of sediment along its entire length to facilitate drainage into the reservoir or Delta Channel. Due to the lack of this type of maintenance and occasional inundation from high flows, flycatcher habitat has developed. Reclamation now maintains this habitat by only removing enough sediment at the wing wall-Delta Channel interface to allow inundation during high flows.

Secondary channels protruding from the Delta Channel will not be excavated for the purpose of draining water from adjacent areas. Breaks in the berms may be constructed or naturally occurring inflow breaches allowed to remain for the purpose of allowing natural drainage into the Delta Channel and to prevent water from accumulating behind the berms, thus compromising their stability. Additionally, these openings allow water from the river to inundate areas behind the levee during the snowmelt runoff, providing a measure of ecosystem function to those areas. These openings will be maintained as necessary within the limits of the existing Delta Channel footprint. The determination to create breaks will be evaluated through an annual adaptive maintenance approach based on the river and reservoir conditions and influenced by habitat for listed species.

Each of the four staging areas in this reach are located near existing equipment launching areas, and will be maintained to the general dimensions originally constructed. These launching areas consist of a ramp into a very short secondary channel where equipment can be put in and taken out of the channel. Airboats are also typically docked in these areas when Delta Channel work is in progress. Maintenance of the launching areas will involve periodic removal of accumulated sediment.

2.3.2. Middle Reach (RM 51.2 to 40.7): Maintenance of the Delta Channel in this section will also focus on maintaining existing berms, management of sediment accumulation, and the management of vegetation growth within the channel cross section to maintain a target conveyance capacity equal to 4,000 cfs. The existing low flow thalweg in this reach will remain, allowing low flows to meander within the boundaries of the channel. Disturbance during maintenance activities will be confined within the existing berm to berm foot print of the channel.

Naturally occurring breaches and secondary channels in this reach will be managed in the same manner as the Upper Reach, as described above in section 2.2.1 Upper Reach.

There are seven existing staging areas located within this reach. Five of these have existing equipment launching areas and no new launching areas will be needed.   Staging and equipment launching areas will be maintained to the original constructed dimensions, as described for the Upper Reach.

2.3.3. Lower Reach (RM 40.7 to Active Reservoir Pool): The Delta Channel width varies from 50 to 75 feet, and the general maintenance strategy will be the same as the Upper and Middle Reaches. The portion of this reach that has been constructed to date ends at RM 38. In some years, this reach may require extensive maintenance if the reservoir inundates the area for periods of time, which typically causes significant damage to the Delta Channel and berms. Following a period of inundation, reconstruction of the channel may be required, in which case reconstruction will be in accordance with the typical section for the lower reach shown in Figure 7. General practice will be to reconstruct the channel in the same location, but conditions may necessitate construction of a new channel utilizing a different alignment.

Below RM 38, field observations during 2012 and 2013 show that a natural dominant channel has formed as the reservoir level dropped below RM 38, due to the naturally steeper reservoir slope downstream of The Narrows. Field observations in 2012 documented this natural channel was beginning to form distributary flowpaths. “A channel with defined banks became naturally established for a distance of more than one mile during April –September 2012 as the reservoir receded below RM 37” (Holste 2013). Reclamation will maintain the alignment of the natural channel below RM 38 until such time that the area is inundated by the rising pool elevation. Reclamation will repeat this process below RM 38 as needed. Maintenance of the naturally formed channel will be in wet conditions, with amphibious excavators, in the same general manner as described for maintaining the existing Delta Channel. Accumulated sediment will be excavated to maintain the natural dominant flowpath and used to form berms along the side.

Reservoir recession may expose cottonwood and salt cedar snags that will be removed during maintenance of the naturally formed channel. Prior to removal of such snags, a biological evaluation will be conducted to determine their significance for raptor and other migratory bird use.

Maintenance of this reach may also include excavation of secondary channels extending a short distance from the main Delta Channel, in order to provide an outlet to the main Delta Channel for isolated side pools or side channels in the delta area. These are low areas in the delta area (where there is limited vegetation) that continue to hold water after the reservoir pool recedes; connecting them to the main Delta Channel will reduce evaporation losses and increase deliveries to the reservoir for Compact deliveries. Construction of these channels will not be conducted in a manner that would completely drain the large isolated pool on the west side of the Delta Channel, between RM 40 and RM 41. However, if extremely dry conditions persist and the reservoir recedes, it is uncertain if groundwater flows will continue to keep the isolated pool wet.

2.3.4. Equipment Operations and Channel Disturbance: Delta Channel maintenance work on all reaches generally consists of removal of sediment deposits within the channel and repair of damage to berms. Berm damage may occur in several ways, including: 1) erosion of berm slopes or overtopping of berms due to high flows within the channel; and 2) saturation of berm material or overtopping of berms due to arroyo flows. Typical channel maintenance procedures involve removal of sediment from within the channel and placement of the material on the berms. It is expected that all of the removed sediment will be used on the berms. In rare cases, however, sediment may be used for road maintenance. Before sediment can be used for road work, excavators will place it at one of the identified staging areas to dry.

In-water maintenance work is performed by amphibious excavators, and dozers often work on the berms, pushing material deposited by excavators into place for berm repairs. Dozers may also work on the elevated floodplain bench surface within the existing channel of the Upper Reach. Maintenance work will include removal of vegetation from point bars within all reaches. Vegetation on the sides and tops of berms contributes to the desired stability of the berms and will not be removed, except in rare cases where feasibility and/or operator safety may be concerned. Two such rare cases where vegetation may need to be removed on the berms, are: 1) when vegetation lower on the inside of a berm interferes with the required channel capacity; and 2) on the outside of a meander bend where the channel is too deep for an excavator to safely work and the work must be done from the top of the berm. In the latter case, berm vegetation would be removed or moved out of the way so that the equipment operator can safely work from the top of the berm. Vegetation removal may be accomplished by excavators or dozers.

Amphibious excavators are conventional tracked excavators mounted on pontoons to allow operation on very soft ground. Excavators generally work in the channel, often in water, and also move between work sites within the channel. At a work site they are typically set up in a stable position for performing work within a radius of approximately 40 feet. When work within that radius is complete, the excavator moves and begins excavation from the new setup location. When work in the general area is complete, the excavator moves to the next work site.

Typical excavator operation involves removal of accumulated sediment from the channel and placement of the material on berms. In some cases, the berms have been eroded and have vertical banks on the Delta Channel side, and these berms are reconstructed using material from the channel. The excavators move material from the channel to the berm in three ways: 1) working from the channel, the excavator scoops up a bucket of channel material, often mixed with water, and then dumps the bucket on the berm; 2) working from the channel, the excavator pushes material from the channel up the slope of the berm with the back of the bucket; 3) working from the berm, the excavator pulls material up the slope of the berm with the bucket. Excavator operators are given instructions to structure their excavation operations to avoid the creation of isolated pools that could trap fish. Although it is possible that fish could be caught in the excavator bucket and placed on the berms, operators and inspectors report that they have not observed this happening during the last 12 years.

Delta Channel maintenance activities for all reaches will be confined to the area within the existing construction footprint and will not occur between April 15 and September 1. The regular maintenance period is September 1 to April 1 every year, although the work typically does not last through that entire period. An exception to the regular maintenance period would be in the case of emergency channel and berm repairs during spring runoff, and we expect that this event would happen once in a five year period for a period of two weeks near the end of runoff. Reclamation will coordinate with the Service if emergency work is needed, prior to any activity. If it is determined in the future that Delta Channel maintenance between April 15 and September 1 needs to become a routine annual activity, Reclamation will coordinate with the Service prior to implementing that decision, and migratory bird surveys would be conducted prior to any activity that has the potential to disturb migratory bird breeding behavior and no such activity would occur within a 0.25 mile buffer of any migratory bird nests found. Road maintenance, with the exception of mowing and herbicide treatment, may be performed throughout the year.

An estimation of the portion of the Delta Channel impacted by maintenance work each year is as follows. Computation details are provided in Appendix A.

- 75 to 100% of the channel length is traveled by amphibious excavators and fuel transporters, moving back and forth between equipment launching areas and work sites. This computes to an estimated 944 acres of channel disturbance in most years. If workload requires a third crew, there would possibly be an additional 629 acres of channel disturbance, for a total possible 1,573 acres in those years with three crews.

- Active work sites, where excavation is performed within the channel, are estimated to cover approximately 25% of the entire channel area each year for most years. For most years where two crews are needed, this computes to an estimated 113 acres per year that will have an excavator working within the existing channel area. If workload requires a third crew, there would possibly be an additional 82 acres per year that would have an excavator working within the existing channel area. Thus, the total possible area of active work sites would be 195 acres in those years with three crews.

2.4 Delta Channel Maintenance Support Operations

2.4.1. Airboat Transport: Equipment operators and fuel for the equipment are often transported from equipment launching areas to work areas via airboats while maintenance work is in progress. Additionally, airboats cover the entire length of the Delta Channel an average of eight times per year (four round trips) for channel inspections. Channel inspections are typically conducted with two airboats traveling together due to safety concerns.

2.4.2. Refueling: Amphibious excavators are often fueled while in the water, and fuel is transported to them either by airboat or by an amphibious fuel transporter, which is also on tracked pontoons. Excavators are equipped with spill kits, which include booms designed to contain spilled fuel and absorbent pads. Operators are trained and knowledgeable on how to deal with spills should they occur.

2.4.3. Pumping Water from River: To provide dust abatement for access road and staging area maintenance and safety during high traffic periods, water may be pumped from the river at or near existing equipment launching areas, requiring no new ground disturbance. Pumping rates will vary between 1.8 and 2.2 cfs, requiring four to eight minutes to fill a water truck. This would be a minimal impact to river flows, equating to a decrease in flows of approximately 0.7% for river flows of 300 cfs and approximately 0.2% for river flows of 800 cfs for four to eight minutes. A typical project may use four to six truckloads per day and, at a maximum, 18 truckloads per day. This project is expected to use the typical amount or less. Pump intake pipes will use a 0.25 in (0.64 cm) mesh screen at the opening to the intake hose to minimize entrainment of aquatic organisms. Sumps or secondary channels adjacent to the river will be used whenever feasible.

Pumping is not expected to be needed between April 15 and September 1. If pumping is needed between May 1 and July 1 (emergencies only), Reclamation will coordinate with the Service to avoid impacts to minnow eggs and larvae. After September 1 and before the end of the irrigation season (October 31), flows in the Delta Channel may be low. To avoid impacts to juvenile and adult minnows during this period, Reclamation will coordinate with the Service prior to pumping.

3.0 Species' Habitat and Life History

For information pertaining to the life history and habitat needs of the minnow, flycatcher, cuckoo and mouse see Chapter 3, Joint Biological Assessment Part I – Action Area and Species-Related Information, to which this BA is appended. The Delta Channel maintenance area is located downstream of the power lines (approx. RM 62), entirely within the reservoir pool, and ending where the active reservoir pool begins. Designated critical habitat for the minnow is upstream of this maintenance area. The revised designated flycatcher critical habitat and the proposed cuckoo critical habitat extends through the Elephant Butte Reservoir area to RM 54 (Service 2013; Service 2014). The nearest proposed critical habitat for the mouse is approximately 16 river miles upstream at Bosque del Apache National Wildlife Refuge (Service 2014).

4.0 Environmental Baseline

Regulations implementing the ESA define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area; the anticipated impacts of all proposed Federal actions in the action area that have undergone formal or early Section 7 consultation; and the impacts of State and private actions that are contemporaneous with the consultation in progress. The environmental baseline defines the current status of the species and its habitat in the action area to provide a platform to assess the effects of the action.

The Service has produced biological opinions for recent Reclamation activities and other agencies' activities in the Middle Rio Grande (MRG) that describe the environmental baseline with regard to factors affecting the species' environment. In addition, for information pertaining to the environmental baseline see Chapter 4, Joint Biological Assessment Part I – Action Area and Species-Related Information, to which this BA is appended. The following reference covers the environmental baseline for the flycatcher down to the pool of Elephant Butte Reservoir:

Reclamation. 2012. Southwestern Willow Flycatcher Management Plan for the Rio Grande Project. Bureau of Reclamation, Albuquerque Area Office, Albuquerque, New Mexico.

4.1 Current Status of Minnow in Action Area

Construction and maintenance of the Delta Channel is maintaining a riverine habitat suitable for minnows, including slackwater, backwaters, shoals, and pools, in an area that previously lacked any habitat. Minnows are known to be present within the action area. Surveys for minnows in the Delta Channel were conducted by Reclamation at 4 sites in September 2010, 5 sites in September 2011, 4 sites in October 2012, 6 sites in October 2013, and 6 sites in 2014 (Table 6, Figure 9). Mean densities at each 2002 River Mile surveyed by year, are shown in Table 6.

Table 6. Minnow densities found during September/October surveys conducted by Reclamation, 2010-2014.

River Mile[#]	2010	2011	2012	2013	2014
55	**	5.56	**	0.00	0.00
53	**	**	0.00	**	**
52	**	3.47	**	0.00	**
51	63.09	1.33	0.00	**	0.12
50	27.01	**	**	**	0.15
48	1.98	2.40	0.00	0.00	0.35
47	**	1.81	**	**	**
46	10.07	**	0.00	0.34	**
44	**	**	**	**	0.28
43	**	**	**	0.39	**
41	**	**	**	0.00	**
39	**	**	**	**	0.41
37	**	**	**	**	0.00
Overall CPUE[§]	**24.07**	**2.83**	**0.00**	**0.08**	**0.13**

**- Surveys were not conducted.
[#]- Nearest whole 2002 River Mile to the actual coordinates of the seining location (see Figure 10).
[§]- Calculated as all minnows captured divided by total area seined (divided by 100) for that year's survey.

The decrease in density from 2010 to 2014 follows a similar pattern for the minnow throughout the MRG due to drought and decreased spring runoff (Figure 9) (Oliver-Amy pers. comm.).

In February 2014 and 2015, electrofishing sampling was conducted by Reclamation biologists in the Middle Rio Grande near the confluence of the LFCC and downstream into the Delta Channel. The sampling yielded 10 silvery minnow captures in 2014 and 9 in 2015 (Bachus pers. comm.).

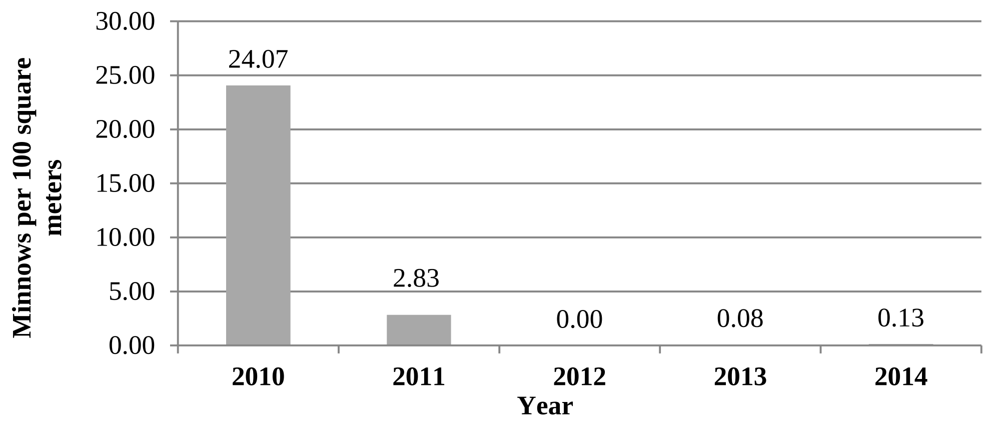
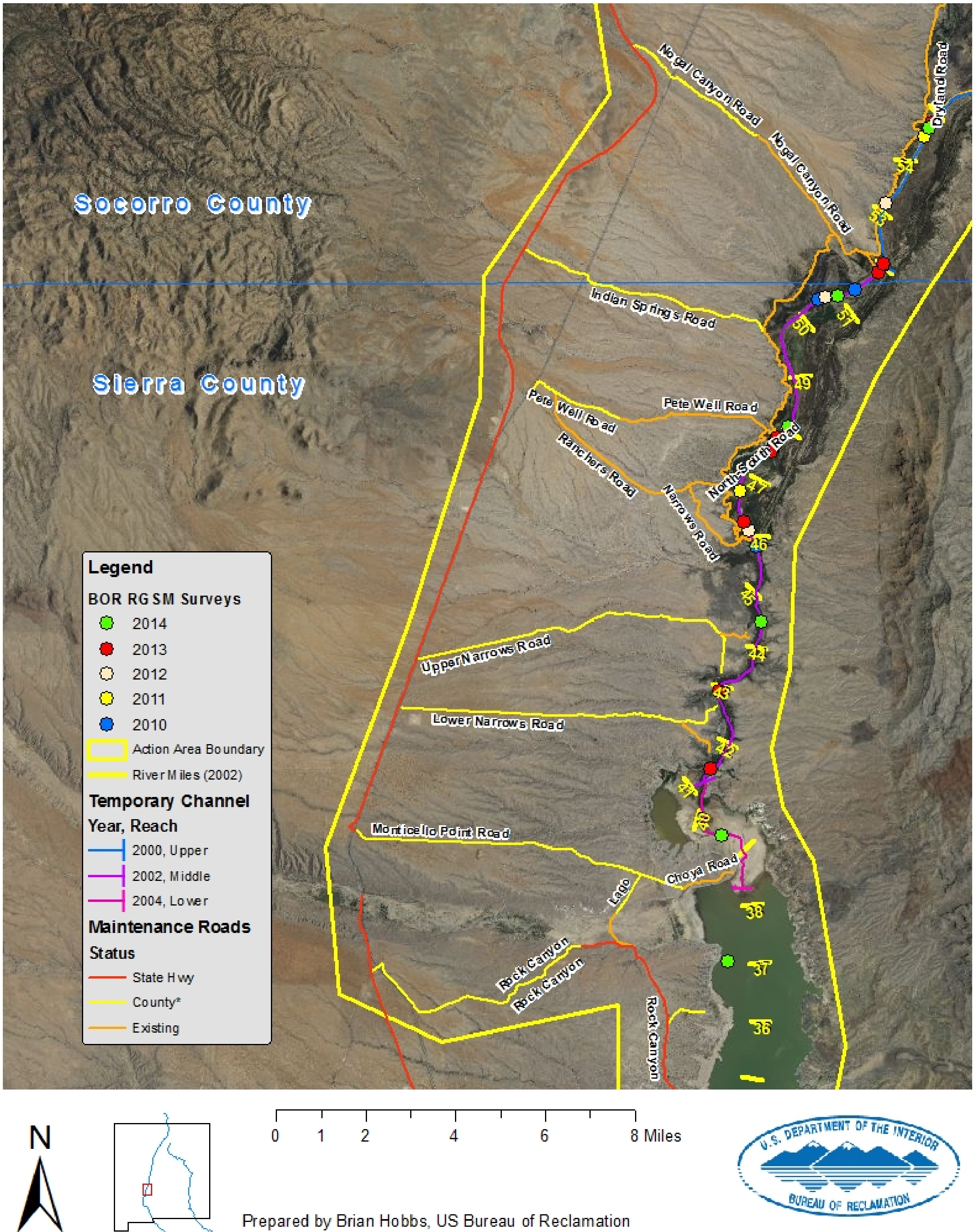


Figure 9. Rio Grande silvery minnow densities during September/October surveys conducted by Reclamation (Sechrist pers. comm.)



Prepared by Brian Hobbs, US Bureau of Reclamation
11 September 2014
NAIP Imagery 2011

Figure 10. Reclamation survey sites for silvery minnow in the Delta Channel since 2010

During the 2010, 2011, and 2013 surveys, minnows were found in suitable habitat (shorelines, backwaters, pools). Though there was not a statistically significant difference between the densities of minnow at individual sites, the upper two sites had higher mean density than the downstream sites (Oliver-Amy pers. comm.).

Minnows are not expected to be found past the inflow to the active reservoir pool (approximately RM 38 as of October 2014).

4.2 Current Status of Southwestern Willow Flycatcher in Action Area

4.2.1 Presence

Patches of vegetation at the northern-most extent within the historic reservoir (considered south of RM 62) began to reach suitability for flycatchers in the mid-1990s. While only 16 territories existed in the San Marcial survey reach in 1996, Figure 11 shows the increase in number of flycatcher territories from 2000 to 2013 in the reach, which extends from the San Marcial railroad trestle (RM 68.6) downstream to the reservoir pool (Moore and Ahlers 2014). Of the total territories in the riparian areas adjacent to the Delta Channel in 2011 (152) and 2012 (103), 85 and 47 (sites DL 6-10), respectively, were 0.25 miles or further from the Delta Channel, with several territories along the unmaintained portion of the LFCC (Moore and Ahlers 2012). The remaining territories are within 0.25 miles of the Delta Channel, and mostly south of RM 55. Appendix B shows general locations of territories; for more specific locations of recent territories in the action area, see Moore and Ahlers (2014).

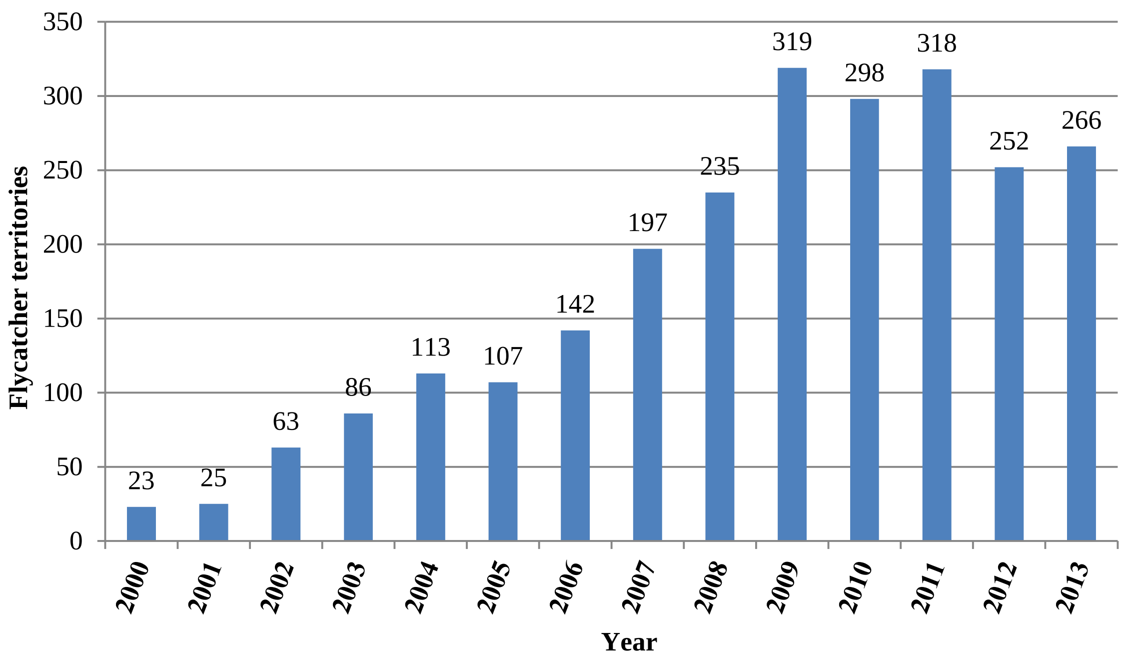


Figure 11. Flycatcher territories in San Marcial Reach (Moore and Ahlers 2014)

The length of the San Marcial flycatcher survey reach has tripled since 1995 as flycatcher habitat developed in new areas made available as the reservoir level dropped. It continues to be the most productive survey reach of the river, with some of the best native habitat within the subspecies' range (Moore and Ahlers 2014). The majority of the territories are within the reservoir pool area, with only 7 and 4 territories between the railroad bridge (RM 68.6) and the power lines (approx. RM 62) in 2012 and 2013, respectively. South of the Narrows, high quality flycatcher habitat that has developed as a result of more recent reservoir recession continues to improve and harbor nesting and migrant flycatchers (Moore and Ahlers 2014).

Flycatchers and suitable flycatcher habitat are not expected to occur within the Delta Channel (berm to berm), because it has been maintained, as proposed in this BA since 1999 and it is occasionally scoured by high flows from spring runoff and/or monsoons. Flycatchers and their habitat are present in areas that are adjacent to the channel, outside of the berms, where suitable vegetation exists.

4.2.2 Geomorphology

In one specific area, sites DL-03 and DL-04 (just north of RM 58), vegetative decline followed an apparent drop in alluvial groundwater levels and subsequent water stress on the willows. At these sites, prior to and during 2005, groundwater levels were near the surface, oftentimes with moist soils present. Under such conditions, trees likely had a very shallow root system. Between 2000 and 2005, the number of territories at these sites increased and in 2005, these two sites had 22 total nests found (with fates known) and 55% nest success. Bed degradation in this area began during the 2005 spring runoff (discussed in further depth below and in Holste (2013)) and the bed had degraded almost 12 feet by 2007 in comparison to 2002 (Holste 2013). Beginning in 2006, observations during annual flycatcher surveys reported soils were no longer moist at these sites (Ryan pers. comm.). Although monitoring wells did not exist in this area at that time, it is likely there was a rapid drop in groundwater below the root zone of the trees, resulting from the combined effects of bed degradation and recurring dry conditions. Drought conditions in New Mexico ranged from abnormally dry to extreme drought from 2006 to 2008, contributing to the effects of previously dry conditions since 2000 (U.S. Drought Monitor 2013). Also, no springs or other groundwater controls exist nearby that might have prevented or minimized the drop in groundwater. A decline in vegetative health was observed to begin in 2006 and by 2008, only 3 nests were found at these sites. One nest was predated and the other two nest fates were unknown. The remaining vegetation in this area is now mainly salt cedar instead of Goodding's willow, as previously existed. Nesting has not occurred at these sites since 2008.

In other areas, the reasons for declines in groundwater level are not clear-cut because groundwater levels are complex and can be highly variable across time and space. Near the river, groundwater levels show an influence from water surface elevations (Tetra Tech 2010), but data at different locations suggest a complicated interaction. Holste (2013) includes an analysis of groundwater wells, bed degradation, and river discharge near the BDANWR south boundary, near San Marcial, and RM 63 (south of Fort Craig). The analysis shows a groundwater level that is a gradient between the river water surface and the LFCC water surface. Also, thalweg elevation appears to have less effect on groundwater levels than river discharge. Groundwater peaks occur during spring runoff or other high flow events, while low groundwater elevation corresponds to periods of low river discharge. Figure 12 shows river thalweg elevation, groundwater elevation, and river discharge near RM 63. Similar figures for other wells near San Marcial and the BDANWR south boundary are available in Holste (2013). Analyzing these figures, it appears that groundwater levels are "primarily a function of river discharge (or river water surface elevation) and nearby groundwater controls (i.e., LFCC and ponded areas). River thalweg elevation trends over time and space can influence, but may not directly correspond to, trends in groundwater elevation" (Holste 2013). While the vegetation in areas such as DL-03, DL-04 and other sites has clearly shown decreased health and mortality probably due to lowered water tables, it is difficult to separate the impacts of extended drought (reduced discharge) and channel degradation on groundwater levels.

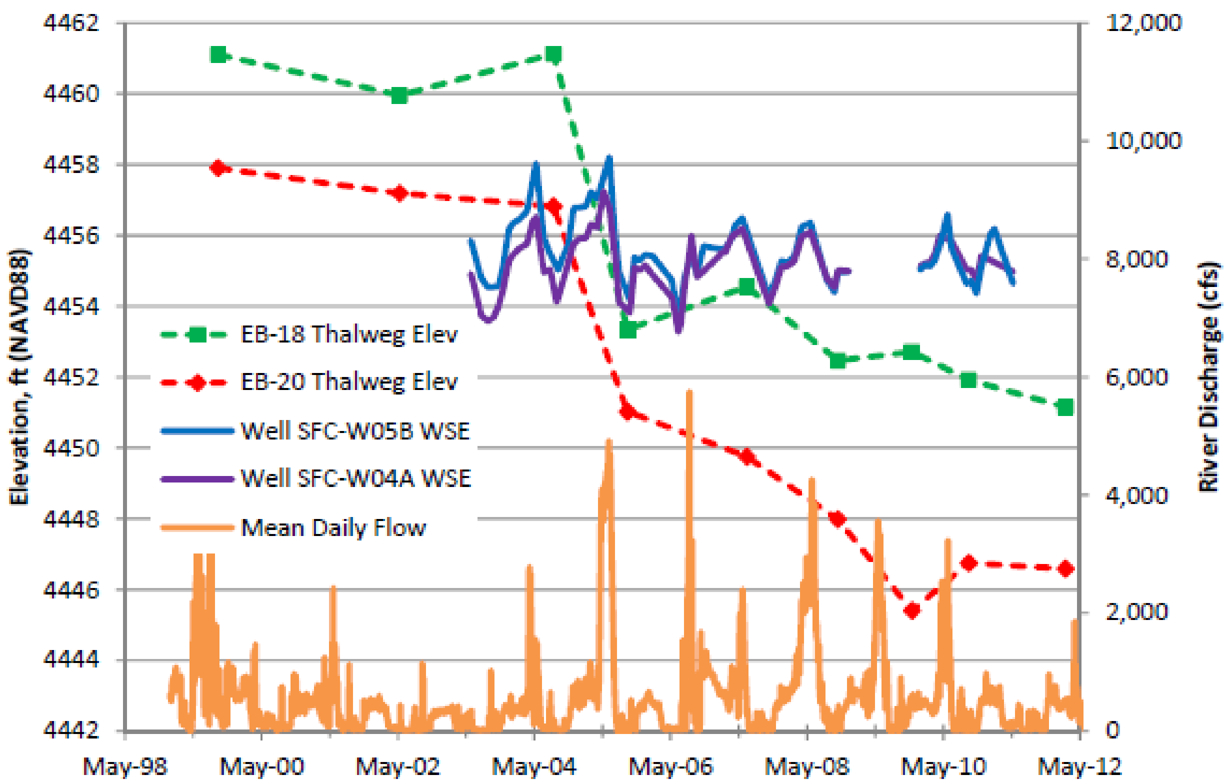


Figure 12. River thalweg elevation, groundwater elevation, and river discharge over time near RM 63.

Similar to groundwater levels, the causes of channel degradation are complicated. Based on information in Reclamation's October 2007 BA, the Service's 2008 Biological Opinion (BO) on the effects of the Temporary Channel Maintenance Project stated the degradation was initiated by a headcut that formed in 2003. The 2007 BA and 2008 BO recognized the primary driver for the headcut was lowering of the reservoir due to drought, but also indicated an expectation that Delta Channel maintenance and excavation work was expected to create additional riverbed degradation. Today's best available data and a more thorough analysis of that data provide a clearer understanding of how and when the headcut formed and whether degradation was caused by the Delta Channel. Reclamation has conducted a thorough assessment of channel conditions and dynamics in the reach from the Highway 380 Bridge to Elephant Butte Dam (60 miles) to examine potential effects from initial Delta Channel construction and recurring maintenance (Holste 2013). This assessment considers the past and present impacts of Delta Channel construction and maintenance within a geomorphic framework that considers the primary physical processes that govern alluvial river morphology. Furthermore, while initial Delta Channel construction effects were combined with recurring Delta Channel maintenance effects in previous assessments, Holste (2013) makes it clear that both the action and the subsequent effects are distinctly different for initial construction and recurring maintenance activities. The following discussion is a summary of the assessment, which describes the relative impacts of natural events and past Delta Channel construction and maintenance actions.

The morphology (planform, cross-sectional shape, slope, bed elevation, and other characteristics) of the MRG, like other alluvial rivers, is continuously changing in response to changes in water discharge, sediment load, base level, and anthropogenic actions. In geomorphic terms, the river is responding to upstream drivers and downstream controls. The primary drivers in alluvial channel morphology are the flow regime and sediment load (Schumm 1977, Watson et al. 2007) and the controls are the base level of the stream system and channel and floodplain characteristics. Controls either constrain or amplify the effect that the drivers have on channel adjustment (Makar and AuBuchon, 2012).

Geomorphic Drivers

On the Rio Grande upstream of Elephant Butte, the geomorphic drivers of water discharge and sediment load, coupled with the primary control of downstream base level (reservoir pool) elevation, have varied significantly from the early 1900's to the present. During dry periods from 1943 – 1978 and 1996 – present, most of the recorded peak flows were substantially less than 5,000 cfs, and the annual flow volume has been typically less than one million acre-feet. Wet periods from 1903 – 1942 and 1979 – 1995 saw streamflow peaks significantly greater than 5,000 cfs and annual flow volumes greater than one million acre-feet.

Flow duration is also important because peak discharges may occur during prolonged snowmelt runoff events or short-lived monsoon events. "Historically, most significant channel adjustments on the Middle Rio Grande have occurred during high magnitude, long duration runoff events. The river also adjusts to periods of low flows, but at a more gradual rate" (Holste 2013).

High variability in the balance between sediment load and sediment transport capacity on the Rio Grande drives continuous channel adjustments as the channel changes to balance the capacity to do work (related to sediment transport) with the work that must be done (related to sediment supply). Typically, sediment supply exceeds the transport capacity on the Rio Grande upstream of Elephant Butte because of the high sediment loads and the relatively flat slope upstream of the reservoir pool, inducing deposition and causing aggradation of the channel (Holste 2013).

Geomorphic controls

An important geomorphic control for upstream reaches of a river is the base level. The base level is the downstream limit of the river system and the origin of the thalweg profile; on the Rio Grande (between San Acacia Diversion Dam and Elephant Butte Dam), the base level is the level of Elephant Butte Reservoir pool and it is a dominant geomorphic control.

The Rio Grande base level has fluctuated greatly since 1915 (Figure 13). After dam construction in 1915 and the initial filling of the reservoir, the water surface "has fluctuated over a vertical range of 150 feet (a shift in the horizontal water surface of around 32 river miles) corresponding to climatic wet and dry periods" (Holste 2013). In recent history, the average annual pool elevation increased 101 feet between 1978 and 1986, with the reservoir essentially full between 1985 and 1995. After declining slightly between 1995 and 1998, the average pool elevation dropped 90 feet between 1998 and 2004. An increase of 35-40 feet in elevation between 2004 and 2009 was followed by a similar decrease of 30-40 feet through 2012. The minimum 2012 elevation was only 3.2 feet higher than the minimum 2004 elevation (both in September) (Holste 2013). The riverbed responds to these fluctuations in base level, with downstream reaches (closest to the reservoir) responding quickly and upstream reaches responding later.

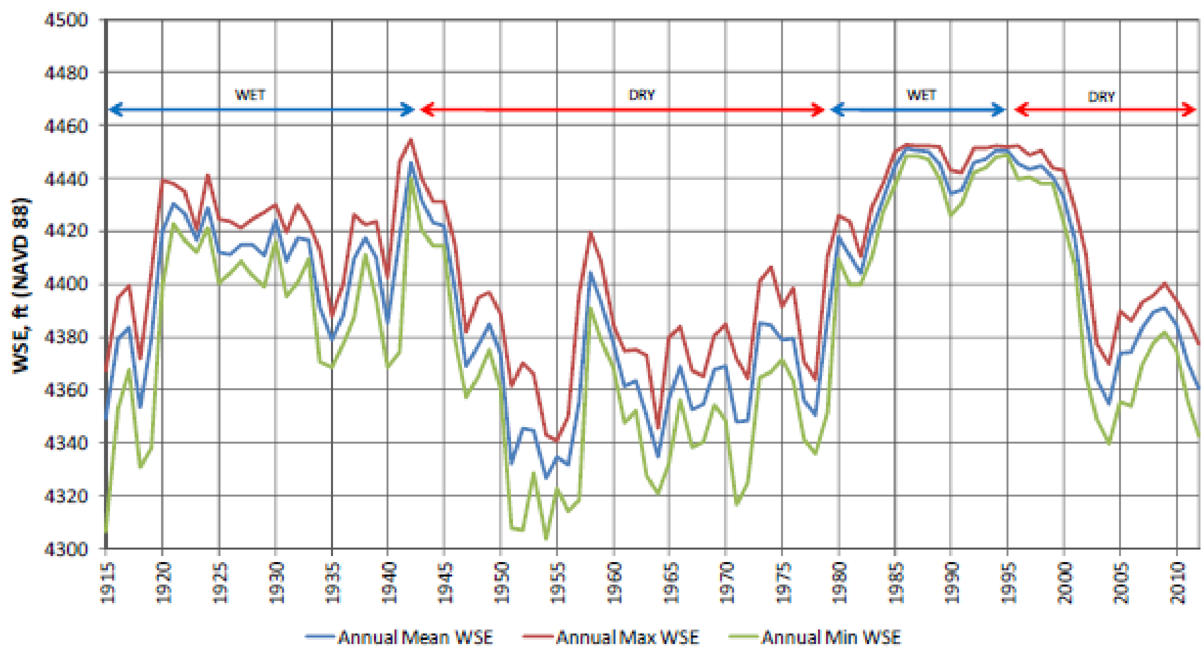


Figure 13. Elephant Butte Reservoir pool elevation time series (1915 – 2012) (modified from Owen 2012).

A rise in base level, such as the rise that began at the reservoir in 1978 and held through 1995, reduces local transport capacity, as discussed previously, with resulting aggradation of the streambed. In fact, "aggradation is the most dominant characteristic of this reach over time. The riverbed elevation at San Marcial has increased by a cumulative total of about 18 feet since 1915, while areas further downstream near the historic average pool location (the Narrows) have aggraded 40-50 feet" (Holste 2013). The aggradational effect tends to travel less far upstream than the headcut migration induced by lowering of the reservoir (Knighton 1998, Leopold et al. 1964). When the base level drops, it exposes the steep slope that exists downstream of the transition between the aggraded streambed and the former level of the reservoir pool, as shown in Figure 14. Strand and Pemberton (1982) describe the development of the upstream riverbed elevation (topset slope) relative to a reservoir pool, with the oversteep slope (foreset slope) beginning at the transition between the stream and the initial base level. On average, the topset slope is half of the original channel slope and the foreset slope is 6.5 times steeper than the topset slope.

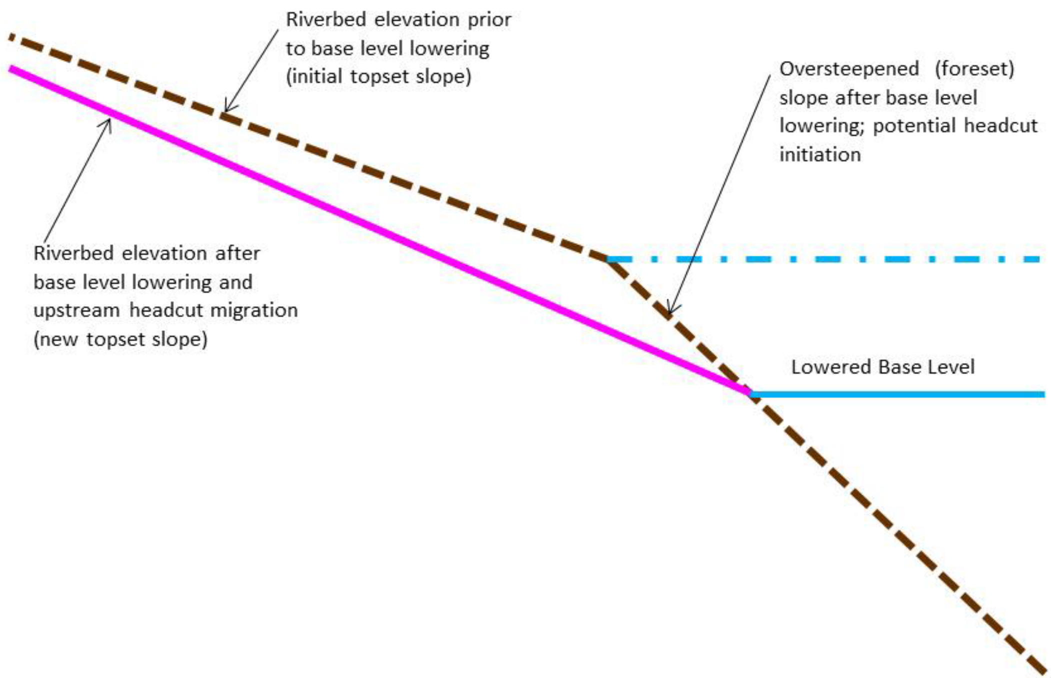


Figure 14. Conceptual diagram of upstream headcutting caused by base level lowering.

When the reservoir pool elevation drops, it exposes the steeper (foreset) slope. This increases the sediment transport capacity beyond the sediment supply, causing this abrupt break in slope (headcut or knickpoint) to migrate upstream as the stream adjusts. The streambed degradation typically moves upstream fairly quickly, then slows over time and declines with distance from the reservoir (Knighton 1998).

Aggradation and degradation on the Rio Grande

These cycles of aggradation and degradation have occurred before on the Rio Grande over the history of the reservoir. Figure 15 compares the water surface elevation of the reservoir to the average bed elevation at San Marcial gage, which is about 42 miles upstream of Elephant Butte Dam, 31 miles upstream of the average 2012 pool elevation, and about 5 miles upstream of the full reservoir pool. Periods of increasing or full reservoir pool correspond to the largest rates of aggradation, from 1920 to 1948 and from 1978 to 1995. Periods of low or declining reservoir elevation correspond to periods of historical degradation, 1949 – 1972 and 2005–2011. Both 1949 and 2005 had large spring runoff events, both about seven to ten years after the reservoir pool began to lower. The degradation rate between 1949 and 1972 was about one half to one third of the rate between 2005 and 2011, mostly due to the substantially higher sediment load that existed on the MRG between 1949 and 1972. Figure 15 also shows significant short-term degradation events that occurred during 1937 (Happ 1948), 1991, and 1995, caused by avulsions or sediment plugs that reduced upstream sediment supply (Holste 2013).

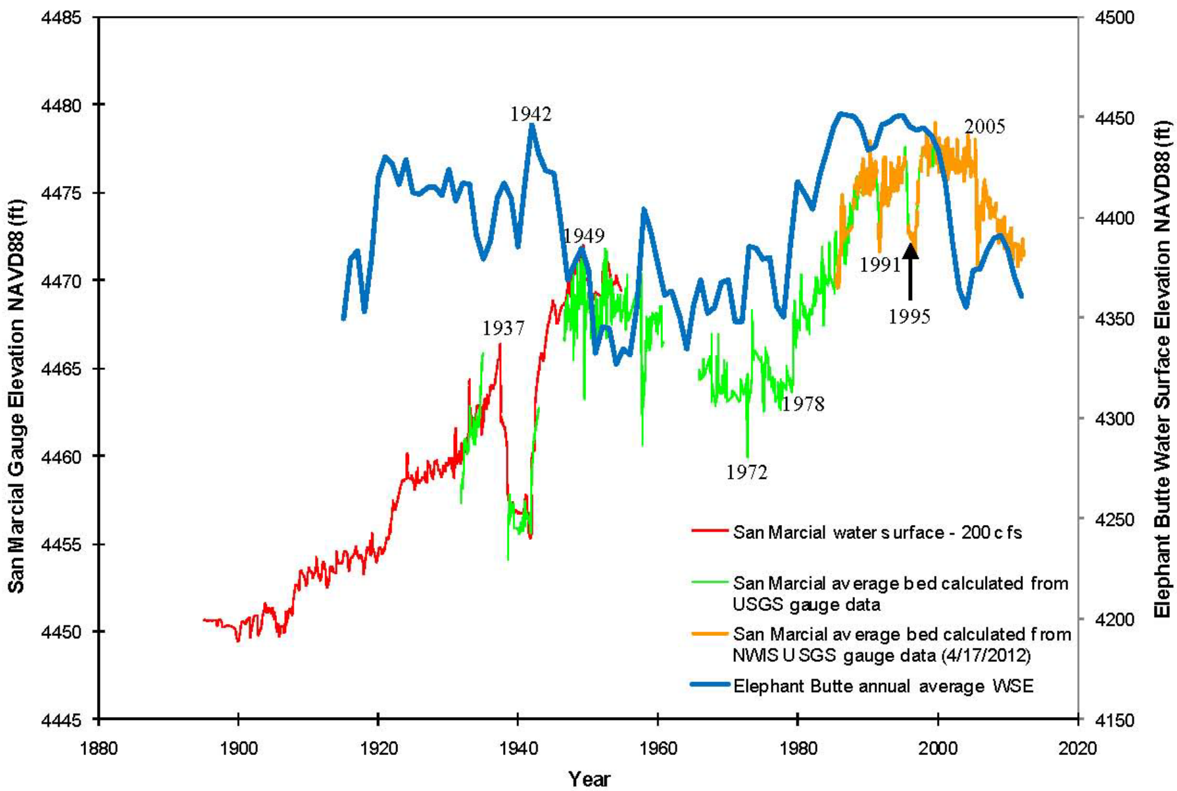


Figure 15. Elevation changes of the USGS San Marcial gauge and Elephant Butte Reservoir pool over time (modified from Makar 2013, pers. comm.)

As discussed, degradation and aggradation can be induced by either upstream drivers (water discharge, sediment load) or downstream controls (base level). Table 7 identifies the different primary causes for downstream and upstream progression of bed elevation changes. Also, controls and drivers interact, such that the effects from the reservoir level lowering downstream on a river can be amplified or dampened by upstream water discharge and sediment load. Thus, in a river like the Rio Grande, where water discharge and sediment inputs are highly variable and the base level is changing, the geomorphological response to events is highly complex and reaching dynamic equilibrium is nearly impossible.

Table 7. Main Causes of Streambed Elevation Change (adapted from Knighton 1998)

Type of Bed Elevation Change	**Upstream Driver – Cause of Downstream Progression**	**Downstream Control – Cause of Upstream Progression**
Degradation	water discharge increase; sediment supply decrease	base-level fall
Aggradation	water discharge decrease; sediment supply increase	base-level rise

The complexity and dynamic nature of the MRG and Elephant Butte Reservoir can clearly be seen in Figure 16, which overlays six different pool elevations on longitudinal reservoir profiles from 1915, 1988, 1999, and 2007. Figure 16 is also presented in an expanded view. The grade breaks or knickpoints discussed previously can be seen in historic reservoir longitudinal profiles, corresponding to specific pool water surface locations. A knickpoint can be seen at the Narrows in the more recent profiles, where the greatest historical aggradation (40-50 feet) has occurred. This is not surprising because that is also the elevation of the historical average reservoir pool.

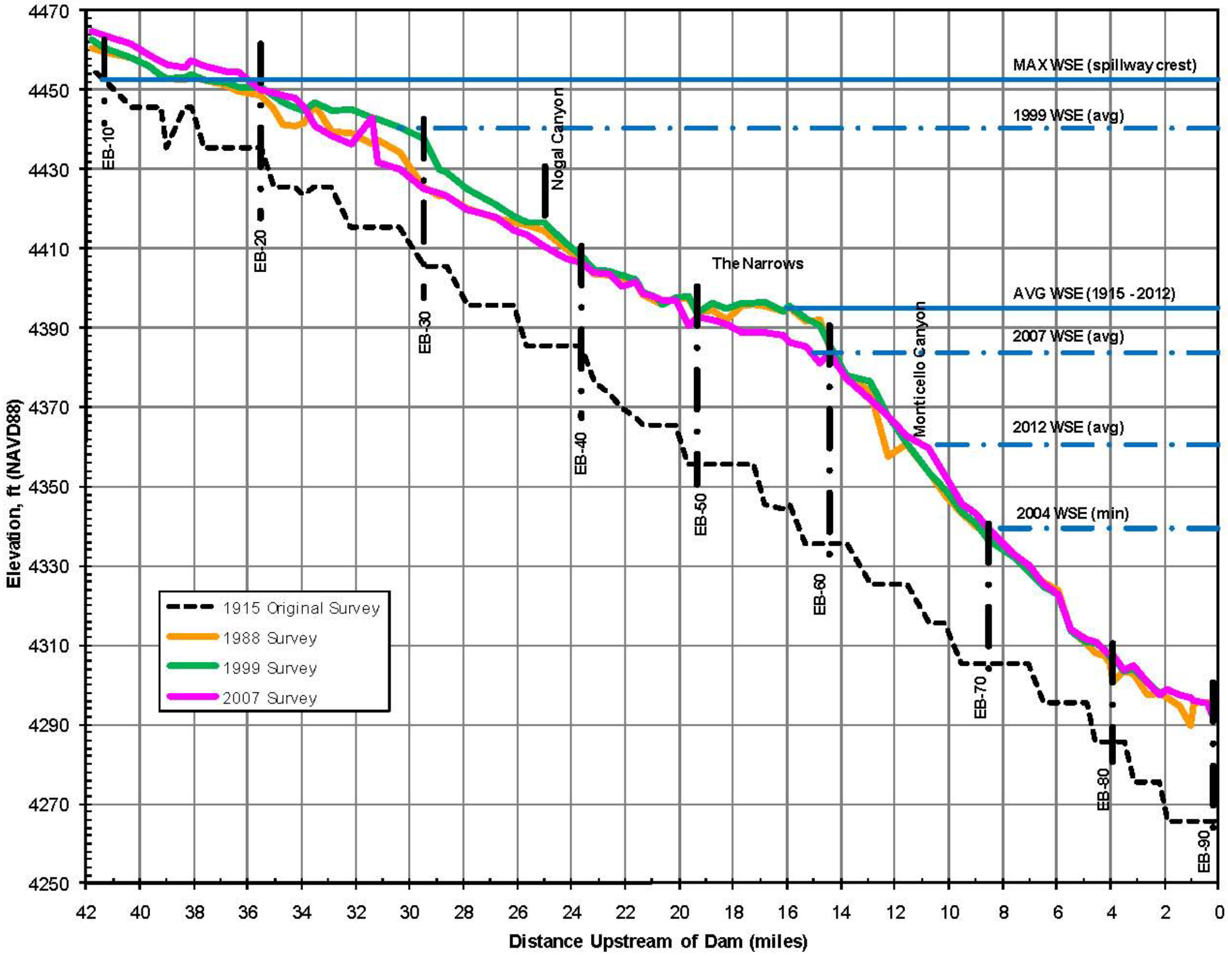


Figure 16. Elephant Butte Reservoir longitudinal profiles and pool elevations (modified from Ferrari 2008) (presented next page in an expanded view)

The 1999 longitudinal profile reveals a second pivot point at EB-30 (RM 56), just downstream of the 1999 pool location. "The reservoir pool had been mostly full and operating at an elevation between 4450 feet and 4440 feet from 1985 to 1999 so the development of a pivot point at an elevation of approximately 4438 feet is not surprising. The 1999 topset slope above EB-30 is about 70% of the 1915 bed slope, and the 1999 foreset slope is about 3 times steeper than the topset slope. As the reservoir pool continued to drop between 1999 and 2004, the previously submerged foreset slope was exposed and became the new river thalweg. This resulted in an oversteepened local slope between EB-30 and EB-33 and a relatively steep slope between EB-30 and EB-47 upstream of the Narrows" (Holste 2013).

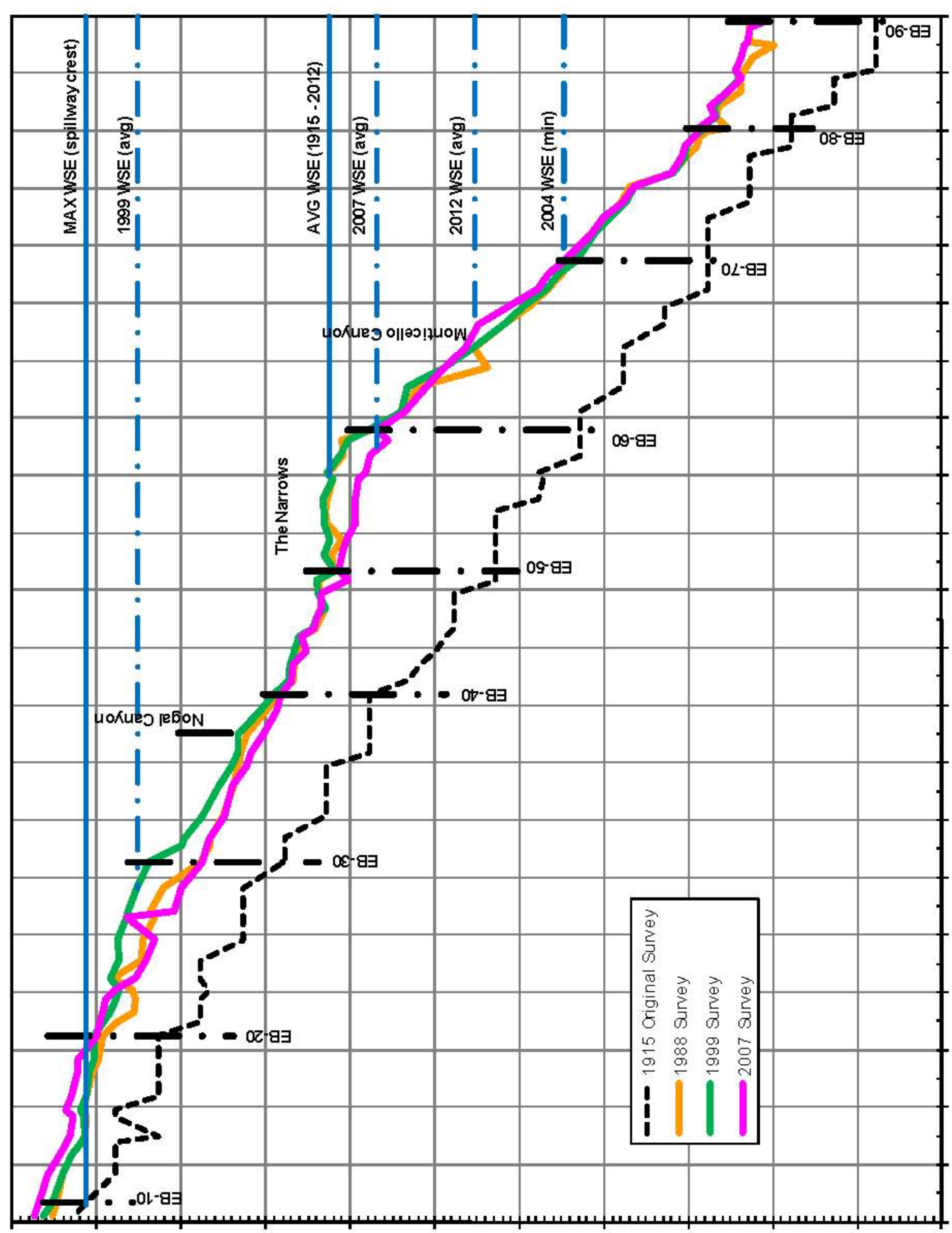


Figure 16. Elephant Butte Reservoir longitudinal profiles and pool elevations (modified from Ferrari 2008) (expanded)

Slope adjustments
Initial construction on the Delta Channel began in 1999 to restore the river's connection to the receding reservoir pool. A flowpath about 3 feet deep was excavated through the delta, whereas there was 90 feet of drop in the reservoir pool between 1998 and 2004. Comparing the 3 foot drop to the 90 foot drop makes it clear that the 3 foot excavation was not a significant base level change (as contrasted to the 90 foot drop). A sinuous design was used, such that the channel length remained within 1% of the 1972 length and the slope within the area of excavation was not overly steepened. A close examination of the 1999, 2002, and 2004 thalweg profiles reveals that it is probable that initial excavation was responsible for a local slope increase of only about 8-12% within the upper reservoir delta (from about RM 58 to RM 46). The slope was steepened somewhat (8-12%), but not overly steepened (given that the foreset slope is naturally 6.5 times steeper than the topset slope on average) (Holste 2013). Also, this slope change must be viewed in concert with slope changes caused by changes to the reservoir pool.

Figure 17 shows a clear relationship between changes in channel slope and reservoir pool elevation during the period of Delta Channel initial construction and maintenance for the two subreaches upstream of the reservoir pool: an upper subreach of 8.9 miles, measured along the thalweg, from near RM 68 to near RM 60 (EB-10 to EB-24A) and a lower subreach of 8.9 thalweg miles from near RM 60 to near RM 52 (EB-24A to EB-38). The lines connecting the discrete slope values in the figure do not represent the channel slope itself but instead are meant to show the direction of slope change. The actual values of the channel slope are labeled on the left y-axis and reversed (steeper slope values are at the bottom of the graph).

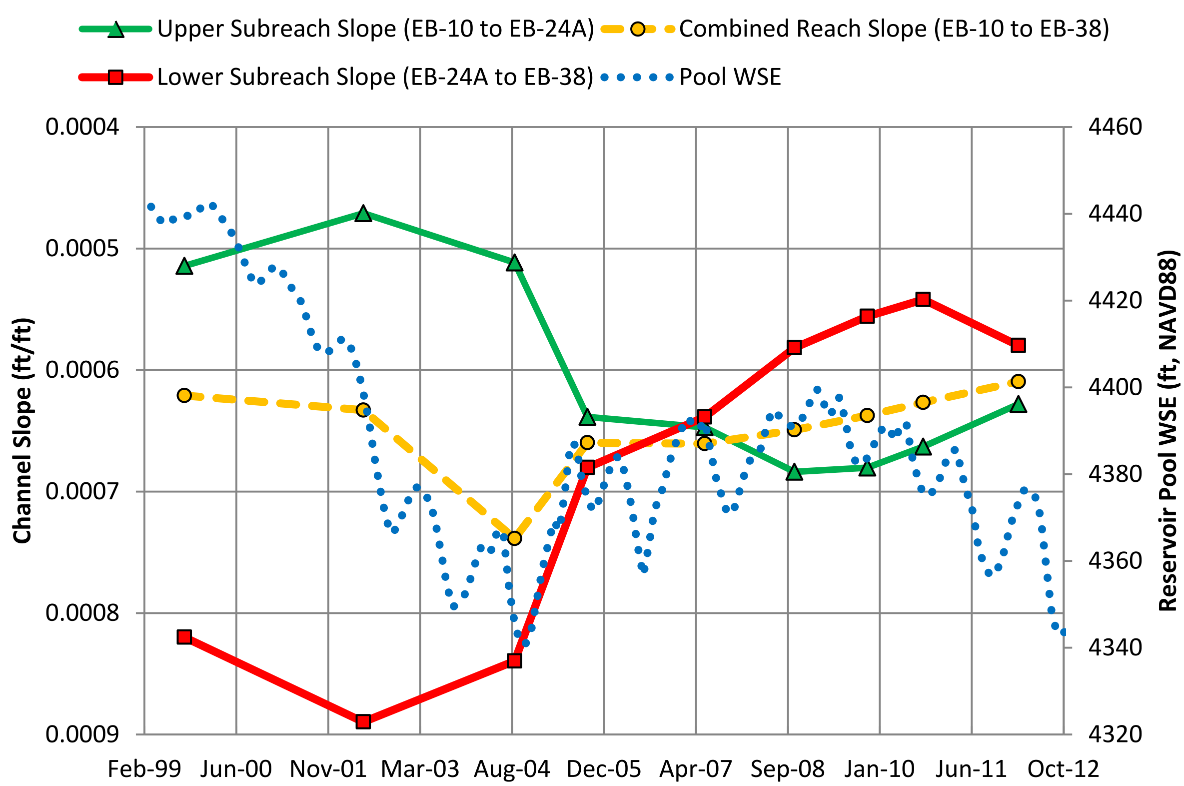


Figure 17. Changes to Rio Grande channel slope over time (1999–2012)

In 1999, the lower subreach was partially inundated by the reservoir pool and includes the transition into the upper Delta Channel work area that began in 2000. This lower subreach also contains the 1999 pivot point at EB-30. The channel slope trend of the lower subreach closely follows the pool elevation while the change in slope of the upper subreach is out of phase with changes to the pool elevation. This indicates the delayed response discussed previously for reaches further from the base level (reservoir pool). The changes in the upper subreach are naturally later in time because it is responding to changes in the lower subreach that were earlier induced by the change in reservoir pool elevation.

2005 spring runoff
The degradation that was already occurring as a result of the drop in the reservoir level was greatly accelerated in 2005 due to a confluence of several events that resulted in magnified feedback for geomorphic effects. Between 1998 and 2004, the average pool elevation dropped 90 feet. A sediment plug formed during the 2005 spring runoff slightly upstream of San Marcial that blocked most of the upstream sediment supply (in contrast to the high sediment load during degradation occurring between 1949 and 1972). Also, a high magnitude, long duration (above normal) spring runoff occurred that year. Thus, all three of the primary degradation causes (Table 7) were present in 2005: water supply increase, sediment supply decrease, and a lowered base level.

Figure 18 is a time-series plot of rangeline thalweg elevations between Highway 380 and the reservoir along with reservoir pool elevation. The figure illustrates the migration of the headcut, with degradation occurring first closer to the reservoir and a dampened effect as the changes propagate upstream. The 2005 sediment plug can be clearly seen at SO-1665. Holste (2013) discusses Figure 18: "After river connectivity was restored, sediment was eroded from the plug and deposited downstream as represented by the 2005-2007 aggradation at SO-1701.3. Attenuation of the upstream migrating headcut is depicted by degradation at SO-1665 from 2005 to 2007, and a minor or negligible amount of degradation at SO-1626 and SO-1585 from 2007 to 2008. The area between RM 78 and RM 74, represented by SO-1585 and SO-1626, has been the most stable section between Highway 380 and the reservoir pool." For a more detailed explanation of MRG slope changes and bed degradation, including the 2005 time period, see Table 3 in Holste (2013).

Geomorphic changes and Delta Channel construction and maintenance
Reclamation's assessment of geomorphic effects on the Rio Grande (Holste 2013) provides a clearer understanding than was available at the time of the 2008 Section 7 consultation for the Delta Channel. To summarize, channel degradation occurred when the average pool elevation dropped about 90 feet between 1998 and 2004, whereas the Delta Channel excavation was about 3 feet in that same time period. While the initial Delta Channel construction is estimated to be responsible for steepening the local slope (~RM 58 to RM 46) about 8 – 12%, slope changes are also clearly related to the reservoir pool levels. Finally, the headcut formed in 1999 (prior to the original Delta Channel construction in 2000), not in 2003, and migrated upstream about 3 miles between 1999 and 2004. In contrast, during the 2005 spring runoff, the headcut migrated about 10 miles upstream due to the confluence of events previously discussed. The slope change from the Delta Channel construction may have temporarily increased the rate of channel lowering after 2000, but the lower reservoir pool and 2005 events would have eventually created the elevation changes seen in the reaches upstream of the Delta Channel. Moreover, the Delta

Channel aggraded by a cumulative average of almost 3 feet from 2004 to 2010, with maintenance occurring every year (Holste 2013).

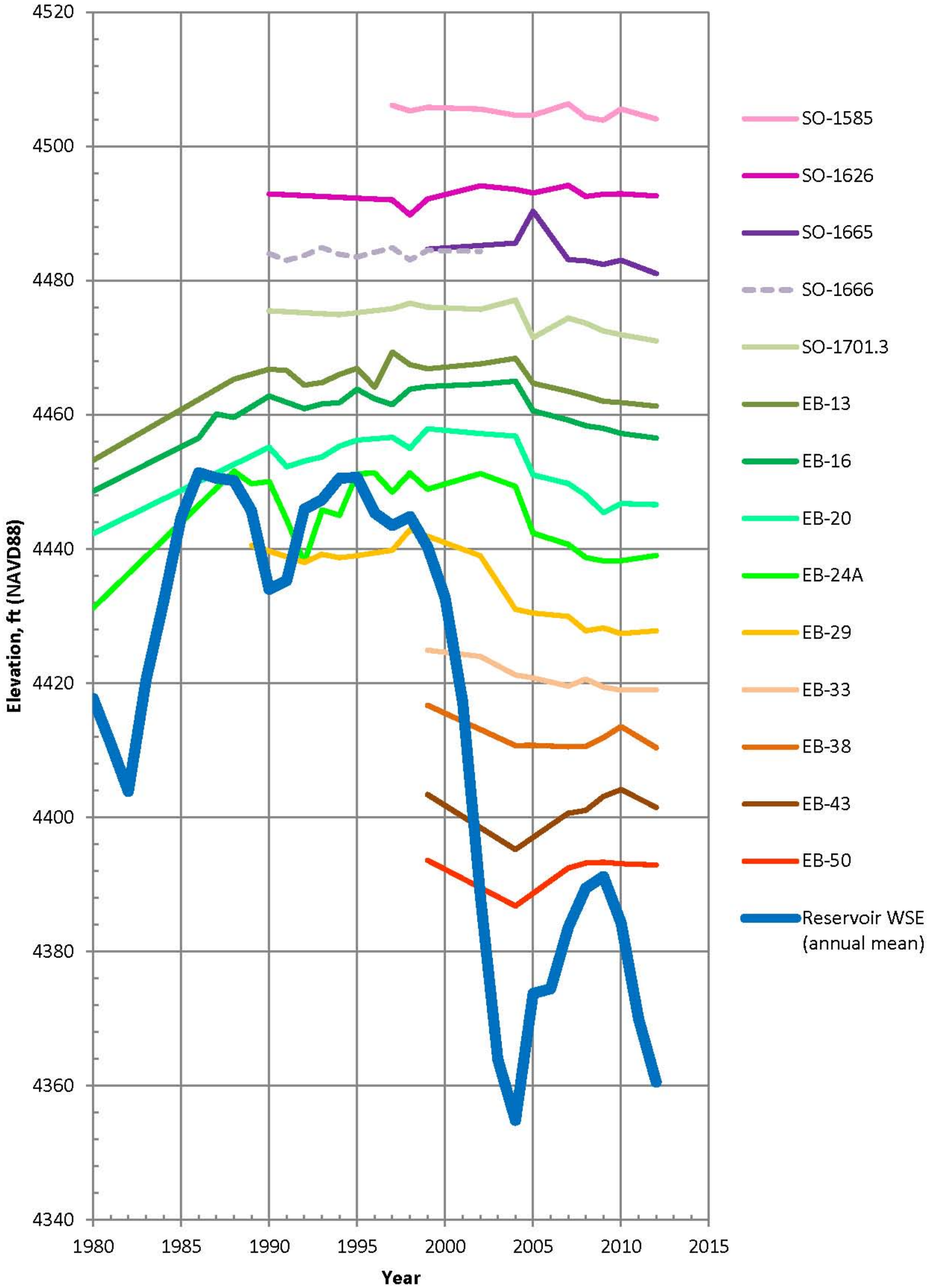


Figure 18. Change in thalweg and reservoir pool elevation over time (after Owen 2012)

Figure 19 shows a distance-weighted, reach-average thalweg elevation for the Delta Channel between 2004 and 2012, illustrating the aggradation that occurred even though sediment was frequently removed to maintain channel capacity. Also, this figure clearly highlights the similar trends in average thalweg elevation and reservoir water surface elevation.

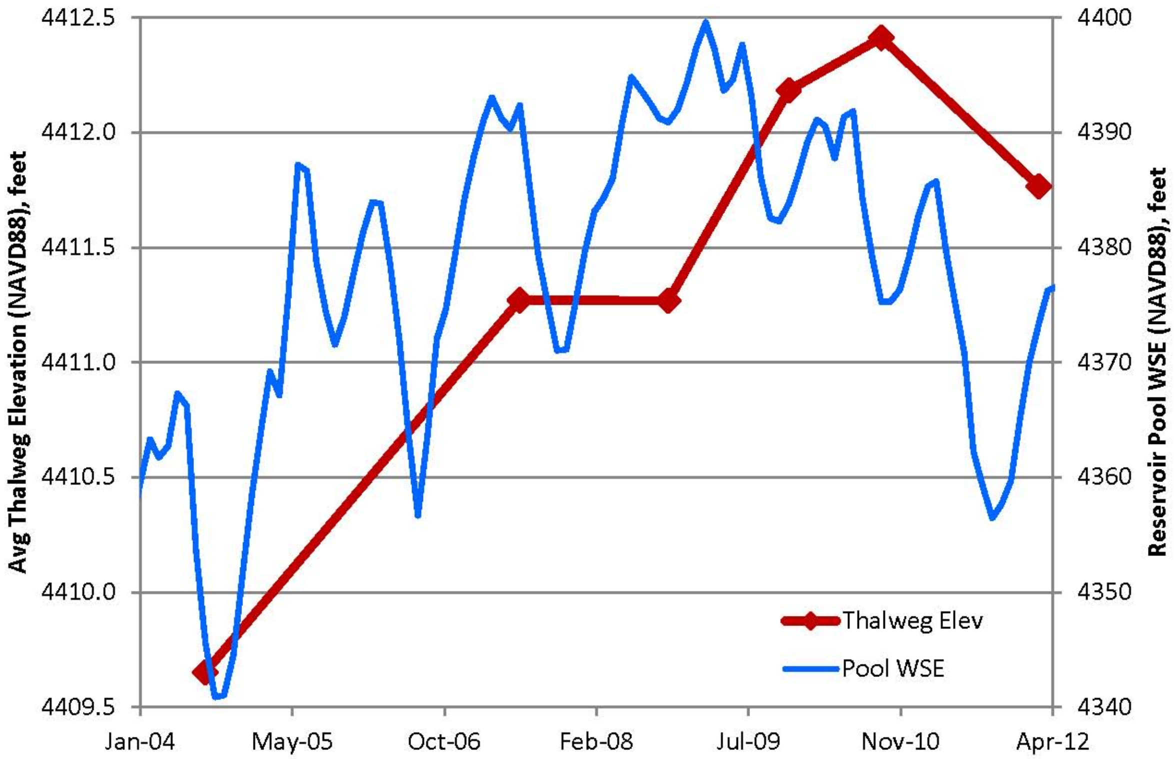


Figure 19. Distance-weighted average thalweg elevation over time for the Delta Channel between EB-28 and EB-50 during recurring channel maintenance (Holste 2013)

Furthermore, nesting in the San Marcial reach outside the reservoir pool and in the Tiffany reach has consistently been low for several years, but the number of territories have greatly expanded both upstream (in the Bosque del Apache reach) and downstream in the reservoir pool. The 2012 data shows a drop in territories in the reservoir pool, but that is clearly due to the drought and resulting reduced overbank flows in this area. These conditions have persisted with the 2013 data showing a similar, but slightly higher, number of territories. Flycatcher habitat is naturally dynamic with suitable habitat developing and then declining in relatively short periods of time. The recent decrease in nest success in the Tiffany reach is an example of this, as flycatchers disperse to more favorable sites.

4.2.3 Reclamation's efforts to minimize effects to flycatchers

Terms and conditions in the 2008 BO for the Delta Channel (then referred to as Temporary Channel) included the planning and implementation of a restoration project to establish flycatcher habitat on the Rio Grande, outside of the San Marcial Reach. Reclamation worked with the NMISC, the State Parks Division of the New Mexico Energy, Minerals and Natural Resources Department and local stakeholders on a flycatcher habitat restoration project on the Broad Canyon property along the Rio Grande approximately 15 miles north of Las Cruces. The project was completed in February 2013, with employees from the NMISC and Reclamation and volunteers from Audubon New Mexico planting 4.5 acres with 4,650 coyote willow poles and 600 Goodding's willows. Planting parameters were in accordance with the Flycatcher Recovery Plan (Service 2002) for patch size (4.5 acres) and minimum width (33 feet), as well as the density (2800 whips or poles per hectare) from the flycatcher habitat quantification report completed for the San Marcial area (Moore 2007). Monitoring of the project, including vegetation and groundwater monitoring will continue for 5 years. Once the vegetation becomes suitable, flycatcher monitoring will also take place. Additionally, in compliance with the terms and conditions of the 2008 BO and 2014 BO, Reclamation continues to monitor the river bed elevations over time and the NMISC has monitored groundwater levels in the area. The bed elevation and groundwater data was used in Reclamation's geomorphic assessment (Holste 2013).

There is a significant amount of flycatcher habitat outside of the berms of the Delta Channel that occurs as a result of breaks in the berms and high groundwater. These breaks may be constructed or naturally occurring inflow breaches which allow natural drainage into the Delta Channel and prevent water from accumulating behind the berms, thus compromising their stability. Additionally, these openings allow water from the river to inundate areas behind the berms during the snowmelt runoff, providing a measure of ecosystem function to those areas. These openings will be maintained as necessary within the limits of the existing Delta Channel footprint. The determination to create breaks will be evaluated through an annual adaptive maintenance approach based on the river and reservoir conditions and influenced by habitat for listed species.

4.2.4 Salt cedar leaf beetle

The salt cedar leaf beetle (*Diorhabda* spp.) (beetle) was released in field cages in six states (California, Nevada, Utah, Texas, Colorado, and Wyoming) in 1999 and field released in 2001 (DeLoach et al. 2003). The beetles defoliate salt cedar during the growing season, which corresponds to the flycatcher breeding season, and take multiple years of continuous defoliation to eventually kill salt cedar (Paxton et al. 2011). The abundance of beetles may provide a temporary food source for flycatchers, however, once defoliation takes place it is likely that other foliage feeding insects would disperse (Paxton et al. 2011). With reduced canopy cover as well as food source, flycatchers occupying habitat composed of mainly salt cedar would be at a disadvantage.

At this time, the Kazakhstan ecotype of the beetle is moving south along the Rio Grande and has been observed as far south as the confluence of the Rio Grande and the Rio Puerco. Also, the Tunisian ecotype of the beetle is moving north from Texas and has been observed as far north as La Mesa, NM (Johnson pers. comm.). Within the MRG, flycatchers use salt cedar as a nesting substrate at a disproportionate rate, which is a concern due to the inevitable expansion of the beetle.

4.3 Current Status of Yellow-billed cuckoo in Action Area

4.3.1 Presence

In Ahlers and Moore's 2013 survey of yellow-billed cuckoos in the Middle Rio Grande (State Highway 60 downstream to Elephant Butte Reservoir), the San Marcial Reach (RM 68.5 to 38.5) had the largest amount of cuckoo habitat of any of the other reaches in the survey. Their survey results indicate that the number of cuckoos detected and the number of territories occupied was also the highest and most consistent over time in this reach. Figure 20 shows the numbers of detections and territories over the last five years in the San Marcial Reach. Appendix B shows general locations of territories; for more specific locations of recent territories in the action area, see Moore and Ahlers (2014).

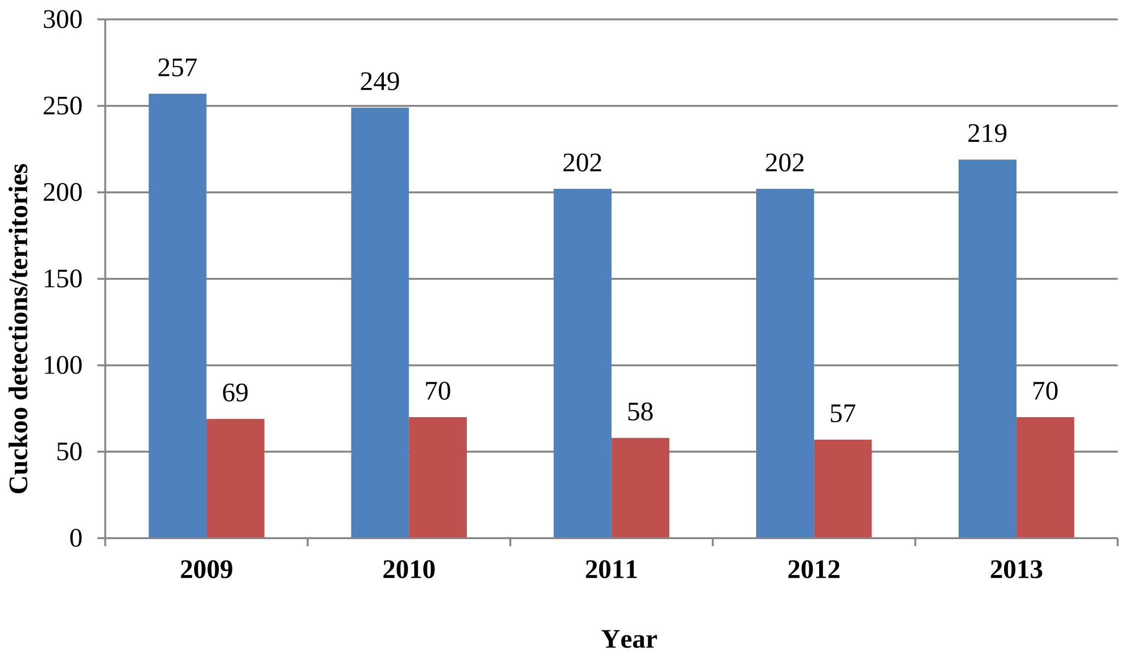


Figure 20. Cuckoo detections (blue columns) and territories (red columns) in San Marcial Reach (Ahlers and Moore 2014). Surveys have been conducted since 1998 but methods were not refined or consistent until 2009.

Cuckoos and suitable cuckoo habitat are not expected to occur within the Delta Channel because it has been maintained, as proposed in this BA, since 1999 and it is occasionally scoured by high flows from spring runoff and/or monsoons. Cuckoos and their habitat are present in areas that are adjacent to the channel, outside of the berms, where suitable vegetation exists.

4.3.2 Geomorphology

The analysis in section 4.2.2 Geomorphology considers the geomorphic and hydrologic factors affecting flycatcher presence in the San Marcial Delta. The specifics of that analysis will not be repeated here; however, the conclusion that prior Delta Channel maintenance was not responsible for the loss of flycatcher habitat also holds true for cuckoos and their habitat. Over time, natural geomorphic processes will likely change again, as will habitat. So, while some habitat is lost due to river degradation induced by lowering of the Reservoir, habitat in other areas increases (e.g. the Narrows, Bosque del Apache).

4.3.3 Reclamation's efforts to minimize effects to cuckoos

As stated in more detail in Section 4.2.3 above, the terms and conditions in the 2008 BO for the Delta Channel included the planning and implementation of a restoration project to establish flycatcher habitat on the Rio Grande, outside of the San Marcial Reach. These efforts will also directly benefit cuckoos. Additionally, in compliance with the terms and conditions of the 2008 BO, Reclamation continues to monitor the river bed elevations over time and NMISC has monitored groundwater levels in the area. The bed elevation and groundwater data were used in Reclamation's geomorphic assessment in Holste 2013.

There is a substantial amount of cuckoo habitat outside of the berms of the Delta Channel that occurs as a result of breaks in the berms and high groundwater. These breaks may be constructed or naturally occurring inflow breaches which allow natural drainage into the Delta Channel and prevent water from accumulating behind the berms, thus compromising their stability. Additionally, these openings allow water from the river to inundate areas behind the berms during the snowmelt runoff, providing a measure of ecosystem function to those areas. These openings will be maintained as necessary within the limits of the existing Delta Channel footprint. The determination to create breaks will be evaluated through an annual adaptive maintenance approach based on the river and reservoir conditions and influenced by habitat for listed species.

4.4 Current Status of New Mexico Meadow Jumping Mouse in Action Area

4.4.1 Presence

Mice are not expected to occur within the action area for many reasons. First, the Delta Channel and associated access road and staging areas have been maintained approximately annually by actions similar to those proposed in this BA since 1999. Annual scouring events from spring runoff and/or monsoon flows also contribute to the lack of vegetation and suitable habitat for the mouse. Next, the project area is below 4500 feet (above mean sea level), an elevation that Frey has indicated as a cutoff point for mice (Frey 2013). There is also a lack of moist soils supporting appropriate herbaceous species on berms (Frey 2013) and the berms are steep sided and composed of dry, sandy soils that would not be suitable for burrowing for maternal nesting or hibernation (Ryan pers. comm.). Finally, in similar habitat on BDANWR, Frey and Wright (2012) did not find mice within the Rio Grande floodplain and also did not consider it potentially suitable habitat.

Although trapping surveys for the mouse have not been done in the project area, Frey and Kopp (2014) completed a preliminary assessment of mouse habitat down to RM 38 using GIS-based vegetation mapping and field evaluations of state drains and the Low Flow Conveyance Channel. The mapping exercise did identify potentially suitable habitat (herbaceous and regenerating willow) adjacent to the channel, outside of the berms up to the uplands, but because of the coarseness of the available data, this was a conservative effort which overestimated the amount of potential habitat. The field evaluation portion of the assessment was done approximately every mile, depending on access, down to approximately RM 55.3. Four sites in the upper end of the Upper Reach of the project area were assessed (between RM 55 and RM 58), and none of these sites were considered to be potentially suitable habitat (Frey and Kopp 2014). The nearest known, occupied mouse habitat is upstream of the project area along manmade canals in dense herbaceous habitats at BDANWR (Frey and Wright 2012), over 16 river miles upstream. Based on an October 2014 survey of action area sites where there was potentially suitable habitat identified by Frey and Kopp (2014), only the Pete Well launching site was considered to possibly have suitable habitat (Ryan pers. comm., Stuart pers. comm.). While it is not considered likely to contain suitable mouse habitat, the Pete Well equipment launching site will be resurveyed in June or July 2015 to make the final determination. The nearest designated critical habitat for the mouse is at BDANWR.

The habitat that Frey and Kopp (2014) identified outside of the Delta Channel berms via GIS is primarily composed of large woody vegetation and/or herbaceous vegetation consisting mostly of cattails (*Typha* spp.). These areas are inundated at least annually in the winter by high groundwater and sometimes during the monsoon season (Armstrong pers. comm.), which provides excellent conditions for the type of habitat that is preferred by flycatchers and cuckoos but not the mouse (Stuart pers. comm.). Only the portions of the potentially suitable mouse habitat that Frey and Kopp (2014) identified that intersected with the project work sites were visited in October, so there remains a slim chance that there could be mouse habitat adjacent to project activities, outside of the berms, but these are not areas that are expected to be impacted by the proposed actions in this BA.

4.4.2 Geomorphology

The analysis in section 4.2.2 Geomorphology considers the geomorphic and hydrologic factors affecting flycatcher presence in the San Marcial Delta. The specifics of that analysis will not be repeated here; however, the conclusion that prior Delta Channel maintenance was not responsible for the loss of flycatcher habitat also likely holds true for mice and their habitat. Over time, natural geomorphic processes will likely change again, as will habitat. So, while some habitat is lost due to river degradation induced by lowering of the Reservoir, habitat in other areas increases (e.g. the Narrows, Bosque del Apache).

4.4.3 Reclamation’s efforts to minimize effects to mice

Because the mouse was just recently listed, efforts to minimize effects to the mouse have been limited to date. Reclamation did, however, fund Frey and Kopp’s (2014) survey of mouse habitat along the Delta Channel, which has helped to define potentially suitable habitat. Though these data are coarse and need to be refined with on-the-ground habitat surveys, it is a good start in our understanding of where suitable habitat for this species may occur, if it does, south of

BDANWR. As time moves forward, Reclamation will continue efforts to define mouse habitat near the Delta Channel and incorporate Conservation Measures, as appropriate.

5.0 Effects of the Action

Effects of the proposed action are summarized in Table 8 below.

The designated critical habitat for the minnow extends to the power lines (approx. RM 62), upstream of the action area for in-channel work. Road maintenance will extend on roads up to RM 62 but does not involve any work in the channel itself; therefore, there is no minnow critical habitat within the Delta Channel maintenance action area, which is downstream of the power lines (approx. RM 62) and within the reservoir pool (Figure 21).

Designated critical habitat for the flycatcher and proposed critical habitat for the yellow-billed cuckoo includes the Elephant Butte Reservoir area down to RM 54 (Figure 21).

There is no proposed mouse critical habitat within the Delta Channel maintenance action area. The nearest proposed mouse critical habitat is located about 16 river miles upstream of the project area at Bosque del Apache National Wildlife Refuge (BDANWR) (Figure 21).

Table 8. Summary of direct and indirect effects of proposed action on listed species and designated/proposed critical habitat in the reservoir pool

Action	***Effects on minnow***	***Effects on flycatcher and designated critical habitat***	***Effects on cuckoo and proposed critical habitat***	***Effects on mouse***
Site access maintenance	Direct – no effect because only existing roads will be maintained, there is no in-water work for this action, and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Direct – no effect because only existing roads will be maintained, roads are not in flycatcher habitat, and vegetation control will be done when flycatchers are not present	Direct – no effect because only existing roads will be maintained, roads are not in cuckoo habitat, and vegetation control will be done when cuckoos are not present	Direct – no effect because there is no suitable mouse habitat on or adjacent to roads
	Indirect – no effect because only existing roads will be maintained, there is no in-water work for this action, and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because only existing roads will be maintained and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because only existing roads will be maintained and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because there is no suitable mouse habitat on or adjacent to roads

Staging area maintenance	Direct – no effect because only existing roads will be maintained, there is no in-water work for this action, and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Direct – no effect because only existing roads will be maintained, roads are not in flycatcher habitat, and vegetation control will be done when flycatchers are not present	Direct – no effect because only existing roads will be maintained, roads are not in cuckoo habitat, and vegetation control will be done when cuckoos are not present	Direct – no effect because there is no suitable mouse habitat on or adjacent to staging areas
	Indirect – no effect because only existing roads will be maintained, there is no in-water work for this action, and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because only existing roads will be maintained and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because only existing roads will be maintained and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because there is no suitable mouse habitat on or adjacent to staging areas
Equipment launching site maintenance	Direct – may affect, likely to adversely affect because movement of excavators, airboats, and fuel transporter in the side channel and excavation of sediment from the side channel may disturb or injure minnows	Direct – no effect because only existing launching sites will be maintained, sites are not in flycatcher habitat, and vegetation control will be done when flycatchers are not present	Direct – no effect because only existing launching sites will be maintained, sites are not in cuckoo habitat, and vegetation control will be done when cuckoos are not present	Direct – no effect because there is no suitable mouse habitat on or adjacent to equipment launching sites; although unlikely, there may be an effect to mice at the Pete Well site if this site is determined to be suitable habitat during a habitat survey in June or July 2015
	Indirect – may affect, not likely to adversely affect because existing sites are being used and Conservation Measures are in place to minimize risk to water quality (spills, etc.)	Indirect – no effect because only existing launching sites will be maintained and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because only existing launching sites will be maintained and only Service-approved herbicides (and recommended buffers) will be used for vegetation control	Indirect – no effect because there is no suitable mouse habitat on or adjacent to equipment launching sites; although unlikely, there may be an effect to mice at the Pete Well site if this site is determined to be suitable habitat during a habitat survey in June or July 2015

Maintenance of existing Delta Channel and the naturally formed channel below RM 38	Direct – may affect, likely to adversely affect because movement of excavators, airboats, and fuel transporter in the channel and excavation of sediment from the channel may harass or injure minnows	Direct – may affect, not likely to adversely affect because maintenance activities will not occur between April 15 and September 1 when flycatchers would be present, and overbanking at both constructed and natural breaches which provides and maintains flycatcher habitat outside of the berms will be allowed to continue	Direct – may affect, not likely to adversely affect because maintenance activities will not occur between April 15 and September 1 when cuckoos would be present, and overbanking at both constructed and natural breaches which provides and maintains cuckoo habitat outside of the berms will be allowed to continue	Direct – no effect because there is no suitable mouse habitat within the channel or on the berms
	Indirect – may effect, not likely to adversely affect because Conservation Measures are in place to minimize risk to water quality (spills, etc.)	Indirect – no effect because vegetation removed in the channel is not flycatcher habitat and channel degradation caused by the proposed action is not expected to occur; thus, it will not affect adjacent or upstream flycatcher habitat	Indirect – no effect because vegetation removed in the channel is not cuckoo habitat and channel degradation caused by the proposed action is not expected to occur; thus, it will not affect adjacent or upstream cuckoo habitat	Indirect – no effect because there is no suitable mouse habitat within the channel or on the berms
Connecting isolated pools and channels in lower reach	Direct – may affect, likely to adversely affect because movement of excavators, airboats, and fuel transporter in the channel and excavation of sediment from the channel may harass or injure minnows	Direct – no effect because channel excavation would occur in areas where no flycatcher habitat exists and maintenance activities will not occur between April 15 and September 1 when flycatchers could be present in nearby locations	Direct – no effect because channel excavation would occur in areas where no cuckoo habitat exists and maintenance activities will not occur between April 15 and September 1 when cuckoos could be present in nearby locations	Direct – no effect as maintenance activities would not occur in mouse habitat
	Indirect – may affect, not likely to adversely affect because Conservation Measures are in place to minimize risk to water quality (spills, etc.)	Indirect – no effect as channel excavation would occur in areas where no flycatcher habitat exists	Indirect – no effect as channel excavation would occur in areas where no cuckoo habitat exists	Indirect – no effect as maintenance activities would not occur in suitable mouse habitat

Re-fueling Equipment	Direct – may affect, likely to adversely affect because movement of excavators, airboats, and fuel transporter in the channel and excavation of sediment from the channel may harass or injure minnows	Direct – no effect, as equipment refueling would occur in areas where no flycatcher habitat exists	Direct – no effect, as equipment refueling would occur in areas where no cuckoo habitat exists	Direct – no effect, as equipment refueling would occur in areas where no mouse habitat exists
	Indirect – may affect, not likely to adversely affect because Conservation Measures are in place to minimize risk to water quality (spills, etc.)	Indirect – no effect to flycatchers or habitat as refueling would occur where no flycatcher habitat exists	Indirect – no effect to cuckoos or habitat as refueling would occur where no cuckoo habitat exists	Indirect – no effect, as equipment refueling would occur in areas where no mouse habitat exists
Pumping water from river for dust abatement	Direct – may affect, not likely to adversely affect because of small amount of water being pumped, pump intake will be screened, no pumping will occur during the spawning season (May 1 to July 1) and Reclamation will coordinate with the Service if pumping is needed from September 1 to October 31 (end of irrigation season)	Direct – no effect to flycatchers or habitat, pumping sites will be at existing equipment launching areas, and dust abatement activities will occur on existing roads and staging areas and when flycatchers are not present	Direct – no effect to cuckoos or habitat, pumping sites will be at existing equipment launching areas, and dust abatement activities will occur on existing roads and staging areas and when cuckoos are not present	Direct – no effect as pumping would not occur in suitable mouse habitat; although unlikely, there may be an effect to mice at the Pete Well site if this site is determined to be suitable habitat during a habitat survey in June or July 2015
	Indirect – may affect, not likely to adversely affect because of small amount of water being pumped, pump intake will be screened, no pumping will occur during the spawning season (May 1 to July 1) and Reclamation will coordinate with the Service if pumping is needed from September 1 to October 31 (end of irrigation season)	Indirect – no effect to flycatchers or habitat	Indirect – no effect to cuckoos or habitat	Indirect – no effect as pumping would not occur in suitable mouse habitat; although unlikely, there may be an effect to mice at the Pete Well site if this site is determined to be suitable habitat during a habitat survey in June or July 2015

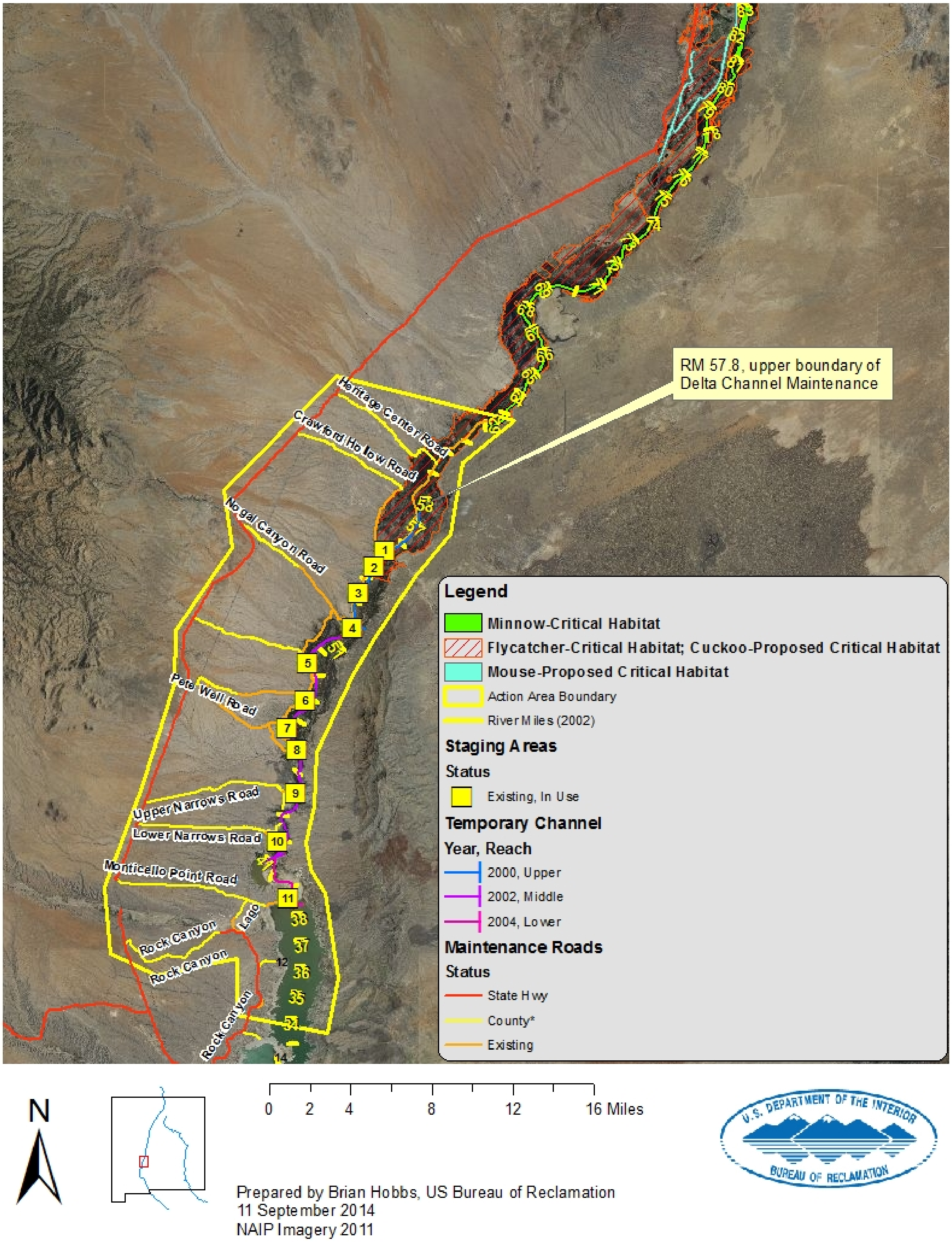


Figure 21. Critical Habitat for minnow, flycatcher, cuckoo, and mouse near, or in, the project area

5.1 Rio Grande Silvery Minnow

5.1.1 Direct Effects

Potential effects to minnows are summarized in Table 8 above.

Site access and staging areas: All necessary project-related roads, staging areas, and equipment launching sites have been built and maintained to date. There is access from the uplands to the Delta Channel along existing access roads (Figure 8). No new access roads, staging areas, or equipment launching sites are planned at this time. If they should become needed, Reclamation will coordinate with the Service prior to any construction activity.

Road maintenance such as grading and washout repair may be performed throughout the year to maintain safe access to and from the river and are not expected to affect minnows because access roads are not in or adjacent to minnow habitat. Vegetation along access roads and on staging areas will be mowed and/or treated with herbicides and applicators will follow the label directions and observe Service-recommended buffer zones (see Table 5), so herbicide treatment is also not expected to affect minnows.

Annual staging area maintenance is also not expected to affect minnows because maintenance does not occur in minnow habitat and herbicide treatment will follow the label directions and observe Service-recommended buffer zones (Table 5).

Reclamation assumes there are minnows present in the side channels that lead to the Delta Channel from the equipment launching sites. Movement of excavators, fuel transporters, and airboats and excavation of sediment during the maintenance of the equipment launching sites and associated side channels may harass or injure minnows. These effects would likely be of short duration and the equipment moves slowly enough to allow minnows to escape to safety. Also, increases in turbidity and suspended sediments would likely have minimal effect because minnows are expected to have fled the area as the excavators move into place to begin activity. The distance from the equipment launching sites to the Delta Channel averages about 500 feet. Direct effects from the equipment once it enters the river channel are described in the following section *Delta Channel maintenance*.

Delta Channel maintenance: Channel maintenance, including maintenance of the naturally formed channel below RM 38 (as needed), will be done every year, with the excavators moving in the channel to work sites, working at the work site, and returning to a staging area. Maintenance activities will include maintaining existing berms and removing vegetation within the channel and on the berms (as needed), as well as removing a portion of accumulated sediment to maintain the channel capacity (some aggradation will likely remain depending on reservoir pool elevation). These maintenance activities will not occur between April 15 and September 1. An exception to this would be in the case of emergency channel and berm repairs during spring runoff, and we expect that this event would happen once in a five year period for a period of two weeks near the end of runoff. If emergency channel and/or berm repairs are needed, Reclamation will coordinate the activity with the Service.

The amphibious excavators move slowly at an average speed of two miles per hour (mph) and the fuel transporter about ten mph along the channel. The swath of disturbance can be considered to be 24 feet (ft) for the excavator with a three-foot avoidance area on either side for a total of 30 ft. This slow movement should allow for fish to be able to move away from the excavator. An estimation of the portion of the impacted area by the Delta Channel maintenance work each year is as follows (computation details are provided in Appendix A.):

- 75 to 100% of the total channel length is traveled by an amphibious excavator and fuel transporter. The excavator and transporter generally travel from the equipment staging areas to the work sites and back. This computes to an estimated 944 acres of channel disturbance in most years. If workload requires a third crew, there would possibly be an additional 629 acres of channel disturbance, for a total possible 1573 acres per year in those years with three crews

- Active work sites, where excavation is performed within the channel, are estimated to cover approximately 25% of the entire channel area each year for most years. For most years where two crews are needed, this computes to an estimated 113 acres per year that will have an excavator working within the existing channel area. If workload requires a third crew, there would possibly be an additional 82 acres per year that would have an excavator working within the existing channel area. Thus, the total possible area of active work sites would be 195 acres per year in those years with three crews.

Reclamation assumes that minnows are present in the Delta Channel when the excavators are moving in the channel to the work sites and at the work sites. As the excavators move along the channel, they displace water which cause the fish to flee the area, but this is short in duration. As shown above and in more detail in Appendix A, Reclamation is estimating the area maintained per year as an attempt to establish an area of impact, but there is no way to know up front the exact level of work for each year because the sediment load and flows are dependent on spring runoff, the summer monsoons, and localized rain storms. Channel excavation may also cause localized increases in turbidity and suspended sediments, but minnows are expected to have fled the area as the excavators move into place and/or begin activity.

Connecting isolated pools and channels in the lower reach: Maintenance of the lower reach may also include excavation of secondary channels that would extend a short distance from the main Delta Channel to connect water-holding low areas that occur as the reservoir fluctuates. Minnows are not expected to be found within the reservoir, and these low areas with water should not have minnows present prior to being connected to the main Delta Channel. Short-term adverse effects on minnows could occur during excavation at the confluence of the secondary channels and the Delta Channel, but minnows are expected to exhibit an avoidance response to the excavator activity. These secondary channels will extend a distance of no more than ½ mile from the main Delta Channel.

Airboat Transport: Daily transport of personnel and fuel to the equipment via airboats has limited disturbance but does not expose fish to propeller blades. Normal avoidance behavior would protect all fish species from injury by airboats in the river, and airboats move mainly along the thalweg of the channel.

Refueling: Even though refueling over water has been done with the excavators for many years without any major spills and each excavator has a fuel spill kit, there is a potential for a fuel spill. The fuel spill would be limited to the area of the spill and downstream. The buoyancy of diesel fuel would keep it on the water surface until it evaporates or is contained and absorbed by a fuel spill kit. Given the low risk of a spill occurring and the measures in place to minimize risk should a spill occur, the risk to silvery minnows from refueling is discountable.

Pumping Water from the River: To provide dust abatement for access road and staging area maintenance and safety during high traffic periods, water may be pumped from the river at or near existing equipment launching areas, requiring no new ground disturbance. Pumping rates will vary between 1.8 and 2.2 cfs, requiring four to eight minutes to fill a water truck. This would be a minimal impact to river flows, equating to a decrease in flows of approximately 0.7% for river flows of 300 cfs and approximately 0.2% for river flows of 800 cfs for four to eight minutes. A typical project may use four to six truckloads per day and, at a maximum, 18 truckloads per day. This project is expected to use the typical amount or less. Pump intake pipes will use a 0.25 in (0.64 cm) mesh screen at the opening to the intake hose to minimize entrainment of aquatic organisms. Sumps or secondary channels adjacent to the river will be used whenever feasible.

Pumping is not expected to be needed between April 15 and September 1. If pumping is needed between May 1 and July 1 (emergencies only), Reclamation will coordinate with the Service to avoid impacts to minnow eggs and larvae. After September 1and before the end of the irrigation season (October 31), flows in the Delta Channel may be low. To avoid impacts to juvenile and adult minnows during this period, Reclamation will coordinate with the Service prior to pumping.

5.1.2 Indirect Effects

The Delta Channel continues to provide additional habitat for the minnow that did not exist prior to the construction of the Delta Channel. Furthermore, the Delta Channel has remained wet under the recent severe drought conditions and likely provided habitat for minnows, given the species presence in this area during October and February sampling. The habitat for the minnow is likely good within the Delta Channel because the original construction provided sinuosity (meandering). Sinuosity is beneficial to the minnow as it provides variable depth and flow velocity, that help to create preferred habitat conditions for juvenile and adult minnows. The thalweg is allowed to meander in both upper and middle reaches which allows for the formation of point bars, underwater shelves, and small backwater areas. These naturally-formed features are constantly being created by the channel flow and do not need to be artificially constructed. Occasionally, point bars are removed in order to maintain the design conveyance capacity of the 250 foot wide channel, and to maintain the low flow channel with effective sediment transport capacity, which has a width that varies from 50 to 100 feet. The maintenance program aims to allow these dynamic and natural processes to continue to provide quality habitat for minnows while achieving the goal of conveyance to the reservoir.

The removal of excess sediment does not change the composition of the substrate, and the channel bed is kept at a shallow, stable level. The increase in turbidity and suspended sediments caused by excavation may temporarily decrease primary production and negatively impact aquatic invertebrates, a food base for silvery minnows. However, any excavation related increase in turbidity would be of short duration and minor compared to the high sediment concentration already present. Also, Conservation Measures (water quality monitoring, compliance with CWA permitting processes) will help minimize the risks due to dispersal of suspended sediments. Therefore, no significant indirect effects are expected to occur due to suspended sediments.

The proposed action does not occur within minnow critical habitat and the proposed action will have no effect on upstream designated critical habitat, because maintenance of the existing Delta Channel will not cause bed degradation within or upstream of the Delta Channel (see section 5.2.2 or for a detailed discussion, Holste 2013). Channel bed lowering is expected to occur as long as the reservoir pool continues to lower, but that would occur due to natural geomorphic processes whether maintenance activities occurred or not. In fact, a natural channel with defined banks has already formed for a distance of one mile where the reservoir receded below RM 37.

5.2 Southwestern Willow Flycatcher

5.2.1 Direct Effects

Potential effects to flycatchers are summarized in Table 8 above.

Site Access and staging areas: All necessary project-related roads, staging areas, and equipment launching sites have been built and maintained to date. There is access from the uplands to the Delta Channel along existing access roads (Figure 8). No new access roads, staging areas, or equipment launching sites are planned at this time. If they should become needed, Reclamation will coordinate with the Service prior to any construction activity.

Road maintenance such as grading and washout repair may be performed throughout the year to maintain safe access to and from the river. Vegetation control is not planned to occur between April 15 and September 1. The majority of roads are in upland areas, and some roads are near flycatcher habitat, including within the critical habitat designation. Grading and washout repair have occurred routinely for several years between April 15 and September 1 with no negative impacts to flycatchers, which have continued to nest successfully near the roads. Vegetation along access roads and on staging areas will be mowed or treated with herbicides that are Service-approved for use near flycatcher habitat. All herbicide applications will follow the label directions and observe Service-recommended buffer zones (see Table 5).

Vegetation control consisting of mowing and herbicide treatment is not anticipated between April 15 and September 1. The areas treated consist mostly of young salt cedar, are not suitable habitat, and do not meet the criteria for overall critical habitat. If mowing should be needed between April 15 and September 1, migratory bird surveys (April 15 to August 15) or cuckoo surveys (June 1 to September 1) will be conducted prior to mowing and no mowing will occur within a 0.25 mile buffer of any nests found. Therefore, road maintenance will have no effect on flycatchers or critical habitat.

Maintenance work (including grading and vegetation control) on staging areas and equipment launching sites will occur between September 1 and April 15. If mowing should be needed between April 15 and September 1, migratory bird surveys (April 15 to August 15) or cuckoo surveys (June 1 to September 1) will be conducted prior to any work being done and no mowing will occur within a 0.25 mile buffer of any nests found. Therefore, staging area and equipment launching site maintenance will not affect flycatchers or critical habitat.

Delta Channel Maintenance: Channel maintenance, including maintenance of the naturally formed channel below RM 38 (as needed), will be done every year, with the excavators moving in the channel to work sites, then working at the work site, and returning to a staging area. Channel maintenance activities will not occur between April 15 and September 1. An exception to this would be in the case of emergency channel and berm repairs during the spring runoff, and we expect that this event would happen once in a five year period for a period of two weeks near the end of runoff. If emergency channel and/or berm repairs are needed, Reclamation will coordinate the activity with the Service.

Maintenance activities will include maintaining existing berms and removing vegetation within the Delta Channel, as well as removing a portion of accumulated sediment to maintain channel capacity (some aggradation will likely remain depending on reservoir pool elevation). The vegetation to be removed is located in small areas on sandbars within the channel, and is not suitable habitat for flycatchers, both in patch size and vegetation maturity. Vegetation on the sides and tops of berms contributes to the desired stability of the berms and will not be removed, except in rare cases where feasibility and/or operator safety may be concerned. Two such rare cases where vegetation may need to be removed on the berms, are: 1) when vegetation lower on the inside of a berm interferes with the required channel capacity; and 2) on the outside of a meander bend where the channel is too deep for an excavator to safely work and the work must be done from the top of the berm. In the latter case, berm vegetation would be removed or moved out of the way so that the equipment operator can safely work from the top of the berm. Vegetation on any part of the berms is not habitat for flycatchers because it is sparse and does not have the required habitat elements needed by the flycatcher. This is likely because the dry soil that makes up the berms is a poor substrate for vegetation growth. Excavators and the maintenance activity for all reaches will be confined to the area within the existing construction footprint (berms and channel) and would not affect vegetation in adjacent areas.

Overbanking at both constructed and natural breaches in the berms would likely increase the development of flycatcher habitat as well as improve vegetative health and territory establishment outside of the berms. Maintenance of the wing wall will no longer occur in order to preserve the flycatcher habitat that has developed in this location. Sediment plugs within the Delta Channel need to be removed to improve water delivery; however, prior to removal, sediment plugs temporarily increase overbank flows in the local area, benefitting the vegetation.

Work will be done when flycatchers are not present, only unsuitable habitat would be removed within the channel, and overbanking at breaches will be allowed to continue; therefore, activities related to Delta Channel maintenance may affect but will not likely adversely affect flycatchers. Critical habitat may be affected, but will not likely be adversely affected because there is only a small amount of designated critical habitat in the upper part of the project area and the effect of removing small areas of non-suitable habitat within the channel is insignificant and will not diminish the capability of existing critical habitat to satisfy the essential requirements for the flycatcher. Furthermore, overbanking of breaches in the berms, which provides and maintains flycatcher habitat outside of the berms throughout the action area (including in the Upper Reach where there is designated critical habitat), will be allowed to continue.

Connecting isolated pools and channels in the lower reach: Maintenance of the lower reach may also include excavation of secondary channels that would extend a short distance (no more than ½ mile) from the main Delta Channel to connect water-holding low areas that occur as the reservoir recedes. The areas of excavation, in the Reservoir's delta area, are not vegetated and outside of critical habitat; therefore, this action will have no effect on the flycatcher or critical habitat.

Airboat Transport: Brief periods of noise disturbance from airboats may interrupt flycatcher behavior (feeding, sheltering, and breeding), but in the past flycatchers have been observed to nest successfully near the San Marcial railroad trestle which carries daily train traffic that produces significant noise (Ryan pers. comm.). Also, while airboats are expected to have no effect on flycatchers, airboat transport is not expected to be needed between April 15 and September 1. If airboat transport is needed between April 15 and September 1, Reclamation will coordinate with the Service prior to the activity.

Refueling: Fueling of equipment will primarily take place over water or on berms adjacent to the Delta Channel. This activity would have no effect on flycatchers or critical habitat.

Pumping Water from the River: Water will be pumped from the river at times for wetting of road surfaces to facilitate grading of roads, and for dust abatement during high traffic periods to insure safe conditions and reduce environmental impacts. Pumping sites will be at or near existing equipment launching areas, requiring no new ground disturbance. The amount of water used in pumping for dust abatement is insignificant (less than 1% of river flow; see Section 5.1.1 above). Also, given the observed lack of response of flycatchers to train noise and the fact that pumping will occur when flycatchers are not present, the pump noise would have no effect on flycatchers. Thus, there is no effect to flycatchers or flycatcher critical habitat from pumping from the river.

5.2.2 Indirect Effects

The proposed action consists of maintaining Delta Channel capacity, repairing berms, and other associated activities to sustain the current Delta Channel condition. No new Delta Channel construction is planned, and the maintenance action will be to remove a portion of accumulated sediment to maintain channel capacity (some aggradation will likely remain depending on reservoir pool elevation). Specific maintenance activities for each year would be dependent on the channel adjustment that occurred during the previous six months between mid-April and mid-October.

The geomorphic indirect effects of this proposed action on the flycatcher must be evaluated in the context of the geomorphic drivers and controls, as described in Section 4.2, Current Status of Southwestern Willow Flycatcher in Action Area. Future riverbed elevation within the Delta Channel will be primarily controlled by the rate, magnitude, and duration of reservoir pool elevation fluctuations. Riverbed elevation further upstream will be controlled by the response of the naturally formed channel (below RM 38), and then the response of the Delta Channel to reservoir pool levels, as well as upstream water and sediment discharges. The following discussion analyzes net geomorphic effects of the proposed actions in the light of reservoir pool levels and Table 9 summarizes these potential future scenarios.

Rising reservoir pool
A rising reservoir pool would be the result of high water discharge years. Assuming water and sediment discharge are similar to 2005–2010 or increased, such years would likely require the greatest amount of maintenance. With the increase in pool elevation, a decrease in bed slope would occur. Also, sediment deposition would occur throughout the Delta Channel, spoil berms would possibly be breached, overbanking would increase, and sediment plugs and avulsions would be more likely. Delta Channel maintenance would remove accumulated sediment and repair spoil berms to maintain the target capacity specified in Section 2.0 (Proposed Action) for each reach. Overbanking flow would likely occur at Delta Channel breaches during high flow events (i.e., spring runoff and late summer monsoons) and repair of these breaches during the following fall/winter maintenance season would minimize continued overbanking. Sediment plugs block sediment supply, consequently causing or increasing local degradation downstream of the plug, and interfere with water delivery; therefore, sediment plugs would be removed. The probability of breaches or avulsions would be decreased by Delta Channel maintenance, but not eliminated. If a high flow event created a channel avulsion, Reclamation would assess the location of the avulsion and its impact to water delivery and habitat when deciding whether to reconstruct the original alignment. If the pool elevation remains high for an extended period of time (more than one year), net aggradation throughout the Delta Channel would be the likely result with the greatest amount of aggradation closest to the active reservoir pool.

Stable reservoir pool
If the reservoir level stabilized for multiple years, the prevailing aggradational trend would continue at a lesser rate. The proposed action is the same recurring maintenance that has been occurring since 2005, during which aggradation has been the prevailing trend within the Delta Channel. "Sediment was frequently removed in order to maintain channel capacity, yet the riverbed aggraded by a cumulative average of almost 3 feet from 2004 to 2010 before degrading about 0.5 feet from 2010 to 2012" (Holste 2013). Aggradation is expected to continue under the proposed action as long as the reservoir pool is relatively stable and conditions are similar to the recent past (2007–2012).

In this scenario, fewer substantial maintenance activities would be required. The maintenance would cause some reduction in the aggradation rate and it may be possible for Delta Channel maintenance to facilitate a balance between sediment supply and sediment transport capacity. If so, there is potential to achieve some level of short-term channel stability in terms of dynamic equilibrium. Overbanking at breach points, sediment plugs and avulsions would be less likely to occur and would be treated as described under the *Rising reservoir pool* scenario.

Lowering reservoir pool

The analysis of geomorphic effects caused by the proposed action also needs to consider the scenario of additional reservoir pool lowering. The historic minimum pool elevation (August 1954) is only about 40 feet lower than the 2012 minimum, and a further decline in pool elevation will likely occur if the current dry hydrology continues. Longitudinal reservoir profiles (Figure 16) show that the slope is naturally steeper below the Narrows than above the Narrows (foreset and topset slopes, Fig 10). This difference in slope should allow the river to form a competent channel downstream of about RM 38 if the pool elevation decreases. Figure 22 illustrates that this is already beginning to occur, as observed in the field during August 2012 near RM 37 and from the air in April 2013 (see Holste 2013 for additional photos (Figure 27) and discussion). Therefore, construction of additional channel will not be needed and Reclamation will maintain the naturally formed channel.

Figure 22. Naturally formed reservoir Delta Channel (looking southeast) near RM 37 (August, 2012)

However, as long as the reservoir pool continues to lower, bed elevation lowering could occur in the Delta Channel and then progress upstream. This process, described in detail in Holste 2013 and summarized in section 4.2, Current Status of Southwestern Willow Flycatcher in Action Area, is not a result of Delta Channel maintenance activities. Instead, it is caused by the drop in reservoir pool elevation, which induces a degradation wave that forms a natural channel for the water (as currently observed near RM 37). The degradation wave may move further upstream, depending on the rate, magnitude, and duration of the reservoir recession as well as the discharge and sediment supply conditions. It is not possible to accurately predict the magnitude or extent of the degradation as those factors are highly variable and have a complex interaction. However, a future degradation wave is likely to be less severe than the degradation caused by the 1998–2004 lowering, because the reservoir cannot physically lower that far (an additional drop of 60 feet from the 2012 average would completely empty the reservoir compared to the 90 feet drop in 1998–2004). In such a scenario, minimal channel maintenance would be needed, including removal of in-channel immature vegetation to prevent channel narrowing and possible localized removal of sediment accumulation and berm repair. These activities would be insignificant compared to the base level (pool elevation) control, as discussed previously, and would not decrease Delta Channel overall bed elevation any further than what is caused by the reservoir lowering and would therefore have an insignificant geomorphic effect.

Table 9. Potential future scenarios and effects upstream of Elephant Butte Reservoir.

Water and Sediment Discharge	Reservoir Pool	Expected Maintenance and Effects	Net Geomorphic Effects
Similar to recent past (2007–2012)	Relatively stable: between about RM 37 (~4355 ft) and RM 42 (~4385 ft)	Standard maintenance actions causing some reduction in aggradation rate	Current channel conditions are maintained; some areas aggrade and some areas are stable
Similar to 2005–2010, or increased peak flows, annual flow volumes, and sediment load	Rising above RM 46 (~4395 ft); continues to rise or stabilizes above RM 46	Increased maintenance actions causing some reduction in aggradation rate and possibly reducing likelihood of channel avulsion	Slope decrease, significant aggradation, increased overbanking, increased likelihood of sediment plugs and avulsions
Similar to 1998–2004, 2010–2012, or high flow event after period of reservoir lowering	Receding below about RM 36 (~4345) for multiple years	Minimal maintenance (removal of in-channel vegetation to prevent channel narrowing; possible localized removal of sediment and berm repair) causing negligible effects	Slope increase, possible initiation of new degradation wave depending on rate/magnitude/duration of reservoir recession

Indirect effects on vegetation and flycatcher habitat

Beneficial effects to the flycatcher would occur, as a result of how Delta Channel maintenance activities are implemented. Naturally occurring breaches are often allowed to remain open for a period of several months during the spring and summer, providing overbanking flow to the adjacent floodplain. Such breaches are typically not viewed as emergencies and usually not repaired immediately for a variety of reasons, such as flows may be too high to safely work in the river, spawning is occurring, and to avoid disturbance to nesting migratory birds. The flows from the breaches return to the main Delta Channel at a downstream location. Also, breaks in the berms may be constructed or naturally occurring inflow breaches allowed to remain for the purpose of allowing natural drainage into the Delta Channel and to prevent water from accumulating behind the berms, thus compromising their stability. Additionally, these openings allow water from the river to inundate areas behind the levee during the snowmelt runoff. These openings will be maintained as necessary within the limits of the existing channel footprint. Overbanking at both constructed and natural breaches would likely increase the development of flycatcher habitat as well as improve vegetative health and territory establishment. Furthermore, in the past, maintenance of the wing wall included periodic removal of sediment; however, maintenance is no longer planned for this feature in order to preserve the flycatcher habitat that has developed in this location.

Sediment plugs can have both positive and negative effects and would be removed to improve water delivery and prevent local degradation that would negatively affect downstream vegetation. However, prior to removal, the sediment plugs increase overbank flows in the local area, benefitting the vegetation. Maintenance actions for avulsions will consider habitat impact as well as water delivery and are not expected to have an adverse effect to critical habitat or occupied critical habitat. If maintenance action for an avulsion should require an impact to either critical habitat or occupied suitable habitat, Reclamation will coordinate with the Service to minimize the effect prior to the maintenance action.

Under the rising pool and stable pool scenarios discussed previously, the proposed maintenance actions in the channel will result in a relatively stable or somewhat aggrading bed elevation, as has mostly occurred since 2005 (Figure 19) during recurring maintenance, which is the same as the currently proposed actions. If water discharge increases, the combination could have a positive effect on groundwater levels and a beneficial effect to flycatcher habitat, including critical habitat. Thus, there will be no negative impact to vegetation in the Delta Channel or in upstream reaches and no adverse effect to flycatcher habitat, including critical habitat. If drought continues, vegetation could suffer, but that will not be an effect of channel maintenance activities.

Under the lowering reservoir pool scenario, bed degradation could occur in the Delta Channel due to the change in base level and then progress upstream. No new anthropogenic channel construction would occur and the minimal maintenance required in this scenario would maintain the naturally occurring bed elevation, consistent with the adjustments in response to the reservoir pool lowering. Any slope changes and bed degradation would be a result of the drop in the reservoir pool (rate, magnitude, and duration), either amplified by water discharge and sediment supply as seen in the large spring runoff events of 1949 and 2005, or reduced by those factors as seen in the comparison of the degradation of the 1949–1972 period to the 2005–2011 period. Thus, although the degradation would likely have an adverse effect to groundwater levels and flycatcher habitat, that effect is not due to the proposed action. To restate, using data from previous years, no correlation can be made between recurring maintenance actions and geomorphic effects and consequent effects to flycatcher habitat; whereas, there are clearly significant geomorphic effects that are caused by upstream water discharge, sediment load, and downstream reservoir pool elevation.

As in past years, Reclamation will continue to monitor the channel morphology in the Delta Channel and upstream of the power lines (approx. RM 62) to improve understanding of the river and develop appropriate management alternatives. Reclamation will also monitor flycatcher populations in this area.

Based on the preceding discussion of indirect effects, Reclamation has determined the proposed action is not likely to have adverse, indirect effects to designated critical habitat for the flycatcher and will not alter the function and intended conservation role of flycatcher critical habitat.

5.3 Yellow-Billed Cuckoo

5.3.1 Direct Effects

Potential effects to cuckoos are summarized in Table 8 above.

Site Access and staging areas: All necessary project-related roads, staging areas, and equipment launching sites have been built and maintained to date. There is access from the uplands to the Delta Channel along existing access roads (Figure 8). No new access roads, staging areas, or equipment launching sites are planned at this time. If they should become needed, Reclamation will coordinate with the Service prior to any construction activity.

Road maintenance such as grading and washout repair may be performed throughout the year to maintain safe access to and from the river. Vegetation control is not planned to occur between April 15 and September 1. The majority of roads are in upland areas, and some roads are near cuckoo habitat, including within the proposed critical habitat designation. Grading and washout repair have occurred routinely for several years between April 15 and September 1 with no indication of any impacts to cuckoos, which have continued to nest successfully near the roads. Vegetation along access roads and on staging areas will be mowed or treated with herbicides that are Service-approved for use near cuckoo habitat. All herbicide applications will follow the label directions and observe Service-recommended buffer zones (see Table 5).

Vegetation control consisting of mowing and herbicide treatment is not anticipated between April 15 and September 1. The areas treated consist mostly of young salt cedar, are not suitable habitat, and do not meet the proposed criteria for critical habitat. If mowing should be needed between April 15 and September 1, migratory bird surveys (April 15 to August 15) or cuckoo surveys (June 1 to September 1) will be conducted prior to mowing and no mowing will occur within a 0.25 mile buffer of any nests found. Therefore, road maintenance will have no effect on cuckoos or proposed critical habitat.

Maintenance work (including grading and vegetation control) on staging areas and equipment launching sites will occur between September 1 and April 15. If maintenance work should be needed between April 15 and September 1, migratory bird surveys (April 15 to August 15) or cuckoo surveys (June 1 to September 1) will be conducted prior to any work being done and no mowing will occur within a 0.25 mile buffer of any nests found. Therefore, staging area and equipment launching site maintenance will not affect cuckoos or proposed critical habitat.

Delta Channel Maintenance: Channel maintenance, including maintenance of the naturally formed channel below RM 38 (as needed), will be done every year, with the excavators moving in the channel to work sites, working at the work site, and returning to a staging area. Channel maintenance activities will not occur between April 15 and September 1. An exception to this would be in the case of emergency channel and berm repairs during runoff, and we expect that this event would happen once in a five year period for a period of two weeks near the end of runoff. If emergency channel and/or berm repairs are needed, Reclamation will coordinate the activity with the Service.

Maintenance activities will include maintaining existing berms and removing vegetation within the Delta Channel, as well as removing a portion of accumulated sediment to maintain channel capacity (some aggradation will likely remain depending on reservoir pool elevation). The vegetation to be removed is located in small areas on sandbars within the channel, and is not suitable habitat for cuckoos, both in patch size and vegetation maturity. Vegetation on the sides and tops of berms contributes to the desired stability of the berms and will not be removed, except in rare cases where feasibility and/or operator safety may be concerned. Two such rare cases where vegetation may need to be removed on the berms, are: 1) when vegetation lower on the inside of a berm interferes with the required channel capacity; and 2) on the outside of a meander bend where the channel is too deep for an excavator to safely work and work must be done from the top of the berm In the latter case, berm vegetation would be removed or moved out of the way so that the equipment operator can safely work from the top of the berm. Vegetation on any part of the berms is not habitat for cuckoos because it is sparse and does not have the habitat elements needed by the cuckoo. This is likely because the dry soil that makes up the berms is a poor substrate for vegetation growth. Excavators and the maintenance activity for all reaches will be confined to the area within the existing construction footprint (berms and channel) and would not affect vegetation in adjacent areas.

Overbanking at both constructed and natural breaches in the berms would likely increase the development of cuckoo habitat as well as improve vegetative health and territory establishment outside of the berms. Maintenance of the wing wall will no longer occur in order to preserve the cuckoo habitat that has developed in this location. Sediment plugs within the Delta Channel need to be removed to improve water delivery; however, prior to removal, sediment plugs temporarily increase overbank flows in the local area, benefitting the vegetation.

Work will be done when cuckoos are not present, only unsuitable habitat would be removed within the channel, and overbanking at breaches will be allowed to continue; therefore, activities related to Delta Channel maintenance may affect but will not likely adversely affect cuckoos. Proposed critical habitat may be affected but will not likely be adversely affected because there is only a small amount of proposed critical habitat in the upper part of the project area and the effect of removing small areas of non-suitable habitat within the channel is insignificant and will not diminish the capability of existing critical habitat to satisfy the essential requirements for the cuckoo. Furthermore, overbanking of breaches in the berms, which provides and maintains cuckoo habitat outside of the berms throughout the action area (including in the Upper Reach where there is designated critical habitat), will be allowed to continue.

Connecting isolated pools and channels in the lower reach: Maintenance of the lower reach may also include excavation of secondary channels that would extend a short distance (no more than ½ mile) from the main Delta Channel to connect water-holding low areas that occur as the reservoir recedes. The areas of excavation, in the Reservoir's delta area, are not vegetated and outside of proposed critical habitat; therefore, this action will have no effect on the cuckoo or proposed cuckoo critical habitat.

Airboat Transport: Brief periods of noise disturbance from airboats may interrupt cuckoo behavior (feeding, sheltering, and breeding), but since at least 2006, airboating in the summer does not seem to have effected population numbers which have been increasing in the Delta

Channel reach (Ryan pers. comm.). Also, while airboats are expected to have no effect on cuckoos, airboat transport is not expected to be needed between April 15 and September 1. If airboat transport is needed between April 15 and September 1, Reclamation will coordinate with the Service prior to the activity.

Refueling: Fueling of equipment will primarily take place over water or on berms adjacent to the Delta Channel. This activity would have no effect on cuckoos or proposed cuckoo critical habitat.

Pumping Water from the River: Water will be pumped from the river at times for wetting of road surfaces to facilitate grading of roads, and for dust abatement during high traffic periods to insure safe conditions and reduce environmental impacts. Pumping sites will be at or near existing equipment launching areas, requiring no new ground disturbance. The amount of water used in pumping for dust abatement is insignificant (less than 1% of river flow; see Section 5.1.1 above). Noise from water pumping is not likely to affect cuckoos since this work is not expected to be needed between April 15 and September 1when cuckoos would be present. Thus, there is no effect to cuckoos or proposed cuckoo critical habitat from pumping from the river.

5.3.2 Indirect Effects

The proposed action consists of maintaining Delta Channel capacity, repairing berms, and other associated activities to sustain the current Delta Channel condition indefinitely. No new Delta Channel construction is planned, and maintenance action will be to remove a portion of accumulated sediment to maintain channel capacity (some aggradation will likely remain depending on reservoir pool elevation). Specific maintenance activities for each year would be dependent on the channel adjustment that occurred during the previous six months between mid-April and mid-October.

The geomorphic effects of this proposed action must be evaluated in the context of the geomorphic drivers and controls, as described in Section 4.3, Current Status of Yellow-Billed Cuckoo in Action Area. Future riverbed elevation within the Delta Channel will be primarily controlled by the rate, magnitude, and duration of reservoir pool elevation fluctuations. Riverbed elevation further upstream will be controlled by the response of the naturally formed channel (below RM 38), and then the response of the Delta Channel to reservoir pool levels, as well as upstream water and sediment discharges. The following discussion analyzes net geomorphic effects of the proposed actions in the light of reservoir pool levels and Table 9 summarizes these potential future scenarios.

Rising reservoir pool
A rising reservoir pool would be the result of high water discharge years. Assuming water and sediment discharge are similar to 2005–2010 or increased, such years would likely require the greatest amount of maintenance. With the increase in pool elevation, a decrease in bed slope would occur. Also, sediment deposition would occur throughout the Delta Channel, spoil berms would possibly be breached, overbanking would increase, and sediment plugs and avulsions would be more likely. Delta Channel maintenance would remove accumulated sediment and

repair spoil berms to maintain the target capacity specified in Section 2.0 (Proposed Action) for each reach. Overbanking flow would likely occur at Delta Channel breaches during high flow events (i.e., spring runoff and late summer monsoons) and repair of these breaches during the following fall/winter maintenance season would minimize continued overbanking. Sediment plugs block sediment supply, consequently causing or increasing local degradation downstream of the plug, and interfere with water delivery; therefore, sediment plugs would be removed. The probability of breaches or avulsions would be decreased by Delta Channel maintenance, but not eliminated. If a high flow event created a channel avulsion, Reclamation would assess the location of the avulsion and its impact to water delivery and habitat when deciding whether to reconstruct the original alignment. If the pool elevation remains high for an extended period of time (more than one year), net aggradation throughout the Delta Channel would be the likely result with the greatest amount of aggradation closest to the active reservoir pool.

Stable reservoir pool
If the reservoir level stabilized for multiple years, the prevailing aggradational trend would continue at a lesser rate. The proposed action is the same recurring maintenance that has been occurring since 2005, during which aggradation has been the prevailing trend within the Delta Channel. "Sediment was frequently removed in order to maintain channel capacity, yet the riverbed aggraded by a cumulative average of almost 3 feet from 2004 to 2010 before degrading about 0.5 feet from 2010 to 2012" (Holste 2013). Aggradation is expected to continue under the proposed action as long as the reservoir pool is relatively stable and conditions are similar to the recent past (2007–2012).

In this scenario, fewer substantial maintenance activities would be required. The maintenance would cause some reduction in the aggradation rate and it may be possible for Delta Channel maintenance to facilitate a balance between sediment supply and sediment transport capacity. If so, there is potential to achieve some level of short-term channel stability in terms of dynamic equilibrium. Overbanking at breach points, sediment plugs and avulsions would be less likely to occur and would be treated as described under the *Rising reservoir pool* scenario.

Lowering reservoir pool
The analysis of geomorphic effects caused by the proposed action also needs to consider the scenario of additional reservoir pool lowering. The historic minimum pool elevation (August 1954) is only about 40 feet lower than the 2012 minimum, and a further decline in pool elevation will likely occur if the current dry hydrology continues. Longitudinal reservoir profiles (Figure 15) show that the slope is naturally steeper below the Narrows than above the Narrows (foreset and topset slopes, Figure 11). This difference in slope should allow the river to form a competent channel downstream of about RM 38 if the pool elevation decreases. Figure 22 illustrates that this is already beginning to occur, as observed in the field during August 2012 near RM 37 and from the air in April 2013 (see Holste 2013 for additional photos (Figure 27) and discussion). Therefore, construction of additional channel will not be needed and Reclamation will maintain the naturally formed channel.

However, as long as the reservoir pool continues to lower, bed elevation lowering could occur in the Delta Channel and then progress upstream. This process, described in detail in Holste 2013 and summarized in section 4.3, Current Status of Yellow-Billed Cuckoo in Action Area, is not a result of Delta Channel maintenance activities. Instead, it is caused by the drop in reservoir pool elevation, which induces a degradation wave that forms a natural channel for the water (as currently observed near RM 37). The degradation wave may move further upstream, depending on the rate, magnitude, and duration of the reservoir recession as well as the discharge and sediment supply conditions. It is not possible to accurately predict the magnitude or extent of the degradation as those factors are highly variable and have a complex interaction. However, a future degradation wave is likely to be less severe than the degradation caused by the 1998–2004 lowering, because the reservoir cannot physically lower that far (an additional drop of 60 feet from the 2012 average would completely empty the reservoir compared to the 90 feet drop in 1998–2004). In such a scenario, minimal channel maintenance would be needed, including removal of in-channel immature vegetation to prevent channel narrowing and possible localized removal of sediment accumulation and berm repair. These activities would be insignificant compared to the base level (pool elevation) control, as discussed previously, and would not decrease Delta Channel overall bed elevation any further than what is caused by the reservoir lowering and would therefore have an insignificant geomorphic effect.

Indirect effects on vegetation and cuckoo habitat

Beneficial effects to the cuckoo would occur, as a result of how Delta Channel maintenance activities are implemented. Naturally occurring breaches are often allowed to remain open for a period of several months during the spring and summer, providing overbanking flow to the adjacent floodplain. Such breaches are typically not viewed as emergencies and usually not repaired immediately for a variety of reasons, such as flows may be too high to safely work in the river, spawning is occurring, and to avoid disturbance to nesting migratory birds. The flows from the breaches return to the main Delta Channel at a downstream location. Also, breaks in the berms may be constructed or naturally occurring inflow breaches allowed to remain for the purpose of allowing natural drainage into the Delta Channel and to prevent water from accumulating behind the berms, thus compromising their stability. Additionally, these openings allow water from the river to inundate areas behind the levee during the snowmelt runoff. These openings will be maintained as necessary within the limits of the existing channel footprint. Overbanking at both constructed and natural breaches would likely increase the development of cuckoo habitat as well as improve vegetative health and territory establishment. Furthermore, in the past, maintenance of the wing wall included periodic removal of sediment; however, maintenance is no longer planned for this feature in order to preserve the cuckoo habitat that has developed in this location.

Sediment plugs can have both positive and negative effects and would be removed to improve water delivery and prevent local degradation that would negatively affect downstream vegetation. However, prior to removal, the sediment plugs increase overbank flows in the local area, benefitting the vegetation. Maintenance actions for avulsions will consider habitat impact as well as water delivery and are not expected to have an adverse effect to proposed critical habitat or occupied suitable habitat. If maintenance action for an avulsion should require an impact to either proposed critical habitat or occupied suitable habitat, Reclamation will coordinate with the Service to minimize the effect prior to the maintenance action.

Under the rising pool and stable pool scenarios discussed previously, the proposed maintenance actions in the channel will result in a relatively stable or somewhat aggrading bed elevation, as has mostly occurred since 2005 (Figure 17) during recurring maintenance, which is the same as the currently proposed actions. If water discharge increases, the combination could have a positive effect on groundwater levels and a beneficial effect to cuckoo habitat, including proposed critical habitat. Thus, there will be no negative impact to vegetation in the Delta Channel or in upstream reaches and no adverse effect to cuckoo habitat, including proposed critical habitat. If drought continues or if reservoir levels completely submerge vegetation, cuckoo habitat could be negatively impacted, but that will not be an effect of channel maintenance activities.

Under the lowering reservoir pool scenario, bed degradation could occur in the Delta Channel due to the change in base level and then progress upstream. No new anthropogenic channel construction would occur and the minimal maintenance required in this scenario would maintain the naturally occurring bed elevation, consistent with the adjustments in response to the reservoir pool lowering. Any slope changes and bed degradation would be a result of the drop in the reservoir pool (rate, magnitude, and duration), either amplified by water discharge and sediment supply as seen in the large spring runoff events of 1949 and 2005, or reduced by those factors as seen in the comparison of the degradation of the 1949–1972 period to the 2005–2011 period. Thus, although the degradation would likely have an adverse effect to groundwater levels and cuckoo habitat, that effect is not due to the proposed action. To restate, using data from previous years, no correlation can be made between recurring maintenance actions and geomorphic effects and consequent effects to cuckoo habitat; whereas, there are clearly significant geomorphic effects that are caused by upstream water discharge, sediment load, and downstream reservoir pool elevation.

As in past years, Reclamation will continue to monitor the channel morphology in the Delta Channel and upstream of the power lines (approx. RM 62) to improve understanding of the river and develop appropriate management alternatives. Reclamation will also monitor cuckoo populations in this area.

Based on the preceding discussion of indirect effects, Reclamation has determined the proposed action is not likely to have adverse effects to proposed critical habitat for the cuckoo and will not alter the function and intended conservation role of proposed cuckoo critical habitat.

5.4 New Mexico Meadow Jumping Mouse

5.4.1 Direct Effects

Potential effects to mice are summarized in Table 8 above.

Site Access and staging areas: All necessary project-related roads, staging areas, and equipment launching sites have been built and maintained to date. There is access from the uplands to the Delta Channel along existing access roads (Figure 8). No new access roads, staging areas, or equipment launching sites are planned at this time. If they should become needed, Reclamation will coordinate with the Service prior to any construction activity.

Road maintenance such as grading and washout repair may be performed throughout the year to maintain safe access to and from the river. Access roads are in dry, upland areas and are not in potentially suitable mouse habitat. Vegetation control (mowing and/or herbicide treatment) along the roads is not planned to occur between April 15 and September 1. Vegetation along access roads will be mowed and/or treated with herbicides that are Service-approved. All herbicide applications will follow the label directions and observe Service-recommended buffer zones (see Table 5). Therefore, road maintenance will have no effect on mice or critical habitat.

All maintenance work on staging areas and equipment launching sites (including grading and vegetation control) may occur between September 1 and April 15. A survey of the access roads, staging areas, and equipment launching sites in the action area conducted in October 2014 concluded that there may be marginal habitat at the Pete Well launching site and that it should be resurveyed in early summer to make a final determination (Stuart pers. comm.). Therefore, Reclamation will conduct a survey at the Pete Well equipment launching site in June or July 2015 for potentially suitable mouse habitat. If suitable mouse habitat is found, Reclamation will coordinate with the Service prior to working at this site. Vegetation along the perimeter of the staging areas will be mowed and/or treated with herbicides that are Service-approved. All herbicide applications will follow the label directions and observe Service-recommended buffer zones (see Table 5). If emergency Delta Channel maintenance work should be needed at staging areas and/or equipment launching sites between April 15 and September 1 and up to October 31 at the Pete Well site if mouse habitat is found (see Delta Channel Maintenance section below), Reclamation would coordinate needed activities with the Service prior to beginning work. In consideration of the above conditions, staging area and equipment launching site maintenance will not affect mice or mouse critical habitat.

Delta Channel Maintenance: Channel maintenance, including maintenance of the naturally formed channel below RM 38 (as needed), will be done every year with the excavators moving in the channel to work sites, working at the work site, and returning to a staging area. Channel maintenance activities will occur between September 1 and April 15. An exception to the above would be in the case of emergency channel and berm repairs during spring runoff, and we expect that this event would happen once in a five year period for a period of two weeks near the end of runoff. If emergency channel and/or berm repairs are needed, Reclamation will coordinate the activity with the Service.

Maintenance activities will include maintaining existing berms and removing vegetation within the Delta Channel, as well as removing a portion of accumulated sediment to maintain channel capacity (some aggradation will likely remain depending on reservoir pool elevation). The vegetation to be removed is located in small areas on sandbars within the channel. These areas are not suitable mouse habitat since these areas are routinely maintained or scoured by spring runoff and/or monsoon flows. Therefore, there will be no effect to mouse within the berms from the project. Vegetation on the sides and tops of berms contributes to the desired stability of the berms and will not be removed, except for some rare cases where the vegetation lower on the inside of a berm interferes with the required channel capacity. Vegetation on the berms, however, is not likely to be potentially suitable mouse habitat because the berms consist of dry, sandy soils that do not support the type of herbaceous vegetation that the mouse needs for feeding and cover. Excavators and the maintenance activity for all reaches will be confined to the area within the existing construction footprint (berms and channel) and would not affect potentially suitable habitat outside of the berms. Therefore, the proposed work of maintaining the existing Delta Channel would have no effects to the mouse or potentially suitable mouse habitat outside of the berms. There is also no effect to proposed critical habitat because no proposed critical habitat occurs in the project area.

Connecting isolated pools and channels in the lower reach: Maintenance of the lower reach may also include excavation of secondary channels that would extend a short distance (no more than ½ mile) from the main Delta Channel to connect water-holding low areas that occur as the reservoir recedes. The areas of excavation, in the reservoir's delta area, are not vegetated and outside of critical habitat; therefore, this action will have no effect on the mouse or critical habitat.

Airboat Transport: Airboats are not expected to harass mice or their habitat because airboats are primarily used in the Delta Channel where no mouse habitat exists. There may be very brief disturbances as a result of airboat launching from the side channels at the equipment launching sites but airboat use is not expected from April 15 to September 1and these are previously maintained areas that are unlikely to be, or be adjacent to, potentially suitable mouse habitat. Also, personnel at BDANWR routinely mow known mouse habitat during the mouse's active season with no negative impacts to the mouse or its habitat (Bosque del Apache NWR 2013). If airboats are needed between September 1 and October 31, Reclamation will survey the equipment launching site to determine if there is any potentially suitable habitat. If suitable habitat is present, Reclamation will coordinate with the Service. Therefore, there will be no effect to mice from airboat transport.

Refueling: Fueling of equipment will primarily take place over water or on berms adjacent to the Delta Channel. This activity would have no effect on mice or critical habitat because it will occur in previously disturbed and maintained areas which are not in or near mouse habitat.

Pumping Water from the River: Water will be pumped from the river at times for wetting of road surfaces to facilitate grading of roads, and for dust abatement during high traffic periods to insure safe conditions and reduce environmental impacts. Pumping sites will be at or near existing equipment launching areas, requiring no new ground disturbance. The amount of water used in pumping for dust abatement is insignificant (less than 1% of river flow; see Section 5.1.1 above). There may be very brief disturbances as a result of pump noise at the equipment launching sites but pumping is not expected from April 15 to September 1and these are previously maintained areas that are not, except for the Pete Well site, potentially suitable mouse habitat. If suitable mouse habitat is found at the Pete Well site in summer 2015, Reclamation will coordinate with the Service prior to pumping.

5.4.2 Indirect Effects

The proposed action consists of maintaining Delta Channel capacity, repairing berms, and other associated activities to sustain the current Delta Channel condition. No new Delta Channel construction is planned, and maintenance action will be to remove a portion of accumulated sediment to maintain channel capacity (some aggradation will likely remain depending on reservoir pool elevation). Specific maintenance activities and locations for each year would be dependent on the channel adjustment that occurred during the previous six months between mid-April and mid-October.

The geomorphic indirect effects of this proposed action on the mouse must be evaluated in the context of the geomorphic drivers and controls, as described in Sections 4.2.2 and 4.2.3 of this document. Future riverbed elevation within the Delta Channel will be primarily controlled by the rate, magnitude, and duration of reservoir pool elevation fluctuations. Riverbed elevation further upstream will be controlled by the response of the naturally formed channel (below RM 38), and then the response of the Delta Channel to reservoir pool levels, as well as upstream water and sediment discharges. The following discussion analyzes net geomorphic effects of the proposed actions in the light of reservoir pool levels and Table 9 summarizes these potential future scenarios.

Rising reservoir pool

A rising reservoir pool would be the result of high water discharge years. Assuming water and sediment discharge are similar to 2005–2010 or increased, such years would likely require the greatest amount of maintenance. With the increase in pool elevation, a decrease in bed slope would occur. Also, sediment deposition would occur throughout the Delta Channel, spoil berms would possibly be breached, overbanking would increase, and sediment plugs and avulsions would be more likely. Delta Channel maintenance would remove accumulated sediment and repair spoil berms to maintain the target capacity specified in Section 1.0 for each reach. Overbanking flow would likely occur at Delta Channel breaches during high flow events (i.e., spring runoff and late summer monsoons) and repair of these breaches during the following fall/winter maintenance season would minimize continued overbanking. Sediment plugs block sediment supply, consequently causing or increasing local degradation downstream of the plug, and interfere with water delivery; therefore, sediment plugs would be removed. The probability of breaches or avulsions would be decreased by Delta Channel maintenance, but not eliminated. If a high flow event created a channel avulsion, Reclamation would assess the location of the avulsion and its impact to water delivery and habitat when deciding whether to reconstruct the original alignment. If the pool elevation remains high for an extended period of time (more than one year), net aggradation throughout the Delta Channel would be the likely result with the greatest amount of aggradation closest to the active reservoir pool.

Stable reservoir pool

If the reservoir level stabilized for multiple years, the prevailing aggradational trend would continue at a lesser rate. The proposed action is the same recurring maintenance that has been occurring since 2005, during which aggradation has been the prevailing trend within the Delta Channel. “Sediment was frequently removed in order to maintain channel capacity, yet the riverbed aggraded by a cumulative average of almost 3 feet from 2004 to 2010 before degrading about 0.5 feet from 2010 to 2012” (Holste 2013). Aggradation is expected to continue under the proposed action as long as the reservoir pool is relatively stable and conditions are similar to the recent past (2007–2012).

In this scenario, fewer substantial maintenance activities would be required. The maintenance would cause some reduction in the aggradation rate and it may be possible for Delta Channel maintenance to facilitate a balance between sediment supply and sediment transport capacity. If so, there is potential to achieve some level of short-term channel stability in terms of dynamic equilibrium. Overbanking at breach points, sediment plugs and avulsions would be less likely to occur and would be treated as described under the *Rising reservoir pool* scenario.

Lowering reservoir pool

The analysis of geomorphic effects caused by the proposed action also needs to consider the scenario of additional reservoir pool lowering. The historic minimum pool elevation (August 1954) is only about 40 feet lower than the 2012 minimum, and a further decline in pool elevation will likely occur if the current dry hydrology continues. Longitudinal reservoir profiles (Figure 16) show that the slope is naturally steeper below the Narrows than above the Narrows (foreset and topset slopes, Figure 11). This difference in slope should allow the river to form a competent channel downstream of about RM 38 if the pool elevation decreases. Figure 22 illustrates that this is already beginning to occur, as observed in the field during August 2012 near RM 37 and from the air in April 2013 (see Holste 2013 for additional photos (Figure 27) and discussion). Therefore, construction of additional channel will not be needed and Reclamation will maintain the naturally formed channel.

However, as long as the reservoir pool continues to lower, bed elevation lowering could occur in the Delta Channel and then progress upstream. This process, described in detail in Holste 2013 and summarized in section 4.4 Current Status of New Mexico Meadow Jumping Mouse in Action Area, is not a result of Delta Channel maintenance activities. Instead, it is caused by the drop in reservoir pool elevation, which induces a degradation wave that forms a natural channel for the water (as currently observed near RM 37). The degradation wave may move further upstream, depending on the rate, magnitude, and duration of the reservoir recession as well as the discharge and sediment supply conditions. It is not possible to accurately predict the magnitude or extent of the degradation as those factors are highly variable and have a complex interaction. However, a future degradation wave is likely to be less severe than the degradation caused by the 1998–2004 lowering, because the reservoir cannot physically lower that far (an additional drop of 60 feet from the 2012 average would completely empty the reservoir compared to the 90 feet drop in 1998–2004). In such a scenario, minimal channel maintenance would be needed, including removal of in-channel immature vegetation to prevent channel narrowing and possible localized removal of sediment accumulation and berm repair. These activities would be insignificant compared to the base level (pool elevation) control, as discussed previously, and would not decrease Delta Channel overall bed elevation any further than what is caused by the reservoir lowering and would therefore have an insignificant geomorphic effect.

Indirect effects on vegetation and mouse habitat

Breaches in the berms as a result of spring runoff and monsoon flows are often allowed to remain open for a period of several months during the spring and summer, providing overbanking flow to the adjacent floodplain. Such breaches are typically not viewed as emergencies and usually not repaired immediately for a variety of reasons, such as flows may be too high to safely work in the river, spawning is occurring, and to avoid disturbance to nesting migratory birds. The flows from the breaches return to the main Delta Channel at a downstream location. Also, breaks in the berms may be constructed, or naturally occurring inflow breaches allowed to remain, for the purpose of allowing drainage into the Delta Channel and to prevent water from accumulating behind the berms, thus compromising their stability. Additionally, these openings allow water from the river to inundate areas behind the levee during the snowmelt runoff. These openings will be maintained as necessary within the limits of the existing channel footprint. Overbanking at both constructed and natural breaches would likely increase the development of vegetation behind the berms, and these are the areas that have been identified by Frey and Kopp (2014) as potentially suitable habitat. However, these sites could only be suitable for feeding and cover during the active season if the right soils and herbaceous vegetation were present. They would not be suitable habitat for maternal nesting or hibernation because of the timing and inconsistent nature of inundation events. Therefore, it is possible, though unlikely, that there is potentially suitable mouse habitat outside of the berms which could be indirectly beneficially affected by Delta Channel maintenance activities.

Sediment plugs can have both positive and negative effects and would need to be removed to improve water delivery and prevent local degradation that would negatively affect downstream vegetation. However, prior to removal, the sediment plugs increase overbank flows in the local area, benefitting the vegetation outside of the berms. Maintenance actions for avulsions will consider habitat impact as well as water delivery and are not expected to have an adverse effect to critical habitat or occupied critical habitat. If maintenance action for an avulsion should require an impact to either critical habitat or occupied suitable habitat, Reclamation will coordinate with the Service to minimize the effect prior to the maintenance action.

Under the rising pool and stable pool scenarios discussed previously, the proposed maintenance actions in the channel will result in a relatively stable or somewhat aggrading bed elevation, as has mostly occurred since 2005 (Figure 17) during recurring maintenance, which is the same as the currently proposed actions. If water discharge increases, the combination could raise groundwater levels, particularly outside of the berms, which would further reduce the amount of available maternal nesting and hibernation habitat for the mouse. Thus, there would be no change in the Delta Channel or in upstream reaches and no adverse effect to mouse habitat, including critical habitat. If drought continues, vegetation could suffer, but that will not be an effect of channel maintenance activities.

Under the lowering reservoir pool scenario, bed degradation could occur in the Delta Channel due to the change in base level and then progress upstream. No new anthropogenic channel construction would occur and the minimal maintenance required in this scenario would maintain the naturally occurring bed elevation, consistent with the adjustments in response to the reservoir pool lowering. Any slope changes and bed degradation would be a result of the drop in the reservoir pool (rate, magnitude, and duration), either amplified by water discharge and sediment supply as seen in the large spring runoff events of 1949 and 2005, or reduced by those factors as seen in the comparison of the degradation of the 1949–1972 period to the 2005–2011 period. Thus, although the degradation would likely have an adverse effect to groundwater levels and any potentially suitable mouse habitat, that effect is not due to the proposed action. To restate, using data from previous years, no correlation can be made between recurring maintenance actions and geomorphic effects and consequent effects to mouse habitat; whereas, there are clearly significant geomorphic effects that are caused by upstream water discharge, sediment load, and downstream reservoir pool elevation.

As in past years, Reclamation will continue to monitor the channel morphology in the Delta Channel and upstream of the power lines (approx. RM 62) to improve understanding of the river and develop appropriate management alternatives. Reclamation will also further refine Frey and Kopp's potentially suitable habitat maps and possibly monitor mouse populations in any areas that are identified as suitable habitat and that may have the potential to support mice.

Based on the preceding discussion of indirect effects, Reclamation has determined the proposed action will have no effect to proposed critical habitat for the mouse and will not alter the function and intended conservation role of proposed mouse critical habitat.

6.0 Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area.

The entire Delta Channel is located within the reservoir pool. The operating reservoir pool is non-discretionary and at the mercy of the drought conditions, the use of water by continued human population growth and water based industry along the Rio Grande, deliveries of irrigation water to the south, and Compact deliveries and restrictions. The land use surrounding the area of the Delta Channel is also under the management of the Bureau of Land Management under their grazing allotment program. Recreational activities occur on reservoir land and water. North of the power lines (approx. RM 62), all the way to Cochiti reservoir there are many local and state agencies, private entities and landowners, and Pueblos that are participating with the federal agencies in the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program). As the Collaborative Program transitions to the Recovery Implementation Program (RIP), it will likely continue to fund habitat restoration projects and conduct research that will benefit minnows, flycatchers, cuckoos, and mice. Outside of the Collaborative Program and RIP, there are state, city, other groups, and Pueblos that are improving riparian and riverine conditions along the MRG.

Activities that affect water quality along the MRG consist of municipal wastewater discharges, urban runoff, agricultural runoff, riparian clearing, chemical use for vegetation control and crops, recreation along and in the riparian zone (which can be compounded by urban growth), stocking of exotic and predator fish, industrial growth along the river, and riparian clearing without a revegetation plan, that could affect minnows, flycatchers, cuckoos, and mice and their habitats.

7.0 Best Management Practices

Reclamation and the NMISC propose the following best management practices (BMPs) for the activities presented in this BA to minimize the risk of effects from the proposed actions. These BMPs apply generally to maintenance and/or construction activities, hereafter referred to as work, and may not be applicable in all cases. Updates to these BMPs will be provided to the Service as adaptive management indicates the need.

Timing of the Proposed Action

1. Reclamation and the NMISC will seek to avoid impacts to birds protected by the Migratory Bird Treaty Act (16 U.S.C. 703; MBTA), including the flycatcher and cuckoo, by conducting work activities outside of the normal breeding and nesting season (April 15 to August 15, or September 1 for work in suitable cuckoo habitat).

    1.1. If work is necessary between April 15 and August 15 (or September 1 for work in suitable cuckoo habitat), suitable/occupied migratory bird habitat will be avoided during the construction activities as much as possible, utilizing the most current annual survey results in conjunction with habitat suitability. Reclamation and the NMISC will use current flycatcher and cuckoo monitoring data to avoid work within 0.25 miles of an active nest as much as possible. Coordination and consultation with the Service will occur prior to such work activities.

    1.2. Reseeding or revegetation may be accomplished by hand or by mechanized means, such as using a Truax imprinter followed by hand or tractor broadcast seeding (see section Vegetation Planting and Control below). Planting via mechanized means, includes using a hand-held or tractor-mounted auger. If mechanized means are used for either reseeding or replanting in the April 15 to August 15 timeframe (or September 1 for work in suitable cuckoo habitat), migratory bird surveys would be conducted immediately prior to the work to determine if any breeding birds are present. If birds are detected, Reclamation and/or the appropriate BA partner(s) would coordinate with the Service to determine appropriate next steps.

2. Reclamation and the NMISC will seek to avoid impacts to the New Mexico meadow jumping mouse by not conducting work activities from August 15 to October 31 if suitable mouse habitat is found during mouse habitat surveys conducted prior to work. Mouse habitat surveys will occur in early summer (June or July) or when vegetation that characterizes mouse habitat is most likely to be at its peak growth. If suitable mouse habitat is found, Reclamation and/or the appropriate BA partner(s) will coordinate with the Service prior to work. Road maintenance such as grading and washout repair may be performed throughout the year to maintain safe access to and from the river, but vegetation control will not occur between April 15 and August 15 (or September 1 for work in suitable cuckoo habitat), as per MBTA measure 1 above.

Water Quality

3. Reclamation and the NMISC will obtain all applicable permits prior to implementation of the project, including Clean Water Act permits (CWA). Reclamation and the NMISC will comply with the requirements of the CWA and other permits associated with the project, including required reporting to the appropriate authorities as needed and will not begin work until all required permits are obtained.

4. Silt fences and/or appropriate erosional controls will be used around the project site to manage water runoff in the site in accordance with Clean Water Act requirements.

   4.1. If silt fencing is used, it will be installed approximately 2 feet (0.6m) from the wetted perimeter of the bank in the water interface when construction activities occur in the wet and have the potential for adverse impacts (i.e., impacting the river bank). Water quality parameters will be monitored before silt fencing is installed, and the fencing will not be removed until water quality has returned to within 10% of its original measures.

5. Reclamation and the NMISC will visually monitor for water quality in the areas below areas of river work before and during the work day. Water quality will be monitored during construction and after equipment operates in the river channel. Monitoring will include visual observations and may include direct sampling, as appropriate.

   5.1. If direct sampling is needed, water-quality parameters to be tested include pH, temperature, dissolved oxygen, and turbidity. Parameters will be measured both upstream and downstream of the work area.

   5.2. Responses to changes in water-quality measures exceeding the applicable standards would include reporting the measurements to the New Mexico Environment Department Surface Water Quality Bureau and moving construction activities away from the shore.

Equipment and Operations

6. Maintenance activities that have the potential for adverse impacts will be monitored in order to ensure compliance.

7. Reclamation and the NMISC will excavate an area as few times as possible to minimize disturbance of sediments. When excavating within the wetted channel, the following practices will be used to minimize disturbance of sediments:

   7.1. Minimize movement of excavator tracks;

   7.2. Minimize excavator bucket contact with riverbed when not excavating.

8. Each individual operator will be briefed on and will sign off on local environmental considerations specific to the project tasks.

9. Minimize impact of hydrocarbons: To minimize potential for spills into or contamination of aquatic habitat:

   9.1. Hydraulic lines will be checked each morning for leaks and periodically throughout each work day. Any leaky or damaged hydraulic hoses will be replaced.
   9.2. All fueling will take place outside the active floodplain with a spill kit ready. Fuel, hydraulic fluids, and other hazardous materials may be stored on site overnight, but outside the normal floodplain, not near the river or any location where a spill could affect the river.
   9.3. All equipment will undergo high-pressure spray cleaning and inspection prior to initial operation in the project area.
   9.4. Equipment will be parked on pre-determined locations on high ground away from the river overnight, on weekends, and holidays.
   9.5. Spill protection kits will be onsite, and operators will be trained in the correct deployment of the kits.
   9.6. External hydraulic lines are composed of braided steel covered with rubber. When there is increased risk of puncture such as during mastication while removing vegetation, external hydraulic lines will be covered with additional puncture-resistant material, such as steel-mesh guards, Kevlar, etc. to offer additional protection.

10. Equipment will be removed from the channel in the event of high storm surges.

11. To allow fish time to leave the area before in-water work begins, equipment will initially enter the water slowly. In-water work will be fairly continuous during work days, so that fish are less likely to return to the area once work has begun.

12. Riprap to be placed in the water will be reasonably clean to the extent possible. If there are large clumps of soil bigger than 1 foot within the riprap, those clumps will be set aside during the loading or placing operations.

13. Whenever possible, airboats will be operated through the center of the channel to minimize disturbance to aquatic species, including minnows.

14. Reservoir recession may expose cottonwood and salt cedar snags that will be removed during maintenance of the naturally formed channel below RM 38 or excavation of secondary channels to connect isolated pools to the Delta Channel. Prior to removal of such snags, an evaluation will be conducted by a biologist to determine their significance for raptor use. The channel alignment will be adjusted to avoid removal of significant snags when possible.

15. Reclamation and the NMISC will maintain a floodplain and low flow channel (thalweg) in the upper seven miles of the Delta Channel. To the extent feasible, maintenance actions will allow for the naturally created point bars and small embayments within the low flow channel to remain in place.

Access and Staging

16. Impacts to terrestrial habitats will be minimized by using existing roads whenever possible. In general, equipment operation will take place in the most open area available, and all efforts will be made to minimize damage to native vegetation and wetlands (also see section titled Vegetation below).

17. All necessary permits for access points, staging areas, and study sites would be acquired prior to construction activity.

Vegetation Replanting and Control

18. A variety of revegetation strategies may be used: stem and pole cuttings (Los Lunas Plant Materials Center 2007b); long stem transplants (Los Lunas Plant Materials Center 2007a); and upland planting with and without a polymer, zeolite, or similar compound to maximize soil water retention (Dreesen 2008). Planting techniques may vary from site to site, and may consist of buckets, augers, stingers, and/or water jets mounted on construction equipment. In some areas, a trench may be constructed to facilitate the placement of a significant number of plants, specifically stem and pole cuttings. Seeding would be accomplished using a native seed drill, where feasible, and spread with a protective covering which would provide moisture to the seeds.

19. Vegetation control may consist of mechanical removal, burning, mowing, and/or herbicide treatment. Herbicides will be used when non-chemical methods are unsuccessful or are not economically feasible (see section Herbicide and Pesticide Use below).

    19.1. Vegetation control will be completed between August 15 (or September 1 for work in suitable cuckoo habitat) and April 15. Any need for deviations from this work window would be considered on a project-specific basis and coordinated with the Service. If work is planned within two weeks before April 15 or after August 15 (or September 1 for work in suitable cuckoo habitat), Reclamation and the NMISC will conduct additional surveys, if warranted, to determine the presence of breeding flycatchers, cuckoos, or other breeding birds. Reclamation and the appropriate BA partner(s) will coordinate monitoring and work activities with the Service, as appropriate, if bird nests are found.

20. Native vegetation at work sites will be avoided to the extent possible. If large, native woody vegetation (primarily cottonwood), needs to be trimmed or removed, they will be replaced at a ratio of 10:1. When and where possible, small, native woody vegetation will be removed or harvested at the appropriate season to use for revegetation work at another location in the project area or at another project site. Native vegetation that cannot be replanted may be mulched (mulch will be removed or spread on site at a depth of three inches or less) or temporarily stockpiled and used to create dead tree snags or brush piles in the project area upon completion.

21. Nonnative vegetation that is removed at work sites will be mulched, burned, or removed offsite to an approved location. Mulched vegetation may also be spread on site at a depth of three inches or less.

Herbicide and Pesticide Use

22. The use of chemical herbicides or pesticides may be necessary to control undesirable plant species around stockpile sites and storage yards and also to prevent the spread of invasive species in areas cleared for maintenance activities. It also may be necessary to spray or control: arthropods (spiders, ants, cockroaches, and crickets) that pose a safety problem or are a nuisance in buildings and facilities; birds (pigeons and swallows) roosting in building structures that are considered a nuisance; and mice that get into structures and/or equipment. Since the application of herbicides and chemical spraying is tightly controlled by State and Federal agencies, Reclamation will follow all State and Federal laws and regulations applicable to the application of herbicides, including guidelines described by White (2007). Herbicides or pesticides will not be directly applied to or near water unless they are labeled for aquatic use and appropriate buffers will be observed. Communication with the Service would occur prior to any application to sites with threatened or endangered wildlife species. Reclamation would follow the Albuquerque Area Office Integrated Pest Management Plan and Pesticide General Permit (Reclamation 2015) when applying herbicides or pesticides. The NMISC will follow all applicable State and Federal laws and regulations and their herbicide/pesticide guidance, if applicable. Herbicides or pesticides may be applied using low pressure spray rigs mounted to OHVs, trucks and trailers with spray bars, or backpack sprayers (for spot applications). Treatments will be conducted by trained and approved personnel observing appropriate buffer distances and label directions. Treatment will not take place when winds exceed 10 miles per hour or when rain is forecasted for the local area within 48 hours of application. Care will be taken when mixing or applying any herbicide to avoid runoff onto the ground or into the water. Surfactants may also be added to certain herbicides to maximize herbicide/pesticide performance and minimize retreatments.

Dust Abatement

23. If water is needed for dust abatement or to facilitate grading of roads, water may be pumped from the Rio Grande, irrigation drains, sumps, or secondary channels adjacent to the river. During irrigation season (March 1 to October 31), water will not be pumped from the river but will be pumped from the irrigation drains if possible. Pumping from the river is not expected to be needed between April 15 and August 15 (or September 1 in suitable cuckoo habitat); however, if pumping is needed between May 1 and July 1 (emergencies only), Reclamation and/or the appropriate BA partner(s) will coordinate with the Service to avoid impacts to minnow eggs and larvae. Outside of the irrigation season, an amount not to exceed 5% of river flows at the time of pumping may be drawn from the Rio Grande. Pumping is short duration (minutes) for filling whatever water transport equipment is used. Sumps or secondary channels adjacent to the river will be used, whenever feasible. Pump intake pipes will use a 0.25 in (0.64 cm) mesh screen at the opening of the intake hose to minimize entrainment of aquatic organisms.

Other Measures

24. Reclamation and the NMISC will monitor flows for two years following construction of side channels and, if flows at the nearest gage exceed the target inundation flows, will monitor the side channel for minnow entrapment in accordance with the appropriate protocol. After two years, it may be determined in coordination with the Service that further monitoring is unnecessary.

25. Reclamation will continue to closely monitor channel bed elevation in the Delta Channel and upstream reaches (to RM 69), with data collection performed at least annually.

26. Reclamation will continue to conduct annual fish community surveys and flycatcher and cuckoo surveys (following established protocols) in and around the Delta Channel. A mouse habitat survey will be conducted in summer 2015 at the Pete Well equipment launching site by experienced biologists. If mouse habitat is found and work is needed at this site, Reclamation and the NMISC will coordinate with the Service prior to working at this site.

27. Reclamation and the NMISC will report annually to the Service the results of species surveys and work accomplished on the Delta Channel maintenance project.

28. All project spoils and waste will be disposed of offsite at approved locations or may be used on site as appropriate to the project purpose consistent with applicable environmental requirements.

29. All work projects will have a contract in place for the rental of portable restroom facilities during the duration of the project.

8.0 Determination of Effects of the Proposed Action

8.1 Rio Grande Silvery Minnow

This effects determination considers the population status of the minnow, the occurrence of minnows below the power lines (approx. RM 62) in the reservoir reach, and the possibility of minnows occurring in the vicinity of the excavators, airboat, and fuel transporters. Given the results of Reclamation's silvery minnow surveys in the project area since 2010, we believe minnows are likely to be present in the project area. The maintenance techniques and Conservation Measures in the proposed action are designed to minimize contact with any fish and minimize the potential for harm or harassment. Normal operation of the equipment helps to minimize impacts to fish. Minnows present near the work area would be able to freely move to avoid contact with the equipment and are expected to do so similar to natural predator avoidance (e.g., from birds). Use of airboats and heavy equipment may harass minnows in the immediate area of operation. These effects are spatially localized but not discountable. A diesel fuel spill is considered unlikely during the proposed action and measures in place will minimize the risk of spill occurrence and minimize the area affected such that the overall risk to water quality and any effects on minnows is discountable.

The effects determination encompasses the presence of minnows in the vicinity of excavation equipment. Harm and harassment to minnows may be unavoidable during Delta Channel maintenance, and Reclamation requests Incidental Take for the proposed action. Because of minnows in the existing Delta Channel, and the proposed maintenance activity occurring within the Delta Channel, this proposed action <u>may affect, and is likely to adversely affect the minnow due to harm and harassment</u>. The Delta Channel maintenance activities would occur in an area that has no designated critical habitat and channel maintenance will not cause bed degradation that affects critical habitat; therefore, Reclamation has determined that the proposed action <u>will have no effect on minnow critical habitat</u>.

8.2 Southwestern Willow Flycatcher

This effects determination takes into account the current flycatcher population within the reservoir pool and their suitable (occupied or unoccupied) habitat. The existing flycatchers at the reservoir will not be affected by the proposed action because vegetation adjacent to the Delta Channel will not be affected, and maintenance will not occur between April 15 and September 1, except for emergencies that will be coordinated with the Service prior to any activity occurring. Also, the water that flows to the suitable/occupied habitat on the west side of the Upper Reach comes from the LFCC, which is a reliable source of water that will continue to maintain the conditions that have provided this suitable/occupied habitat.

Degradation occurring in the Delta Channel or in upstream reaches as a result of the proposed Delta Channel maintenance is not expected because the proposed action is maintenance of the existing Delta Channel only. If the reservoir level drops and remains low, that may institute another round of degradation. However, that degradation will be a direct result of the reservoir pool elevation change (rate, magnitude, and duration), and not a direct or indirect effect of this proposed action, which entails minimal maintenance that will not further lower the bed elevation below the elevation that develops as a response to the reservoir level.

The possibility does exist that some minimal disturbance from noise may occur during the flycatcher breeding season from road maintenance activities that will occur year round, including during the flycatcher breeding season. This possible disturbance is not anticipated to be severe enough nor of lengthy duration to where territory establishment and/or reproductive success would be negatively affected, as demonstrated by flycatchers nesting adjacent to roads in the past. Also, airboat transport is not expected to occur between April 15 and September 1. If airboat transport is needed between April 15 and September 1, Reclamation will coordinate with the Service prior to the activity. Therefore, noise would have an insignificant effect on flycatchers.

Beneficial effects to the flycatcher would occur, as a result of how Delta Channel maintenance activities are implemented. Overbanking at both constructed and natural breaches would likely increase the development of flycatcher habitat as well as improve vegetative health and territory establishment. Maintenance of the wing wall will no longer occur in order to preserve the flycatcher habitat that has developed in this location. Sediment plugs within the Delta Channel need to be removed to improve water delivery; however, prior to removal, sediment plugs temporarily increase overbank flows in the local area, benefitting the vegetation.

Therefore, in considering the above effects, our determination is that the proposed action <u>may affect, but is not likely to adversely affect</u> the flycatcher, and will have <u>no effect</u> on designated critical habitat for the flycatcher.

8.3 Yellow-Billed Cuckoo

This effects determination takes into account the current cuckoo population within the reservoir pool and their suitable (occupied or unoccupied) habitat. The existing cuckoos at the reservoir will not be affected by the proposed action because vegetation adjacent to the Delta Channel will not be affected, and Delta Channel maintenance will not occur between April 15 and September 1, except for emergencies that will be coordinated with the Service prior to any activity occurring.

Degradation occurring in the Delta Channel or in upstream reaches as a result of the proposed Delta Channel maintenance is not expected because the proposed action is maintenance of the existing Delta Channel only. If the reservoir level drops and remains low, that may institute another round of degradation. However, that degradation will be a direct result of the reservoir pool elevation change (rate, magnitude, and duration), and not a direct or indirect effect of this proposed action, which entails minimal maintenance that will not further lower the bed elevation below the elevation that develops as a response to the reservoir level

The possibility does exist that some minimal disturbance from noise may occur during the cuckoo breeding season from road maintenance activities that will occur year round. This possible disturbance is not anticipated to be severe enough nor of lengthy duration to where territory establishment and/or reproductive success would be negatively affected, because cuckoos are loosely territorial and occupy large areas. Therefore, noise would have an insignificant effect. Also, airboat transport is not expected to occur between April 15 and September 1. If airboat transport is needed between April 15 and September 1, Reclamation will coordinate with the Service prior to the activity.

Beneficial effects to the cuckoo would occur, as a result of how Delta Channel maintenance activities are implemented. Overbanking at both constructed and natural breaches would likely increase the development of cuckoo habitat as well as improve vegetative health and territory establishment. Maintenance of the wing wall will no longer occur in order to preserve the cuckoo habitat that has developed in this location. Sediment plugs within the Delta Channel need to be removed to improve water delivery; however, prior to removal, sediment plugs increase overbank flows in the local area, benefitting the vegetation.

Therefore, in considering the above effects, our determination is that the proposed action <u>may affect, but is not likely to adversely affect</u> the cuckoo, and will have <u>no effect</u> on proposed critical habitat for the cuckoo.

8.4 New Mexico Meadow Jumping Mouse

This effects determination takes into account the potentially suitable (occupied or unoccupied) mouse habitat that may occur within the reservoir pool. Following a site visit of Frey's (2012) potentially suitable mouse habitat and work sites throughout the action area in October 2014, it was determined that the majority of the work sites did not have the required elements for mouse habitat. One site, the Pete Well equipment launching site, was the only site that was considered to possibly be suitable. A survey will be conducted in June or July 2015 to make a final determination on whether this site is suitable or not. In the unlikely event that suitable habitat is found, Reclamation will coordinate with the Service prior to working at this site. If it is not found suitable, Reclamation will be able to work throughout the action area during the September 1 to April 15 work window.

Degradation occurring in the Delta Channel or in upstream reaches as a result of the proposed Delta Channel maintenance is not expected because the proposed action is maintenance of the existing Delta Channel only. If the reservoir level drops and remains low, that may institute another round of degradation. However, that degradation will be a direct result of the reservoir pool elevation change (rate, magnitude, and duration), and not a direct or indirect effect of this proposed action, which entails minimal maintenance that will not further lower the bed elevation below the elevation that develops as a response to the reservoir level. Noise disturbance to mice at the Pete Well site may occur if this site is found to be suitable habitat. Again, in the unlikely event that it is found to be suitable, Reclamation will coordinate with the Service prior to any work.

In consideration of the above, our determination is that the proposed action <u>will have no effect on</u> the mouse or on critical habitat for the mouse.

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Appendix A: Additional Information on the Area of Disturbance

Table A.1: Estimated In-Water Area of Disturbance per Year Maintenance of Existing Channel (20.8 miles).				
	Amphibious Tracked Machines		Airboats	
	Maintenance Work	Movement in Channel	Maintenance Support	Inspection Trips
	(acres)	(acres)	(miles)	(miles)
Crew #1				
(a) In-channel maintenance work: 25% of channel area in northern 9 miles of channel	63			
(b) Movement of excavators (30' width): 2 excavators @ 2.5 x 9 miles; 1 excavator @ 2.5 x 2 miles		182		
(c) Personnel Transport & Fueling			648	144
Crew #2				
(a) In-channel maintenance work: 25% of channel area in southern 12.4 miles of channel	50			
(b) Movement of excavators (30' wide path): 2 excavators @ 2.5 x 11.8 miles; 1 excavator @ 2.5 x 2 miles		233		
(c) Fueling: Amphibious Transporter (22' wide path): 198 miles per year		529		
(d) Personnel Transport			595	198
Totals (average per year)	**113 acres**	**944 acres**	**1,243 miles**	**342 miles**

Table A.2: Estimated In-Water Area of Disturbance per Year Extra Crew as Needed (9 miles).				
	Amphibious Tracked Machines		Airboats	
	Maintenance Work	Movement in Channel	Maintenance Support	Inspection Trips
	(acres)	(acres)	(miles)	(miles)
Crew #3				
(a) In-channel maintenance work: 100% of channel area	82			
(b) Movement of excavators (30' wide path): 3 excavators @ 2.5 x 9 miles		245		
(c) Fueling, Amphibious Transporter (22' wide path): 144 miles per year		384		
(d) Personnel Transport			432	144
Totals	**82 acres**	**629 acres**	**432 miles**	**144 miles**
	(0.33 km^2)	(2.55 km^2)		

Area Computation Details:

<u>Crew #1 (Reclamation):</u> This crew will cover the northern 9 miles of channel. It was assumed that two excavators will work 4 months per year and a third excavator will work 1 month per year. The first two excavators will cover the entire 9 miles and the third excavator will be brought in only where extensive work is needed, for an assumed length of 2 miles. It was assumed that two different launching areas will be used, to reduce distance from equipment work areas. This pertains to movement of equipment to work areas, transport of operators to excavators each day, and fueling of excavators.

The largest excavator has pontoons that are each 6 feet in width, with a distance from outside to outside of pontoons of 23.5 feet. Areas in table are computed based on a disturbance width of 30 feet for each excavator. For disturbance area due to excavators moving from work sites, it was assumed excavators will cover 2.5 times the distance of channel being maintained. This accounts for moving excavators to each worksite from the launching area, as well as other incidental movement required.

The fueling of excavators and transport of operators from launching areas to equipment will typically be performed by airboat. It is assumed that fueling will be performed every other day and transport of operators every day.

<u>Crew #2 (Contractor):</u> This crew will cover the southern 11.8 miles of channel. It was assumed that two excavators will work 4 months per year and a third excavator will work 1 month per

year. The first two excavators will cover the entire 11.8 miles and the third excavator will be brought in only where extensive work was needed, for an assumed length of 2 miles. It was assumed that two different launching areas will be used, to reduce distance from equipment work areas. This pertains to movement of equipment to work areas, transport of operators to excavators each day, and fueling of excavators.

The largest excavator has pontoons that are each 6 feet in width, with a distance from outside to outside of pontoons of 23.5 feet. Areas in table are computed based on a disturbance width of 30 feet for each excavator. For disturbance area due to excavators moving from work sites, it was assumed excavators will cover 2.5 times the distance of channel being maintained. This accounts for moving excavators to each worksite from the launching area, as well as other incidental movement required.

Fueling of excavators will typically be performed by a tracked amphibious transporter, with pontoon widths of 4 feet and a total width, from outside of pontoons, of 16 feet. Areas in table are computed based on a disturbance width of 22 feet for the fuel transporter. It was assumed that the transporter will fuel excavators every 3 working days.

Transport of excavator operators, from launching areas to equipment work areas, will occur every work day, by airboat.

<u>Crew #3 (Contractor):</u> It was assumed that 3 excavators will work 4 months per year. It was assumed that two different launching areas will be used, to reduce distance from equipment work areas. This pertains to movement of equipment to work areas, transport of operators to excavators each day, and fueling of excavators.

The largest excavator has pontoons that are each 6 feet in width, with a distance from outside to outside of pontoons of 23.5 feet. Areas in table are computed based on a disturbance width of 30 feet for each excavator. For disturbance area due to excavators moving from work sites, it was assumed excavators will cover 2.5 times the distance of channel being constructed. This accounts for moving excavators to each worksite from the launching area, as well as other incidental movement required.

Fueling of excavators will typically be performed by a tracked amphibious transporter, with pontoon widths of 4 feet and a total width, from outside of pontoons, of 16 feet. Areas in table are computed based on a disturbance width of 22 feet for the fuel transporter. It was assumed that the transporter will fuel excavators every 3 working days.

Transport of excavator operators, from launching areas to equipment work areas, will occur every work day, by airboat.

Appendix B: Maps of Flycatcher and Cuckoo Detections

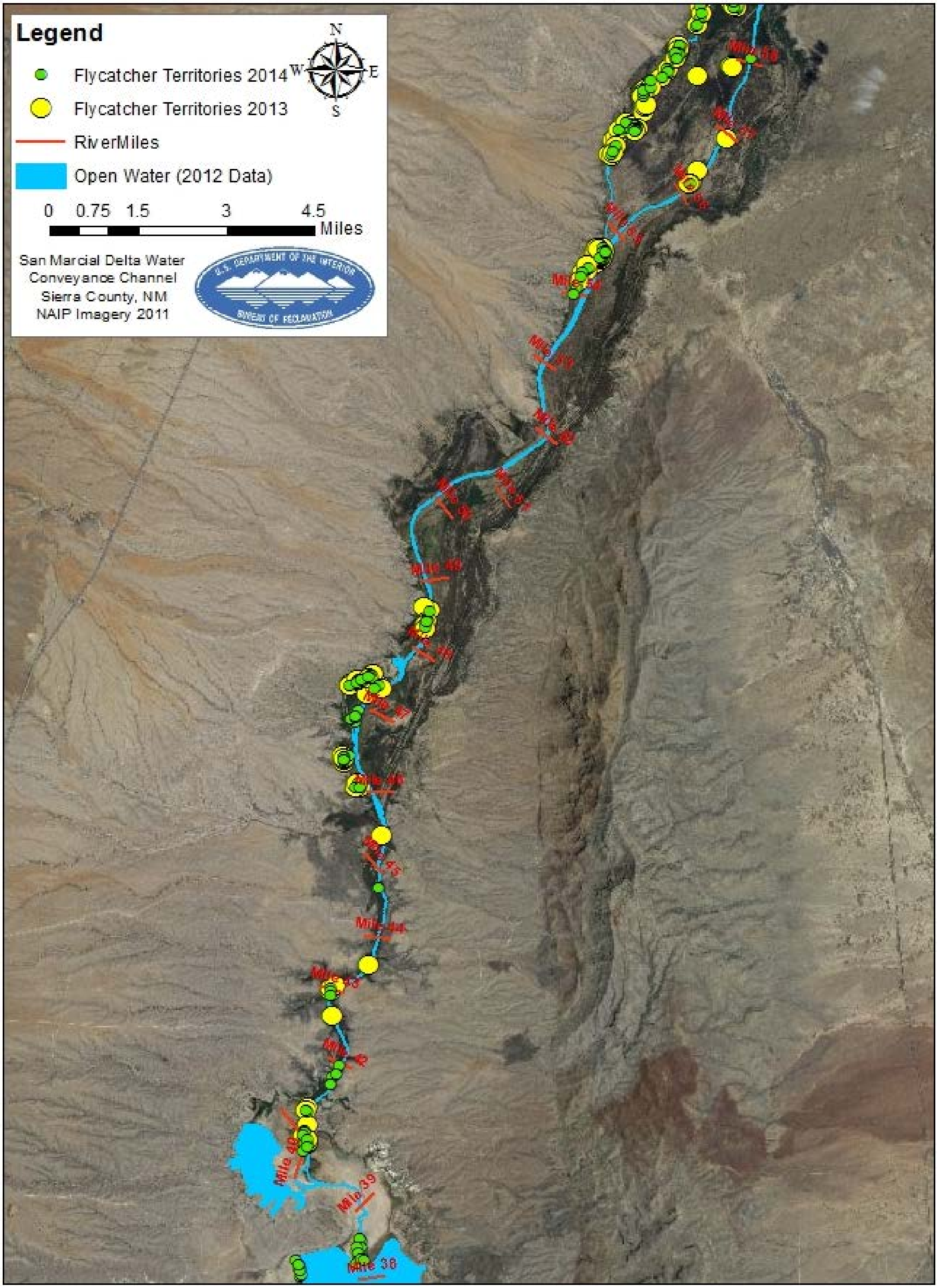

Figure B-1. Map of 2013 and 2014 Flycatcher Detections, Delta Channel.

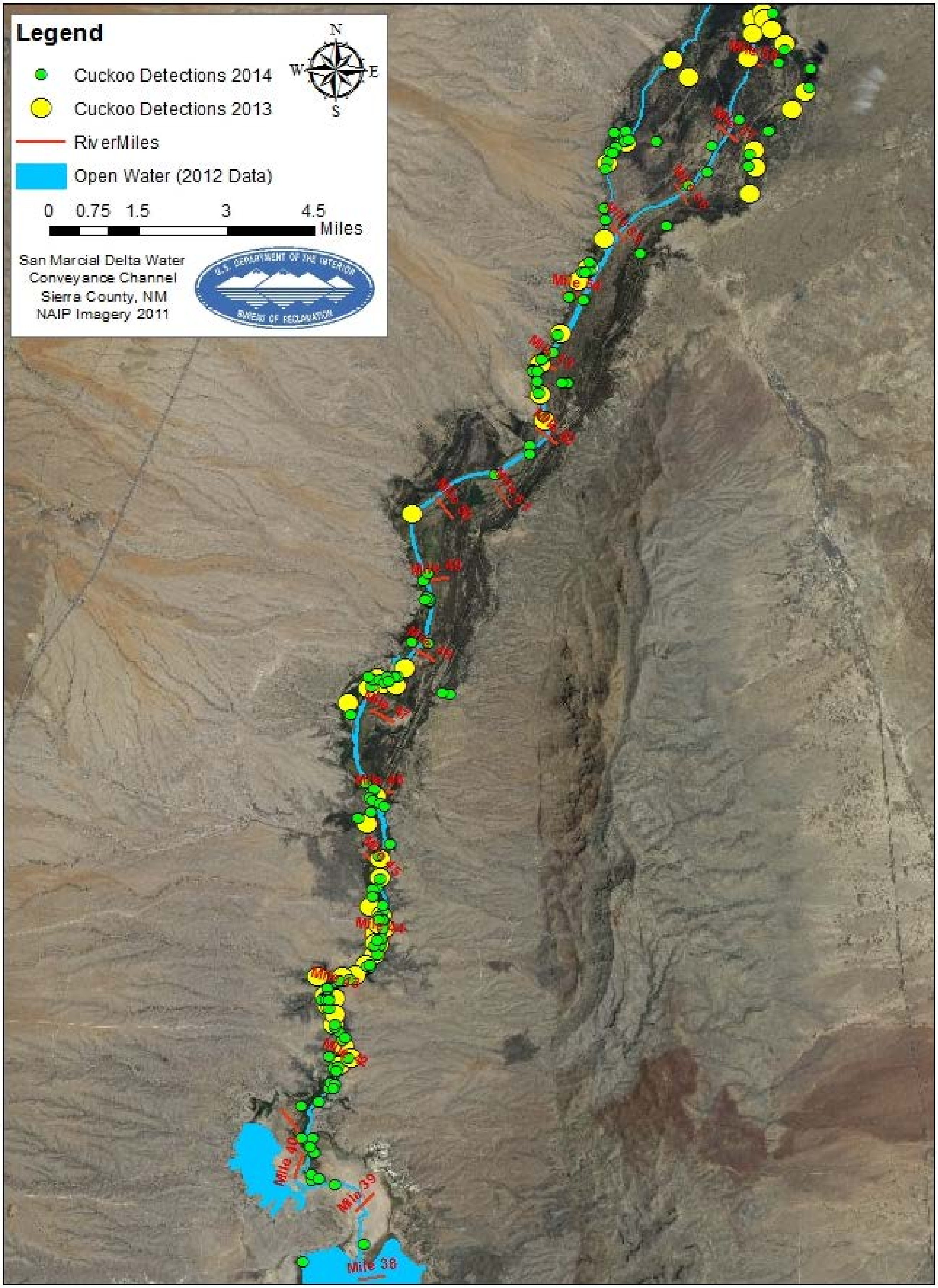

Figure B-2. Map of 2013 and 2014 Cuckoo Detections, Delta Channel.

APPENDIX B

HABITAT RESTORATION TECHNIQUES COMMONLY USED IN THE MIDDLE RIO GRANDE

Appendix B
Habitat Restoration Techiques
Commonly Used in the Middle Rio Grande

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Riparian vegetation establishment	Can cause sediment deposition in overbank areas due to increased flow resistance. Sediment deposition in the overbank can increase main channel sediment transport capacity by raising the bank height.	Directly adds to the amount of riparian vegetation.	Increased growth of riparian vegetation in overbank areas can enhance habitat conditions for both the flycatcher and the silvery minnow. Encroachment of mature vegetation may eventually lead to a narrower and more confined channel which is negative for silvery minnow habitat.
Longitudinal bank and bar/island lowering	Lowered bank line can promote a wider channel width and decreases in main channel velocity, depth, shear stress, and sediment transport capacity. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels. Increases overbank flooding, creating variable depth and velocity habitat. During subsequent years, sediment may deposit in the lowered bank line area occupied by vegetation, which may reduce overbank conveyance capacity.	Promotes overbank flooding favorable for establishment of riparian vegetation as well as creating variable depth and velocity habitat. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels.	Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff. Increased overbank flooding maintains moist soil conditions during flycatcher territory establishment. Growth of native riparian vegetation can enhance habitat conditions for the flycatcher.
Bankline embayments (Willow swales and backwater areas)	Historical channel slow water velocity and shallow depth bank line habitat is restored/rehabilitated. Bank line embayments are zones of sediment deposition and have a finite lifespan without periodic re-excavation.	Slow water velocity and shallow depth bank line habitat.	Increase in egg retention and availability of nursery larval habitat during high flow. Increases probability of native vegetation growth and potential for flycatcher habitat.
LWD/ Perennial pools	Creates pools, generates scour and substrate sorting, and increases depth and velocity complexity. Can promote side channel formation and maintenance. LWD in the Middle Rio Grande can lead to sediment deposition, including formation of islands, in reaches with large sand loads. Prone to sedimentation after inundation. Short life span for LWD using cottonwood trees on Middle Rio Grande.	Adds complexity to the system. Sediment deposition can create areas where new riparian vegetation becomes established. Can create variable depth and velocity habitat. Can provide structure and habitat for fish.	May provide for habitat diversity in areas with monotypic flow patterns and refugia habitat during low flows. These habitats may also provide refuge for predatory fishes. Increased areas of moist or flooded soil conditions could assist in flycatcher territory establishment and native vegetation recruitment.

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Exotic vegetation removal	Exotic vegetation removal may result in channel widening and increased floodplain connectivity. Channel widening could reduce channel flow depth and velocity. Degree of change is dependent on degree of connection between the main channel and the surface upon which the exotic vegetation is being removed. In removal areas that are currently disconnected from the river there is a negligible effect on the fluvial geomorphology of the river channel. The degree of influence exotic vegetation removal has on the geomorphology is also influenced by the timing of peak flows in relation to the period when exotic vegetation removal occurred. May also have an influence on the geomorphology of disconnected, historical floodplain areas as the removal of trees may allow for a higher groundwater table.	Could result in channel widening, increased floodplain connectivity, allow for a higher groundwater table and increase chances of native vegetation outcompeting exotics.	Dependant on site specific details, the removal of exotic vegetation could temporarily remove flycatcher habitat as species such as saltcedar do provide the structural composition required for nesting. Over the long term, if replaced with native vegetation and a wider channel and increased floodplain connectivity, could re-establish better nesting habitat over time. The temporary removal of vegetation may allow for a more active channel with connectivity to the floodplain creating silvery minnow habitat.

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Island and bank destabilization	Promotes a wider channel with greater floodplain connectivity and balances sediment. Reduces further degradation of the channel and lowering of the local water table. Sediments from destabilized areas may deposit new bars suitable for vegetation growth. Can locally increase sediment supply for a temporary period of time if erosion occurs. New sediment balance may be temporary unless incoming loads also increase. Can provide increased flood carrying capacity. Cleared and lowered bankline or island areas can become zones of sediment deposition and my need to be re-cleared and re-excavated for benefits to continue. Degree of change is dependent on degree of connection between the main channel and floodplain and the timing of peak flows in relation to the period when destabilization occurred	Reduces further degradation of the channel and lowering of the water table. Sediments from destabilized areas may deposit new bars suitable for vegetation. learing and destabilization would result in the temporary loss of this habitat. Islands/bars which are more connected to the main channel can provide silvery minnow with a greater variety of depth and velocity habitat types.	Provides low velocity habitat during high flows for adult fish. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff and aids in increasing egg and larval entrainment. Loss of habitat may be temporarily negative depending on site specific details and proximity to flycatcher territories, however, sediment accumulation forming new bars or islands could promote new seed source establishment and potentially young native successional stands to develop into flycatcher habitat. By reducing further degradation of the channel and lowering of the water table, the floodplain has a better chance of connectivity which is better overall for the flycatcher.
Side channel (high flow and oxbow reconnection)	Important to natural systems for passage of peak flows. Maintains higher water surface elevation and ground water table. Can reconnect the floodplain to the channel. Sediment tends to fill in high flow side channels over time. Can decrease peak flow water surface elevation and may decrease sediment transport capacity until sediment blocks the side channel. Method provides for reduced main channel sediment transport capacity. Sediment tends to deposit at the inlets and outlets. Periodic inlets and outlets sediment removal may be needed to maintain project benefits.	Side channels result in raising the ground water table and surface flows to developing riparian areas. Maintains higher water surface elevation and ground water table, adding to the health of the riparian zone. Can reconnect the floodplain to the channel, creating nursery habitat for silvery minnow with variable depth and velocity habitats.	Provides low velocity habitat during high flows for adult fish and developing larvae. Increase in retention of eggs and larvae during high flows. Raising the groundwater table to provide water to developing riparian areas increases vegetation health. Periods of increased surface flows, particularly during mid-May to mid-June, increases probability of flycatcher territory establishment in areas with suitable habitat.

Method	Geomorphic Response	Habitat Characteristics	Biological Response
GRF/sill	Grade controls can reduce the gradient upstream by controlling the bed elevation and dissipating energy in discrete steps. At least during low flows, the upstream water surface is raised, depending on structure height above bed. Upstream velocity is reduced. For low head structures (1 to 2 feet), the amount of upstream sediment storage is low and usually does not cause downstream bed level lowering as a result of upstream sediment storage. In sediment supply-limited reaches, channel degradation downstream of the structure will continue as a result of excessive sediment transport capacity. For a GRF the bed is fixed; For a rock sill the rock launches into the downstream scour hole.	Reduces channel degradation upstream of this feature and can promote overbank flooding and raise the water table. This provides more opportunity for riparian zone establishment and development. Backwater areas could develop upstream, which would raise the water table. If downstream degradation continued, then the water table would be lowered, reducing water availability to the riparian forest.	Increased overbank flooding upstream creates variable depth and velocity habitat types including potential spring runoff silvery minnow nursery habitat. Steeper apron slopes may restrict fish movement, while lower slopes can meet flow velocity requirements for fish passage. A reduction in channel degradation and increase in overbank flooding and water table levels would likely increase vegetative health and could attract flycatchers particularly if overbank flooding conditions occurred during territory establishment. However, the opposite effect would likely occur downstream.
Bendway weirs	The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted, and flows are redirected away from the bank. The outer bank can become a zone of lower velocity. The combined effect of the tip scour and lower velocity along the bank line creates a flow condition of variable depth and velocity. Scalloping can also occur along the bank line, or sediment deposition between structures depending upon local conditions and bendway weir geometry. Can reduce local sediment supplied from bank erosion, because the current river alignment is maintained.	Sediment deposition between structures may allow establishment of riparian vegetation and backwater areas. Channel deepening and tip scour could locally lower the riverbed and lower the ground water table.	Depending on site specific details, bendway weirs would allow for overbank flooding conditions for flycatchers. However, depending on the location and the degree of lowering the ground water table, construction efforts could impact flycatcher suitable habitat. Silvery minnow could be stranded in pools that would form between weirs as flow receeded. However, it could provide habitat diversity and deep habitat during low flow conditions.

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Rootwads	Creates local scour pools and variable depth and velocity habitat Increases flow resistance along the bank line, which dissipates energy, traps and retains sediments, and creates turbulence that can move the main current away from the bank line. Cottonwood tree rootwads have a design span of about 5 years; therefore, this method has been used with many other methods to create habitat.	Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement), which is generally beneficial to the establishment and development of riparian vegetation.	Can provide structure and habitat for silvery minnow. Isolated pools are often maintained in scour pools caused by debris, including rootwads. This can serve as refugia habitat for silvery minnow during low flow periods. Similar to LWD. Could trap sediment and encourage new native vegetative growth.
Jetty removal	Jetty removal may result in channel widening and increased floodplain connectivity. However, vegetation often promotes more bank stability than jetties, thus removal may not result in channel widening and increased floodplain connectivity. Channel widening could reduce channel flow depth and velocity.	The habitat may not change if the existing vegetation has more effect on bank stability than the jetties themselves. Otherwise, channel widening could reduce channel flow depth and velocity and create more bank line habitat.	If banks are destabilized, there can be an increased availability of shallower and lower velocity habitat for the silvery minnow. By destabilizing the bank, could encourage lateral migration of the river providing more opportunity for successional age classes of potentially native vegetation for flycatcher habitat.
Removal of lateral constraints	Can encourage current geomorphic processes to continue, such as lateral migration, and the creation of new floodplain and riparian areas. This may increase opportunities for the river to connect with historical channels and oxbows. For incised channels, may provide an opportunity to establish new inset floodplain and riparian zone. Lateral river movement creates broader floodplain. Lateral bank movement should result in deposition of sediment downstream. The river may establish bars and low surfaces as lateral migration continues to occur. Longer meander bends may establish greater pool depth and eroding banks providing additional complexity.	Lateral river movement creates broader floodplain and more favorable riparian zone habitat. Lateral bank movement should result in deposition of sediment downstream. The river will establish bars and low surfaces, where vegetation can become established. Longer meander bends may establish greater pool depth and eroding banks with vegetation falling into the channel, providing fish cover and habitat complexity.	Inset floodplain and riparian zones increase overbank flooding and create variable depth and velocity habitat types including potential spring runoff silvery minnow nursery habitat. The lateral migration of the river provides more opportunity for successional age classes of potentially native vegetation for flycatcher habitat.

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Longitudinal Stone Toe with Bioengineering	Studies about longer reach response are contradictory. Maintains the local current river alignment and the point bar remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend. Can be susceptible to flanking if upstream channel migration occurs. Eliminates sediment supplied from bank erosion. Bank line vegetation is established.	Prevents lateral migration and the establishment of new depositional zones where vegetation could become established. Eliminates sediment supplied from bank erosion. The steep bank angle on the outside of the bend limits fish cover, except for the riprap interstitial spaces. The point bar remains connected to the main channel and remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend. Bioengineering provides very minimal benefits to riparian community.	

APPENDIX C

RIVER MAINTENANCE METHODS

Appendix C. River Maintenance Methods

1. Introduction

Each strategy can be implemented using a variety of potential methods. The selection of methods depends upon local river conditions, reach constraints, and environmental effects. Method categories are described in Section 3.2.3.

Methods are the river maintenance features used to implement reach strategies to meet river maintenance goals. Methods can be used as multiple installations as part of a reach-based approach, at individual sites within the context of a reach-based approach, or at single sites to address a specific river maintenance issue that is separate from a reach strategy. The applicable methods for the Middle Rio Grande (MRG) have been organized into categories of methods with similar features and objectives. Methods may be applicable to more than one category because they can create different effects under various conditions. The method categories are:

- Infrastructure Relocation or Setback
- Channel Modification
- Bank Protection/Stabilization
- Cross Channel (River Spanning) Features
- Conservation Easements
- Change Sediment Supply

A caveat should be added that, while these categories of methods are described in general, those descriptions are not applicable in all situations and will require more detailed, site-specific, analysis for implementation. It also should be noted that no single method or method combination is applicable in all situations. The suitability and effectiveness of a given method are a function of the inherent properties of the method and the physical characteristics of each reach and/or site. It is anticipated that new or revised methods will be developed in the future that also could be used on the Middle Rio Grande. The description of any new or revised methods developed in the future, tiered off this programmatic river maintenance biological assessment (BA), would be developed with sufficient detail and provided in coordination with the U.S. Fish and Wildlife Service (Service).

2. Infrastructure Relocation or Setback

This method also has been referred to as “Removal of Lateral Constraints.” Riverside infrastructure and facilities constructed near the riverbanks may laterally constrain river migration. By relocating infrastructure, an opportunity is provided for geomorphic processes, especially lateral migration, to occur unencumbered by local lateral infrastructure constraints encouraging the river towards long-term dynamic equilibrium (Newson et al. 1997; Brookes et al., 1996). Bank erosion can remove older growth riparian areas, while deposition can create new floodplain and riparian areas. Potential facilities to be relocated include levees, dikes, access roads, canals, drains, culverts, siphons, utilities, etc. Infrastructure would need to be set back beyond the expected maximum extent of bend migration; otherwise, bank erosion and stability problems may, in time, relocate to the new infrastructure location. Thus, protection of re-located infrastructure still may be required as channel migration approaches these facilities.

3. Channel Modification

Channel modifications are actions used to reconstruct, relocate, and re-establish the river channel in a more advantageous alignment or shape and slope consistent with river maintenance goals. Channel modification actions may potentially result in a larger channel capacity at various flow rates and cause changes in channel shape and slope. Excavating new channel alignments and plugging existing channel entrances are part of this method category. Channel modification techniques also have been used to address geomorphic disequilibrium thereby reducing risks of bank erosion (Washington Department of Fish and Wildlife [WDFW] 2003). These methods include changes to channel profile, slope, plan shape, cross section, bed elevation, slope, and/or channel location.

3.1 Complete Channel Reconstruction and Maintenance

This method would allow for reconstructing the channel when tributary sediment deposition significantly decreases channel capacity, or the channel fills with sediment in aggrading reaches. This method functions to re-establish sediment transport capacity resulting in lower upstream bed elevations. Mechanical removal of sediment deposits involves excavation using buckets and depositing spoil along the channel margins. After dredging, the channel capacity would be about 5,000 cubic feet per second (cfs) or larger design discharge.

3.2 Channel Relocation Using Pilot Channels or Pilot Cuts

Channel relocation can be used to move the river away from an eroding bank line (WDFW 2003); create a more sinuous, longer channel; and reduce channel slope and channel incision (Bravard et al. 1999; Watson et al., 2005). Creating a longer channel can bring sediment transport capacity more in balance with sediment supply in supply-limited, degrading rivers. Pilot channels are excavated to a narrower width than the current main channel to reduce construction costs and reduce the size of sediment disposal requirements. Excavated sediments typically form the banks of the relocated channel. By constructing a narrower channel than exists in the reach, the excavated sediments lining both banks will transport downstream as the channel establishes its dynamic equilibrium width. Excavated sediments along the pilot channel banks may need to be repositioned over time to be fully transported downstream by high flows. The sediment available for transport downstream provides a small amount of sediment enrichment.

The method generally includes vegetation clearing so that the pilot channel widens to the equilibrium width. Bank lowering also can aid in establishing the new channel width. Bank lowering could include creating a compound channel section and widening the channel.

3.3 Island and Bank Clearing and Destabilization (Includes Channel Widening)

In river channels that are experiencing incision, floodplain disconnection, channel narrowing, and are sediment supply limited, clearing and destabilizing islands can be a means to provide floodplain connectivity, reduce vegetated island area, promote channel widening, and provide a small increase in sediment supply. Islands and banks can be cleared of vegetation and root plowed for destabilization to occur. Jetty removal may be necessary depending upon local site conditions. Two-stage channel or lowered terraces or floodplains can be created with this method. Excavation (lowering) of islands or bars may be necessary to lower their elevation and provide destabilization. Excavated sand material can be placed in the areas where river flows will transport spoil downstream, thus providing a small amount of sediment enrichment. Excavated sediments also can be placed on terraces or in overbank areas.

3.4 Bank Line Embayment

Bank line embayments have several different names including shelves, scallops, inlets, backwater areas, and swales. These habitat features are excavated into banks at a range of elevations that allows riverflows to enter during high-flow events such as spring runoff and summer thunderstorms. They are excavated into the bank lines with sufficient width and distance into the bank to provide a drift zone or slack water area of very low velocity for Rio Grande silvery minnow (RGSM) habitat, while allowing inflow and outflow at the inlet mouth. These features generally have a sloping bed surface that can be inundated at a variety of discharges during which RGSM spawning occurs. Discharges at which the invert is wetted can range from 500–1,000 cfs (Bauer 2005). Willows can also be planted (willow swales) in the excavated area.

3.5 Pilot Cuts Through Sediment Plugs

This method consists of excavating a narrow width channel (20–30 feet) through areas where sediment deposits have completely obliterated or plugged the river channel. The action of excavating a small width channel through the sediment plug provides a hydraulic connection between the upstream and downstream river channels, which encourages flows to transport sediments forming the plug downstream, thereby opening the channel back up to the main river flows.

3.6 Side Channels (High Flow, Perennial, and Oxbow Re-establishment)

Side channels consist of channels that can be accessed by river waters during peak flow events (high flow) or perennially, which are adjacent to the main river in the floodplain, bars, and islands. Side channels may be created by excavation. Excavation can consist of creating completely new side channels or enlarging natural topographic low areas on bars or abandoned floodplains when the channel has incised. Side channels also can be created by reconnecting topographic low areas that were former channel locations (abandoned oxbows). This method can reduce the main channel flow velocity and decrease sediment transport.

3.7 Longitudinal Bank Lowering or Compound Channels

This method allows the active floodplain to expand and the river channel to reconnect to the floodplain. In reaches where the river channel is incised, high-flow sediment transport capacity is reduced. The inner channel generally has a capacity for the range of normal flows, while flood flows expand to the larger channel constructed above the mean annual or 2-year return period flow (U.S. Army Corps of Engineers [USACE] 1989; Haltiner et al. 1996). Enlarging the channel using this method can be accomplished along one or two banks (Brookes 1988). The peak flow water surface elevation can be reduced, allowing higher discharges to pass safely. Flood flow storage is increased; and main channel depth, velocity, and shear stress can be reduced leading to reduced bank erosion (McCullah and Gray 2005). Excavated material can be placed in locations where river flows will transport spoil downstream, thus enriching sediment supply, or on terrace or upland areas.

3.8 Longitudinal Dikes

Longitudinal dikes are constructed more or less parallel to the channel to guide and contain high flows (up to the 2-year return period discharge with some freeboard). However, these dikes do not furnish flood protection as is provided by riverside levees. Another purpose is to concentrate high flows to a narrower width of the floodplain, thereby increasing the main channel velocity, sediment transport rates, and channel capacity (Brookes 1988). This can reduce the likelihood of future plug formation in aggrading areas of the Middle Rio Grande. These dikes can be along the riverbank or set back to avoid toe erosion and can be associated with bank protection/stabilization methods. Culverts generally are placed through these dikes to either provide passage of surface runoff or to provide flow into the adjoining floodplain during peak discharges depending upon local conditions and habitat needs. Depressions in the dikes lined with variably sized rock (low water crossings) to allow controlled overtopping also can be a means to provide flows into the adjoining floodplain.

3.9 Levee Strengthening

Levee strengthening includes raising, widening, and reducing the levee side slopes for increased stability and to prevent overtopping. Widening and reducing the side slopes also can reduce the ground pressure underneath the structure to prevent bearing/foundation and slope failures. Generally, levees are designed for a 50- to 100-year return period flood. Other return period floods also can be used based upon economic considerations (Przedwojski et al. 1995). Depending upon local site conditions and needs, levee strengthening is sometimes accomplished for a lower flood peak, such as the 2-year return period flow plus 2–3 feet of freeboard on the Middle Rio Grande in the reach south of San Antonio, New Mexico. Levee strengthening functions to protect land and facilities outside of the floodplain from inundation.

3.10 Jetty/Snag Removal

This method performs the removal of jetty jacks from areas where their function is no longer necessary as a means to protect the bank lines or where the jetties have been moved into main river channel as a result of erosional processes and may pose a hazard. Snags (trees, vehicles, trash, ice, etc.) may be removed from the river in rare occasions to prevent them from posing a serious public hazard. They also may be removed in instances where they are deflecting flows into a bank line causing significant bank erosion.

4. Bank Protection/Stabilization

Bank protection works may be undertaken to protect the riverbank against fluvial erosion and/or geotechnical failures (Hey, 1994; Brookes, 1988; Escarameia, 1998; McCullah and Gray, 2005). Bank protection methods described in this section apply to cases where bank line and toe erosion are the primary mechanism for bank failure. In situations where the bank slope is unstable due to geotechnical processes, other methods would need to be applied in addition to bank stabilization (Escarameia 1998). These methods could include placing additional material at the toe of the slope or removing upslope material to eliminate rotational failure potential (Terzaghi et al. 1996).

4.1 Longitudinal Features

Longitudinal methods involve the placement of stone—variably sized rock material—along the bank line to provide erosion protection. Variably sized rock also may be placed on the top of the bank or in a trench set back from the bank line. Some bank shaping generally is required as part of construction.

4.1.1 Riprap Revetments

Typically, revetments are constructed from variably sized rock material that is placed along the entire bank height or from the toe to an elevation of a design water surface elevation to resist and prevent further erosion. Variably sized rock material generally is used in revetments, due to its ability to self-adjust (filling of scour holes through the self-launching initiated from gravity), preventing failure due to bed scour.

4.1.2 Other Types of Revetments

Revetments also may be constructed using stabilized soil, manufactured revetment units, and cellular confinement systems. Treatment of soils makes them less susceptible to erosion; the most common soil treatment is soil cement. Soil and cement are mixed and compacted to make an erosion-resistant material. Soil cement cannot be constructed under water and is applicable only in unusual circumstances. Several types of manufactured units are available for revetment construction. These units typically are made of concrete and are designed to be placed on the bank in interlocking patterns. The high cost of these systems would limit their use to very special cases. Plastic grid systems, designed to limit movement of soils, also can be used to prevent erosion. These systems use a honeycomb cell sheet anchored to the bank to contain fill material. These systems may be practical in conditions where erosion potential is small. Gabions or wire enclosing variably sized rock also can be used to prevent bank erosion, but structural difficulties arise when construction occurs in the water. The type of material used in a particular application determines the range of applicability—for example, materials or structures, such as gabions or stabilized soil that will fail with vertical movement, would be applicable only in stable bed situations.

4.1.3 Longitudinal Stone Toe with Bioengineering

Longitudinal stone toe with bioengineering involves placing stone variably sized rock material from the toe of the slope up to an elevation where riparian vegetation normally grows. Vegetation is used to protect the remainder of the slope up to the top of the bank or a peak flow design discharge. Bioengineering also can include biodegradable fabrics, wattles, mats, Bio-D Blocks, etc., to assist with vegetation growth and bank stability. Most commonly, willows and cottonwood poles, willow bundles/mats/fascines, or other planting methods would be used. Plantings also can be along the top of the bank or on terraces along the bank line to prevent overland erosion to the bank line.

4.1.4 Trench-Filled Riprap and Riprap Windrows

Trench filled riprap is a stone armor revetment with a large stone toe that is constructed in an excavated trench behind the bank line. A windrow revetment is rock placed on the floodplain surface landward from the existing, eroding riverbank. For both trench-filled riprap and riprap windrow, the river erodes to the predetermined location, and the riprap material launches into the river that forms an armored bank line (Biedenharn et al. 1997; McCullah and Gray 2005). For both applications, additional riprap material may need to be applied due to non-uniform launching along the bank line.

4.1.5 Deformable Stone Toe with Bioengineering and Bank Lowering

This method involves stone toe protection, an internal gravel filter (if needed), soil lifts wrapped in biodegradable coir fabric or other bioengineering, and an aggressive re-vegetation plan (Miller and Hoitsma 1998). The stone toe protection in this method is designed to be moved by the flows, becoming bedload after the vegetation is established, and gradually becomes part of the bed material in the river as the bank deforms. The method also can be used in conjunction with overbank lowering when the channel is incised. This will increase floodplain connectivity and provide a large, vegetated area through which the river may migrate, to achieve a better balance between sediment supply and sediment transport capacity for incising channels. The vegetation in the lowered area will provide some bank stability by virtue of natural root structure, while allowing bank erosion and mobility.

Stone toe protection is sized to erode during the 5- to 10-year frequency flood (relatively small rock). The toe elevation of the stone toe protection generally is placed where vegetation naturally grows in the river reach. The soil lifts, wrapped in biodegradable fabric, provide a series of distinct soil lifts or terraces that are subsequently vegetated and are placed above the stone toe. The biodegradable fabric would have an expected life span of 3–5 years; over which time, the vegetation would be firmly established. The fabric protects the soil lifts and vegetation plantings from erosion during high-flow events. The soil lifts wrapped in biodegradable fabric are called “fabric encapsulated soil” (FES). This method functions to provide a stabilized bank using toe rock, which becomes mobile after vegetation has firmly established along the bank line. Once the variably sized rock toe becomes mobile, the vegetation root structure provides some bank stability while still allowing bank erosion and channel migration.

4.1.6 Bioengineering

This method involves planting vegetation along the bank line for limited erosion resistance. Most commonly, willows and cottonwood poles, willow bundles/mats/fascines, or other planting methods would be used. Plantings also can be along the top of the bank or on terraces along the bank line to prevent overland erosion to the bank line. Vegetation has the lowest erosion resistance of all available methods (Hey 1994), and plantings require time to establish, and bank protection is not immediate (National Resources Conservation Service [NRCS], 1996). Biodegradable fabrics wattles, mats, Bio-D Blocks, fascines, etc., may be used to assist with vegetation growth and bank stability until vegetation becomes well established (Fischenich 2000).

Few plants grow below the base level flow, except for their roots. Establishing plants to prevent undercutting of the bank due to toe scour is difficult (NRCS 1996); therefore, the use of living vegetation as a bank protection material is generally limited to the bank elevations above a base level of flow (Fischenich, 2000). This base level of flow could be the mean annual water surface, bank full elevation, or at the elevation of depositional bars and bank line surfaces where natural vegetation grows in the river system. Most bioengineering methods have some longitudinal toe protection component included (NRCS 1996; Fishenich 2000). This method may be used in situations where the bank line is slowly eroding near infrastructure without channel incision and active meandering.

4.1.7 Riparian Vegetation Establishment

This method involves planting vegetation in the floodplain or active channel areas to reduce velocity and create zones of sediment deposition; it also is used in conjunction with other methods to provide habitat benefits along the river channel as well as along structures such as levee/berms and deformable bank lines. Potential ways to establish vegetation have been described in “Stone Toe with Bioengineering” and “Bioengineering” methods.

4.2 Transverse Features or Flow Deflection Techniques

Transverse features are structures that extend into the stream channel and redirect flow so that the bank line velocity and shear stress are reduced to nonerosive levels. They generally are constructed using variably sized rock with little or no bank shaping being necessary unless an alignment change is necessary. Design guidelines based upon hydraulic performance measurements do not exist at this time. Reclamation and Colorado State University’s Engineering and Research Center currently are working to develop suitable design guidelines. Boulder groupings, rootwads, and large woody debris are included in the section because they deflect flow.

4.2.1 Bendway Weirs

Bendway weirs are features constructed with variably sized rock that extend from the bank line out into the flow. They have horizontal crests that are submerged at high flows and are angled upstream. Bendway weirs are designed to control and redirect currents away from the bank line throughout the bend and immediately downstream from the bend, thus reducing local bank erosion. During low river discharges, the flow is captured by the weir and all directed to the center of the channel. At high flows, secondary currents are redirected which reduces near bank velocity. They also re-align or relocate the river thalweg through the weir field and downstream. Some bank scalloping (erosion) between weirs can occur. A downstream scour hole can occur.

4.2.2 Spur Dikes

Spur dikes are a series of individual structures that are placed transverse to the flow projecting from the riverbank with a horizontal crest, usually at the elevation of the top of bank or design flow water surface elevation. They are placed either perpendicular to the bank or oriented downstream. Spurs deflect flow away from the bank, reducing the near bank velocity and, thus, preventing erosion of the bank in critical areas. L-head, "hockey stick," or T-head added to the spur tip can move scour away from the dike (Biedenharn et al. 1997).

4.2.3 Vanes or Barbs

Vanes, also known as barbs, are discontinuous, transverse structures angled into the flow. They can be used for bank protection, as well as for providing variable depth and velocity habitat. Instream tips are usually low enough to be overtopped by nearly all flows; the crest slopes upward generally to the bank line or bank-full stage elevation at the bank. The tip is inundated at most low flows. They are angled upstream to redirect overtopping flows away from the protected bank. The sloping top redirects flow and reduces local bank erosion, while providing a downstream scour hole. Flow redirection causes the velocity and shear stress along the bank to decrease while creating a secondary circulation cell that transfers energy to the center of the channel (Fischenich 2000), creating a new thalweg location.

Some sediment deposition may occur upstream of and downstream from the structures, resulting from the redirected flows. In situations where sediment deposition occurs between the structures, additional bank protection can develop over time. In certain situations, bank scalloping between weirs may occur.

4.2.4 J-Hooks

J-hooks are vanes (barbs) with a tip placed in a downstream pointing "J" configuration. The "J" tip is partially embedded in the riverbed, so it is submerged during low flows. The "J" tip is intended to create a scour pool downstream from the "J" tip, especially in gravel to cobble substrates (McCullah and Gray 2005). They provide the same bank protection as vanes or barbs and have potential for initiating sediment deposition or bank scalloping between structures.

4.2.5 Trench-Filled Bendway Weirs

Trench-filled bendway weirs are bendway weirs extending transverse to the anticipated future flow direction and are buried in excavated trenches behind the riverbank. The river erodes to the predetermined weir locations, and the erosion resistant weir tips become exposed. The trench bottom elevation usually will be below the high-flow water surface elevation, placed ideally at the channel thalweg elevation; but due to seepage, issues may have to be raised to above the low-flow water surface elevation. Bendway weir stones would launch from the bottom of the trench to the thalweg elevation. After launching, additional rock may need to be added, and the weir tips may need to be reshaped to provide the same hydraulic effect as typical bendway weir installations. After the bank erosion process (and with additional rock placement and reshaping), bendway weirs would provide the same function described above in the bend way weir section.

4.2.6 Boulder Groupings

Boulder groupings are strategically placed, large, immobile boulders and groupings of boulders placed within a channel to increase or restore structural complexity and variable depth and velocity habitat (Saldi-Caromile et al. 2004). If the channel lacks these features, adding boulder groupings can be an effective and simple way to improve aquatic habitat. High-flow events interacting with boulder groupings create and maintain downstream scour pools and provide bed sorting. Large boulders are placed individually, in clusters, or in groups to improve habitat.

4.2.7 Rootwads

Rootwads are trees embedded into the banks or bed of the channel with the root mass or root ball placed in the flow. Rootwads provide some flow redirection; and, if placed close together, they can move the current line away from the bank (McCullah and Gray 2005). They can create additional habitat value, such as local scour pools and substrate sorting when the bed is gravel, and variable velocity habitat (McCullah and Gray 2005; Sylte and Fischenich 2000).

4.2.8 Large Woody Debris

Large woody debris (LWD) structures are made from felled trees and may be used to redirect, deflect, or dissipate erosive flows. LWD also can be used to enhance the effectiveness and mitigate the impacts of other treatments such as variably sized rock, revetments, longitudinal stone toes, and transverse features (WDFW 2003). LWD can be used to enhance the creation of side channels by the formation of medial bars with a pool downstream of the LWD (Saldi-Caromile et al. 2004). Downstream scour can create perennial pools and variable depth and velocity habitat conditions.

5. Cross Channel (River Spanning) Feature

These methods are placed across the channel using variable-sized rock material without grout or concrete (Nielson et al. 1991; Watson et al. 2005). The objective of cross channel or river spanning features is to control the channel bed elevation or grade, which may improve or maintain current floodplain connectivity and ground water elevations. The primary focus of cross channel structures would be slowing or halting channel incision or raising the riverbed. Grade control features also have been used in cases where channel incision has or will cause excessive bend migration and undermining of levees and riverside infrastructure (Bravard et al. 1999).

5.1 Deformable Riffles

This method is new and untested. The goal is to:

- Establish a channel with a stable grade
- Allow some vertical channel bed movement
- Enrich sediment supply by adding a small amount of gravel/small cobble bed material load

This method is more natural than other grade control methods. In this conceptual deformable riffle method, a trench would be constructed across the channel and filled with material that would be stable during most flows, while becoming slightly mobile during less frequent high-flow events, to provide a small amount of sediment enrichment. The trenches also would extend in the longitudinal downstream direction the length of typical stable riffles and with a stable riffle slope. Rock material also could be placed on the bed.

Fluvial entrainment of the deformable riffles would be estimated to take place between 5- and 10-year peak flow events. The gradation of imported variably sized rock would also contain sizes less than the median size, which would be mobile at the 2-year event. Natural riffles may be used to help construct the shape and help determine the particle size, if there is knowledge about the flow range for which the particles are mobilized as bed load.

Riffles could be installed in a single location or in series along the river, spaced at about five to seven river widths apart. Each riffle would contain a supply of material, enough to be mobilized during several 5- to 10-year events; thus, a small amount of gravel/cobble size material would be supplied as bed load to the river during each event. Also, during each 5- to 10-year event, a small amount of erosion of the riffles would occur; but since the material is sized to move as bedload at the higher flows, providing erosional resistance, slope increases across the structure due to erosion is expected to be minimal.

5.2 Rock Sills

Rock sills involve placing stones directly on the streambed that resist erosion within a degradational or incising river zone (Whittiker and Jaeggi 1986; Watson et al. 2005). This method differs from the deformable riffle because rock sills are intended to be constructed of immobile stones, while deformable riffles have smaller stones that are transported during certain high-flow events. The rock sill would deform as the channel establishes small pools and scour between each sill. These can be implemented as a single structure or sequentially in the downstream direction.

5.3 Riprap Grade Control

Variably sized rock grade control structures are constructed by excavating a trench across the streambed which is filled with rock, with the top elevation being the river bed (Biedenharn et al. 1997). The structure is flexile in that as the channel degrades and downstream scour occurs, a portion of the variably sized rock in the trench will launch. In cases where seepage is an issue at low flows, an upstream impervious layer of fill material or a sheet pile wall can be constructed.

5.4 Gradient Restoration Facility

This method raises the river bed about 1-2 feet, and has a long low slope downstream apron to facilitate fish passage. Gradient restoration facilities (GRF) consist of an upstream sheet pile wall, with or without a concrete cap or stable grouted variably sized rock section. The downstream apron location of the structure is also often fixed by a sheet pile wall. Scour protection is added to protect the downstream sheet pile wall from downstream scour. GRFs are designed to replicate long, low slope riffles where fish already pass through and to raise the river bed up to improve floodplain connectivity. These low structures can raise the water surface during low flows and do not generally raise the water surface during higher flows.

5.5 Low Head Stone Weirs

Low head stone weirs can be used to protect banks, stabilize the bed of incising channels, activate side channels, reconnect floodplains, and create in-channel habitat. The structures are most commonly constructed with individually placed stones or smaller variably sized rock; span the river width; and have “U,” “A,” “V,” or “W” shapes. The apex of the “V” weir is pointing upstream while the apexes of the “W” weir can be pointing both upstream and downstream. During low flows, there is a change in water surface elevation through the structures, although some fish can pass through the interstitial spaces between stones. These structures also can be oriented to align the flow toward the center of the downstream, promoting a pool while directing currents away from the bank line and, thereby, limiting bank erosion.

6. Conservation Easements

Conservation easements are land agreements that prevent development from occurring and allow the river to erode through the area as part of fluvial processes. Conservation easements also preserve the riparian zone in its current and future states as determined by fluvial processes and floodplain connectivity.

This method preserves and promotes continuation of riparian forests, ecosystem, and river corridor conservation (Karr et al. 2000). Conservation easements may or may not involve infrastructure relocation or setback. Similar to infrastructure relocation or setback, it may be possible to use conservation easements as an opportunity for the river to access historical floodplain areas.

7. Change Sediment Supply

Sediment transport and supply vary with discharge over time and in space within a river system. Where the supply of sediment is limited or has been reduced, the result is generally channel incision, bank erosion, and possibly a channel pattern change from a low-flow, braided sand channel with a shifting sand substrate to a single-thread, mildly sinuous channel with a coarser bed. In general, the channel width decreases, channel depth increases, local slope decreases, and sinuosity increases (Schumm 1977). The addition of sediment supply can stabilize these tendencies.

When a river system has more sediment supply than sediment transport capacity, channel aggradation (i.e., bed raising due to sediment accumulation) will occur. In general, aggradation results in the channel width increasing, channel depth decreasing, local slope increasing, and sinuosity decreasing (Schumm 1977), and in decreased channel and flood capacity. Sediment berms also can form along the channel banks (Schumm 2005). The reduction of sediment supply can slow or reverse these trends.

7.1 Sediment Augmentation (Sand Sizes)

Sediment augmentation involves adding sediment supply to the river. The objective of this method is to slow or halt the effects of channel incision due to a reduced sediment supply. The timing, magnitude, and location of sediment re-introduction can be adaptively managed. Sediment sources can be from bank/bar/island clearing, destabilization, and lowering, arroyo reconnection, and/or sediment bypass of water storage structures. Bank/bar/island clearing and destabilization involves clearing vegetation and root plowing to loosen sediment for removal by high flows. This is practical if the elevations are low enough to be inundated frequently with erosive flow velocities.

Bank/bar/island lowering involves clearing vegetation, excavating bank material, and placing the excavated material in erosional zones so that river flows will transport sediments downstream during high flows. Bank lowering provides increased floodplain connectivity. Bank/bar/island lowering enables the sediment supply to be increased for incised reaches where the elevation of these surfaces is not frequently inundated with erosive flow velocities. Imported sediment also can be used; but for economic reasons, this is not likely.

7.2 Natural or Constructed Sediment Basins

The reduction of sediment supply can reverse downstream aggradational trends by "controlling sediment delivery to a downstream channel and to localize sediment accumulation" (Sear 1996). The objective of this method is to reduce downstream aggradation and promote sediment storage at strategic locations, such as natural topographic low areas or constructed sediment basins.

Initiating the river to deposit sediment in natural topographic low areas would involve relocating the channel periodically.

Channel relocation and associated actions are described in Section 3.2, "Channel Relocation Using Pilot Channels or Pilot Cuts," in this attachment. Constructed sediment basins provide wide lower velocity conditions that initiate localized sediment deposition. Basins eventually fill with sediment requiring either local dredging and disposal of sediment or relocating the basin to another area that is conducive to sediment storage. Sediment basins would involve constructing flow containment berms and inlet and outlet structures to control flow. Inlet and outlet structures most likely would be variably sized rock guide berms and sills. Sills are variably sized rock structures that raise the outlet channel to a set elevation, and are perpendicular to the flow direction to prevent erosion of the containment berms.

8. Method Combinations

A combination of methods most likely will be used at all river maintenance sites on the Middle Rio Grande to provide multipurpose benefits. For a given strategy, many combinations of methods may be used to provide an effective river maintenance solution. The relationship between individual methods and strategies is shown in the following table 1.

For example the Promote Elevation Stability strategy methods include Grade Control, Deformable Riffles, Rock Sills, GRFs, etc. (table 1). Options such as changing channel slope through adjustments in channel length (Channel Relocation Using Pilot Channels, or Pilot Cuts), floodplain reconnection (Longitudinal Bank Lowering), and sediment augmentation (Increase Sediment Supply) also can promote elevation stability in reaches with excess sediment transport capacity; so combinations of methods, suitable to different strategies, could be used to provide multipurpose benefits.

Table 1. Methods Associated with Strategies

Strategy / Method	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Floodplain	Manage Sediment
INFRASTRUCTURE RELOCATION OR SETBACK				X		
CHANNEL MODIFICATION						
Complete Channel Reconstruction and Maintenance			X		X	
Channel Relocation using Pilot Channels or Pilot Cuts					X	X
Island and Bank Clearing and Destabilization					X	X
Bank Line Embayment					X	
Pilot cuts through sediment plugs			X			
Side Channels (High Flow, Perennial, and Oxbow Re-establishment)					X	
Longitudinal Bank Lowering or Compound Channels					X	
Longitudinal Dikes			X			
Levee Strengthening			X			
Jetty/Snag Removal[1]						
BANK PROTECTION/STABILIZATION						

Table 1. Methods Associated with Strategies

Strategy / Method	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Floodplain	Manage Sediment
Longitudinal Features						
Riprap Revetment		**X**				
Other Type of Revetments		**X**				
Longitudinal Stone Toe with Bioengineering		**X**				
Trench-Filled Riprap		**X**				
Riprap Windrow		**X**				
Deformable Stone Toe/Bioengineering and bank lowering		**X**				
Bio-Engineering		**X**				
Riparian Vegetation Establishment		**X**				

[1] This method can be used with all strategies, and there is not a predominant strategy.

Table 1. Methods Associated with Strategies (continued)

Strategy / Method	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Floodplain	Manage Sediment
Transverse Features or Flow Deflection Techniques						
Bendway Weirs		X				
Spur Dikes		X				
Vanes or Barbs		X				
J-Hook		X				
Trench Filled Bendway Weirs		X				
Boulder Groupings		X				
Rootwads		X				
Large Woody Debris		X				
CROSS CHANNEL (RIVER SPANNING) FEATURES						
Grade Control						
Deformable Riffles	X					
Rock Sills	X					
Riprap Grade Control (with or without Seepage)	X					
Gradient Restoration Facility (GRF)	X					
Low-Head Stone Weirs (Loose Rock)	X					
CONSERVATION EASEMENTS				X	X	
CHANGE SEDIMENT SUPPLY						
Sediment Augmentation (Sand Sizes)						X
Natural or Constructed Sediment Basins						X

9. Methods Level of Confidence, Geomorphic and Habitat Responses

For each method there is a level of confidence, geomorphic, and habitat effect. The confidence that a method will perform its intended purpose is based upon whether the local response is well known; and the amount, level, and type of information known. The definitions for confidence levels are:

Level 3. Well established, widely used, well documented performance, reliable design criteria, numerous case studies, well known local geomorphic response that is well documented.

Level 2. Often used but lacks the level of detail, quality of information and reliability that characterizes Level 3, little or no long-term monitoring, limited design criteria, limited knowledge about the local geomorphic response, and limited documentation.

Level 1. Emerging promising technique that does not have a track record, field or lab data, or design or test data; has few literature citations; has sparse documentation; and where little is known about local geomorphic response, etc.

Many of the methods have promise for successful implementation but do not have design guidelines based upon hydraulic and engineering performance. If design guidelines exist, they are qualitative and based upon anecdotal information that is not applicable to most river systems. Methods that need additional development of criteria and design guides include: longitudinal bank lowering, transverse features, deformable riffles, and low-head stone weirs.

A geomorphic and habitat effect has been identified. Method level of confidence together with these effects for each method is shown in table 2. A more complete description of confidence level, and method geomorphic and habitat effects can be found in Reclamation (2012).

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
INFRASTRUCTURE RELOCATION OR SETBACK	Level 3 (Infrastructure) and Level 2 (Limited Postproject Field Studies – River Response)	Can encourage current geomorphic processes to continue, such as bend migration and the creation of new flood plain and riparian areas. Opportunity to connect to historical channels and oxbows. For incised channels, may provide an opportunity to establish new inset flood plain and riparian zone. Bank erosion also should result in deposition of sediment downstream and potentially establish bars and low surfaces. Bend migration can erode banks causing riparian vegetation to fall into the channel.	Bend migration river movement creates broader flood plain and more favorable riparian zone habitat. Inset flood plain increases overbank flooding and riparian zones that create variable depth and velocity habitat types, including potential spring runoff silvery minnow nursery habitat. The lateral and down valley migration of the river provides more opportunity for successional age classes of potentially native vegetation for flycatcher habitat. Longer meander bends may establish greater pool depth and eroding banks providing additional complexity.
CHANNEL MODIFICATION			
Complete Channel Reconstruction and Maintenance	Level 3	Increased sediment transport through a delta or reconstructed channel. Decreases upstream channel aggradation. Can lead to channel bed lowering upstream of the project site, and low-flow alternate bars can form within the excavated channel. Relatively uniform width, depth, and velocity. Reduces braiding and split delta channels. Can lower the ground water table, and reduce the size of river bars. If medial and alternate bars are not removed as part of ongoing maintenance, then the amount of shallower, lower velocity areas should increase.	Can have more uniform width, depth, and velocity. Limited amount of low or no velocity habitat; low amount of cover. Reduces braiding and distributary channels and, thus, provides less opportunity for riparian growth. Lowers ground water table and reduces the size of river bars. If medial and alternate bars are not removed as part of ongoing maintenance, then the amount of smaller depth and velocity habitat increases.
Channel Relocation using Pilot Channels or Pilot Cuts	Level 2 (Construction and Hydraulics) and Level 1 (Limited Postproject Field Studies)	Lengthening can bring sediment transport capacity more in balance with sediment supply in supply-limited reaches. Re-establishes meanders, increases channel stability, and initiates new areas of bank erosion and deposition. Can provide overbank flooding and can create connected flood plain/wetted areas.	Can provide overbank flooding and establish new areas of riparian vegetation. Can increase the complexity of habitat by creating connected flood plain/wetted areas for RGSM egg entrainment and larval development.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Island and Bank Clearing and Destabilization	Level 1	Promotes a wider channel with greater flood plain connectivity and better transport capacity/supply balance. New sediment balance may be temporary unless increased supply is maintained. Reduces further degradation of the channel and lowering of the water table. Clearing and destabilization would result in the lowering and/or loss of islands and bars, but sediments from destabilized areas may deposit in new bars, which would be more connected to the main channel and suitable for vegetation growth. Cleared areas may become zones of sediment deposition, and vegetation may re-grow, making reclearing necessary for benefits to continue.	Islands/bars that are more connected to the main channel can provide RGSM with a greater variety of depth and velocity habitat types. Provides low velocity habitat during high flows for adult fish. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff and aids in increasing egg and larval entrainment. Loss of habitat may be temporarily negative depending on site-specific details and proximity to flycatcher territories; however, sediment accumulation forming new bars or islands could promote new seed source establishment and potentially young native successional stands to develop into flycatcher habitat. By reducing further degradation of the channel and lowering of the water table, the flood plain has a better chance of connectivity that is better overall for the flycatcher.
Bank Line Embayment	Level 1 Rehab Channel and Flood Plain	Historical areas of channel, slow water velocity and shallow bank line are restored/rehabilitated. Bank line embayments are zones of sediment deposition and have a finite lifespan without periodic re-excavation.	Slow water velocity and shallow depth bank line habitat. Increase in egg retention and availability of nursery larval habitat during high flow. Increases probability of native vegetation growth and potential for flycatcher habitat.
Pilot Cuts Through Sediment Plugs	Level 2	Connecting small channels through sediment plugs results in plug material being transported downstream to re-establish preplug riverine conditions. Restores flow velocity and depth conditions found in the main river channel. Allows sediment transport to continue, which may possibly provide new bars and islands downstream.	Allows sediment transport to continue, which may possibly provide new areas for riparian vegetation establishment. While the sediment plugs block main channel flows, RGSM do utilize overbank channels through the riparian corridor created by the plug. There is increased potential for RGSM stranding during receding flow conditions.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Side Channels (High Flow, Perennial, and Oxbow Re-establishment)	Level 2 (Design Methods Available) and Level 1 (Limited Postproject Field Studies)	Important to natural systems for passage of peak flows. Sediment tends to fill in high-flow side channels over time. Can decrease peak-flow water surface elevation and may decrease sediment transport capacity until sediment blocks the side channel. Periodic inlets and outlet sediment removal may be needed to maintain project benefits. Side channels result in raising the ground water table and can supply surface flows to overbank and flood plain areas. Can reconnect the flood plain to the channel, creating areas with variable depth and velocity.	Can result in higher ground water table, increasing the health of the riparian zone. Can reconnect the flood plain to the channel, creating nursery habitat for RGSM with variable depth and velocity habitats. Provides low velocity habitat during high flows for adult fish and developing larvae. Increase in retention of eggs and larvae during high flows. Raising the ground water table to provide water to developing riparian areas increases vegetation health. Periods of increased surface flows, particularly during mid-May to mid-June, increases probability of flycatcher territory establishment in areas with suitable habitat.
Longitudinal Bank Lowering or Compound Channels	Level 2 (Design Methods Available) and Level 1 (Limited Postproject Field Studies)	Lowered bank line can promote increases in channel width and decreases in main channel velocity, depth, shear stress, and sediment transport capacity. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters, side channels, and flood plain. Increases overbank flooding, creating areas of variable depth and velocity.	Promotes overbank flooding favorable for establishment of riparian vegetation as well as creating variable depth and velocity habitat. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff. Increased overbank flooding maintains moist soil conditions during flycatcher territory establishment. Growth of native riparian vegetation can enhance habitat conditions for the flycatcher.
Longitudinal Dikes	Level 3 (Fixed Bed Design Methods Available) and Level 2 (Few Sets of Field or Lab Data and Limited Information On Mobile Bed Applications)	Can create a zone of higher main channel velocity resulting in increased sediment transport capacity. This potentially can cause the channel to deepen and create a sediment depositional zone downstream. Can decrease overbank flow area and can result in more uniform channel velocity and depth.	Can decrease overbank flows, reducing the health of riparian zone. This can be partially mitigated by providing culverts for wetting the riparian zone. Can result in more uniform channel velocity and depth.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Levee Strengthening	Level 3 (Fixed Bed Design Methods Well Established) and Level 2 (Less Knowledge on Elevation for Mobile Bed Cases)	The geomorphic response associated with levee installation has already occurred for the levee strengthening method. Initial levee construction generally resulted in flood plain narrowing. Raising or enlarging the levee causes very minor or no geomorphic effects. Small amounts of clearing may be required to enlarge the levee and reduce the side slope. May allow channel relocation nearer to levee.	Initial levee construction and the accompanying flood plain narrowing affect the habitat. Raising or enlarging the levee causes very minor to no habitat effects. Small amounts of clearing may be required to enlarge the levee and reduce the side slope.
Jetty/Snag Removal	Level 1	Jetty removal may result in channel widening and increased flood plain connectivity. Channel widening is less likely to occur where the riparian vegetation root zone provides more bank stability than the jetties. Channel widening (unless hampered by existing vegetation) could reduce channel flow depth and velocity.	The habitat may not change if the existing vegetation has more effect on bank stability than the jetties themselves. Otherwise, channel widening could reduce channel flow depth and velocity and create more bank line habitat.
BANK PROTECTION/ STABILIZATION			
Longitudinal Features			
Riprap Revetment	Level 3	Eliminates local bank erosion; causes local scour and channel deepening. Studies about longer reach response are contradictory. Can be susceptible to flanking if upstream channel migration occurs. Prevents local bend migration and the establishment of new depositional zones. Eliminates sediment supplied from bank erosion. The point bar can remain connected to the main channel. The flow velocity, depth, and bank angle would be greater than typically found in natural channels along the outside bank of a river bend. Interstices within the riprap could host low-energy "pockets" along the bank.	Prevents bend migration and the establishment of new depositional zones where vegetation could become established. Eliminates sediment supplied from local bank erosion. The steep bank angle on the outside of the bend limits fish cover, except for the riprap interstitial spaces. The point bar remains connected to the main channel and remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend.
Other Type of Revetments	Level 2	Effects are essentially the same as riprap revetments.	Effects are essentially the same as riprap revetments

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Longitudinal Stone Toe with Bioengineering	Level 3 (Riprap Design, Scour, and Longitudinal Extent of Placement Are Well Known) and Level 2 (Elevation of the Top of the Stone Toe and Bioengineering in Arid Climates is Less Known)	Similar to riprap revetment.	Same as riprap revetment. Bioengineering provides very minimal benefits to riparian community.
Trench-Filled Riprap	Level 2	Bank erosion processes continue until erosion reaches the location of the trench. After launching, response is the same as for riprap revetment.	Same as riprap revetment.
Riprap Windrow	Level 2	Same as trench-filled riprap.	Same as riprap revetment.
Deformable Stone Toe /Bioengineering and Bank Lowering	Level 2 (Riprap Sizing) and Level 1 (Lack of Design Guidelines and Postproject Studies)	The design is intended to allow bend migration at a slower rate than without protection. River maintenance still may be required in the future. Water surface elevations could be lower with bank lowering. After installation, and before the toe of the riprap becomes mobile, the channel bed may scour along the deformable bank line. Bank erosion occurs during peak-flow events, which mobilize the small-sized riprap along the bank toe. Future bank migration would allow new depositional surfaces to be established.	If flood plain is created behind the stone toe and vegetation becomes established before the toe is lost, an expanded riparian area could develop. Future bank migration would allow new depositional surfaces to establish, which would become new riparian areas.
Bioengineering	Level 1	Vegetation has the lowest erosion resistance of all available methods. Plantings require time to become established before any bank protection is realized. Lateral and down-valley bank line movement can continue because bioengineering does not permanently fix the bank location. Allows more natural movement of river channel.	If the technique is successful, it could promote the establishment and development of riparian vegetation without significant armament to the bank line. Allows more natural movement of river channel.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Riparian Vegetation Establishment	Level 2	Can cause sediment deposition in overbank areas due to increased flow resistance. Sediment deposition in the overbank can increase main channel sediment transport capacity by raising the bank height.	Directly adds to the amount of riparian vegetation. Increased growth of riparian vegetation in overbank areas can enhance habitat conditions for both the flycatcher and the silvery minnow. Encroachment of mature vegetation eventually may lead to a narrower and more confined channel that is negative for silvery minnow habitat.
Transverse Features or Flow Deflection Techniques	Level 2 (Limited Design Guidelines Available) and Level 3 (Lack of Quantitative Design Guidelines and Postproject Studies)	These methods may cause local sediment deposition between structures and/or local scalloping along the bank line. Flow is deflected away from the bank line, thereby altering secondary currents and flow fields in the bend. Eddies, increased turbulence, and velocity shear zones are created. Methods induce local channel deepening at the tip. Shear stress increases in the center of the channel, which maintains sediment transport and flow capacity. Sediment deposition between structures may allow establishment of islands, bars, and backwater areas. Channel deepening and tip scour could locally lower the riverbed and the ground water table.	Sediment deposition between structures may allow establishment of riparian vegetation and backwater areas. Channel deepening and tip scour could occur locally. Depending on site specific details, bendway weirs would allow for overbank flooding conditions for flycatchers. Local scour could provide habitat diversity and deep habitat during low-flow conditions.
Bendway Weirs	Level 2 (Limited Design Guidelines Available) and Level 1 (Lack of Quantitative Design Guidelines and Postproject Studies)	The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted, and flows are redirected away from the bank. The outer bank can become a zone of lower velocity. The combined effect of the tip scour and lower velocity along the bank line creates a flow condition of variable depth and velocity. Scalloping also can occur along the bank line or sediment deposition between structures, depending upon local conditions and bendway weir geometry. Can reduce local sediment supplied from bank erosion because the current river alignment is maintained.	Same as transverse features or flow deflection techniques above.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Spur Dikes	Level 2	Spur dikes block the flow up to bank height, thus shifting the thalweg alignment to the dike tips. Peak flow capacity can be reduced initially until the channel adjusts. The channel adjusts to the presence of spur dikes by forming a deeper, narrower cross section with additional scour downstream from each spur dike. Sediment deposition can occur between spur dikes. There is a greater tendency for sediment deposition between spur dikes than the other transverse features.	Same as transverse features or flow deflection techniques above. There is a greater tendency for sediment deposition between spur dikes than the other transverse features.
Vanes or Barbs	Level 2 (Limited Design Criteria) and Level 1 (Very Little Design Test Data)	These structures redirect flow from the bank toward the channel center and reduce local bank erosion while providing a downstream scour hole. Sediment deposition or bank scalloping can occur along the outer bank, depending upon spacing.	Same as transverse features or flow deflection techniques above.
J-Hook	Level 2 (Limited Design Criteria) and Level 1 (Does not Have a Documentable Track Record and Very Little Design Test Data)	Redirects flow away from eroding banks, the same as vanes or barbs, with an added downstream-pointing "J" configuration. The J-hook creates an additional scour hole pool and can produce a local downstream riffle. Remainder of the geomorphic response is the same as for vanes.	Same as transverse features or flow deflection techniques described above. Additional pool habitat is created by the J-hook.
Trench Filled Bendway Weirs	Level 1	Once the bank erosion reaches the bendway weir tips, the flow is redirected away from the eroding bank. The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted. The outer bank can become a zone of lower velocity.	Provided the bendway weirs constructed in a trench remain intact, the habitat characteristics will be about the same as bendway weirs constructed in the channel.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Boulder Groupings	Level 2 Cross Channel Because Constructed Out into the Channel	Creates a zone of local scour immediately downstream from the boulders. Creates areas of variable depth and velocity. Creates velocity shear zones. Effects are localized to the immediate vicinity of the boulders. Increases channel roughness at high flows. Adds complexity to the system.	Can provide structure and habitat for fish.
Rootwads	Level 2 Bank Stab Bank Line Feature	Creates local scour pools and areas of variable velocity. Increases flow resistance along the bank line, which dissipates energy, traps and retains sediments, and creates turbulence that can move the main current away from the bank line. Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement). Cottonwood tree rootwads have a design span of about 5 years; therefore, this method has been used with many other methods to create habitat.	Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement), which is generally beneficial to the establishment and development of riparian vegetation. Can provide structure and habitat for silvery minnow. Isolated pools often are maintained in scour pools caused by debris, including rootwads. This can serve as refugia habitat for silvery minnow during low-flow periods. Similar to LWD. Could trap sediment and encourage new native vegetative growth.
Large Woody Debris	Level 2	LWD can provide local stream cover and scour pool formations, can deflect flows and increase depth and velocity complexity. Can promote side channel formation and maintenance. LWD in the Middle Rio Grande can lead to sediment deposition, including formation of islands, in reaches with large sand material loads. Could establish new sediment deposition areas. LWD constructed from cottonwood trees last about 3–5 years.	Adds complexity to the system. Sediment deposition can create areas where new riparian vegetation becomes established. Can create variable depth and velocity habitat. Can provide structure and habitat for fish. May provide for habitat diversity in areas with monotypic flow patterns and refugia habitat during low flows. These habitats also may provide refuge for predatory fishes. Increased areas of moist or flooded soil conditions could assist in flycatcher territory establishment and native vegetation recruitment.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
CROSS CHANNEL (RIVER SPANNING) FEATURES			
Grade Control (Grade Control Methods Are Shown Below. Effects that Are Common for Cross Channel Methods Are Included Here)		Grade control can reduce the gradient upstream by controlling the bed elevation and dissipating energy in discrete steps. At least during low flows, the upstream water surface is raised, depending on structure height above the bed. Upstream velocity is reduced. There can be a local effect on sediment transport, scour, and deposition, depending on the structure characteristics. For low-head structures (1–2 feet), the amount of upstream sediment storage is low and usually does not cause downstream bed level lowering as a result of upstream sediment storage. In supply-limited reaches, channel degradation downstream from the structure will continue as a result of excessive sediment transport capacity. The slope of the downstream apron would be designed to provide fish passage and prevent local scour downstream from the structure. Due to the potential for the continuation of the downstream channel incision trend, adaptive management may be necessary to provide for continued fish passage. Reduces channel degradation upstream of this feature and can promote overbank flooding and raise the water table. Backwater areas could develop upstream, which also would raise the water table. If downstream degradation continued, the water table would be lowered.	Increased upstream connectivity with side channels at low flows, creating variable depth and velocity habitat. By preventing future upstream local degradation, the current level of flood plain connectivity can continue. Increased upstream water levels (except for peak flows) likely would increase vegetative health and could attract flycatchers, particularly if overbank flooding conditions occurred during territory establishment. Low downstream apron slopes would be designed to provide for fish passage.
Deformable Riffles	Level 3	During low-flow conditions, where these structures are fixed, the effects upon channel morphology are described in the "grade control" response above. When the riprap material forming the riffle launches or deforms downstream, the bed can lower a relatively small amount.	Same as grade control above.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
Rock Sills	Level 2	Riverbed elevation is held constant, while rock launches into the downstream scour hole. Since the bed is fixed, the effects on geomorphology are the same as for grade control.	Same as grade control above.
Riprap Grade Control (With or Without Seepage)	Level 2	Riprap is flexible and deforms into a scour hole. Can be at bed level or above. Can have short or long low-slope apron. Because the bed is fixed, the effects upon geomorphology are the same as for grade control.	Same as grade control above.
Gradient Restoration Facility	Level 3 (Hydraulic Design Is Well Documented) and Level 2 (Limited Postproject Field Studies)	Bed is fixed. The effects upon geomorphology are the same as for grade control.	Same as grade control above.
Low-Head Stone Weirs (Loose Rock)	Level 2 (Limited Design Criteria and Level 1 (Limited Postproject Field Studies and Design Test Data)	These structures typically are constructed above the bed elevation without grout. During low flows, there is an abrupt change in the water surface elevation through the structures, creating an upstream backwater effect. Generally, these structures do not raise the water surface during high flows. Sediment continuity can be re-established after the scour pool and tailout deposits are formed. A series of structures can dissipate energy and reduce channel degradation. Can interrupt secondary currents and move main current to the center of the channel if constructed in bendways.	Same as grade control above. Can provide pool habitat. Fish usually can pass through the interstitial spaces between weir stones.
CONSERVATION EASEMENTS	Level 2	Allows space for existing fluvial processes to continue, which can preserve flood plain connectivity. Allows more natural river movement with variable depth and velocity and promotes greater area of undisturbed streamside terrain.	Allows more natural river movement and promotes greater area of undisturbed habitat.

Table 2. Methods Level of Confidence, Geomorphic and Habitat Effects

Method	Level of Confidence	Geomorphic Effects	Habitat Effects
CHANGE SEDIMENT SUPPLY			
Increase Sediment Supply	Level 2 (Examples Exist of the Benefits of Adding Sediment to Rivers) and Level 1 (Middle Rio Grande is a Non-equilibrium River Where Changes in Sediment Supply Could have large effects)	Where the river is lacking in sediment, the addition of sediment can stabilize or even reverse channel incision. Addition of sand-sized sediment can reduce bed material size, especially where coarser material is available in an incising channel. May result in sand deposits in pools, reduction of gravel riffle height, decreased depth, and increased width-to-depth ratio. Additional sediment could result in the establishment of river bars and terraces. Could increase the potential for overbank flooding and raise the water table elevation.	Additional sediment could result in the establishment of river bars and terraces, which would be conducive to the establishment and development of riparian areas. Could increase the potential for overbank flooding and raise the water table elevation.
Decrease Sediment Supply	Level 2 (Examples Exist of the Benefits of Reducing Sediment Supply to Some Rivers) and Level 1 (Middle Rio Grande Is a Non-equilibrium River Where Changes in Sediment Supply Could Have Large Effects)	Where the river has excess sediment supply, the reduction or removal of sediment supply can stabilize or reverse aggradational trends. Reduction of sediment supply could cause the bed material to coarsen. In general, a more uniform channel depth and velocity would result. In addition, the tendency for the channel to braid and form split delta channels would be reduced. Water table may fall.	In general, more uniform depth and velocity habitat would result, which decreases habitat complexity for the RGSM. The opportunity for the channel to braid and form distributary channels would be reduced, providing less opportunity for riparian growth.

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APPENDIX D

MOST LIKELY STRATEGIES AND METHODS BY REACH

Appendix D. Most Likely Strategies and Methods by Reach

This attachment shows which strategies are suitable in each reach, the method categories, , how they are associated with each strategy, and the most likely methods for each reach. The most likely methods by reach are based upon the most likely strategies and the methods most commonly used to implement each strategy. Methods can be used as part of a reach strategy or to address site-specific river maintenance purposes. The suitability and effectiveness of a given method are a function of the inherent properties of the method, the physical characteristics of the reach, and the reach strategy. As such, there is no single method that applies to all situations; and while the most commonly used methods have been identified for each reach, other methods also may be used. In addition, new methods are likely to be developed in the future that will be described in future reach or site-specific biological assessments. Table 1 shows which strategies are most suitable for each reach. Additional information may be found in the report entitled, *Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide, Appendix A* (Reclamation 2012).

Table 2 contains the most applicable method category for each strategy. For a given strategy, more than one method category can apply.

Table 3 is the most applicable methods for each reach. For a given strategy and reach, more than one method can apply. The combination of methods used depends upon local river conditions, reach trends, reach constraints, and the inherent properties of the method.

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Table 1. Summary of Most Likely Strategies by Reach

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Velarde to Rio Chama	Not Suitable	Suitable	Not Suitable	Suitable	Suitable	Not Suitable
Rio Chama to Otowi Bridge	Suitable	Suitable	Not Suitable	Suitable	Suitable	Not Suitable
Cochiti Dam to Angostura Diversion Dam	Suitable	Suitable	Not Suitable	Suitable	Suitable	Not Suitable
Angostura Diversion Dam to Isleta Diversion Dam	Suitable	Suitable	Not Suitable	Not Suitable	Suitable	Suitable
Isleta Diversion Dam to Rio Puerco	Suitable	Not Suitable	Suitable	Suitable	Suitable	Suitable
Rio Puerco to San Acacia Diversion Dam	Not Suitable	Suitable	Not Suitable	Suitable	Suitable	Not Suitable
San Acacia Diversion Dam to Arroyo de las Cañas	Suitable	Suitable	Not Suitable	Suitable	Suitable	Suitable
Arroyo de las Cañas to San Antonio Bridge	Suitable	Not Suitable	Suitable	Not Suitable	Not Suitable	Suitable
San Antonio Bridge to River Mile 78	Suitable	Not Suitable	Suitable	Suitable	Not Suitable	Suitable
River Mile 78 to Full Pool Elephant Butte Reservoir Level	Suitable	Not Suitable	Suitable	Suitable	Not Suitable	Suitable

Table 2. Method Categories Associated with Strategies

Method	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Floodplain	Manage Sediment
Infrastructure Relocation or Setback				X		
Channel Modification			X		X	X
Bank Protection/ Stabilization		X				
Cross Channel (River Spanning) Features	X					
Conservation Easements				X	X	
Change Sediment Supply						X

Table 3. Most Likely Methods for Each Reach[1]

Method	Velarde to Rio Chama	Rio Chama to Otowi Bridge	Cochiti Dam to Angostura Diversion Dam	Angostura Diversion Dam to Isleta Diversion Dam	Isleta Diversion Dam to Rio Puerco	Rio Puerco to San Acacia Diversion Dam	San Acacia Diversion Dam to Arroyo de lasCañas	Arroyo de las Cañas to San Antonio Bridge	San Antonio Bridge to River Mile 78	River Mile 78 to Full Pool Elephant Butte Reservoir Level
Infrastructure Relocation or Setback	X	X	X		X	X	X		X	X
Channel Modification										
Complete Channel Reconstruction and Maintenance					X			X	X	X
Channel Relocation Using Pilot Channels or Pilot Cuts	X	X	X	X	X	X	X	X	X	X
Island and Bank Clearing and Destabilization	X	X	X	X	X	X	X			
Bankline Embayment			X	X	X	X	X			
Pilot Cuts Through Sediment Plugs								X	X	X
Side Channels (High Flow, Perennial, and Oxbow Re-establishment)	X	X	X	X	X	X	X			
Longitudinal Bank Lowering or Compound Channels	X	X	X	X	X	X	X			
Longitudinal Dikes					X			X	X	X
Levee Strengthening								X	X	X
Jetty/Snag Removal	X	X	X	X	X	X	X	X	X	X
Bank Protection/Stabilization										
Longitudinal Features-										
Riprap Revetment	X	X	X	X		X	X			
Other Type of Revetments	X	X	X	X		X	X			

Table 3. Most Likely Methods for Each Reach[1]

Method	Velarde to Rio Chama	Rio Chama to Otowi Bridge	Cochiti Dam to Angostura Diversion Dam	Angostura Diversion Dam to Isleta Diversion Dam	Isleta Diversion Dam to Rio Puerco	Rio Puerco to San Acacia Diversion Dam	San Acacia Diversion Dam to Arroyo de lasCañas	Arroyo de las Cañas to San Antonio Bridge	San Antonio Bridge to River Mile 78	River Mile 78 to Full Pool Elephant Butte Reservoir Level
Longitudinal Stone Toe with Bioengineering	X	X	X	X		X	X			
Trench Filled Riprap	X	X	X	X		X	X			
Riprap Windrow	X	X	X	X		X	X			
Deformable Stone Toe /Bioengineering and bank lowering		X	X	X		X	X			
Bioengineering	X	X		X		X	X			
Riparian Vegetation Establishment	X	X	X	X		X	X			
Transverse Features or Flow Deflection Techniques										
Bendway Weirs		X	X	X		X	X			
Spur Dikes		X	X	X		X	X			
Vanes or Barbs		X	X	X		X	X			
J-Hook		X	X	X		X	X			
Trench Filled Bendway Weirs		X	X	X						
Boulder Groupings	X	X	X	X		X	X			
Rootwads	X	X	X	X		X	X			
Large Woody Debris	X	X	X	X		X	X			
Cross Channel (River Spanning) Features										
Grade Control										
Deformable Riffles		X	X	X	X		X			
Rock Sills		X	X	X	X		X			
Riprap Grade Control (With or Without Seepage)		X	X	X	X		X			

Table 3. Most Likely Methods for Each Reach[1]

Method	Velarde to Rio Chama	Rio Chama to Otowi Bridge	Cochiti Dam to Angostura Diversion Dam	Angostura Diversion Dam to Isleta Diversion Dam	Isleta Diversion Dam to Rio Puerco	Rio Puerco to San Acacia Diversion Dam	San Acacia Diversion Dam to Arroyo de lasCañas	Arroyo de las Cañas to San Antonio Bridge	San Antonio Bridge to River Mile 78	River Mile 78 to Full Pool Elephant Butte Reservoir Level
Gradient Restoration Facility (GRF)		X	X	X	X		X			
Low-Head Stone Weirs (Loose Rock)		X	X	X	X		X			
Conservation Easements	X	X	X	X	X	X	X		X	X
Change Sediment Supply										
Sediment Augmentation (Sand Sizes)					X		X			
Natural or Constructed Sediment Basins								X	X	X

[1]This table identifies the most likely methods to be used in each reach. Due to river channel variability, every method may be used in each reach.

APPENDIX E

GEOMORPHIC STRATEGY EFFECTS

Appendix E. Geomorphic Strategy Effects

Tables 1–6 provide a list, by strategy, of the general reach geomorphic trends addressed (not in order of importance), the geomorphic effects of implementing each strategy in a reach, additional potential strategies that address the same geomorphic trends (complementary strategies), and the geomorphic effects of strategy implementation in downstream and upstream reaches. Observed geomorphic trends may be directly addressed by a strategy through stopping the trend, reducing the trend, reversing the trend, and allowing the trend to continue while reducing the need for river maintenance. The tables describe the geomorphic effects from strategy implementation based on the currently observed relationship between sediment transport capacity and sediment supply. The addressed strategy changes are different if the sediment transport capacity is greater than or less than the sediment supply. If a strategy only lists one condition, such as sediment transport capacity less than sediment supply for Reconstruct and Maintain Channel Capacity, then it can be assumed that this strategy is not applicable to the other condition—sediment transport capacity greater than sediment supply. These are general reach effects; therefore, uncertainty may exist in the magnitude of physical effect. Where the probable magnitude of physical effect is known, it is so stated. In tables 1–6, method categories are used for some strategies where effects of methods within a method category have essentially the same reach effects. For some strategies, specific methods are included where there are dissimilar effects of methods within a method category. Where possible, the effects relating to a common geomorphic response are grouped together. Method categories and methods associated with strategies are described in the River Maintenance Methods Attachment.

Table 1. Promote Elevation Stability Strategy: Trends Addressed and Geomorphic Effects

<table>
<tr><td>Trends Addressed</td><td>Increased bank height
Incision or channel bed degradation
Coarsening of bed material
Aggradation</td></tr>
<tr><td>Reach Effects

Sediment transport capacity greater than sediment supply (erosional)</td><td>General
Strategy maintains or raises bed elevation, but effects upon channel capacity are expected to be small.
Effects evaluation is based upon cross channel features ~ 2 feet high or less.
Fixes local lateral channel location and width (to prevent flanking, except deformable; see below).
Reduces the probability of additional future bed material coarsening.
Stabilizes current bed elevation (except deformable; see below).
Could increase bank erosion if bank stability below erosion threshold. This effect could be local when the future potential channel slope change is small.
Downstream degradation is expected to continue and may create possible fish passage issues. This can be addressed through adaptive management.
Can prevent lateral migration by preventing erosion below root zone or beyond geotechnically stable height. This effect could be local when the future potential slope change is small.
Cross channel features
At bed – Maintain upstream water surface elevation (WSE) at same discharge.
No effect on bed elevation downstream—sediment passes through structure; does not halt downstream channel degradation.
Current slope and upstream bed elevation maintained.
Above bed – Raise WSE at same discharge (effects evaluation is based upon low height cross channel structures ~ 2 feet high or less).
Long-term effect is raise bed upstream, ~ height of structure tapering to the next upstream riffle or high point in the bed.
No long-term effect on bed elevation downstream—sediment passes through structure, but local initial degradation possible that would fill in later.
Previous upstream slope is generally recreated.
Temporary – Aggradation from back water effect.
Can promote increased floodplain connectivity and greater velocity and depth variability depending upon the amount of past channel incision.
Deformable – Maintain upstream water surface elevation at same discharge. Reduces and slows bed erosion—structure is mobile at design discharge.</td></tr>
</table>

Table 1. Promote Elevation Stability Strategy: Trends Addressed and Geomorphic Effects

Reach Effects (continued) *Sediment transport capacity greater than sediment supply (erosional)*	• Effects are similar to at bed or above bed structures when cross channel feature is intact, except that lateral channel location and width may not be fixed. **Complementary strategies:** • Promote Alignment Stability, Increase Available Area to the River– – Increases length of channel. • Manage Sediment – Increases sediment supply. • Rehabilitate Channel and Floodplain – Reduces sediment transport capacity.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity greater than sediment supply (erosional)*	*Cross channel features* At bed • Upstream effects: Because future channel bed degradation is reduced or halted, there may be a reduced tendency for degradation in the upstream reach. This would most likely result in the bed material size remaining the same, or coarsening at a reduced rate. • Downstream effects: There could be a small reduction in the downstream sediment supply since future degradation is reduced or halted. This is likely to have only a minimal effect upon the downstream reach bed elevation and potential future channel evolution. Bed material size is not likely to be affected in the downstream reach. Above bed • Upstream effects: The bed would be raised to the nearest riffle or high point in the bed upstream of the structures. Sediment fills the reach upstream at about the previous slope, which is determined by channel width, hydrology, sediment load and size, bed and bank material size, and any geologic controls, etc. Thus, there would be little, if any, additional effects upon upstream bed elevation, bed material size, or channel slope from those listed for the at bed condition. • Downstream effects: Initially, sand sizes or finer gravel sizes could deposit upstream of these structures depending upon the size of the supplied sediment. This could reduce downstream sediment supply for a temporary period of time. During this temporary period of time, there could be a small amount of downstream channel degradation; however, this effect would be minimal, because the amount of sediment storage upstream of these structures is small. After this temporary period of time, sediment delivery to the downstream reaches would be about the same as pre-implementation. Bed material size is not likely to be affected in the downstream reach. Deformable • Effects are similar to the above bed and at bed structures when cross channel feature is intact, except that lateral channel location and width may not be fixed.

Table 1. Promote Elevation Stability Strategy: Trends Addressed and Geomorphic Effects

Reach Effects *Sediment transport capacity less than sediment supply (depositional)*	**Addressed through complementary strategies:** Reconstruct/Maintain Channel Capacity – Increases sediment transport capacity. Manage Sediment – Reduces sediment supply. Increase Available Area to the River – Increases area for sediment deposition.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity less than sediment supply (depositional)*	See complementary strategy effects on upstream/ downstream reaches for the sediment transport capacity less than sediment supply case.

Table 2. Promote Alignment Stability: Trends Addressed and Geomorphic Effects

<table>
<tr><td>Trends Addressed</td><td>Bank erosion
Channel plugging with sediment
Perched channel conditions</td></tr>
<tr><td>Reach Effects
Sediment transport capacity greater than sediment supply (erosional)</td><td>General
Strategy allows lateral migration until infrastructure is threatened.
Some increase in sinuosity with potential for new deposition.
Bank Protection/Stabilization
Longitudinal features: Fixed bank
Bank line does not move.
No sediment supply from banks.
No new depositional zones.
Increase in local flow velocity and depth.
Longitudinal features: Mobile bank - degree of mobility varies with method.
Moves to a fixed location—then effects same as above.
Either fixed in advance or when needed.
Temporary sediment supply from banks.
Temporary continuation of lateral migration channel process.
Reduces sediment supply from banks.
Reduces new depositional zones.
Temporary increase in local flow velocity and depth.
Transverse Features or Flow Deflection Techniques.
Fixed bend – Constructed from bank line into channel.
Mobile Bend – Constructed in channel bank.
New location either fixed in advance or as needed.
Moves to a fixed location—then effects same as above.
Temporary sediment supply from banks.
Reduces sediment supply from banks.
Potential for local bank sediment deposition and/or scalloping between structures.
Reduces new depositional zones on opposite bank.
Creates local eddies, with variable turbulence and velocity shear zones.
Local channel deepening with greater deepening at tip.
Creates local scour pools.
Variable depth and velocity effects are reduced at higher flows.
Local sediment deposition upstream and along scour pool.
May help form and maintain side channels.
May form bars and islands.</td></tr>
</table>

Table 2. Promote Alignment Stability: Trends Addressed and Geomorphic Effects

Reach Effects (continued) *Sediment transport capacity greater than sediment supply (erosional)*	**Complementary strategies:** • Promote Elevation Stability – Reduces channel incision through cross channel structures which could either increase or reduce bank erosion. • Reconstruct/Maintain Channel Capacity – Keeps the channel in the same location or a selected relocated alignment. • Rehabilitate Channel and Floodplain – Reduces sediment transport capacity. • Increase Available Area to the River – Moves infrastructure. • Manage Sediment – Increases sediment supply.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity greater than sediment supply (erosional)*	Upstream and downstream effects are expected to be similar within the Bank Protection/Stabilization method category. Upstream – As the channel lengthens, sediment transport capacity is reduced, lowering the tendency for channel bed degradation. If the upstream reach is degrading then this tendency could be reduced. A less degrading upstream bed could result in the bed material sizes remaining about the same or become smaller. Potential changes in flow velocity and channel depth are expected to be minimal. Downstream – To the extent that the sediment supply from bank erosion of the affected reach is reduced, there could be possible impacts to the downstream reach. These impacts could be incision or bed degradation, slope reduction and increased bed material size depending upon the portion of the sediment load being supplied by lateral migration. Depending upon reach sediment supply from tributaries, this effect could be small.
Reach Effects *Sediment transport capacity less than sediment supply (depositional)*	When the trends of channel plugging with sediment or perched channel conditions are present, channel avulsion or relocation is possible. This strategy reinforces the new bank and has the same effects as listed under sediment transport capacity greater than sediment supply **Complementary strategies:** Reconstruct and Maintain Channel Capacity – Removes sediment, relocates channel, or raises/strengthens levees. Increase Available Area to the River – Moves infrastructure. Manage Sediment – Reduces sediment supply.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity less than sediment supply (depositional)*	Upstream – No change is expected. Downstream – If active bank erosion within the affected reach adds significantly to the sediment supply, and this is reduced, than this may bring the sediment supply of the affected reach and the downstream reach more into a dynamic equilibrium with the sediment transport capacity. This may help to minimize deposition within the channel downstream.

Table 3. Reconstruct and Maintain Channel Capacity: Trends Addressed and Geomorphic Effects

<table>
<tr><td>Trends Addressed</td><td>Channel narrowing
Vegetation encroachment
Aggradation
Channel plugging with sediment
Perched channel conditions</td></tr>
<tr><td>Reach Effects

Sediment transport capacity less than sediment supply (depositional)</td><td>General
Since the implementation reach is experiencing loss of channel capacity, maintenance of this strategy is likely. Implementation effects are described below. Maintenance would not incur additional geomorphic strategy effects beyond those listed below. This strategy may help reduce future differential between bed and valley elevation.
Channel Modification (for applicable methods, see River Maintenance Methods Attachment)
Complete Channel Reconstruction and Maintenance
Generally more uniform width, depth, and velocity.
Low-flow bars can form within excavated channel with increased local depth and velocity variation. Adaptive management can allow more variation.
Reduces braiding and split delta channels.
Reduces water surface area.
Lowers ground water table.
Pilot Cuts Through Sediment Plugs
Temporary increase in velocity and bed lowering.
Temporary increase in sediment load delivered downstream.
Generally less uniform width, depth, and velocity than complete reconstruction.
Extent of sediment removal is flow peak and duration dependent.
Channel width may be narrower than existed before sediment plugging with increase in depth and velocity.
Spoil piles may disconnect floodplain, but adaptive management could reduce this effect.
Effects which occur at a slower rate:
Reduces braiding and split delta channels.
Reduces water surface area and evapotranspiration losses.
Lowers ground water table.
Longitudinal Dikes
Can create zone of increased main channel flow velocity and depth.
Created at high flows and may remain for low flows.
Can increase uniformity of channel dimensions.
Created at high flows and may remain for low flows.</td></tr>
</table>

Table 3. Reconstruct and Maintain Channel Capacity: Trends Addressed and Geomorphic Effects

Reach Effects (continued) *Sediment transport capacity less than sediment supply (depositional)*	• Decreases surface area of overbank flow. o Adaptive management can reduce this effect. • Can cause local bed lowering. Levee Strengthening • Increased high-flow capacity. • May allow channel relocation closer to levee. **Complementary strategies:** • Increase Available Area to the River – Moves infrastructure. • Manage Sediment – Decreases sediment supply.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity less than sediment supply (depositional)*	Upstream and downstream effects are expected to be similar for the applicable methods within the Channel Modification method category. Upstream – Bed degradation could occur which would increase sediment transport capacity. Higher flows would be required to go over bank and lowered groundwater tables may accompany degradation. Sediment supply could increase temporarily during the degradational process. Bed material size may coarsen. Since the implementation reach is experiencing aggradation, maintenance of this strategy is likely. As the channel fills between periods of river maintenance, the upstream reach could begin to aggrade and then degrade after river maintenance, with this cycle potentially being repeated. Downstream – Increased sediment supply, because the sediment transport capacity is restored to its previous condition. This could steepen the channel slope in the downstream reach due to sediment deposition and channel aggradation. The bed material could become finer. It is likely that maintenance of this strategy will be needed since the channel is aggrading in the implementation reach. As the channel fills between maintenance events, there could be a decrease in sediment supply to the downstream reach causing channel bed degradation. There would then be an increase in the sediment supply in the downstream reach after periods of river maintenance in the implementation reach. This cycle could potentially be repeated with each river maintenance action.

Table 4. Increase Available Area: Trends Addressed and Geomorphic Effects

Trends Addressed	*Sediment transport capacity greater than sediment supply* (allows evolution and/or increased length): Channel narrowing Increased bank height Incision or channel bed degradation Bank erosion Coarsening of bed material Increased channel uniformity *Sediment transport capacity less than sediment supply (*allows channel relocation): Aggradation Channel plugging with sediment Perched channel conditions
Reach Effects *Sediment transport capacity less than or greater than sediment supply (depositional or erosional)*	**General** *Infrastructure relocation or setback/Conservation Easements* • Wider area for natural channel processes. • Encourages new floodplain areas and side channels. • Provides opportunity to reconnect historical floodplain and side channels. • Encourages variability in channel dimensions and velocity. • Provides opportunity to increase bank erosion and new deposition. • Preserves floodplain connectivity. • Possible temporary change in sediment supply. For reaches with sediment transport capacity less than sediment supply, this would likely be a reduction through deposition. For reaches with sediment transport capacity greater than sediment supply, this would likely be an increase through bank/bed erosion. • Reduces future maintenance. Extent of reduction depends upon the area needed versus. the area acquired. **Complementary Strategies (Transport capacity greater than supply)** • Reconstruct/Maintain Channel Capacity – Strengthens/raises levee to allow channel migration closer to levee and reduce area needed. **Complementary Strategies (Transport capacity less than supply)** • Manage Sediment – Sediment removal

Table 4. Increase Available Area: Trends Addressed and Geomorphic Effects

Effects on Upstream/ Downstream Reaches *Sediment transport capacity greater than sediment supply (erosional)*	Upstream –The channel slope in the implementation reach would likely decrease as the channel lengthens. If the upstream reach is degrading, then this tendency could be reduced resulting in bed material sizes to remain about the same or become smaller than the current size. This may also cause a slight reduction in the sediment supply. Downstream – There may be a short-term effect of increased sediment supply from bank erosion, but the long-term effect downstream would likely be reduced sediment supply as the channel lengthening lowers sediment transport capacity. In addition, there would likely be new depositional features such as bars, or an inset floodplain, which would form and/or grow in size during lateral migration. These sediment storage areas could also lower downstream sediment supply. Reduced sediment supply could initiate channel incision or bed degradation, coarsen the bed material, increase channel discharge capacity, and increase flows necessary to go over bank.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity less than sediment supply (depositional)*	Upstream –The upstream reach effect depends upon whether or not there is a change in the water surface elevation in the area where the river migrates or avulses to. For the case where the water surface elevation in the implementation reach decreases, then the upstream bed will degrade increasing the sediment transport capacity and the discharge to go over bank. Bed material size would likely increase but remain sand-sized in sand-dominated reaches. Upstream degradation will continue until such time as the relocated channel bed fills with sediment. Then, the upstream bed elevation could increase to the previous or higher level. For the case where the water surface elevation does not change, then the upstream effect would be minimal. Downstream – Sediment deposition could occur in the area where the river migrates or avulses to, which would decrease downstream sediment supply. This could cause bed degradation, bed coarsening, increased channel capacity, and increased flow necessary to go over bank. Over time the area available for sediment deposition may fill, during which time downstream sediment supply would increase potentially leading to channel aggradation and finer bed material sizes.

Table 5. Rehabilitate Channel and Floodplain: Trends Addressed and Geomorphic Effects

Trends Addressed	Channel narrowing Vegetation encroachment Increased bank height Incision or channel bed degradation Bank erosion Coarsening of bed material Increased channel uniformity
Reach Effects *Sediment transport capacity greater than sediment supply (erosional)*	**General** This strategy applies to implementation reaches that are experiencing channel degradation or incision associated with channel narrowing. Implementation of this strategy would reduce channel erosion, and encourage sediment deposition by increasing floodplain connectivity. Maintenance may be needed that would not incur additional geomorphic effects beyond those listed below. Conservation easements could provide additional area for river relocation and side channel development. *Channel Modification* Complete construction – Longitudinal bank lowering and channel reconstruction flow goes overbank at lower discharge—greater floodplain connectivity. • Can increase high flow capacity. • Wider surface area at high flows. • More depth and velocity variation at high flows. • Decrease high-flow velocity and depth because reduces energy of higher flows that could reduce future incision, bank erosion, or induce overbank deposition. • Could increase braiding. • Promotes increased connectivity with backwaters and side channels. • Preserves ground water table. Partial construction – Clearing, destabilizing, encouraging sediment movement. • Takes longer, only applicable where there is some floodplain connection already. • May induce temporary bank erosion until transport/load balanced. • Same effects as complete construction above but to lesser degree. Partial channel realignment – Clearing, pilot cut, encourage channel widening along new alignment. • May reduce high- flow energy, which reduces incision and/or migration. • May change channel length. • Promotes increased connectivity with backwaters and other side channels (if close enough to bank line). • Temporary decrease in velocity and depth variability. • Temporary increase in sediment supply downstream.

Table 5. Rehabilitate Channel and Floodplain: Trends Addressed and Geomorphic Effects

Reach Effects (continued) *Sediment transport capacity greater than sediment supply (erosional)*	Side channel construction • May raise ground water table. • Promotes increased connectivity with backwaters and other side channels (if close enough to bank line). • May reduce high-flow energy which reduces incision and /or migration. • Increase velocity and depth variability. • May reduce high-flow water surface elevations. • Increase high-flow water surface area. **Complementary strategies:** • Promote Elevation Stability – Reduces channel incision. • Manage Sediment – Increases sediment supply. • Increase Available Area to the River – Allows space for river to readjust.
Effects on Upstream/ Downstream Reaches *sediment transport capacity greater than sediment supply (erosional)*	Upstream and downstream effects are expected to be similar for the Change Sediment Supply and applicable methods within the Channel Modification method category. Upstream: This strategy may allow the reach of implementation to experience sediment deposition. This may have the effect on upstream reaches of also causing a slope reduction that, in turn, may cause the sediment supply to decrease and the bed material to become finer. This sediment deposition could also result in lower discharges to go over bank. Downstream: There may be a short-term effect of increased sediment supply depending upon the method and where the excavated material is placed. But the long-term effect downstream would likely be reduced sediment supply, potentially resulting in channel degradation and coarsening of bed material. The slope of the channel could decrease. Channel degradation would likely result in a higher discharge being needed to go over bank and increased sediment transport capacity.

Table 6. Manage Sediment: Trends Addressed and Geomorphic Effects

Trends Addressed	*Transport Capacity greater than Supply* • Increased bank height • Incision or channel bed degradation • Coarsening of bed material • Increased channel uniformity *Transport Capacity less than Supply* • Aggradation • Channel plugging with sediment • Perched channel conditions • Increased channel uniformity
Reach Effects *Sediment transport capacity greater than sediment supply (erosional)*	**General** Once sediment is added, this would need continue indefinitely for benefits to be realized in the long term. *Change Sediment Supply* Sediment Augmentation • Effects are dependent on volume of sediment, and sediment volume depends upon high-flow discharge amount and duration. • Flow goes overbank at lower discharge. • May have wider surface area at high flows. • May increase depth and velocity variation at high flows. • May decrease high-flow velocity and depth. • Could induce overbank deposition. • Could increase braiding. • Promotes increased connectivity with backwaters and side channels. • Preserves groundwater table. • Likely to require adaptive management (continuing adjustment of augmentation volume and location). • Could reduce bed material size (dependent on size supplied). • May fill in pools and/or create bars. • May increase width-depth ratio. *Channel Modification* Some methods within this method category provide indirect sediment augmentation—clearing, destabilization, encouraging sediment movement. • Effects are similar to direct augmentation • Slower rate of additional sediment supply **Complementary Strategies** Increase Available Area – potential area to increase channel length thus decreasing sediment transport capacity. Rehabilitate Channel and Floodplain – Reduces sediment transport capacity.

Table 6. Manage Sediment: Trends Addressed and Geomorphic Effects

<table>
<tr>
<td>Effects on Upstream/ Downstream Reaches

Sediment transport capacity greater than sediment supply (erosional)</td>
<td>Upstream and downstream effects are expected to be similar for the applicable methods to augment sediment supply

Upstream – If the augmentation results in the river bed elevation increasing, then the downstream portion of the upstream reach bed elevation could increase potentially resulting in a reduced channel slope. It is expected that the augmentation rate and location can be planned and adaptively managed in the implementation reach so that the upstream bed elevation remains at about the current elevation.

Downstream – The effects downstream are dependent on the amount of sediment augmentation, but an increase in the sediment supply may be possible. This would have the effect of increasing the channel slope through deposition/aggradation of the bed elevation in the implementation reach increases. Deposition in local subreaches of the downstream reach could result in a local flatter slope. The bed material size could reduce depending upon the size of augmentation sediments. The downstream channel bed elevation could increase resulting in lower discharge to go over bank. The effects can be adaptively managed.</td>
</tr>
<tr>
<td>Reach Effects

Sediment transport capacity less than sediment supply (depositional)</td>
<td>General

Once sediment is removed, this will need to continue indefinitely for benefits to continue in the long term.

Change Sediment Supply

Constructed basins

Slows or reverses aggradational trends.
Could increase discharge necessary to go over bank.
Could cause downstream bed size coarsening.
Reduce braiding potential.
Provide new areas of deposition.
In-Channel – Dredging low area in the channel bed, then allowing deposition to occur and re-dredge.

Local widening and subsequent dredging or movement to new area.
Provides new areas of deposition.

Floodplain (berm enclosed basin with inlet and outlet channel).

Similar to In-channel.
More likely to relocate when full than tributary.
More vegetation clearing than tributary or channel.

Tributary – More likely to dredge than floodplain.
</td>
</tr>
</table>

Table 6. Manage Sediment: Trends Addressed and Geomorphic Effects

Reach Effects (continued) *Sediment transport capacity less than sediment supply (depositional)*	Natural topography basins • Similar effects to constructed basins. • Becomes the new channel alignment. • In-Channel – May relocate when full and provides new areas of deposition. • Floodplain similar effects to in-channel but more vegetation clearing than channel. **Complementary Strategies** Increase Available Area – Potential area for sediment deposition.
Effects on Upstream/ Downstream Reaches *Sediment transport capacity less than sediment supply (depositional)*	Upstream and downstream effects are expected to be similar for the applicable methods within the Change Sediment Supply. Upstream • Constructed Basins- Depending upon the method used, the subsequent maintenance, and the sediment deposition area volume relative to the incoming sediment supply, upstream aggradation or channel bed raising could occur. This could result in lower discharges being needed to go overbank, decreased bed sediment size, and increased tendency for braiding. • Natural topography basins – Effects would be similar to upstream effects for the Increase Available Area strategy for the sediment transport capacity less than sediment supply case. Downstream • Constructed Basins – No change expected unless amount of sediment reduced is significant. If the sediment load reduction is significant, there may be channel degradation or bed lowering, which would cause a higher discharge to go over bank, less velocity, depth variability, and bed material coarsening. The amount of bed lowering is not expected to increase bank erosion rates or lead to significant lateral migration. • Natural topography basins – Effects would be similar to downstream effects for the Increase Available Area strategy for the sediment transport capacity less than sediment supply case.

APPENDIX F

STATE OF NEW MEXICO, INTERSTATE STREAM COMMISSION AND OFFICE OF THE STATE ENGINEER

PROPOSED ACTIONS, HYDROLOGIC IMPACTS AND SPECIES EFFECTS IN THE RIO GRANDE BASIN UPSTREAM OF ELEPHANT BUTTE RESERVOIR, NEW MEXICO

With attached

OFFSETTING MEASURES AND CONSERVATION MEASURES

As modified in response to Interstate Stream Commission direction, June 9, 2015

Reclamation provides the following information for this appendix: “This appendix contains additional information provided to Reclamation by the State of New Mexico (State) regarding its proposed actions and effects analysis in Part II, as well as to provide additional context and supporting information for the State’s Offsetting and Conservation Measures provided in Part IV. The State analysis provided in this appendix does not supersede the analysis in Part II. This information is attributable to the State and examines effects from State actions in the context of an analysis conducted by the State.”

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1. Introduction

This document is provided by the State of New Mexico Interstate Stream Commission (NMISC), Office of the State Engineer (NMOSE), and New Mexico Attorney General's Office (collectively referred to as the State) to the U.S. Bureau of Reclamation (Reclamation) to be included with the August 2015 Joint Biological Assessment, Bureau of Reclamation, Bureau of Indian Affairs, and Non-Federal Water Management and Maintenance Activities on the Middle Rio Grande, New Mexico; Middle Rio Grande Project, New Mexico, San Juan-Chama Project, New Mexico, Upper Colorado Region (BA). The State is joining Reclamation, the Middle Rio Grande Conservancy District (MRGCD), and the U.S. Bureau of Indian Affairs (BIA) in seeking a new Biological Opinion (BO) for Middle Rio Grande (MRG) water operations and river maintenance activities. The August 2015 BA includes, as part of its Proposed Action, the State's proposed actions, hydrologic impacts, evaluation of effects, and proposed measures to offset those effects.

This document, included as an appendix to the BA as a stand-alone document, provides a more detailed description of the State's future actions, updated baseline information, and analyses of hydrologic impacts and species effects.

In drafting this document, the State has not included water-related actions of the MRGCD, the six MRG Pueblos, the Albuquerque Bernalillo County Water Utility Authority (ABCWUA), or the Buckman Direct Diversion Project (BDD).[1]

This document addresses the effects of water-related actions proposed by the State on the species listed under the Endangered Species Act (ESA)—Rio Grande silvery minnow, Southwestern willow flycatcher, western yellow-billed cuckoo, New Mexico meadow jumping mouse, Pecos sunflower, and interior least tern—within the MRG riparian area. This document does not address localized effects to other species (including federally listed, proposed, or candidate species) that may exist in upstream tributary areas or outside the action area.

Proposed Offsetting and Conservation Measures for the State are provided as Attachment 1 of this document ("Proposed 'State of New Mexico' Commitments through the Interstate Stream Commission to the 2015 Middle Rio Grande Water Operations and River Maintenance Biological Opinion and Recovery Program," as modified in response to Interstate Stream Commission direction, June 9, 2015)." By requesting this coverage and proposing the Offsetting and Conservation Measures, the State does not concede that all the water-related actions

[1] The MRGCD's and six MRG Pueblos' water-related actions are not included in this document because they are separately seeking coverage for their, and their members', specific water-related actions. Further, the State understands that the water-related actions of the ABCWUA and BDD are covered by their respective existing biological opinions. The State is supportive of the efforts of the MRGCD, six MRG Pueblos, ABCWUA, and BDD.

described herein adversely affect the listed species or that requirements of the ESA necessarily apply to all of the described actions.

2. Consultation Coverage

As requested by Reclamation for inclusion in its BA, the State's future actions, their hydrologic impacts, and effects on listed species are described at an action-by-action level in this document, as well as included as part of the Proposed Action in Reclamation's BA. Future State actions are described within four categories in Section 5.

Where applicable, measures are proposed to offset the effects of the State's actions (Offsetting Measures), and Conservation Measures are also offered that are above and beyond the Offsetting Measures to assist in species conservation (see Section 9 and Attachment 1) as part of the State's contribution and cost share to the Middle Rio Grande Endangered Species Collaborative Program's (MRGESCP) recovery implementation program (RIP).

It is anticipated that future actions not specified in this document but falling within these four action categories will be able to rely on the RIP as their means for ESA compliance, to be described in RIP governance documents.

3. Background and Baseline Information

Under New Mexico law, water rights are established by the beneficial use of water within the State. Many water rights were established prior to State Engineer jurisdiction. Rights established under State Engineer jurisdiction are only established through the permitting process. Except for small domestic, livestock, and temporary water uses, the State Engineer conditions all permits in the Rio Grande Basin (which extends from the Colorado state line to the headwaters of Elephant Butte Reservoir) to require full offset of the maximum diversion amount. State water policy and guidelines for the region are designed and applied in order to protect existing water rights and to preserve compliance with the Rio Grande Compact by ensuring that delivery of Rio Grande water into Elephant Butte Reservoir, and the flows of the Rio Grande at the Otowi gage are not diminished.

All State actions described in this document before February 2013 are included in the baseline for the BA. This document summarizes the effects of the State actions that are continuing for the duration of the BO. The following sections provide background information on the Rio Grande Compact, the State administration of surface water and groundwater rights and the offset program.

3.1 The Rio Grande Compact

The 1938 Rio Grande Compact (53 Stat. 785) (Compact) is both a federal and state law that poses significant restrictions on water management, most specifically reservoir management, in the MRG. The Compact apportions the native waters of the Rio Grande among the states of Colorado, New Mexico, and Texas, and is administered by the Rio Grande Compact Commission. For purposes of the Compact, “New Mexico” is the reach between the state line with Colorado and Elephant Butte Dam, which is roughly equivalent to the area encompassed by the MRGESCP. For purposes of this document, the Upper Rio Grande (URG) is defined as the reach from the Colorado-New Mexico state line to the Otowi gage including the Rio Chama, and the MRG is defined as the reach from the Otowi gage to Elephant Butte Reservoir. New Mexico has an explicit but variable annual delivery requirement to the State of Texas at Elephant Butte Dam. New Mexico’s depletion entitlement for the MRG is based upon the recorded annual native Rio Grande flow at the Otowi gage. For New Mexico, the explicit annual allocation requires that a minimum of 57% of the annual native Rio Grande flow at the Otowi gage be delivered to Elephant Butte Dam. The allocation to Texas excludes tributary inflows between the Otowi gage and Elephant Butte Dam. Tributary inflows in this reach are highly variable and, generally, unpredictable but these inflows may be fully consumed by New Mexico.

The Compact does not require the State of Colorado or the State of New Mexico to deliver the exact amount of water scheduled annually each and every year, but allows for the accumulation of over-deliveries (credit) and under-deliveries (debit). It is up to each state to decide how its water is used. In New Mexico, any new use of water has to be approved by the State Engineer and must be balanced by reduction of an existing use unless it is an imported source of water, such as San Juan-Chama (SJC) Project water. Approval of new uses is required because the Compact puts an upper limit on basin-wide water depletions.

Regardless of how wet a period may be, New Mexico's depletions between the Otowi gage and Elephant Butte Dam are capped at 405,000 acre-feet per year (AFY) plus the local tributary inflows. In wet years (anything above about 1 million acre-feet [AF] at the Otowi gage), the higher flows must be passed through the MRG and delivered to Elephant Butte Reservoir, and associated carriage losses must be made up from New Mexico's allocation. In very wet years, these carriage losses can deplete a large portion of New Mexico's annual allocation. For this reason, wet years are more likely than dry years to result in a Compact debit. In many cases, debits accrued in wet years must be made up for in dry or average years.

Several Compact restrictions affect reservoir operations in post-Compact reservoirs (reservoirs upstream of Elephant Butte that were constructed after 1929) and associated surface water management. All the reservoirs operated by the U.S. Army Corps of Engineers (the Corps) and Reclamation are subject to these restrictions. However, Reclamation's Heron Reservoir and Nambe Falls Reservoir are excluded from these restrictions because they only store imported transbasin SJC Project water.

Under Article VI of the Compact, New Mexico remains in compliance with the Compact if its accrued debit is less than 200,000 AF. If New Mexico is in debit status and is holding native Rio Grande water in storage in a post-1929 reservoir, New Mexico must retain the water in storage to the extent of its accrued debit. If and when a spill occurs from Elephant Butte Reservoir, the accrued credits for Colorado or New Mexico, or both, are reduced in proportion to their respective credits by the amount of the actual spill. Colorado or New Mexico may release accrued credits in part, or in full, in advance of an actual spill. Following a spill, all accrued debits for Colorado or New Mexico, or both, are cancelled.

Under Article VII of the Compact, whenever Usable Water in Rio Grande Project storage at Elephant Butte and Caballo reservoirs is less than 400,000 AF, New Mexico and Colorado may not increase the storage of native Rio Grande Basin water in upstream reservoirs constructed after 1929. Usable water is defined as water in Elephant Butte and Caballo reservoirs that is available for release to the Rio Grande Project. In New Mexico, the primary impacts of Article VII storage prohibitions are experienced at El Vado and Nichols and McClure reservoirs. Article VII also provides that, upon acceptance by Texas, New Mexico may relinquish all or part of its accrued credits so that New Mexico may store, at any time, an equivalent amount of water in post-1929 upstream reservoirs when storage restrictions are in effect. Additionally, for the City of Santa Fe, during times that Article VII is in effect, it may elect to store native water when otherwise prohibited and release a like amount of SJC Project water (an exchange) to the Rio Grande.

Article XVI of the Compact states, “Nothing in this Compact shall be construed as affecting the obligations of the United States of America to Mexico under existing treaties, or to the Indian Tribes, or as impairing the rights of the Indian Tribes.” SJC Project water is imported trans-basin water, is accounted as such, and is not subject to the Rio Grande Compact.

3.2 Credit Water Relinquishment

Since signing the Emergency Drought Water Agreement (EDWA) in 2003, the State has made relinquishment credit available as follows: 91,000 AF for Reclamation to use in its Supplemental Water Program, 191,000 AF for the MRGCD for irrigation purposes, and 8,500 AF to the City of Santa Fe for municipal and industrial uses. As a result of implementing the EDWA, a total of 255,600 AF of relinquishment water was stored on the Rio Chama during the snowmelt runoff periods of 2003 to 2014. All of this water was stored during periods when it would otherwise not have been allowed because Article VII storage restrictions were in effect.

The water stored and made available pursuant to the EDWA has been released during low natural flow periods enabling the MRGCD to meet irrigation demand and to help meet the 2003 BO Albuquerque gage flow targets for a longer time period. Consequently, during those time periods, Reclamation did not have to release stored water to meet the Albuquerque gage flow targets. Reclamation has also used water allotted to it under the EDWA to meet the 2003 BO flow targets at other times. Provided the right circumstances are present, the State would likely continue to propose relinquishments in the future. However, New Mexico’s ability to relinquish accrued credit water depends on its Compact credit status and the constraints of the Compact.

3.3 State Administration of Water Rights

The State Engineer administers surface water and groundwater sources conjunctively in the Rio Grande Basin to prevent impairment to valid existing water rights by regulating depletions, thereby maintaining the overall hydrologic system balance. The State Engineer executes his statutory duties in accordance with State law, adjudications, and court orders.

Under New Mexico law, water rights are established by beneficial use of water. Many water rights were so established prior to State Engineer jurisdiction (1907 for surface water rights, 1931 and subsequent basin declaration dates for groundwater rights). Rights established under the State Engineer’s jurisdiction follow a permitting process.

Administration is a term that encompasses numerous actions by the NMOSE in oversight of the exercise of existing water rights, the permitting process for changes in water use, and enforcement of New Mexico water law in the case of illegal water use. Examples of administration include:

1) Enforcement of offset requirements associated with permits (discussed in detail below).
2) Enforcement of diversion limits associated with permits, licenses, and adjudications of the court.
3) Enforcement against waste of water and illegal water use.
4) Administration of water rights by date of priority during shortages or under a priority call (priority administration).
5) Facilitation of the development of Alternative Administration and enforcement of Alternative Administrative conditions. Alternative Administration is based upon agreements by water right owning parties that resolve water disputes under conditions of shortage without the necessity for priority administration and curtailment of junior water rights. Examples of Alternative Administration in the MRG and URG include:
    a. The alternative administration program on the Rio Chama, in which diversions by the Rio Chama acequias downstream of Abiquiu Reservoir in excess of their very senior right to native water are repaid by exchange to MRGCD through purchase of SJC Project water.
    b. An alternative administration mechanism that has been developed for the Taos Valley as part of the Abeyta Adjudication, in which: (1) the Taos Pueblo has agreed to limit exercise of its senior irrigation water rights until junior acequia rights are retired, and (2) it has been agreed that major groundwater users can deal with their tributary impacts by making offsets directly to the Rio Grande, while contributing to a tributary mitigation system involving augmentation wells and a recharge project for the Buffalo Pastures wetland.
    c. An alternative administration on the Jemez River that is based on an agreement adopted on July 2, 1996 between the United States, the Pueblo of Jemez, the Pueblo of Zia, and the Jemez River Basin Water Users Association. Under this agreement, a priority call may be made by the Pueblos of Jemez and Zia during times of shortage. Under these circumstances, all non-Pueblo entities must follow rotation schedules under which surface water will be provided to the Pueblos and the members of the Jemez River Basin Water Users Association.
6) Granting of licenses for pre-basin declared water rights limited to the historical legal maximum diversion amount.
7) Evaluating and acting upon applications to appropriate water (and thus obtain water rights) and/or modify water use associated with existing water rights, such that:

a. NMOSE does not accept applications to develop new water rights in most of the Rio Grande Basin. Surface water has been considered fully appropriated since 1907, and any additional groundwater use in aquifers hydrologically connected to the Rio Grande or its tributaries must be fully offset (as described in more detail below).
b. Applications accepted by the NMOSE are evaluated, as per Statute, and in accordance with applicable NMOSE rules, guidelines and policies (such as the 2006 Surface Water Transfer Requirement to Offset Effects on the Rio Grande, the 2009 Return Flow and Discharge Credit, and the 2011 Depletion Offsetting for Habitat Restoration Projects within the Middle Rio Grande Project policies). The NMOSE evaluates the potential for impairment of other water rights, and whether granting the application would be contrary to conservation within the State or detrimental to the public welfare of the State.
c. If the State Engineer approves an application, conditions are applied to ensure water use does not exceed the legal extent of the water rights, and to ensure full offset of impacts to the Rio Grande (as described in more detail below).

Further, in the Rio Grande Basin, the following specific constraints related to protection of the flows of the Rio Grande are generally applied in approval of such applications:

1) In order to maintain compliance with the Rio Grande Compact, depletions to the Rio Grande above the Otowi gage must be maintained at or below pre-Compact levels (1929).
2) Water rights are not transferable from above the Otowi gage to below the Otowi gage, or vice versa.
3) There can be no net increase of impact to the Rio Grande stream system (including tributaries). All surface-water impacts occurring at a new location as the result of a transfer must be offset by a decrease in surface-water depletion at the move-from location. Exceptions to the offset requirement apply to small domestic, livestock, and temporary-use wells approved under NMSA 1978 §§ 72-12-1 *et seq*.
4) Water rights are not transferable from above Elephant Butte Dam to below Elephant Butte Dam, or vice versa.

3.4 Surface Water

Most surface water uses in the MRG and URG were initiated prior to enactment of the March 17, 1907 Surface Water Code. These uses were not established through any permitting process. Exceptions include diversions of permitted MRGCD rights, diversions of Bosque del Apache rights, and diversions of contracted SJC Project Water.

3.5 Groundwater

The State Engineer first declared jurisdiction over a large corridor along the main stem of the MRG and URG in 1956. The State Engineer expanded this jurisdictional area to most of the outlying areas of the MRG and URG during the 1960s, 1970s and 1980s. Groundwater rights established by beneficial use prior to 1956, and later in the extended areas (i.e., established prior to the declaration of the groundwater basins), are referred to as “pre-basin” groundwater rights. In general, there are no offset requirements associated with the exercise of pre-basin rights.

Groundwater rights established after a basin was declared require a permit from the State Engineer. In addition, the transfer or other significant modification of a water right also requires a permit from the State Engineer. As specified in statute, the State Engineer shall grant applications if he finds that the proposed activity would not impair existing water rights, would not be contrary to conservation of water within the State, and would not be detrimental to the public welfare of the State.

3.6 Permitted Groundwater Pumping Offset Programs

The State Engineer calculates groundwater pumping impacts to the Rio Grande by means of numerical models or by an analytical technique (Glover-Balmer method). Groundwater in the MRG and URG is pumped primarily from thick basin-fill aquifers that are in hydrologic connection with the Rio Grande. In general, all groundwater pumping from these aquifers will eventually be felt as impacts to the Rio Grande, but this may take hundreds of years.

In addition, in issuing groundwater permits, the State Engineer requires that impacts to tributaries to the Rio Grande are offset (this includes numerous streams, including the Rio Chama, the tributaries to the Rio Chama, and the numerous Rio Grande tributaries located in the Taos, Pojoaque, Espanola and other valleys). In general, depletions to a tributary stream must be offset on the affected tributary itself in order to prevent impairment of existing water rights associated with the tributary. In some cases an alternative method for offset and mitigation can be developed such as has occurred in the Taos Valley as part of the Abeyta Settlement, which allows tributary impacts to be offset on the Rio Grande, as long as mitigation is provided to the acequias on the tributaries.

Originally, the State Engineer issued permits that required offsets to be obtained and applied at the time when the surface water impacts were calculated to occur. Since the adoption of the Middle Rio Grande Administrative Area (MRGAA) (Turney 2000) Guidelines in 2000, groundwater users in that area are required to obtain offsets up front. That is, permits in the MRGAA are conditioned to require that the maximum permitted diversion be limited to the amount of valid surface rights transferred, plus the amount returned directly to the river. Surface water rights obtained in excess of currently calculated impacts may be leased back for use on the farm in the interim until the impacts are calculated to reach the Rio Grande. Similar conditions are also applied to permits throughout the Rio Grande Underground Water Basin, from the Colorado state line to Elephant Butte. The result of these offset requirements is that groundwater right owners must provide offsets to the Rio Grande equal to the total groundwater diversion amount, which is the maximum surface water impact that could be created by their diversions.

Offsets to stream depletions are accomplished by a combination of the three mechanisms described below:

1) Transfer of existing valid surface water rights.
    a. Only valid pre-1907 water rights may be used for this purpose. In the MRG this is determined by a rigorous historical land use evaluation process.
    b. In cases where surface water used for irrigation is transferred to a different use, only a fraction of the actual diversion may be transferred to offset the groundwater use—the part generally corresponding to the calculated consumptive irrigation requirement. The carriage-water component of the diversion is not transferrable, and remains in the surface water system.
    c. The NMOSE routinely provides the MRGCD with geospatial data that identifies all those lands from which pre-1907 surface water rights have been severed.
2) Actual return flow of surface water to the Rio Grande, pursuant to an NMOSE approved return flow plan.
3) The NMOSE “Letter Water Program” for the release and/or storage by exchange of SJC Project water under contract by the permitted groundwater rights owners, to offset their impacts.

Each of these mechanisms is described in more detail below.

3.7 Transfer of Pre-1907 Water Rights

The primary water rights that the NMOSE accepts for offset purposes are valid pre-1907 surface water rights. The State Engineer has a rigorous historical-use evaluation process to determine valid pre-1907 surface-water rights in the MRG. This is necessary because some lands are irrigated with relatively junior rights associated with the creation of the MRGCD. Such rights are not acceptable for offset of groundwater-pumping impacts on surface water, and thus need to be distinguished from pre-1907 rights. Another class of water right that may be deemed acceptable for offset purposes are pre-basin groundwater rights established before the Rio Grande Compact was adopted in 1939.

When water rights are transferred from one use to another in the MRG, only a portion of the water right is allowed to be transferred. For irrigation rights, this transferrable portion of the water right is the consumptive irrigation requirement of 2.1 AF per acre. An estimated total of 7.5 AF per acre (2.1 AF per acre divided by an estimated MRGCD project efficiency of 0.28) must be diverted from the river to supply irrigated move-from lands with the transferrable portion of the water right. When MRGCD is using natural river flow to meet irrigation demand, and transfers have occurred, less water needs to be diverted to meet irrigation demand, and the river and MRGCD benefit by the amount of conveyance water that is left in the river as a result of the transfers.

3.8 Actual Return Flow

Certain NMOSE groundwater permits allow permitted users to use return flow to the Rio Grande to offset their river impact pursuant to an NMOSE approved return flow plan (Sizemore, 2009). Return flow offsets the effect on the river resulting from groundwater pumping. While the exact number varies from year to year, approximately 67,000 AF of diverted water is directly returned annually to the river in the MRG between the Otowi gage and Elephant Butte Dam. Approximately 58,000 AF of that return flow is returned by the ABCWUA. In general, such return flows are composed of treated municipal wastewater, and the return flows are used to offset the impacts of groundwater pumping on surface water supplies. Return flows associated with municipal water use occur on a year-round basis.

3.9 The Letter Water Program

The NMOSE accepts SJC Project water to offset the hydrologic impacts of groundwater pumping on the water supply of the middle valley water users and to offset impacts on the State’s delivery of water to Elephant Butte Reservoir under the Rio Grande Compact.

Offsets to the middle valley water users take the form of an exchange of SJC Project water in reservoir storage from a SJC Project contractor to the MRGCD. The MRGCD is the only entity that diverts surface water from the Rio Grande in the middle valley for irrigation purposes and it supplies the water to its constituents and others (such as the La Joya Acequia). This additional SJC Project water gives the MRGCD the ability to release sufficient water to overcome the impacts associated with the groundwater pumping.

Offsets to the State’s delivery of water to Elephant Butte Reservoir are generally accomplished through the State’s release of the SJC Project offset water (“Letter Water”) during the winter (normally November or December) when no river diversions are occurring. That is to ensure that the vast majority of the released SJC Project water is physically delivered to Elephant Butte Reservoir before the end of a particular calendar year.

The NMOSE provides Reclamation with letters describing, for each groundwater pumper with SJC Project water that needs or chooses to release SJC Project water for offset purposes, the volume of SJC Project water that must be released by Reclamation or provided to MRGCD, and a deadline to do so. The impacts are described by the NMOSE as cumulative effects on Elephant Butte Reservoir (and therefore to New Mexico's deliveries under the Compact), and cumulative effects on the Rio Grande in the MRG due to impacts above and/or below the Otowi gage.

In addition, on occasion SJC Project water is stored by exchange in Nichols and McClure Reservoirs by the City of Santa Fe. In such instances, Santa Fe stores water in Nichols and McClure reservoirs when they otherwise would be prohibited from doing so (such as when Article VII of the Compact is in effect). After the storage operations are complete, the amount of water stored is accounted and the NMOSE sends a letter to Reclamation directing the release of the same amount of SJC Project water to the Rio Grande. Additionally, on occasion and usually during the winter months, the ABCWUA or City of Santa Fe, after coordination with the State and Reclamation, release some of their SJC Project water from upstream reservoirs and deliver it to Elephant Butte Reservoir.

Water operations associated with the Letter Water Program are described by Reclamation in its July 2012 Joint BA and are included in the Upper Rio Grande Water Operations Model (URGWOM) simulations used to inform water deliveries for development of the BA.

4. Action Area

The action area is defined as all areas to be affected directly or indirectly by the State actions and not merely the immediate area involved in the actions. The action area for the State's actions covers the Rio Grande Basin from the New Mexico state line with Colorado to the full pool of Elephant Butte Reservoir (Figure F-1).

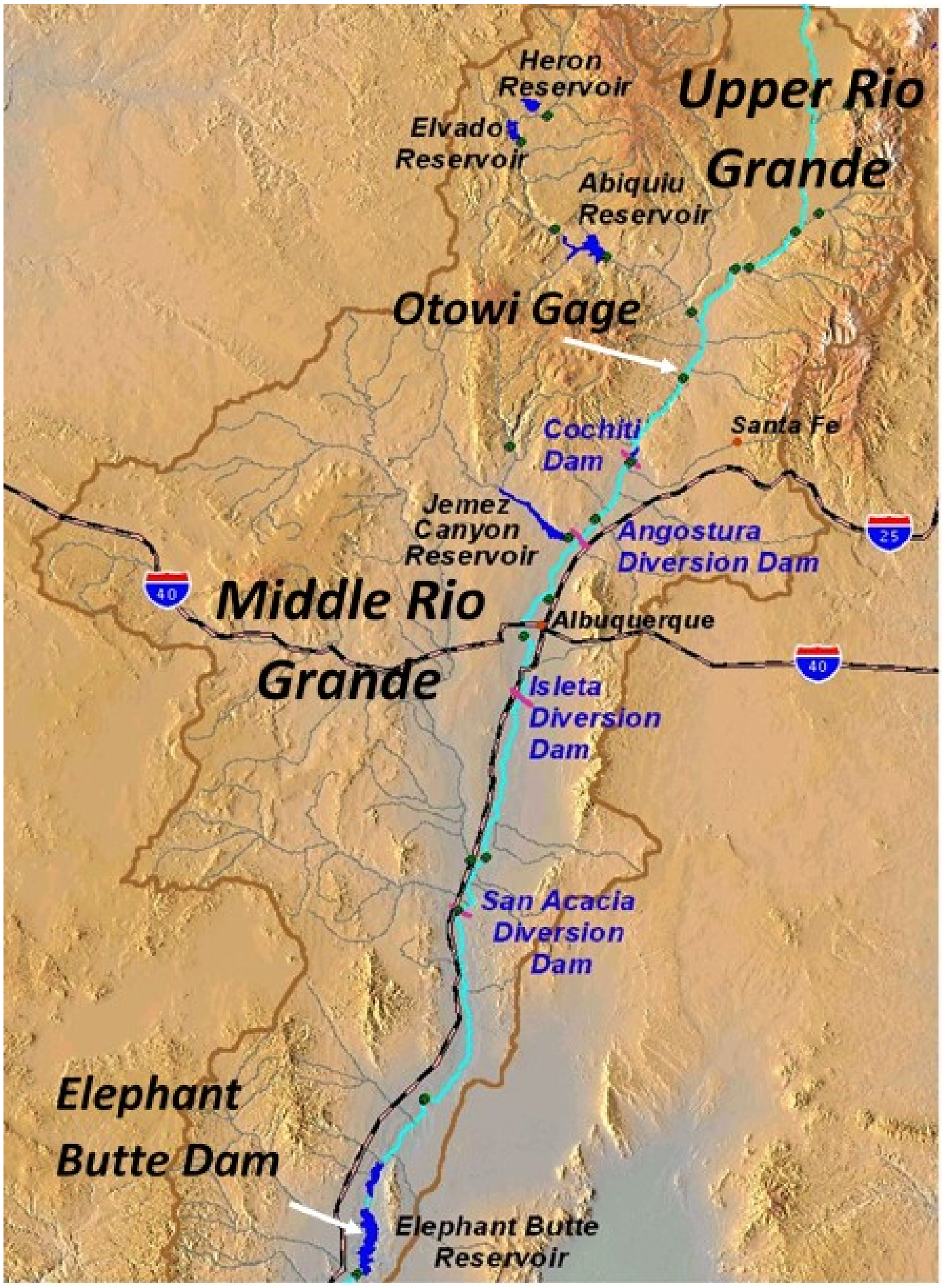

Figure F-1. State Action Area: Upper Rio Grande and Middle Rio Grande.

5. Description of the Proposed Actions

The NMISC, NMOE, and the Office of the Attorney General (collectively, the State) conduct State water-related actions described below and seek ESA coverage for the effects of all lawful actions within the outlined parameters of the action area. The proposed state actions are as follows.

5.1 Administration of the Rio Grande Compact

The NMISC is charged with the administration of all interstate stream compacts to which the State is a party, including the Rio Grande Compact of 1938 (Compact). The NMISC proposes to continue its Rio Grande Compact related activities including the relinquishment of New Mexico Accrued Credit Water and allocation of New Mexico relinquished compact credits.

5.2 Administration of Surface Water and Groundwater Supplies

The State Engineer proposes to continue to administer the surface water and groundwater resources to maintain hydrologic system balance by executing his statutory duties with respect to transfers of valid existing surface water rights and compliance with valid existing state water declarations, permits, licenses, and court adjudications. Specifically:

1) Continue to evaluate applications and issue permits to water rights owners to change the place and/or purpose of use of valid water rights in accordance with statutes, State Engineer policy, and guidelines, including:
    a. Issuance of permits to transfer valid existing surface water rights, established prior to the March 17, 1907 Water Code as acquired by groundwater right owners to comply with offset requirements; and,
    b. Issuance of permits authorizing return flow credits to the river, pursuant to State Engineer approved return flow plans, for offset requirements.
2) Continue to administer compliance of existing water rights in accordance with State Engineer permits and licenses and the adjudications of the courts.
3) Oversee the State Engineer Letter Water Program for the release, and/or storage by exchange, of SJC Project water.

5.3 Administration of Domestic, Municipal, Livestock and Temporary Uses

The State Engineer will continue to administer groundwater resources within the allowable limits in the following manner:

The State Engineer will continue to issue permits for small domestic, livestock, and temporary uses as required by NMSA 1978 Sections 72-12-1.1 through 72-12-1.3, in accordance with the NMOSE 2006 Rules and Regulations Governing the Use of Public Underground Waters for Household and Other Domestic Use.

5.4 River Maintenance

The State proposes to continue to collaborate with Reclamation to fund river conveyance and flood control projects including maintaining the delta channel at the headwaters of the active pool of Elephant Butte Reservoir. More specifically, the State proposes to continue to contribute funding for certain types of projects described in the river maintenance activities section of the BA The full description of the MRG river maintenance program, including State actions, is described in the draft BA Part III.

6. Hydrologic Impact Analysis of the Proposed Actions

The following section presents the hydrologic impact analysis of the proposed actions using analytical approach that assumes full impact on the river (i.e., groundwater pumping has 100 percent impact on the river instantaneously). In addition, URGWOM was used to estimate the expected credit water relinquishment for the next 10 years.

6.1 Administration of the Rio Grande Compact

The NMISC proposes to continue its Compact related activities specifically including administering relinquishment of New Mexico Credit water and allocation of relinquished compact credit. Analysis of the URGWOM simulations used in development of the current BA indicates that relinquishment of New Mexico accrued credit water, and the related ability to store relinquishment water upstream during the snowmelt runoff and release it later by MRG water users and Reclamation, allows an extended MRG irrigation season, and provides storage water to help Reclamation and the Corps meet the 2003 BO flow targets. Article VII of the Compact restricts storage of native Rio Grande water in reservoirs upstream of Elephant Butte Reservoir constructed after 1929 when there are less than 400,000 AF of Usable Water in Rio Grande Project Storage in Elephant Butte and Caballo Reservoirs.

During the period covered by the 2003 BO, New Mexico relinquished credit water several times. If the relinquishments had not occurred, Reclamation and the Corps would have had a more difficult time meeting the flow targets of the 2003 BO and may not have been able to do so under some circumstances. The URGWOM model simulations demonstrate that the frequency and the amount of credit water available for relinquishment depends on the hydrologic sequence simulated. Using the 50% exceedance probability 10-year hydrologic sequence (Roach, 2009) model run, the state would be able to propose to relinquish significant amounts of credit water about 50% of the time (Figure F-2). However, given the history of relinquishments since signing the compact and the current litigation with the State of Texas, that scenario likely overestimates the frequency and volume of future relinquishments. Relinquishments would provide water for storage to meet MRG demands when otherwise prohibited by the Compact.

The effect of the storage and release of the relinquishment water are included in the effect analysis of actions related to El Vado Storage and release by Reclamation and MRGCD.

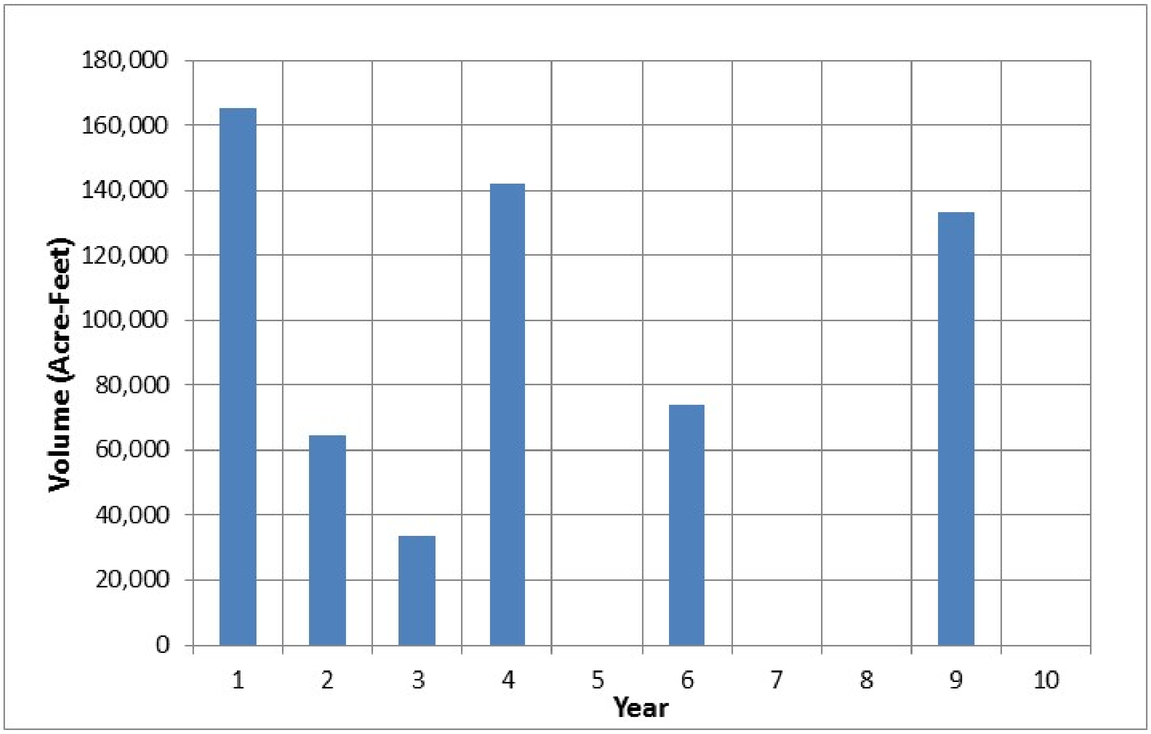

Figure F-2. Estimated amount of New Mexico credit water relinquishment (URGWOM simulation using 50 percent exceedance probability 10-year hydrologic sequence)

Therefore, the effects of the State's proposed actions in administering the Compact are, on the whole, positive as measured by the ability to make relinquishment water available in upstream storage for release to benefit municipal and irrigation needs and to meet flow targets when native water storage would otherwise not be available to do so.

6.2 Administration of Surface and Groundwater Supplies

The State Engineer proposes to continue to administer the surface water and groundwater resources to maintain hydrologic system balance by executing his statutory duties with respect to transfers of valid existing surface water rights and compliance with valid existing state water declarations, permits, licenses, and court adjudications.

Between the state line and the Otowi gage (URG), the NMOSE conjunctively administers surface water and groundwater resources to keep total human depletions at or below the 1929 conditions. All depletions occurring as a result of transfer at the move-to location must be offset by a decrease in depletion at the move-from location, return flow, or releases of SJC Project Water. In addition, the NMOSE conducts alternative administration or water rights administration on the Rio Chama below Abiquiu Reservoir, when necessary, as required within the federal court adjudication. Therefore, the hydrologic impacts of the State actions in the above the Otowi gage (URG) are on the whole neutral, as measured by the effects on the river at the Otowi gage. The four components are summarized below.

Between the Otowi gage and the full pool of Elephant Butte Reservoir (MRG) the NMOSE conjunctively administers surface water and groundwater to offset pumping impact on the Rio Grande. The NMOSE uses three components of the offset program that result in replacement of permitted groundwater pumping impacts to the river on a real-time basis whenever MRGCD is releasing from storage. The NMOSE evaluates groundwater pumping annually to ensure compliance with the permit and its conditions. The three components are summarized below:

6.2.1 Transfer of Senior Water Rights

The total volume of senior water rights transferred to date to offset the effects of permitted groundwater pumping on the river system is about 19,620 AF. This includes senior water rights transferred since the State Engineer's declaration of the Rio Grande Underground Water Basin on November 29, 1956 to offset the effects of permitted groundwater pumping on the river system or, in the instance of the BDD, needed for diversion and consumption. Of that amount, 5,000 AF is held by the ABCWUA and 3,125 AF by the BDD, both of which have coverage under their existing BOs, and are therefore not described further herein. The remainder is 11,495 AF (approximately 340 AF from the Cochiti Division, 1,770 AF from the Albuquerque Division, 6,585 AF from the Belen Division, and 2,800 AF from the Socorro Division). These 11,495 AFY of senior consumptive use rights have been transferred from agricultural use in the MRGCD to municipal and industrial uses. About one-third of these transferred senior water rights are currently needed for offset requirements (NMOSE water rights files). The remaining portion of transferred senior rights is for offset of future impacts. All these historical transfers are included in the baseline conditions and no effect analysis is presented here.

When the purpose of use is changed from irrigation to another use in the MRG, only the consumptive irrigation requirement (CIR) of the water right is transferred. The CIR portion of the water right in the MRG is 2.1 AF per acre or about one-third of the amount that would normally be diverted from the river (about 7.5 AF per acre) to irrigate those move-from lands. Therefore, for existing transfers that are being used for offset (not being leased back) when the natural flow is greater than MRGCD demand, MRGCD needs to divert less water to meet the demand. As a result, the river flow would increase by the amount of conveyance water that is left in the river as a result of the transfers.

Since 2003, most specifically due to irrigation improvements, MRGCD has reduced its annual river diversions by about 40 percent. As a result, MRGCD is using less natural river flow to meet its irrigation demand, and is leaving water in storage when the natural flows are sufficient to meet its demands. At times when MRGCD is releasing stored water to meet irrigation demand, less water needs to be released to meet demand, which means MRGCD can extend its delivery time period and, indirectly, help meet the Albuquerque gage flow target of the 2003 BO.

The State is expecting that about 5,000 AF of water will be transferred in the next 10 years in the MRG. Using the same historical distribution of the water rights transfer (i.e., 80 percent of the transfers are from Socorro and Belen divisions to Albuquerque division), the hydrologic impact for these transfers would result in a reduction of flow at the Albuquerque gage of 0 to 5.5 cubic feet per second (cfs) 10 years later. However, in general, during spring runoff or when MRGCD is releasing stored water, transfer of a senior water right has a *de minimis* effect on river flow. During the winter months the river flow is continuous, however transfers may have a small impact on river flows due to continuing groundwater pumping at the move-to location. During summer months, transfers have an impact during periods of low river flows or during periods when the MRGCD has no stored water to release. This reduction of the flow is small in comparison to average annual flow at the Central gage, and is within the margin of uncertainty for most flow measurements. In addition, this reduction of the flow assumes that all the consumptive rights are currently needed for offset and ignores the benefits of the non-transferable portion of the right staying in the river system.

During low-flow time periods, the MRGCD routinely diverts almost all of the water required for its Belen and Socorro Divisions at the Isleta Diversion Dam. Thus, transfers of senior surface water rights from these divisions upstream into the Albuquerque Division have no impact on the river below the Isleta Diversion Dam during those time periods.

In summary, the impact of water rights transfers on river flow varies in relation to the amount of flow in the river and whether the transfer is to an upstream or downstream point of diversion. In general, during periods of higher flow such as during winter months and spring runoff, transfer of a senior water right for offset of historical and ongoing pumping impacts at either an upstream or downstream point of diversion has a *de minimis* effect on river flow. During lower natural flow periods when the MRGCD is releasing water from storage, transfer of a senior water right for offset to either an upstream or downstream point of diversion most likely will have a small, positive, impact on the river due to retention of irrigation system conveyance flows resulting from the transfers remaining in reservoir storage. During low-flow periods when the MRGCD has no stored water to release, transfer of a senior water right for offset to either an upstream or downstream point of diversion will have a small, negative, impact on the river. Therefore, the overall hydrologic impact of the State action of permitting transfers of senior water rights is minimal as measured by the effects on the river flow.

6.2.2 Return Flow Component

State Engineer groundwater permits allow permitted users to use return flow to offset their river impact pursuant to an approved return flow plan. Offset credit for return flow can only be obtained by application and permit based on a return flow plan acceptable to the NMOSE (see baseline section). Return flow occurs simultaneously with diversions throughout the course of the year. Therefore, return flows provide a real time offset of the effect of groundwater pumping on the river. Currently about 67,000 AFY of water is returned directly into the river between the Otowi gage and Elephant Butte Dam. Of this quantity about 58,000 AFY consists of ABCWUA direct returns. Because the ABCWUA has its own existing BO for all its water management activities, ABCWUA actions are not evaluated as part of the state actions and are not included in the state's hydrologic impact analysis. In certain instances, return flows exceed required offsets such that the river flow is augmented because groundwater pumping impacts are less than the return flows. The hydrologic impacts of the State action approving return flow plans are in the whole neutral, as measured by the effects on the river and may even have some positive effects due to the augmentation.

6.2.3 The Letter Water Program

For each groundwater pumper that has SJC Project water in storage for use as an offset, the NMOSE periodically provides Reclamation with letters requesting release or exchange of stored SJC Project water by certain dates to offset a portion of the permitted pumping impact. The impacts are quantified by the NMOSE as cumulative effects on Elephant Butte Reservoir (and therefore to New Mexico's deliveries under the Compact) and cumulative effects on the Rio Grande due to impacts in the MRG below the Otowi gage.

Impacts that occur during the irrigation season when MRGCD is releasing stored water to meet demand are considered effects on the MRG and are replenished by exchange of the SJC Project water in storage to the MRGCD, which holds that water for release when needed to meet demand. As such, it provides a near real-time offset of the groundwater pumping effects on the river system except during times when the MRGCD is not releasing water from storage. These conditions have occurred for portions of three irrigation seasons in the last 10 years and not at all in the 20 preceding years. When it has occurred, it has been during the months of September and October. The maximum amount of SJC Project water that has been exchanged to the MRGCD (excluding by the ABCWUA) was about 350 AF in 2007. The State is expecting a total of 350 AFY of future SJC Project exchange during summer months, which would equate to a reduction of the flow of about 1.5 cfs during September and October time period.

Impacts that occur during the months of November through March are considered effects on Elephant Butte Reservoir (and therefore to New Mexico's delivery under the Rio Grande Compact). The maximum amount needed for offset (again excluding the ABCWUA) was

870 AF in 2005. This SJC Project water is generally released to the Rio Grande in the winter for delivery to Elephant Butte Reservoir. While there is some flexibility in when the water is delivered to Elephant Butte, it cannot be depleted in the middle valley.

In general, the amount of the letter water currently utilized in the Offset Program (excluding ABCWUA) has an insignificant effect on river flows as measured at the Albuquerque gage. Letter water, including the SJC Project water that is stored by exchange in Nichols and McClure Reservoirs by the City of Santa Fe, has little or no effect on the river flow during spring runoff, when MRGCD is releasing stored water, or during winter months. During summer months, letter water can have a small impact at low river flows, especially when MRGCD has no stored water to release. Therefore, the hydrologic impacts of the State letter water component of the MRG offset program are limited to certain periods and overall are minimal, as measured by the effects on the river flow.

Water operations associated with the Letter Water Program are also described by Reclamation in its draft BA and are included in the URGWOM model simulations used in development of the draft BA.

In summary, the hydrologic impacts of the State's proposed actions in administering surface and groundwater supplies is calculated as a reduction of flow in the Albuquerque reach of about 1.5 cfs at the beginning of the consultation increasing to 7 cfs after 10 years. In addition, the State proposes to add 3 cfs of possible additional flow reduction at the Albuquerque gage after 10 years as part of the evaluation. The addition is specific to the State intent for the RIP to afford broad coverage for New Mexico water users into the future.

6.3 Administration of Domestic, Municipal, Livestock and Temporary Uses

The NMOSE is required by statute to grant permits for domestic wells, i.e. this action is non-discretionary action. The current State Engineer policy is to grant permits up to 1 AFY for watering livestock, irrigation of trees lawn or garden, or for household or domestic use. In the Nambe, Tesuque, Pojoaque Basin, requirements for domestic wells are more restrictive. The total estimated diversion amount of domestic use in the URG is about 4,400 AFY (NMOSE Water Use Report, 2005) distributed as follows: 1,480 AFY in Taos County, 2,320 AFY in Rio Arriba County, and 600 AFY in Santa Fe County. All these historical diversions and their effects are included in the baseline. The NMOSE is expected to issue about 1,000 AFY of domestic well diversion permits in the URG over the next 10 years. Assuming about 50 percent of total domestic well diversions is returned to the hydrologic system, the impact on the river at the Otowi gage is a reduction of flow about 500 AFY or about 0.7 cfs. This amount is insignificant and will not have any impact on the spring runoff at Central gage or during low-flow periods. In addition, the NMOSE conjunctively administers surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). The hydrologic impacts of the domestic well uses in the URG are in the whole neutral, as measured by the effects on the river.

In the MRG, the total estimated historical diversion amount of domestic and livestock uses is about 18,300 AFY (NMOSE Water Use Report, 2005) distributed as follows: 2,425 AFY in Santa Fe County, 2,880 AFY in Sandoval County, 6,415 AFY in Bernalillo County, 4,835 AFY in Valencia County, and 1,715 AFY in Socorro County. Effects of these historical groundwater uses are included in the baseline. For the purposes of this assessment, the NMOSE assumes it will issue about 5,000 AFY of domestic well permits in the MRG over the next 10 years (we have intentionally overestimated the number of domestic permits to be issued), and that the effects of those wells will be distributed similar to the current distribution. Assuming 50 percent of total domestic well diversions return to the hydrologic system, the total impact on the river is a reduction of flow of about 2,500 AF or about 3.5 cfs at the headwaters of Elephant Butte Reservoir. The expected impact at the Albuquerque gage is a reduction of flow of about 2.25 cfs after 10 years. The State recognizes it does not have any ESA responsibility for these non-discretionary actions; however, the State proposes to implement Conservation Measures for them as part of its effort to confirm broad coverage for legal uses of water in the MRG.

6.4 River Maintenance Actions

The State proposes to continue to collaborate with Reclamation to fund river conveyance and flood control projects including maintaining the delta channel at the headwaters of the active pool of Elephant Butte Reservoir. More specifically, the State proposes to continue to contribute funding for certain types of projects described in the river maintenance activities section of the Reclamation BA. The full hydrologic impact of the MRG river maintenance program, including State actions, is described in Reclamation's draft BA Part III.

7. Species Effects

The following is an assessment of the effects of actions proposed by the State of New Mexico (State's actions) for the federally listed species: Rio Grande silvery minnow (silvery minnow), Southwestern willow flycatcher (flycatcher), yellow-billed cuckoo (cuckoo), New Mexico meadow jumping mouse (jumping mouse), Pecos sunflower (sunflower), and interior least tern (least tern). A detailed description of the life history of each species is available in Part I of the BA.

In summary, effects determinations for the State action's are as follow: no effect for the Pecos sunflower; may affect, but not likely to adversely affect for the Southwestern willow flycatcher, yellow-billed cuckoo, New Mexico meadow jumping mouse, and interior least tern; and may affect and likely to adversely affect for the Rio Grande silvery minnow (Table F-1).

Table F-1. Summary of effects determination for the State's actions

Species	Effects Determination
Rio Grande silvery minnow (*Hybognathus amarus*)	May affect and likely to adversely affect
Southwestern willow flycatcher (*Empidonax traillii extimus*)	May affect, but not likely to adversely affect
Yellow-billed cuckoo (*Coccyzus americanus*)	May affect, but not likely to adversely affect
New Mexico meadow jumping mouse (*Zapus hudsonius luteus*)	May affect, but not likely to adversely affect
Pecos sunflower (*Helianthus paradoxus*)	No effect
Interior least tern (*Sterna antillarum athalassos*)	May affect, but not likely to adversely affect

The effects determinations for each of the species listed above by action category are described in the following text and tables. Because the State's action may change over time, the effects determinations are based on maximum effect even though it may occur in the latter part of the 10-year consultation period. At the beginning of this consultation (based on the environmental baseline), the total combined effect of the administration of surface water and groundwater supplies is negligible (1.5 cfs flow reduction). As time moves through the 10-year consultation period, various transactions take place and water is used in new and different places, and hydrologic impacts begin to occur on the river. We assume the uses affect the river system linearly in time, at about one additional cfs each year. Therefore, the total calculated effect increases over 10 years from 1.5 cfs at the start to about 10 cfs in 30 percent of years during September October in the Albuquerque Reach. Similarly, administration of domestic, municipal, and livestock uses is expected to increase linearly over the 10-year period to 2.25 cfs at the Albuquerque gage to 3.5 cfs at the headwaters of Elephant Butte Reservoir.

These flow reductions are a small amount of hydrologic impact in the MRG, given a river with flow that ranges from 600 to 800 cfs in winter (Nov thru Mar), 800 to 6,000 cfs in spring (Apr into Jun), and 250 to 700 cfs in summer (Jun thru Oct). Given these anticipated water transactions, the effects determination reflects changes in hydrology through time. Hence, there is no effect initially; may affect, but not likely to adversely affect after 5 years; and may affect, but not likely to adversely affect after 10 years, except under very specific natural low-flow conditions when there may be an adverse effect. Because of the anticipated effect of flow reduction in the latter years of this consultation, we determine that the State's administration of water supplies does not adversely affect the listed species, except possibly for the Rio Grande silvery minnow.

7.1 Rio Grande Silvery Minnow

7.1.1 Summary of Effects on the Silvery Minnow

A summary of hydrologic impacts of the State's actions by category and associated direct and indirect effects to the silvery minnow is provided in Table F-2. This action category allows other entities to store water during the spring runoff to meet water needs at other times of the year, and relinquished NM credit provides water during low-flow periods to help maintain river flow and provide more wetted habitat. In summary, the administration of the Rio Grande Compact may affect, but is not likely to adversely affect the silvery minnow or adversely affect critical habitat. This action category is likely to benefit all life stages of the silvery minnow and its critical habitat.

Administration of surface water and groundwater supplies, and administration of domestic, municipal, livestock, and temporary uses may affect, and are likely to adversely affect the silvery minnow or adversely affect critical habitat. This determination is based on flow reduction during low-flow periods that could contribute to habitat reduction and possibly river drying. The magnitude of flow reduction from these action categories is small and immeasurable during spring peak flows and will have an insignificant effect on the silvery minnow.

River maintenance is included in the Reclamation River Maintenance Analysis and no effects analysis was done in this section.

Table F-2. Summary of hydrologic impacts and direct and indirect effects of the State's actions on the Rio Grande silvery minnow

Action Category	Summary of Hydrologic Impact	Summary of Effects to Silvery Minnow
Administration of Rio Grande Compact	• Allocation of New Mexico relinquished credit for irrigation, M&I and environmental uses is beneficial to the ecosystem since it provides more water to the system during low-flow periods. • The effect of storing and releasing the water is analyzed with the El Vado storage action above.	• This action allows other entities to store water almost exclusively during the spring runoff to meet water needs at other times of the year. Providing relinquished NM credit water during low natural flow periods helps to maintain river flow and provide more wetted habitat. This action may affect, but is not likely to adversely affect the Rio Grande silvery minnow or adversely affect its critical habitat. This action is likely to benefit the silvery minnow.
Administration of Surface Water and Groundwater Supplies	• Upper Rio Grande: There is no hydrologic impact to the middle Rio Grande from the Upper Rio Grande because of the State Engineer's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). • Middle Rio Grande: The total hydrologic impact of administering surface water and groundwater supplies is calculated as a reduction of flow in the Albuquerque Reach of about 1.5 cfs at the beginning of the consultation increasing to 10 cfs after 10 years.	• The continued administration of surface water and groundwater supplies above the Otowi gage has no effect on the Rio Grande silvery minnow or its critical habitat. • A flow reduction of 1.5 cfs in the MRG is part of the SJC offset program and is small and immeasurable. • A flow reduction of up to 7-10 cfs could occur in the Albuquerque Reach during times when MRGCD is not releasing water from storage (about 30% of years for about 2–3 months (Aug-Oct timeframe) resulting in a reduction of wetted habitat for a short time period in some dry years in the Albuquerque Reach only. • In total, this action may affect, and is likely to adversely affect the Rio Grande silvery minnow or adversely affect its critical habitat in the Albuquerque Reach only.
Administration of Domestic, Municipal, Livestock and Temporary Uses	• Upper Rio Grande: There is no hydrologic impact to the middle Rio Grande from the Upper Rio Grande because of the NMOSE's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). • Middle Rio Grande: The total hydrologic impact of administering domestic, municipal, livestock and temporary uses is estimated to be zero cfs at the beginning of the consultation period increasing to about 2.25 cfs at the Albuquerque gage and 3.5 cfs at the headwaters of Elephant Butte Reservoir after 10 years.	• The continued administration of surface water and groundwater supplies above the Otowi gage has no effect on the Rio Grande silvery minnow or its critical habitat. • A flow reduction ranging longitudinally from 2.25 cfs at the Albuquerque gage to 3.5 cfs at the headwaters of Elephant Butte Reservoir is small and immeasurable during spring peak flows; however, during low-flow periods, this flow reduction (in addition to 1.5 cfs reduction from the offset program) could contribute to river drying in the Isleta and San Acacia Reaches during extremely low flows. This action may affect, and is likely to adversely affect the Rio Grande silvery minnow or adversely affect its critical habitat.
River Maintenance (included above)	• Included in the Reclamation River Maintenance Analysis.	• Effect analysis is included in Reclamation River Maintenance Part III of the BA.

7.1.2 Effects on the Silvery Minnow by Action Category

A summary of the hydrologic impact of the State's action by category was previously presented in Table F-2. This section describes the direct and indirect effects of each action category on life stages and primary constituent elements of critical habitat of the Rio Grande silvery minnow.

7.1.2.1 Administration of the Rio Grande Compact

The effects of the State's administration of the Rio Grande Compact on the silvery minnow are as a whole positive, as measured by the ability of making relinquished NM credit water available in upstream storage for release to fulfill municipal, irrigation, and environmental needs and when native water storage would otherwise not be available (Table F-3). Water stored during snowmelt runoff and released during low-flow periods provides a higher frequency of continuous flow in the MRG that benefits the silvery minnow by maintaining habitat for all life stages, especially in summer. Low-flow periods are particularly critical to the silvery minnow as the river may become intermittent or dry in some portions. Providing water during low-flow events reduces the frequency, duration, or magnitude of drying and provides more persistent habitat. The silvery minnow lives only 2-4 years and all ages participate in spawning (including fish reaching one year of age), so maintaining river habitat, especially during dry periods is beneficial by sustaining the reproductive stock and maintaining population self-sustainability.

Helping to maintain flow during low-flow periods also helps to protect the primary constituent elements of critical habitat for the silvery minnow, including space for individual and population growth; food; water quantity and quality; cover or shelter; sites for breeding, reproduction, or rearing of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of the species. Continuous summer flow helps to maintain habitat, including water depth, temperature, and quality, as well as food production.

In summary, the State's administration of the Rio Grande Compact may affect, but is not likely to adversely affect the Rio Grande silvery minnow or adversely affect its critical habitat. Providing relinquished credit water during low-flow periods is likely to benefit the species by maintaining river flow and providing continuous wetted habitat.

Table F-3. Direct and indirect effects of the State's administration of the Rio Grande Compact on life stages and critical habitat of the Rio Grande silvery minnow

Season	Life Stage				
	Spawning	**Eggs**	**Larval**	**Juvenile**	**Adult**
Spring (March-May)	• There is no effect to spring peak flow from this action and no effect on spawning, eggs, or larval life stages of the silvery minnow.			• There is no effect to spring peak flow from this action and no effect on juvenile or adult life stages of the silvery minnow.	
Summer (June-August)	• The amount of spawning that may occur in summer is small and inconsequential; this action provides more water during low-flow periods, and is likely to benefit spawning, egg, and larval life stages of the silvery minnow.			• This action provides more water during low-flow periods in summer, fall, and winter, and is likely to benefit juvenile and adult life stages of the silvery minnow.	
Fall (September-November)	• Spawning, egg, and larval life stages of the silvery minnow do not normally occur in fall or winter.				
Winter (December-February)					
Primary Constituent Element (PCE)					
A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.	• Water released during low-flow periods provides more flowing water that helps to maintain a diversity of aquatic habitats for all life stages of silvery minnow; this action is likely to enhance this PCE of critical habitat for the silvery minnow.				
Presence of a diversity of habitats for all life history stages					
Sufficient flows from early spring (March) to early summer (June) to trigger spawning	• There is no effect on flows from March to June from this action and no effect on spawning triggers for the silvery minnow.				
Flows in the summer (June) through fall (October) that do not increase prolonged periods of low or no flow	• Water released during low-flow periods (Jun-Oct) provides more flowing water that reduces the periods of low or no flow; this action is likely to enhance this PCE of critical habitat for the silvery minnow.				
Constant winter flow	• Water released in winter will help to maintain constant flows and provide persistent habitat for fish, especially in deepened pools and around instream woody debris; this action is likely to enhance this PCE of critical habitat for the silvery minnow.				
River reach length	• Water released during low-flow periods helps to maintain river continuity and reach length; this action is likely to enhance this PCE of critical habitat for the silvery minnow.				
Habitat "quality" in each reach and refugial habitats	• Water released during low-flow periods helps to maintain habitat quality in each reach and habitats where fish can take refuge during extremely low flows; this action is likely to enhance this PCE of critical habitat for the silvery minnow.				
Substrates of predominantly sand or silt	• This action does not affect sediment transport or substrate composition of the river.				
Temp >1˚ - <30˚C.	• Water released during low-flow periods helps to maintain river flow, dilution, and circulation that benefits water quality; this action is likely to enhance these PCEs of critical habitat for the silvery minnow.				
DO > 5 mg/L					
pH (6.6-9.0)					
Other Contaminants					

7.1.2.2 Administration of Surface Water and Groundwater Supplies

This action category includes administration of surface water and groundwater supplies above and below the Otowi gage, including transfer of senior water rights and the letter water program. The NMOSE administers surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (i.e., 1929 conditions). Administering water supplies above the Otowi gage results in a discountable effect on the silvery minnow as the gage is located far upstream of occupied or critical habitat.

The State is expecting that about 5,000 AF of water will be transferred through senior water rights in the next 10 years in the MRG. In general, during spring runoff or when MRGCD is releasing stored water, transfer of a senior water right has a *de minimus* effect on river flow. During winter months, river flow is continuous, however, and transfers have a small impact on flow due to continuing pumping at the move-to location. During summer months, transfers have an impact during periods of low river flows or when MRGCD has no stored water to release. These conditions have occurred about three times in September and October of the last 10 years (i.e., 30% of years) and not at all in the 20 preceding years. The impact of senior water rights transfers from the Isleta and Socorro Divisions to the Albuquerque Reach would result in a flow reduction of 0 cfs at the Central gage (Albuquerque Reach) increasing linearly to 5.5 cfs after 10 years. This flow reduction is small in comparison to average annual flow, and is within the margin of uncertainty for flow measurement. However, in years of extremely low flow, this reduction could adversely affect habitat and the silvery minnow in the Albuquerque Reach only (Table F-4).

In general, the amount of letter water has an insignificant effect on river flows as measured at the Central gage (1.5 cfs). Letter water has no effect on river flow during spring runoff, or when MRGCD is releasing stored water or during winter months. The letter water program is likely to have little effect on the silvery minnow and its critical habitat. The letter water program provides a near real-time offset of the groundwater pumping effects on the river system, except during times when MRGCD is not releasing water from storage. These conditions have occurred about three times in September and October of the last 10 years and not at all in the 20 preceding years. Total effect of administering surface water and groundwater supplies in the action area is a flow reduction in the Albuquerque Reach of about 1.5 cfs increasing linearly to 10 cfs after 10 years.

In summary, the State's Administration of surface water and groundwater supplies in the Middle Rio Grande may affect and is likely to adversely affect the Rio Grande silvery minnow or adversely affect its critical habitat. Flow reduction in years of extremely low flow could adversely affect habitat and the silvery minnow in the Albuquerque Reach only.

Table F-4. Direct and indirect effects of the State's Administration of Surface Water and Groundwater Supplies in the Middle Rio Grande on life stages and critical habitat of the Rio Grande silvery minnow

<table>
<tr><th rowspan="2">Season</th><th colspan="5">Life Stage</th></tr>
<tr><th>Spawning</th><th>Eggs</th><th>Larval</th><th>Juvenile</th><th>Adult</th></tr>
<tr><td>Spring (March-May)</td><td colspan="5">• Flow reduction of 1.5 cfs in the MRG and increasing to 7 cfs in the Albuquerque Reach only is small and immeasurable compared to snowmelt spring runoff and the effect on all life stages of silvery minnow is likely to be insignificant.</td></tr>
<tr><td>Summer (June-August)</td><td colspan="3">• Flow reduction of 1.5-10 cfs in the Albuquerque Reach could reduce flow stability and habitat for spawning, egg, and larval life stages of the silvery minnow, but the effect is expected to be inconsequential because there is little spawning in summer.</td><td colspan="2" rowspan="3">• Flow reduction of 1.5 cfs river-wide is immeasurable and would have an insignificant effect on the silvery minnow.
• Flow reduction of 1.5-10 cfs in the Albuquerque Reach could increase periods of low flow and reduce fish habitat in summer, fall, and winter; this action is likely to adversely affect these life stages in the Albuquerque Reach only.</td></tr>
<tr><td>Fall (September-November)</td><td colspan="3" rowspan="2">• Spawning, egg, and larval life stages of the silvery minnow do not normally occur in fall or winter.</td></tr>
<tr><td>Winter (December-February)</td></tr>
<tr><td>Primary Constituent Element (PCE)</td><td colspan="5"></td></tr>
<tr><td>A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.</td><td colspan="3" rowspan="2">• Flow reduction of 1.5 cfs in the MRG and increasing to 10 cfs in the Albuquerque Reach after 10 years is small and immeasurable compared to snowmelt spring runoff and the effect on the hydrologic regime and habitat diversity for spawning, egg, and larval life stages of silvery minnow is likely to be insignificant.</td><td colspan="2" rowspan="2">• Flow reduction of 1.5 cfs river-wide is immeasurable and would have an insignificant effect on the silvery minnow.
• Flow reduction of 1.5-10 cfs in the Albuquerque Reach may have a small effect on the hydrologic regime during low-flow periods and reduce habitat diversity in summer, fall, and winter; likely to adversely affect these PCEs of critical habitat for these life stages in the Albuquerque Reach only.</td></tr>
<tr><td>Presence of a diversity of habitats for all life history stages</td></tr>
<tr><td>Sufficient flows from early spring (March) to early summer (June) to trigger spawning</td><td colspan="5">• As described above, generally flow reduction is small and immeasurable in spring but could adversely affect habitat during low-flow periods that can occur in May or June in the Albuquerque Reach; this action is likely to adversely affect this PCE of critical habitat in the Albuquerque Reach only.</td></tr>
<tr><td>Flows in the summer-fall (Jun-Oct) that do not increase prolonged periods of low or no flow</td><td colspan="5">• Flow reduction of 1.5-10 cfs in the Albuquerque Reach could prolong periods of low flow during Jun-Oct; this action is likely to adversely affect this PCE of critical habitat for the silvery minnow in the Albuquerque Reach only.</td></tr>
<tr><td>Constant winter flow</td><td colspan="5">• Flow reduction of 1.5-10 cfs in the Albuquerque Reach would not be expected to affect the constancy of flow in winter; this action is not likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>River reach length</td><td colspan="5">• Flow reduction of 1.5-10 cfs in the Albuquerque Reach would not be expected to affect river reach length; this action is not likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>Habitat "Quality" in each reach and refugial habitats</td><td colspan="5">• Flow reduction of 1.5 cfs is immeasurable and would not prolong periods of low or no flow in the Isleta or San Acacia Reaches; flow reduction of 1.5-10 cfs in the Albuquerque Reach could prolong periods of low flow and reduce habitat quality and availability of refuge habitats; this action is likely to adversely affect this PCE of critical habitat in the Albuquerque Reach only.</td></tr>
<tr><td>Substrates of predominantly sand or silt</td><td colspan="5">• This action does not affect sediment transport or substrate composition of the river.</td></tr>
<tr><td>Temp >1˚ - <30˚C.</td><td colspan="5" rowspan="4">• Flow reduction of 1.5 cfs is immeasurable and would not affect water temperature, DO, pH, or contaminants in the Isleta or San Acacia Reaches; flow reduction of 1.5-10 cfs in the Albuquerque Reach could prolong periods of low flow and affect water temperature, DO, pH, or contaminants; likely to adversely affect these PCEs of critical habitat for the silvery minnow in the Albuquerque Reach only.</td></tr>
<tr><td>DO > 5 mg/L</td></tr>
<tr><td>pH (6.6-9.0)</td></tr>
<tr><td>Other Contaminants</td></tr>
</table>

7.1.2.3 Administration of Domestic, Municipal, Livestock and Temporary Uses

The NMOSE administers surface water and groundwater supplies for the purpose of domestic, municipal, livestock, and temporary uses in the State of New Mexico. This includes administration of water supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (i.e., 1929 conditions), which has a discountable effect on the silvery minnow as the gage is located far upstream of occupied or critical habitat.

The State is expecting about 5,000 AF of domestic well permits in the MRG over the next 10 years and that the effects of those wells will be distributed similar to the current distribution. Assuming 50 percent of total domestic well diversions return to the hydrologic system, the total impact on the river is a reduction of flow of about 2,500 AF or about 3.5 cfs at the headwaters of Elephant Butte Reservoir. The expected impact at the Albuquerque gage is a reduction of flow of about 2.25 cfs after 10 years.

This amount of flow reduction is small and immeasurable during snowmelt spring runoff and the effect of this reduction on the silvery minnow is expected to be insignificant (Table F-5). However, flow reduction of 2.25 cfs at Albuquerque to 3.5 cfs at the headwaters of Elephant Butte could prolong periods of low or no flow in the Isleta and San Acacia Reaches and adversely affect the silvery minnow or its habitats.

In summary, the State's Administration of domestic, municipal, livestock and temporary uses in the Middle Rio Grande may affect and is likely to adversely affect the Rio Grande silvery minnow or adversely affect its critical habitat. Flow reduction during low-flow periods could prolong periods of low or no flow and adversely affect the silvery minnow or its habitat.

7.1.2.4 River Maintenance

River maintenance is included in the Reclamation River Maintenance Analysis and no effects analysis was done in this section.

Table F-5. Direct and indirect effects of the State's Administration of Domestic, Municipal, Livestock and Temporary Uses in the Middle Rio Grande on life stages and critical habitat of the Rio Grande silvery minnow

<table>
<tr><th rowspan="2">Season</th><th colspan="5">Life Stage</th></tr>
<tr><th>Spawning</th><th>Eggs</th><th>Larval</th><th>Juvenile</th><th>Adult</th></tr>
<tr><td>Spring (March-May)</td><td colspan="5">• The magnitude of flow reduction (2.25 cfs at Albuquerque to 3.5 cfs at the headwaters of Elephant Butte) is small and immeasurable compared to snowmelt spring runoff and the effect on all life stages of silvery minnow is likely to be insignificant.</td></tr>
<tr><td>Summer (June-August)</td><td colspan="3">• Flow reduction of 2.25-3.5 cfs could reduce flow stability and habitat for spawning, egg, and larval life stages of the silvery minnow, but the effect is expected to be inconsequential because there is little spawning in summer.</td><td colspan="2" rowspan="3">• Flow reduction of 2.25-3.5 cfs could increase periods of low flow and reduce fish habitat in summer, fall, and winter; this action is likely to adversely affect juvenile and adult life stages of the silvery minnow.</td></tr>
<tr><td>Fall (September-November)</td><td colspan="3" rowspan="2">• Spawning, egg, and larval life stages of the silvery minnow do not normally occur in fall or winter.</td></tr>
<tr><td>Winter (December-February)</td></tr>
<tr><td>Primary Constituent Element (PCE)</td><td colspan="5"></td></tr>
<tr><td>A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.</td><td colspan="3" rowspan="2">• The magnitude of flow reduction (2.25-3.5 cfs) is small and immeasurable compared to snowmelt spring runoff and the effect on the flow regime and habitat diversity for spawning, egg, and larval life stages of silvery minnow is likely to be insignificant.</td><td colspan="2" rowspan="2">• Flow reduction of 2.25-3.5 cfs could have a small effect on the hydrologic regime during low-flow periods and reduce habitat diversity in summer, fall, and winter; this action is likely to adversely affect these PCEs of critical habitat for these life stages.</td></tr>
<tr><td>Presence of a diversity of habitats for all life history stages</td></tr>
<tr><td>Sufficient flows from early spring (March) to early summer (June) to trigger spawning</td><td colspan="5">• Flow reduction of 2.25-3.5 cfs is small and immeasurable during runoff in early spring (Mar-Apr), but could adversely affect habitat during low-flow periods that can occur in May or June; this action is likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>Flows in the summer (June) through fall (October) that do not increase prolonged periods of low or no flow</td><td colspan="5">• Flow reduction of 2.25-3.5 cfs could prolong periods of low flow during Jun-Oct; this action is likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>Constant winter flow</td><td colspan="5">• Flow reduction of 2.25-3.5 cfs would not be expected to affect the constancy of flow in winter; this action is not likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>River reach length</td><td colspan="5">• Flow reduction of 2.25-3.5 cfs could affect river reach length in the Isleta or San Acacia Reaches; this action is likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>Habitat "Quality" in each reach and refugial habitats</td><td colspan="5">• Flow reduction of 2.25-3.5 cfs could prolong periods of low or no flow and reduce habitat quality and availability of refuge habitats; this action is likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>Substrates of predominantly sand or silt</td><td colspan="5">• This action does not affect sediment transport or substrate composition of the river.</td></tr>
<tr><td>Temp >1˚ - <30˚C.</td><td colspan="5" rowspan="4">• Flow reduction of 2.25-3.5 cfs could prolong periods of low flow and affect water temperature, DO, pH, or contaminants; this action is likely to adversely affect this PCE of critical habitat for the silvery minnow.</td></tr>
<tr><td>DO > 5 mg/L</td></tr>
<tr><td>pH (6.6-9.0)</td></tr>
<tr><td>Other Contaminants</td></tr>
</table>

7.2 Southwestern Willow Flycatcher

7.2.1 Summary of Effects on the Flycatcher

In summary, the State's actions may affect, but are not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat. Flow reductions from administration of water supplies and other uses are small in magnitude compared to snowmelt-spring runoff and early summer when the birds are nesting and fledging, and most effects are either discountable or insignificant (Table F-6). Administration of the Rio Grande Compact and surface water and groundwater supplies generally help to provide water during low natural flow periods that offset groundwater depletions and maintain flow during conveyance. These actions help to provide more reliable river flow and help reduce the frequency, duration, or magnitude of drying. These actions also maintain water in the river that helps to sustain the overall river ecosystem and riparian areas used by the flycatchers for nesting, feeding, and stopover.

Table F-6. Summary of hydrologic impacts and direct and indirect effects of the State's actions on the Southwestern willow flycatcher

Action Category	Summary of Hydrologic Impacts	Summary of Effects to Flycatcher
Administration of Rio Grande Compact	• Allocation of New Mexico relinquished credit for irrigation, M&I and environmental uses is beneficial to the ecosystem since it provides more water to the system during low-flow periods. • The effect of storing and releasing the water is analyzed with the El Vado storage action above.	• This action allows other entities to store water almost exclusively during the spring runoff to meet water needs at other times of the year. Providing relinquished NM credit water during low natural flow periods helps to maintain river flow and provide more wetted habitat. This action may affect, but is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat. This action is likely to benefit the flycatcher.
Administration of Surface Water and Groundwater Supplies	• Upper Rio Grande: There is no hydrologic impact to the middle Rio Grande from the Upper Rio Grande because of the State Engineer's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). • Middle Rio Grande: The total hydrologic impact of administering surface water and groundwater supplies is calculated as a reduction of flow in the Albuquerque Reach of about 1.5 cfs at the beginning of the consultation increasing to 10 cfs after 10 years.	• The continued administration of surface water and groundwater supplies above the Otowi gage has no effect on the flycatcher or its critical habitat. • A flow reduction of 1.5 cfs is part of the SJC offset program and is small and immeasurable. • ; A flow reduction of up to 10 cfs could occur in the Albuquerque Reach during times when MRGCD is not releasing water from storage (about 30% of years for about 2–3 months in Sep-Nov). This flow reduction occurs after the birds have nested and fledged and would have no effect on the more mobile juveniles and adults. This action may affect, and is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat. • In summary, this action may affect, and is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat.
Administration of Domestic, Municipal, Livestock and Temporary Uses	• Upper Rio Grande: There is no hydrologic impact to the middle Rio Grande from the Upper Rio Grande because of the State Engineer's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). • Middle Rio Grande: The total hydrologic impact of administering domestic, municipal, livestock and temporary uses is estimated to be zero cfs at the beginning of the consultation period increasing to about 2.25 cfs at the Albuquerque gage and 3.5 cfs at the headwaters of Elephant Butte Reservoir after 10 years.	• The continued administration of surface water and groundwater supplies above the Otowi gage has no effect on the Southwestern willow flycatcher or its critical habitat. • A flow reduction ranging longitudinally from 2.25 cfs at the Albuquerque gage to 3.5 cfs at the headwaters of Elephant Butte Reservoir is immeasurable during spring peak flows and the effect on nesting and fledging flycatchers would be insignificant; during low-flow periods, this flow reduction (in addition to 1.5 cfs reduction from the offset program) would occur after the birds have nested and fledged and would have no effect on the more mobile juveniles and adults. This action may affect, but is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat.
River Maintenance (included Above)	• Included in the Reclamation River Maintenance Analysis.	• No effects analysis was done for river maintenance.

7.2.2 Effects on the Flycatcher by Action Category

A summary of the hydrologic impact of the State's action by category was previously presented in Table F-6. This section describes the direct and indirect effects of each action category on life stages and primary constituent elements of critical habitat of the Southwestern willow flycatcher.

7.2.2.1 Administration of the Rio Grande Compact

The effects of the State's administration of the Rio Grande Compact are as a whole, inconsequential or slightly positive as measured by the ability of making relinquished credit water available in upstream storage for release to fulfill municipal, irrigation and environmental needs and when native water storage would otherwise not be available. Water stored during runoff and released during low-flow periods provides a higher frequency of continuous flow in the MRG that could benefit the flycatcher by providing a more stable riparian vegetative community (Table F-7).

The flycatcher uses some sites of the MRG for nesting and rearing in spring and early summer, and at other times of the year there are either few birds in the area or the birds of all ages are mobile and move to necessary feeding and resting sites. The release of the relinquished water during spring runoff has immeasurable impact on peak flow and is expected to have little effect on the flycatcher.

This action may affect, but is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat.

Table F-7. Direct and indirect effects of administration of the Rio Grande compact on life stages and critical habitat of the Southwestern willow flycatcher.

Life Stage	Migration (April-June & July-September)	Arrival to Territories/ Territory Establishment/ Nest Building (May-July)	Egg Laying/Incubation/ Nestling/Fledgling (June-August)
Breeding Season (April to September)	• This action would have no effect on flycatcher stopover locations during migration due to the fact that flycatchers will use habitat that is less suitable and farther away from water sources during this time.	• This action could provide a more reliable continuous river flow, but the effect is expected to be negligible to flycatchers establishing territories and building nests during spring when river flow is otherwise high; water released during low-flow periods is likely to be a small benefit to the species.	• Nesting flycatchers are in their territories and less likely to abandon nests if conditions dry or decline in value; water released during low-flow periods is likely to be a small benefit to the species.
Primary Constituent Element (PCE)			
Riparian Vegetation	• Riparian habitat is in a dynamic successional environment to be used for nesting, foraging, migration, dispersal and shelter. Dense tree or shrub vegetation are in close proximity to open water or marsh areas. This action, on the whole, is slightly positive as measured by the ability of making relinquished water available for more river flow; this action is likely to benefit or have negligible effect on this PCE of critical habitat of the flycatcher.		
Insect Prey Populations	• A variety of insect prey populations is found in close proximity to riparian flood plains or moist environments. Water released during low-flow periods may enhance aquatic insect populations, but the effect is expected to be inconsequential on this PCE. Many insect populations are found in ponded water or low-lying areas or drains adjacent to the river.		

7.2.2.2 Administration of Surface Water and Groundwater Supplies

This action category includes administration of surface water and groundwater supplies above and below the Otowi gage, including transfer of senior water rights and the letter water program. The NMOSE administers surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (i.e., 1929 conditions). Administering water supplies above the Otowi gage results in a discountable effect on the flycatcher as the gage is located far upstream of occupied or critical habitat.

Flow reductions of 1.5 cfs river-wide and 1.5-7 cfs in the Albuquerque Reach are not expected to affect migration, establishment of territories, nesting, or fledging of flycatchers (Table F-8). This flow reduction is of small magnitude and should not decrease the potential for overbank flooding or overall water availability for vegetation, and it should not cause a decline in territories or canopy cover/plant health/seed establishment.

This action may affect, but is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat.

Table F-8. Direct and indirect effects of administration of surface water and groundwater supplies in the middle Rio Grande on life stages and critical habitat of the Southwestern willow flycatcher.

Life Stage	Migration (April-June & July-September)	Arrival to Territories/ Territory Establishment/ Nest Building (May-July)	Egg Laying/Incubation/ Nestling/Fledgling (June-August)
Breeding Season (April to September)	• This action would have no effect on flycatcher stopover locations during migration due to the fact that flycatchers will use habitat that is less suitable and farther away from water sources during this time.	• Flow reduction of 1.5-10 cfs is not expected to be of large enough magnitude to affect establishment of territories or nest building; this flow reduction should not decrease the potential for overbank flooding or overall water availability for vegetation, and it should not cause a decline in territories or canopy cover/plant health/seed establishment.	• Nesting flycatchers are in their territories and less likely to abandon nests if conditions dry or decline in value; flow reductions of 1.5 cfs river-wide and 1.5-10 cfs in the Albuquerque Reach are not expected to reduce availability of nesting sites or feeding areas for fledging of young.
Primary Constituent Element (PCE)			
Riparian Vegetation	• Riparian habitat is in a dynamic successional environment to be used for nesting, foraging, migration, dispersal and shelter. Dense tree or shrub vegetation are in close proximity to open water or marsh areas. Flow reductions of 1.5 cfs river-wide and 1.5-10 cfs in the Albuquerque Reach are not expected to reduce availability of riparian vegetation; this action is expected to have little or negligible effect on this PCE of critical habitat of the flycatcher.		
Insect Prey Populations	• A variety of insect prey populations found in close proximity to riparian flood plains or moist environments. Flow reductions of 1.5 cfs river-wide and 1.5-10 cfs in the Albuquerque Reach are not expected to adversely affect availability of insect prey populations; this action is expected to have negligible effect on this PCE. Many insect populations are found in ponded water or low-lying areas or drains adjacent to the river.		

7.2.2.3 Administration of Domestic, Municipal, Livestock and Temporary Uses

The NMOSE will continue to issue permits for small domestic, livestock and temporary uses as required by NMSA 1978 Sections 72-12-1.1 through 72-12-1.3, in accordance with the NMOSE 2006 Rules and Regulations Governing the Use of Public Underground Waters for Household and Other Domestic Use.

The State is expecting about 5,000 AF of domestic well permits in the MRG over the next 10 years and that the effects of those wells will be distributed similar to the current distribution. Assuming 50 percent of total domestic well diversions return to the hydrologic system, the total impact on the river is a reduction of flow of about 2,500 AF or about 3.5 cfs at the headwaters of Elephant Butte Reservoir. The expected impact at the Albuquerque gage is a reduction of flow of about 2.25 cfs after 10 years.

This amount of flow reduction is small and immeasurable during snowmelt spring runoff and the effect of this reduction on the flycatcher is expected to be insignificant (Table F-9). The magnitude of flow reduction of 2.25 cfs at Albuquerque to 3.5 cfs at the headwaters of Elephant Butte is within the margin of measurement error for base flow and the effect to the flycatcher is expected to be insignificant.

This action may affect, but is not likely to adversely affect the Southwestern willow flycatcher or adversely affect its critical habitat.

Table F-9. Direct and indirect effects of administration of domestic, municipal, livestock and temporary uses in the middle Rio Grande on life stages and critical habitat of the Southwestern willow flycatcher.

Life Stage	Migration (April-June & July-September)	Arrival to Territories/ Territory Establishment/ Nest Building (May-July)	Egg Laying/Incubation/ Nestling/Fledgling (June-August)
Breeding Season (April to September)	• This action would have no effect on flycatcher stopover locations during migration due to the fact that flycatchers will use habitat that is less suitable during this time and farther away from water sources.	• Reductions in flow of 2.25 to 3.5 cfs in the MRG would have an insignificant effect on snowmelt runoff. • This action is not expected to decrease the potential of overbank flooding or decrease the overall water available for vegetation, and no decline in territory recruitment and canopy cover/plant health/seed establishment is expected.	• Flycatchers during nesting are in their territories and less likely to abandon nests if conditions dry or decline in value.
Primary Constituent Element (PCE)			
Riparian Vegetation	• Riparian habitat is in a dynamic successional environment to be used for nesting, foraging, migration, dispersal and shelter. Dense tree or shrub vegetation are in close proximity to open water or marsh areas. Flow reductions of 2.25 to 3.5 cfs in the MRG are not expected to reduce availability of riparian vegetation; this action is expected to have little or negligible effect on this PCE of critical habitat of the flycatcher.		
Insect Prey Populations	• A variety of insect prey populations found in close proximity to riparian flood plains or moist environments. Flow reductions of 2.25 to 3.5 cfs in the MRG are not expected to adversely affect availability of insect prey populations; this action is expected to have negligible effect on this PCE. Many insect populations are found in ponded water or low-lying areas or drains adjacent to the river.		

7.3 Yellow-Billed Cuckoo

The western distinct population segment of the yellow-billed cuckoo was listed as threatened in October 2014 (79 FR 59992). The geographical breeding range of the yellow-billed cuckoo in western North America includes suitable habitat within the low- to moderate-elevation areas west of the crest of the Rocky Mountains in Canada, Mexico, and the United States, including the upper and middle Rio Grande and other western river basins. The Middle and Lower Rio Grande are also used as a migration corridor by the species. The alteration of riparian systems in western river basins through changes in hydrologic function and the introduction of nonnative plants, like tamarisk, have negatively impacted the nesting, roosting, and feeding habitat of the cuckoo. There is currently a low occurrence of the yellow-billed cuckoo in the MRG and effects of the State’s actions are expected to be discountable or insignificant because the impact on river flows due to the proposed State actions are within the margin of uncertainty for flow measurement.

The entire MRG from below Cochiti Dam to Elephant Butte Reservoir has been proposed as critical habitat for the yellow-billed cuckoo (79 FR 48548). This is based on the number of yellow-billed cuckoo breeding pairs identified in the area, the amount of habitat available, and the relationship and importance of the Elephant Butte Reservoir and Rio Grande to other yellow-billed cuckoo habitat in New Mexico and the southwest. Other areas of proposed critical habitat are located along the Rio Grande upstream and downstream of the MRG, but these are too removed from the action area as to be affected by the State's action as described in this BA. For the proposed critical habitat within the action area, flow reductions by the State are small and would have insignificant effects on habitat of the cuckoo.

The State's action may affect, but is not likely to adversely affect the yellow-billed cuckoo or adversely affect its proposed critical habitat.

7.4 New Mexico Meadow Jumping Mouse

The New Mexico meadow jumping mouse was listed as endangered throughout its range in Arizona, Colorado, and New Mexico in June 2014 (79 FR 33119). The jumping mouse has exceptionally specialized habitat requirements to support these life-history needs and maintain adequate population sizes. Habitat requirements are characterized by tall (averaging at least 61 cm), dense riparian herbaceous vegetation (plants with no woody tissue) primarily composed of sedges and forbs. This suitable habitat is found only when wetland vegetation achieves full growth potential associated with perennial flowing water. The historical distribution of the jumping mouse is the Rio Grande Valley from Española to Bosque del Apache National Wildlife Refuge (NWR). The species is currently found only along the irrigation ditches and canals in the area of the wildlife refuge and managed by the refuge.

Three areas of historical habitat are included in proposed critical habitat for the jumping mouse (78 FR 37328): the Isleta Marsh on land owned by the Isleta Pueblo, the Ohkay Owingeh Marsh on land owned by the Ohkay Owingeh Tribe, and Bosque del Apache NWR canal administered by the U.S. Fish and Wildlife Service (the Service). Only the last area is currently occupied by the species. Because the jumping mouse is found in laterals that are some distance from the river, the State's actions are removed from the immediate management of these laterals and are considered discountable or insignificant with respect to the State administration of water.

The State's action may affect, but is not likely to adversely affect the New Mexico meadow jumping mouse or adversely affect its proposed critical habitat.

7.5 Pecos Sunflower

One of seven populations of the sunflower occurs near the Rio Grande in New Mexico. The main population presently exists within the La Joya State Wildlife Area (SWA), a unit of the Ladd S. Gordon Waterfowl Complex, managed by the New Mexico Game and Fish Department. The La Joya SWA was excluded from critical habitat designation for the species because of the development of a habitat management plan that adequately protects the species. In 2010, the population was extended to a ditch (cleared of tamarisk and seeded with Pecos sunflowers) that delivers water between ponds within the La Joya SWA.

The Pecos sunflower in the MRG is limited to the areas described above within the La Joya SWA. The State's actions have little effect on the area occupied by the sunflower and on the canals that transfer water from ponds within the La Joya SWA.

The State's actions will have no effect on the Pecos sunflower.

7.6 Interior Least Tern

The least tern has been observed as a "vagrant" or "highly unusual" species amongst the avian species detected at the BDA since 1940 (Service 1995). Historically, nesting by the tern has been confirmed on reservoirs in Texas and in the Pecos River, but not in the MRG. A range-wide survey completed in 2005 showed that the Rio Grande/Pecos river systems collectively made up 0.8% of the population (Lott 2006). No critical habitat rules have been published for the interior least tern.

Given the low occurrence of the tern in the MRG and the lack of evidence for historical nesting in the MRG, the State's action may affect, but is not likely to adversely affect the interior least tern.

8. Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions, and not involving a federal action, that are reasonably certain to occur in the action area considered in the BA. The State does not anticipate reasonably foreseeable additional future State (excluding federal) or private actions in the action area, aside from those actions described herein and in Reclamation's draft BA.

9. State's Proposed Commitments

The BA incorporates a number of Conservation Measures that have been defined for the purposes of the Section 7 consultation as Offsetting Measures and Conservation Measures. Offsetting Measures are commitments that Reclamation, BIA, MRGCD, and the State will implement to minimize and/or avoid anticipated adverse effects of their Proposed Actions.

Additional proposed commitments to address species and river system considerations beyond those needed to minimize or avoid anticipated adverse effects of the Proposed Actions are described in the BA as Conservation Measures. For the State, the Conservation Measures are specific commitments that are tied to the implementation of a collaborative RIP. The State will continue to utilize its authority to support objectives that alleviate jeopardy and help to recover listed species in a manner consistent with existing and future water uses and with State laws. Because many of these Offsetting Measures are flow-related and involve providing water at times of low flow, they are likely to benefit more than one listed species and will also benefit the river ecosystem. Neither the Offsetting Measures nor the additional Conservation Measures were taken into consideration in the effects determination stated in Part V of the BA.

The State's Offsetting Measures are shown in Table F-10, and are also included in the BA combined table of Offsetting Measures for Reclamation, MRGCD, BIA, and the State (see Part IV of the BA). These Offsetting Measures are believed to be more than sufficient for minimizing or avoiding the identified effects of the State's proposed actions. The Offsetting Measures are also described in narrative form in Attachment 1. The State's contributions to the river maintenance activities are described in the BA and all Offsetting Measures are included as Reclamation's proposed commitments.

The State's Conservation Measures that have been proposed to date and accepted by the NMISC Commissioners on June 9, 2015 are listed categorically in Attachment 1. In the BA the State's Conservation Measures are combined with Conservation Measures from other entities in the BA Part IV to address the four priority categories identified by the Service. The State will work with other entities, including RIP members once established, to accomplish Conservation Measures identified in the BA as allowable under State law, regulations, and policies.

The proposed commitments that NMISC staff has developed and the Commission approved are separated into three elements:

- Element 1: These are projects and activities that directly address the adverse effects of the State's Proposed Actions, as described in the BA, on listed species. They are termed "State Offsetting Measures" and are listed with the corresponding proposed State Action.

- Element 2: These are projects and activities the NMISC has conducted in the past, at times with other members of the Collaborative Program, to help maintain broad ESA compliance for New Mexico water users living and using water in the Rio Grande Basin from Elephant Butte Dam north to the state line with Colorado. They are termed "State Voluntary Conservation Measures" to the new BA executed by the NMISC through the Collaborative Program/Recovery Program.

- Element 3: These are additional projects and activities (possible additional voluntary Conservation Measures) that the BA Partners have been discussing with the Service.

NMISC staff has been conducting the Element 1 and Element 2 projects and activities for a number of years using existing NMISC staff and annual general fund, trust fund, and other appropriations (e.g., Emergency Drought Water Agreement, Federal grants, Capital Appropriations, Water Trust Board Grants). The Element 3 projects and activities are not included in the Rio Grande Bureau's 2015 ESA Section Work Plan and would require a currently unknown amount of additional monetary and staffing commitments. The additional commitments are needed to address specific requests of the Service to the Collaborative Program related to their formulation of the new BO. Any additional Voluntary Conservation Measures agreed to for the new BO would be implemented through the Recovery Program.

Table F-10. Summary of the hydrologic effects and the Offsetting Measures

Action Category	Summary of Impacts and Effects	Offsetting Measures
Administration of Rio Grande Compact: Relinquishment – Allocation of relinquishment credit and storage and release of relinquished water	**May affect, but not likely to adversely affect:** • Action is beneficial for silvery minnow and for critical habitat. • Allocation of New Mexico relinquished credit for irrigation, M&I and environmental uses is beneficial to the ecosystem because it provides more water to the system during low-flow periods.	• Beneficial, no Offsetting Measure is warranted.
Administration of Surface Water and Groundwater Supplies	**May affect and likely to adversely affect:** • Upper Rio Grande: There is no hydrologic effect to the Middle Rio Grande from the Upper Rio Grande because of the NMOSE's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). Therefore, there is no effect to silvery minnow or critical habitat PCEs. • Middle Rio Grande: The total hydrologic impact of administering surface water and groundwater supplies is calculated as a reduction of flow in the Albuquerque Reach of about 1.5 cfs at the beginning of the consultation increasing to 10 cfs after 10 years.	For the URG: no Offsetting Measures are warranted. For the MRG: • The State will provide up to 250 AF per event (not to exceed a total of 4,500 AF in any 15-year period) of Rio Grande Compact relinquishment credit for storage in El Vado Reservoir under State Engineer Permit 1690 for later release at low flow rates when MRGCD is not otherwise releasing stored water. • The State will work with its Program partners to maintain existing overbank habitat constructed by the State since 2006 in the Albuquerque and Isleta Reaches for a period of at least 15 years, which will result in habitat availability at a greater range of flows in which spawning, egg incubation, and larval rearing can occur. • The State will provide depletion offsets for the Corps MRG Floodway projects in accordance with existing agreements. • In addition to the Offsetting Measures listed above, for the two State action categories with "may affect and likely to adversely affect" determinations, the State will provide funding for staffing of operations of the Los Lunas Silvery Minnow Refugium seeking to produce more than 17,000 adult silvery minnow per year of sufficient size for tagging and stocking in the Rio Grande.

Table F-10. Summary of the hydrologic effects and the Offsetting Measures

Action Category	Summary of Impacts and Effects	Offsetting Measures
Administration of Domestic, Municipal, Livestock and Temporary Uses	**May affect and likely to adversely affect:** • Upper Rio Grande: There is no hydrologic effect to the middle Rio Grande from the Upper Rio Grande because of the State Engineer's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). Therefore, there is no effect to silvery minnow or critical habitat PCEs. • Middle Rio Grande: The total hydrologic effect is estimated to be zero cfs at the beginning of the consultation period increasing to about 2.25 cfs at the Albuquerque gage and 3.5 cfs at the headwaters of Elephant Butte Reservoir after 10 years. A flow reduction ranging longitudinally from 2.25 cfs at the Albuquerque gage to 3.5 cfs at the headwaters of Elephant Butte Reservoir is small and immeasurable during spring peak flows. During low-flow periods, for the purposes of this evaluation, this is considered as a minor adverse effect on juveniles and adults and critical habitat PCEs although the effect is almost immeasurable. Note: The State recognizes it does not have ESA responsibility for the non-discretionary actions herein such as domestic well permits. Nonetheless, the State proposes to implement Conservation Measures for them as part of its effort to confirm broad coverage for legal uses of water in the MRG.	For the URG, no Offsetting Measures are warranted. For the MRG: • The State will provide up to 150 AF per event (not to exceed a total of 1,500 AF in any 15-year period) of Rio Grande Compact relinquishment credit for storage in El Vado Reservoir under State Engineer Permit 1690 for later release at low flow rates when MRGCD is not otherwise releasing stored water. • The State will provide up to 250 AF of senior consumptive use rights from the Strategic Water Reserve (N.M. Stat. § 72-14-3.3) to Reclamation and/or the Corps for offsets of depletions resulting from deviations at Corps reservoirs for the benefit of threatened and endangered species; and • The State will operate and maintain the Atrisco habitat restoration site to function as a holding pond for silvery minnow rescued from the Rio Grande when and if flows in Albuquerque are so low as to warrant doing so. Continued testing and application to FWS for permitting of the site to be used as refugial habitat will occur in 2015-2016. • In addition to the Offsetting Measures listed above, for the two State action categories with "may affect and likely to adversely affect" determinations, the State will provide funding for staffing of operations of the Los Lunas Silvery Minnow Refugium seeking to produce more than 17,000 adult silvery minnow per year of sufficient size for tagging and stocking in the Rio Grande.
River Maintenance	• Included in the Reclamation River Maintenance Analysis.	• See Reclamation BA

10. References

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Attachment 1: Proposed 'State of New Mexico' Commitments through the Interstate Stream Commission to the 2015 Middle Rio Grande Water Operations and River Maintenance Biological Opinion and Recovery Program

As modified in response to Interstate Stream Commission direction, June 9, 2015

Background

As part of development of the 2015 Middle Rio Grande (MRG) Water Operations and River Maintenance Biological Assessment (BA), the U.S. Bureau of Reclamation (Reclamation), the Middle Rio Grande Conservancy District (MRGCD), and the State of New Mexico (State) have been discussing possible projects that would address short-term needs while ultimately resulting in realistic, economically viable and long-term solutions to protect the interests of the State and its water users, and to achieve a hydrologically realistic Biological Opinion (BO) and to implement an effective Recovery Program. In that vein, the parties have developed discrete commitments that, if conducted, would directly offset the effects of their individual proposed actions on the listed species. In addition, they have discussed possible additional commitments that would improve baseline conditions for the federally listed species.

The proposed commitments that the Interstate Stream Commission (ISC) staff has developed for Commissioner's consideration are separated into three elements:

> **Element 1:** These are projects and activities that directly address the adverse effects of the State's Proposed Actions, as described in the BA, on listed species. They are termed "State Offsetting Measures" and are listed with the corresponding proposed State Action.
>
> **Element 2:** These are projects and activities the ISC has conducted in the past, at times with other members of the Collaborative Program, to help maintain broad Endangered Species Act (ESA) compliance for New Mexico water users living and using water in the Rio Grande Basin from Elephant Butte Dam north to the stateline with Colorado. They are termed "State Voluntary Conservation Measures" to the new BA executed by the ISC through the Collaborative Program/Recovery Program.
>
> **Element 3:** These are additional projects and activities (possible additional voluntary Conservation Measures) that the BA Partners have been discussing with the U.S. Fish and Wildlife Service (Service).

The ISC staff has been conducting the Element 1 and Element 2 projects and activities for a number of years using existing ISC staff and annual general fund, trust fund, and other appropriations (Emergency Drought Water Agreement, federal grants, Capital Appropriations, and Water Trust Board Grants). The Element 3 projects and activities are not included in the Rio

Grande Bureau's 2015 ESA Section Work Plan and would require a currently unknown amount of additional monetary and staffing commitments. The additional commitments are needed to address specific requests of the Service to the Collaborative Program related to their formulation of the new BO. Any additional Voluntary Conservation Measures agreed to for the new BO would be implemented through the Recovery Program.

Staff Request

- Request the Commission approve staff to continue to conduct the proposed "State" Offsetting Measures and Voluntary Conservation Measures (Elements 1 and 2 Project and Activities) for a period of not less than 15 years subject to annual appropriations for Rio Grande Basin projects remaining stable such that there are no new net costs from the ISC funding sources. The 15-year commitment is needed to support the proposed 10- to 15-year term of the new BO. The Rio Grande Bureau FY 2016 ESA Section Work Plan provides a good estimate of the level of requested Commission commitment for these two elements (annual budget of approximately $2 million total).

- Request Commission approval to continue discussions with the BA Partners, Collaborative Program, and Service on the Element 3 projects and activities with no specific Commission commitment at this time. Further, once and if a final set of additional voluntary Conservation Measures has been completed, staff will present it, including associated additional resource needs, if any, to the Commission for consideration and direction.

Element 1: Proposed "State" Offsetting Measures for Each Action Proposed by the State in the BA

1. Proposed Action: Relinquishment – Allocation of relinquishment credit and storage and release of relinquished water for existing uses
   - Allocation of New Mexico relinquished credit for irrigation, municipal and industrial, and environmental uses is beneficial to the ecosystem because it provides more water to the system during low-flow periods. It is included as a Conservation Measure that supports the BO and the Recovery Program.
   - Release and use of this water helps to maintain flows and habitat for larvae, juveniles, and adults.

Proposed Offsetting Measures:

Action is beneficial, no Offsetting Measures warranted.

2. Proposed Action: Administration of Surface water and Groundwater Supplies
   - Upper Rio Grande (URG): There is no hydrologic impact to the MRG from the URG because of the Office of the State Engineer's (NMOSE's) continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). Therefore, there is no effect to Rio Grande silvery minnow (silvery minnow) or critical habitat primary constituent elements (PCEs).
   - Middle Rio Grande (MRG): The total hydrologic impact of administering surface water and groundwater supplies is calculated as a reduction of flow in the Albuquerque Reach of about 1.5 cfs at the beginning of the consultation increasing to 7 cfs after 10 years. A flow reduction of 1.5 cfs in the MRG is part of the San Juan-Chama offset program and is small and immeasurable; however, a flow reduction of up to 5.5 cfs could occur in the Albuquerque Reach in September–October during times when the MRGCD is not releasing water from storage (about 30% of years for about 2–3 months). This flow reduction would increase over the 10-year period and reduce habitat for juveniles and adults and affect critical habitat PCEs for a short time period in the Albuquerque Reach only.

   Proposed Offsetting Measures:

   - For the URG, no Offsetting Measures are warranted.
   - For the MRG:
     1. The State will provide up to 250 AF per event (not to exceed a total of 4,500 AF in any 15-year period) of Rio Grande Compact relinquishment credit for storage and

later release at low flow rates when the MRGCD is not otherwise releasing stored water.

2. The State will work with its Program partners to maintain existing overbank habitat constructed by the State since 2006 in the Albuquerque and Isleta Reaches for a period of at least 15 years, which will result in habitat availability at a greater range of flows in which spawning, egg incubation, and larval rearing can occur for silvery minnow.
3. The State will provide depletion offsets for the U.S. Army Corps of Engineers (the Corps) MRG Floodway projects in accordance with existing agreements.

3. Proposed Action: Administration of Domestic, Municipal, Livestock and Temporary Uses

- URG: There is no hydrologic impact to the MRG from the URG because of the NMOSE's continued administration of surface water and groundwater supplies above the Otowi gage to maintain the status quo of the hydrologic system balance (1929 conditions). Therefore, there is no effect to silvery minnow or critical habitat PCEs.

- MRG: The total hydrologic impact is estimated to be 0 cfs at the beginning of the consultation period increasing to about 2.25 cfs at the Albuquerque gage and 3.5 cfs at the headwaters of Elephant Butte Reservoir after 10 years. A flow reduction ranging longitudinally from 2.25 cfs at the Albuquerque gage to 3.5 cfs at the headwaters of Elephant Butte Reservoir is small and immeasurable during spring peak flows. During low-flow periods, for the purposes of this evaluation, this is considered as a minor adverse effect on juveniles and adults and critical habitat PCEs although the effect is almost immeasurable.

Proposed Offsetting Measures:

- For the URG, no Offsetting Measures are warranted.
- For the MRG:

1. The State will provide up to 150 AF per event (not to exceed a total of 1,500 AF in any 15-year period) of Rio Grande Compact relinquishment credit for storage and later release at low flow rates when the MRGCD is not otherwise releasing stored water.
2. The State will provide up to 250 AF of senior consumptive use rights from the Strategic Water Reserve (N.M. Stat. § 72-14-3.3) to Reclamation and/or the Corps for offsets of depletions resulting from deviations at Corps reservoirs for the benefit of listed species.
3. The State will operate and maintain the Atrisco Habitat Project to function as a holding pond for silvery minnow rescued from the Rio Grande when and if flows in Albuquerque are so low as to warrant such action. Continued testing and application to Service for permitting of the site to be used as refugial habitat will occur.

In addition to the Offsetting Measures listed above, for both categories of actions with "may affect and likely to adversely affect" determinations, the State will provide funding for staffing of operations of the Los Lunas Silvery Minnow Refugium seeking to produce more than 17,000 adult silvery minnow per year of sufficient size for tagging and stocking in the Rio Grande.

Element 2: Proposed "State" Voluntary Conservation Measures currently authorized for implementation and funding as part of the Collaborative Program

The projects and activities described below would occur under the current level of funding for the Rio Grande Bureau and use of grants and contracts or as described for a specific proposed measure.

1. Allocation of Relinquishment Credit – The State will provide and/or sell, through a separate agreement with the United States, over 100,000 AF of previously allocated New Mexico Rio Grande Compact relinquishment credit to the United States for use over the next several years when the Rio Grande Compact Article VII storage restrictions are in effect to storage water and later release it to meet both MRGCD irrigation demand and flows for ESA compliance.

2. Reservoir Operations Modifications – The State will work with the BA Partners and the Rio Grande Compact Commission (RGCC) to assess the steps needed for future Corps deviations from normal operations at its Flood Control Reservoirs to improve flow management for silvery minnow spawning in a manner consistent with previous RGCC approval(s). In addition, the State will seek opportunities to conduct modified operations at other reservoirs and/or San Juan-Chama exchanges that may benefit the listed species.

3. Increase safe channel capacity in the Middle Rio Grande Valley to allow for higher snowmelt runoff flows – Continue to support the Socorro Levee Project. The project is one of several needed before the Corps can increase its safe channel capacity releases from Cochiti and Jemez Canyon reservoirs so that higher snowmelt runoff flows can safely be passed through the middle valley.

4. Maintenance of the Delta Channel – The State will continue maintenance of the Delta Channel at up to $1 million per year primarily as a means of aiding in compact compliance but also, potentially, to accrue additional Rio Grande Compact credit water that could be relinquished and provide future relinquishment credit allocations.

5. Albuquerque Reach Habitat Restoration – The State will conduct upwards of $500,000 of Phase II habitat restoration work at the City of Rio Rancho Bosque Open Space located in the upper portion of the Albuquerque reach by spring 2017.

6. San Acacia Diversion Dam (SADD) River Connectivity Pilot Project – The State will provide up to $25,000 of technical assistance to MRGCD per year for 3 years to design and prepare fish passage concepts at the SADD, set-up alternative designs, and test them through Service approved fish movement studies.

7. Lower Isleta and Upper San Acacia Reach Habitat Restoration – The State will provide up to $500,000 to plan, design, and lower approximately 50 acres of backwater and ephemeral channels to provide inundation at lower spring runoff flows (1500 cfs).

8. Los Lunas Silvery Minnow Refugium – The State will spend $900,000 to build out and test the Los Lunas Silvery Minnow Refugium, over the next four to five years, to better support the Service's propagation and augmentation efforts by producing up to 50,000 adult silvery minnow per year of sufficient size for tagging and stocking in the Rio Grande.

9. River Eyes and Species and Habitat Monitoring – The State will provide up to $75,000 per year of assistance or funding to the Recovery Program for these purposes.

Element 3: Possible "Additional Voluntary Conservation Measures"

The following projects and activities (not ordered in priority) are being discussed for possible inclusion in the BA/BO. All need further development and will require partnership with multiple entities. The Commission did not commit to implement any of the possible additional measures. Rather, staff will engage the BA Partners on them and other possible additional voluntary Conservation Measures, periodically update the Commission on the discussions, and may bring a refined set to the Commission for consideration and discussion during the fall of 2015.

1. San Acacia Diversion Dam (SADD) River Connectivity Test Project
2. River Connectivity at other Diversion Dams
3. General Collaborative Program Habitat Restoration Planning and Construction
4. Lower Reach (San Acacia) Planning Efforts
5. Strategic Water Reserve
6. Bosque del Apache River Realignment Project
7. Projects that Increase Safe Channel Capacity in the Middle Rio Grande Valley
8. Minnow Propagation Facility Improvements
9. Continue Habitat Restoration Initiatives in the Albuquerque and Isleta Reaches

APPENDIX G

MRGCD PROPOSED CONSERVATION MEASURES – APPROVED BY THE MRGCD BOARD OF DIRECTORS ON JULY 24, 2012 AND JULY 13, 2015

Middle Rio Grande Conservancy District

Memorandum

To: MIKE HAMMAN, AREA MANAGER – US BUREAU OF RECLAMATION

From: SUBHAS K. SHAH, CE/CEO

Date: JULY 24, 2012

Re: **PROPOSED BA CONSERVATIONS MEASURES**

Attached are the proposed Conservation Measures to the Biological Assessment that were approved by the Middle Rio Grande Conservancy District Board of Directors at their regular meeting on July 23, 2012.

Please contact me if you have additional questions.

SKS/eb

Attachment

Proposed MRGCD Conservation Measures

Preamble

1. Pursuant to its statutory general grant of powers (NMSA 1978, § 73-14-48), MRGCD has authority to enter into an endangered species Recovery Implementation Program (RIP) and to undertake certain species survival and recovery actions to be incorporated within the MRGRIP Action Plan. However, MRGCD has no authority to violate its statutory obligations and MRGCD is specifically prohibited from relinquishing control of the waters or lands of the District or from administering or managing District waters in such a way as to impair the private water rights of individual irrigators or its own statutory water rights (NMSA 1978, § 73-14-47).[1]

2. MRGCD has the authority to develop an Operating Plan to carry out some of the programs within the RIP that will benefit listed species (NMSA 1978, §§ 73-14-48 *et seq.*), but MRGCD has no authority to relinquish its authority to implement the terms of such an Operating Plan to any third party, particularly when such implementation may involve control of the use of the District waters or lands (NMSA 1978, § 73-14-47).

3. MRGCD has the authority to lease or otherwise provide reservoir storage space for a "supplemental water pool" and to assist in developing programs for use of that storage to provide protection for the RGSM consistent with the RIP, and as a contribution to cost-share, but it cannot do so in a way that reduces storage for persons entitled to receive water from the MRGCD (NMSA 1978, § 73-14-47).

Consistent with the above limitations, the MRGCD proposes the following actions for conservation of the species:

A. The MRGCD recognizes the need for ESA compliance and the need to continue to cooperate with Reclamation in future compliance efforts, which include the conjunctive management of water for species needs, municipal withdrawals, RGC obligations, and irrigation needs. The MRGCD will develop annually an Operating Plan. This Plan will coordinate the delivery of irrigation water to water rights holders and water users within the MRGCD. The Plan will also assist in meeting the needs of the listed species for population survival and recovery, including spawning, recruitment and survival habitat needs as determined by using the best available scientific information. The development and implementation of this MRGCD

[1] *See Gutierrez v. MRGCD*, 34 N.M. 346, 282 P. 1 (1929) (citing the full protection of private water rights afforded by Section 316 of the Conservancy Act).

Operating Plan will be incorporated into the Middle Rio Grande Recovery Implementation Program (MRGRIP) Action Plan as part of the conservation actions and/or tasks which are expected to permit the MRGRIP to attain and maintain compliance with the ESA.

B. The MRGCD will cooperate with state and federal agencies in creation and operation of a "supplemental water pool" consisting of up to 30,000 AF to be stored in available space in Abiquiu reservoir. Water stored for ESA purposes may, subject to ISC approval, be stored under the authority of the Strategic Water Reserve. Water stored separately by MRGCD for irrigation purposes will be managed by the MRGCD under its authority contained in the Conservancy Act. The conjunctive management of MRGCD water will provide some environmental and biological benefits to RGSM. The creation of the SWR was authorized by the NM Legislature in 2005, for the purposes of providing a water reserve to help New Mexicans manage through drought periods. In addition to meeting the needs of water users and NM's delivery obligations under the RGC, a goal of the pool will be to assist in providing flows needed for ESA purposes, and in so doing, to protect the rights of existing water users. Storage space at Abiquiu Reservoir for the pool was set aside by the ABCWUA as a result of a settlement between ABCWUA and Environmental groups when the ABCWUA was seeking to permit and construct its SJC Diversion works.

Water supply for the pool may come from a variety of sources including uncontracted SJC water and purchases of SJC water by the Federal Government from willing sellers. The use of surplus SJC water would be a primary choice for development of water supply, along with RG water stored as a result of NM having relinquished credit water in Elephant Butte reservoir to Texas under the Rio Grande Compact. Use of this water would be subject to the limitations of New Mexico water law. MRGCD is largest and most likely recipient of credit water stored as a result of relinquishment and in the absence of ESA requirements would logically be the recipient of most of this water. Relinquishment credit water (more correctly stated as the right to store water against relinquished NM RGC credits) is made available by the New Mexico Rio Grande Compact Commissioner. MRGCD will urge that a percentage of water resulting from credit relinquishments to the pool be allocated for ESA purposes. MRGCD will cooperate with appropriate entities to maximize NM credit status under the RGC, and increase the opportunities for future credit relinquishment to benefit both the ESA needs and MRGCD water supply. Concurrently, MRGCD will expand its opportunity for storage to manage through drought by completion of agreements with ABCWUA to store up to 50,000 AF of water at Abiquiu Reservoir. Space at Abiquiu reservoir for this purpose was pledged by ABCWUA as a result of MRGCD withdrawing its objections to permitting and construction of the ABCWUA SJC diversion works. While MRGCD has authority over water it holds in storage, MRGCD will cooperate and coordinate with NMISC, ABCWUA, BOR and other appropriate entities to conjunctively manage releases from storage and releases from the pool to maximize flexibility in Rio Chama water operations for the benefit of environmental/recreational concerns, and to minimize evaporative or conveyance losses.

C. Depending on the available water supply and consistent with its primary statutory mission of conveying and delivering water for its use in agriculture, when MRGCD has water surplus to the needs of its irrigators within its canal system, the MRGCD will manage its diversions and outfalls to return excess flows to the Rio Grande for habitat areas and other designated sites, as determined by, and consistent with tasks identified within the MRGRIP Action Plan. The MRGCD will participate with other MRGRIP entities, in particular with the U.S. Fish and Wildlife Service, the MRGRIP Science Coordinator and scientific workgroups, and the MRGRIP management and Executive Committee, to identify and study key habitat areas to which water can be returned, especially during critically dry periods, to serve species population needs for survival and recovery, as determined by the best available scientific information, by maintaining wetted habitat for silvery minnow when drying is occurring elsewhere in the river. This commitment will not compel the District to deliver water to habitat or other sites when it is needed to serve irrigators' requirements.

When the MRGCD determines that water surplus to irrigation needs is not available within the MRGCD system, and flow to designated habitat or other areas for species needs is desired, MRGCD will convey water to these areas from available species water resources. MRGCD's contribution will be to bear the conveyance loss from point of release at a reservoir to point of delivery at habitat area, if MRGCD is delivering water along these same pathways for irrigation purposes. An exception may occur if delivery of water to a designated habitat area requires the use of a canal or other water pathway which is not normally or currently in use, in which case species water would be required to incur actual conveyance losses.

D. The MRGCD will cooperate and assist with the creation and enhancement of specific habitat areas, the so-called "String of Pearls" to provide a series of refuge areas where RGSM populations may be maintained during normal periods of low and intermittent flow in the MRG. These areas tend to be located near MRGCD outfalls which typically discharge excess water, or which can be readily used to convey species water with minimal losses. These areas are located in the Albuquerque, Isleta, and San Acacia reaches of the Rio Grande. The MRGCD will maintain its outfalls and, consistent with existing agreements, the federal agencies will provide maintenance and enhancement of river areas through channel shaping, bank modification, vegetation management, food management, and biological management (non-native or predator removal) to provide conditions suitable to preserving maximum numbers of RGSM in good health for extended periods of time. The "String of Pearls" will provide RGSM refugial habitat between Cochiti reservoir and Bosque del Apache. The locations of the pearls are illustrated in the following map:

E. To allow more precise control and management of water supply to San Acacia dam, MRGCD will pursue construction of a siphon near Bernardo, NM to deliver excess irrigation returns from the San Juan Riverside Drain system directly to the Unit 7/Socorro Main Canal system. This is envisioned to allow for more reliable water supply to the MRGCD Socorro division while simultaneously reducing the total annual volume of water required for diversion at San Acacia dam. This would be anticipated in turn to benefit peak flows through San Acacia dam, and sediment movement and river morphology upstream and downstream of San Acacia dam with associated benefits for RGSM. During times of low or no flow, the Bernardo siphon could be envisioned to assist with management of the "String of Pearls" by creating a refugial area downstream of the siphon itself, and creating a more dependable water supply at San Acacia dam for the maintenance of a refugial area downstream of the dam. It is anticipated that costs of this project operations will be borne in part by the MRGCD, and in part by the federal government. Once the anticipated water supply benefits of the Bernardo Siphon Project have been realized, distribution of water supplies resulting from the Project could be directed by the District to meet the needs of water users in the MRGCD Socorro division in conjunction with those of the listed species.

F. To provide a water supply for the last pearl on the string, MRGCD will construct a return flow collection system at its southern boundary. Excess water from the San Antonio Acequia, the Socorro Main South Canal, the Socorro Riverside Drain, and the Elemendorf Drain will be routed to a central collection/distribution point. At the distribution point, water will be directed into the Low Flow Conveyance Channel and will be lifted back to the Rio Grande through a permanent electrically powered pumping station to be constructed by the MRGCD and operated and maintained by the BOR. It is anticipated that costs of these operations will be supported as cost-share by the MRGCD, and also by the federal agencies and the MRGRIP. Distribution of water at this point will be to meet the needs of the listed species, the water rights of the Bosque del Apache National Wildlife Refuge, and RGC delivery obligations.

G. Recession Management

During inevitable low and intermittent flow periods on the RG, RGSM mortality may be greatly reduced by controlled rates of recession, allowing individuals to move to suitable habitat locations (the String of Pearls). Controlling this rate of recession can be challenging, and has in the past resulted in usage of large amounts of species water. This may be at the conclusion of the spring snowmelt period, or after periods of heavy precipitation. To the extent permitted by the Rio Grande Compact, a controlled rate of recession may be produced by USACE reducing releases from Cochiti reservoir in a series of small steps. As a part of the conservation measures to the MRGRIP, the MRGCD will establish a policy where during times of floodwater storage and managed recession for RGSM, MRGCD available natural flow will be determined by the theoretical release from Cochiti reservoir in the absence of any such managed recession. In this way, USACE may have greater flexibility in controlling the rate of recession for RGSM without affecting NM's RGC deliveries to Elephant Butte. This mechanism would require an update to the Water Control Manual for Cochiti reservoir.

H. The MRGCD will actively participate in the creation of habitat to benefit the lifecycle of the RGSM. Habitat creation will be the responsibility of an interagency team consisting of MRGCD, the NMISC, BOR, USFWS, and USACE. The MRGCD will provide assistance in obtaining funding (cost share, etc.) and/or land for habitat restoration. Habitat restoration may be focused on enhancing the interconnection between active river channel and floodplain, as well as other types of restoration. Habitat restoration will be engineered to provide progressively greater levels of inundation at increasing flows, resulting in a range of habitat types. An initial goal over a XX year period will be 75 acres of RGSM habitat across the range of discharges.

I. To the degree permitted by New Mexico water law, the MRGCD will cooperate with efforts to establish a program whereby groundwater users within the MRGCD may offer water for lease to BOR or other groups for the express purpose of providing flows from wells for endangered species. Water provided to this program will be from willing lessees with pre-1907 or pre-basin groundwater pumping rights for agricultural use. Transfers of use of irrigation wells to instream uses will need to go through the OSE application and permitting process. Administration of this program must necessarily involve close coordination with the NMOSE and MRGCD to establish appropriate volumes of water and rates of flow, and to insure and verify that land from which pre-1907 water rights have been transferred for species use do not continue to be irrigated (absent an MRGCD water bank withdrawal).

J. While the development of new modeling and analysis continues to assist in addressing species management uncertainties, the MRGCD will continue to fund the current PVA and statistical data analysis efforts through a research agreement as a contribution to the scientific understanding of the RGSM.

RESOLUTION OF BOARD OF DIRECTORS
OF THE MIDDLE RIO GRANDE CONSERVANCY DISTRICT

Resolution Adopting Additional MRGCD Offsetting Measures and Conservation Measures for Inclusion in the 2015 Biological Assessment Re-Submittal, to Supplement Those Measures Already Adopted By the MRGCD Board in 2012

M-07-13-15-139

WHEREAS, the Middle Rio Grande Conservancy District ("MRGCD" or "District") is an actively participating member of the Middle Rio Grande Endangered Species Collaborative Program's Executive Committee ("Collaborative Program EC"), which was created by Congress to ensure compliance with the current Biological Opinion issued in 2003 by the U.S. Fish and Wildlife Service ("Service") covering federal and non-federal water operations in the Middle Rio Grande, including the District's; and

WHEREAS, in July 2013, the Collaborative Program EC voted to endorse the Program's transition to a Recovery Implementation Program ("RIP") to serve the goals of contributing to the conservation and recovery of listed species and simultaneously protecting existing and future water uses, and the District has played a leading role in crafting the RIP's foundation documents, such as its Program Document and its Five-Year Action Plan, in particular to include a commitment to implement an adaptive management program to resolve significant scientific uncertainties affecting species management decisions so that resources can be committed to species conservation efforts in the most effective and resource-efficient manner; and

WHEREAS, as part of this RIP effort, aimed at implementing the RIP commitments, MRGCD is evaluating its ongoing and prospective contributions to the Collaborative Program and to the RIP species conservation and recovery efforts, including its water management efforts and provision of access to District lands, and has concluded that implementation of these measures would cost multiple millions of dollars; and

WHEREAS, the MRGCD is participating in a Section 7 consultation along with the U.S. Bureau of Reclamation and the State of New Mexico and the New Mexico Interstate Stream Commission (collectively, the "BA Partners"), and is proposing a set of water operations and river maintenance actions to be included in a Biological Assessment ("BA") that is expected to result in an Incidental Take Statement within a biological opinion that will protect the District from Endangered Species Act ("ESA") "take" proscriptions; and

WHEREAS, this Biological Assessment, through a July 2015 submittal of additional information, will be relying on an approach utilizing an action-by-action analysis of the BA Partners' proposed water operations and river maintenance actions for the Service's consideration; and

WHEREAS, development by the District of offsetting measures to be undertaken as part of the District's proposed actions, and implementation of conservation measures that support species recovery, will support the District's and the BA Partners' conclusions that these offsetting measures and conservation measures will avoid or minimize potential adverse species effects caused by the District's actions; and

WHEREAS, this Biological Assessment, as re-submitted in 2015, will contain a clarified and more focused analysis of species effects of the actions being analyzed in the consultation process, with particular focus on the effects on the endangered Rio Grande silvery minnow ("minnow") and its habitat; and

WHEREAS, in response to that more focused analysis, the District is proposing to implement targeted offsetting and conservation measures that will create and maintain habitat to offset reductions in minnow habitat that might occur as a result of the District's on-going diversions during specific environmental conditions; and

WHEREAS, the District, with the goal of becoming a full partner in the protection of the minnow and other species, while protecting the needs of its constituents, considers that it should develop its own set of offsetting and conservation measures, that are: a) consistent with its primary mission of ensuring the delivery of water to its irrigators, and b) will avoid conflict over measures that might be proposed by the Service that could needlessly pit the interests of irrigation, recreation and cultural preservation against the needs of the minnow; and,

WHEREAS, the District's proposed set of offsetting and conservation measures, because they provide the optimal balance of interests, should become part of the 2015 Biological Opinion and upon incorporation will satisfy the regulatory obligation of the Service for protection of the listed species while at the same time assuring the District, its Board and the District's constituents that those measures will provide protection of the interests of Rio Grande water users; and

WHEREAS, since late 2014, the District has been engaged in the BA Partners' critical efforts to reframe the analysis of effects on the minnow of ongoing District actions presented in the proposed BA re-submittal, by providing more refined and additional carefully crafted offsetting and conservation measures to address the impacts of particular categories of water operations actions, and by providing a more rigorous analysis of the effectiveness of the proposed offsetting measures; and

WHEREAS, on July 23, 2012, the District Board of Directors, in consideration of the Collaborative Program's transition to a Recovery Implementation Program, and subject to statutory limitations on its authority described in a "Preamble," endorsed a suite of MRGCD Conservation Measures "a" through "j" that have now been incorporated into the 2015 BA re-submittal and refined analysis; and

WHEREAS, the District Board of Directors views the final stage of assembling this 2015 BA re-submittal as an opportunity to approve commitment to additional offsetting and conservation measures representing the limit of the contributions that the District can provide given the impact on its resources; and

WHEREAS, the District is confident that the programs and projects will avoid or minimize any adverse effects that the District's ongoing actions may have on listed species and will support conservation and recovery of these species.

NOW, THEREFORE, BE IT RESOLVED by the MRGCD BOARD OF DIRECTORS, that the following initiatives be adopted by the MRGCD for inclusion in the 2015 BA Submittal to the Service as additional Offsetting Measures and Conservation Measures, subject to the limitations described in the following "Preamble" repeated from the 2012 MRGCD Conservation Measures, to supplement those measures already adopted by the MRGCD Board in 2012.

PREAMBLE

1. Pursuant to its statutory general grant of powers (NMSA 1978, § 73-14-48), MRGCD has authority to enter into an endangered species Recovery Implementation Program (RIP) and to undertake certain species survival and recovery actions to be incorporated within the MRGRIP Action Plan. However, MRGCD has no authority to violate its statutory obligations and MRGCD is specifically prohibited from relinquishing control of the waters or lands of the District or from administering or managing District waters in such a way as to impair the private water rights of individual irrigators or its own statutory water rights (NMSA 1978, § 73-14-47).
2. MRGCD has the authority to develop an Operating Plan to carry out some of the programs within the RIP that will benefit listed species (NMSA 1978, §§ 73-14-48 *et seq.*), but MRGCD has no authority to relinquish its authority to implement the terms of such an Operating Plan to any third party, particularly when such implementation may involve control of the use of the District waters or lands (NMSA 1978, § 73-14-47).
3. MRGCD has the authority to lease or otherwise provide reservoir storage space for a "supplemental water pool" and to assist in developing programs for use of that storage to provide protection for the RGSM consistent with the RIP, and as a contribution to cost-share, but it cannot do so in a way that reduces storage for persons entitled to receive water from the MRGCD (NMSA 1978, § 73-14-47).

Proposed Supplemental Offsetting Measures:

k) For MRGCD's operation of the District Diversions, the District will maintain selected MRGCD drain and waste way outfalls to keep sites viable and productive for targeted species, as well as for overall ecosystem health. This program will be managed in a manner consistent with the overall purposes of the MRGCD.

l) For MRGCD's operation of the Isleta Diversion Dam, and specifically related to possible impacts on minnow population viability due to the inability of the minnow to pass from below the Dam to upstream of the Dam when the gates are lowered and checked, MRGCD will implement a program to facilitate fish passage at San Acacia Dam, with assistance from Reclamation and the State, within the first five years of the new BO period. An initial pilot study will test small-scale modifications, to determine a feasible approach for a simplified full-scale fish passage. This is expected to require in-channel grade control structures, along with modification of gates and the apron of San Acacia Dam. This simplified approach will entail that San Acacia Dam remain unchecked (gates raised) for much of the year, requiring concurrent construction of a siphon near the Rio Puerco to deliver a portion of east side drain returns to Drain Unit 7 and provide an alternate source of water supply for the Socorro Division. Under certain conditions, including but not limited to water supply, water quality, and sediment management, San Acacia Dam will require checked operation. Fish passage through San Acacia Dam will remain secondary to the original operational purpose of San Acacia Dam, but the District will strive to maximize the time throughout the year that fish passage is possible, and particularly with the construction of the proposed siphon, operation of San Acacia Dam in the checked condition is expected to be infrequent and of short duration. The District will provide the local cost-share necessary to build these projects, subject to the availability of funds and the other priorities of the District for capital construction and infrastructure rehabilitation projects, with the expectation of federal cost-share also being provided. The construction of the siphon will benefit both the minnow and the irrigators below San Acacia Dam.

As both an Offsetting Measure and an additional Voluntary Conservation Measure:

m) For MRGCD's operation of the District Diversions, the District will provide a minimum of $150,000 in annual ESA and science related funding, a portion of which may support San Acacia reach habitat projects, and may include additional funds for specific habitat projects identified as priorities in the Program.

As additional Voluntary Conservation Measures:

n) Efficiency Improvements: MRGCD will provide a minimum of $500,000 annually toward improving existing water delivery systems to increase flexibility in water operations, for managing during drought, and to improve efficiencies for the dual purposes of better service to water users while incrementally reducing diversions, particularly during spring spawn and recruitment events and to reduce the impact of water withdrawal and effects on species habitat (river drying). These funds will be leveraged with federal and state water conservation and infrastructure programs to accelerate system-wide improvements.

o) Cochiti Reauthorization: The District will utilize MRGCD's extensive lobbying capacities and political capital to encourage the development of federal legislation that reauthorizes Cochiti Dam and Reservoir as a dual purpose facility for both flood control and for up to 60,000 af of conservation storage. The MRGCD will work closely with the federal and state agencies as well as the MRG Pueblos to coordinate this effort during the two to four years this may take to get the legislation passed.

p) RIP Science and Habitat Funding: A portion of MRGCD's $150,000 in annual ESA and science related funding cited in Measure "m" may support the process of revising and refining the minnow population monitoring program, as determined through a population monitoring workshop and other forums, to provide reliable indices to track the status and trend of the population and to inform management decisions, and may include additional funds for specific habitat projects identified as priorities in the Program.

q) RIP Adaptive Management: A portion of MRGCD's $150,000 in annual ESA and science related funding cited in Measure "m" will also include support for seeking experts to contribute to the RIP's diverse scientific efforts, including helping to develop and achieve the envisioned adaptive management procedures.

r) Minnow Sanctuary: MRGCD will assist with operation and maintenance of the Minnow Sanctuary, up to an annual expenditure not to exceed $50,000, upon completion of system improvements by others and development of a facility operational plan in coordination with other entities. The facility operational plan, which shall include a detailed forecast of operational and maintenance costs, shall be approved by the Board of Directors prior to final design of the project and at least one fiscal year prior to construction activities.

s) RIP Science Support: MRGCD will continue to work with its BA Partners and other RIP participants to collectively provide scientific and related support with the goal of developing a better understanding of the synergistic needs of both the species and the agricultural community.

t) Water Leasing Program: MRGCD will take the lead in establishing a pilot water leasing program aimed at providing an alternative for pre-1907 water rights owners to selling rights that results in permanently dry associated lands. A wet water pool would be developed for both farm and environmental uses to be allocated in a manner consistent with the needs of the MRGCD's diverse constituents.

PASSED, APPROVED AND ADOPTED this 13th **day of** July **2015.**

MIDDLE RIO GRANDE CONSERVANCY DISTRICT

Derrick Lente, Chairman

ATTEST:

David Fergeson, Secretary-Treasurer

Page 5 of 5

APPENDIX H

MRGCD ANALYSIS OF HYDROLOGIC IMPACTS AND ASSOCIATED EFFECTS OF MRGCD OPERATIONS

Reclamation provides the following information for this appendix: "This appendix contains additional information provided to Reclamation by the Middle Rio Grande Conservancy District (MRGCD) to supplement the effects analysis in Part II, Section 2.4.4 of the BA, as well as to provide additional context and supporting information for the MRGCD's Offsetting and Conservation Measures provided in Part IV. MRGCD's analysis contained in this appendix provides reach-by-reach information on the effects of MRGCD operations, as well as addressing the interaction of releases from storage, diversions, and return flows. This information is attributable to the MRGCD and examines hydrologic impacts and species effects of MRGCD's proposed actions in the context of analyses conducted by the MRGCD. Reclamation supports inclusion of this additional information; because of the limited timeframe for review prior to submittal of the BA, Reclamation has not conducted a comprehensive review of these analyses, including methods, assumptions, and conclusions."

1. Introduction: Impact of the MRGCD Operation of MRG Diversion Dams

As described by the Proposed Actions, the MRGCD diverts water for its irrigation works through the Cochiti Dam outlet works, and operates Diversion Dams at Angostura, Isleta, and San Acacia. These diversions supply water to both Pueblo and non-Indian agricultural lands within the four divisions of the MRGCD irrigation network: the Cochiti Division, Albuquerque Division, Belen Division, and Socorro Division. The MRGCD typically diverts and delivers water from March 1 through October 31 for non-Indian lands and from March 1 through November 15 for Pueblo lands.

Diversions may reduce natural river flows up to the capacity of MRGCD diversions, when water is available. However, releases by Reclamation and the MRGCD of native water stored in El Vado, or of MRGCD's allocation of San Juan-Chama water, also supplements Rio Grande flows. Therefore, the net impact of the MRGCD operations is significantly more complicated than a simple decrease in river flows. The total impact of MRGCD operations may be a decrease in flows at certain times and locations, but an increase in flows at other times and locations. In this section, the impacts of the MRGCD's operation of the diversion dams within the District is explored, in the context of the full suite of MRGCD operations, and other depletions within the MRG.

Diversion rates and their distribution in space and time are partly correlated with climatic conditions and physiologic properties of agricultural crops, and partly with the engineering characteristics of the conveyance system. In most years, diversion is highest during the months of May, June, and July, and tapers off in August and September. From March through mid-June, natural flows in the Rio Grande are generally greater than MRGCD diversion requirements. After the spring runoff ends, natural flows decline precipitously, and are generally less than the diversion needs of the MRGCD. At this time, Reclamation and the MRGCD augment the natural flow of the Rio Grande, up to the MRGCD's diversion needs, with releases of stored water from El Vado Reservoir or from the MRGCD's allocation from Reclamation's SJC Project.

Consumptive use of water by crops is low during the early part of the irrigation season (March through mid-May) and most of the water diverted by the MRGCD is not consumed, being returned directly to the Rio Grande through wasteways and drains in the Cochiti, Albuquerque, and Belen Divisions. Over the course of the growing season, May through August, crops consume an increasingly large portion of the water diverted, and return flow declines accordingly. Through late summer and fall, consumptive use falls off again and diversions tend to be lower, leading up to the complete cessation of diversion in November.

The MRGCD diverts a large portion of all water moving to and through the MRG. In the process, its operations have distinct and measurable impacts on water flow and distribution and, therefore, on the habitat of the listed species. The net effects of all MRGCD operations may be positive or negative for the habitat, depending on the time and location.

To a considerable extent, the operation of the MRGCD mimics the theoretical pre-development hydrology of the MRG valley, in which springtime floods were spread across a broad flood plain and a gradual drying out of the flood plain followed through the summer and fall. Though this process is now artificially controlled, and depletions have been shifted from natural vegetation to agricultural crops, all agricultural water consumption still occurs within the historical flood plain of the river.

The cycling (recycling) of water throughout the MRGCD results in a pattern of dry and wet areas. Resulting river flows are typically lowest just downstream of the diversion dams. Further downstream within a division, return flows restore some river flow, and alluvial groundwater levels are generally higher due to the structure of the geologic basins as well as the configuration of riverside drains. Where return flows re-enter the river, wet areas are created, often producing continuous flow downstream for several miles. Even where return flows do not directly enter the Rio Grande, increased groundwater levels tend to overcome evaporative/riparian loss and produce additional wet areas in the river. This pattern also simulates pre-development conditions in the MRG of an intermittently flowing river with scattered swamps, sloughs, and oxbows.

In the MRGCD's Socorro division, water remaining after satisfying agricultural consumptive demand finds its way, either as surface flow or groundwater, to the LFCC, or is delivered directly to the Service's Bosque del Apache National Wildlife Refuge. Historically, Reclamation has pumped a portion of this water, as required and available, from the LFCC back to the Rio Grande to support species habitat.

While the primary impact of MRGCD operation of the Diversion dams is to remove a portion of flow from the river, resulting in a proportional reduction in flow below each Diversion Dam, the effect is not as simple as it might first appear. The effect of diversion is often moderated through the release of MRGCD storage from El Vado Reservoir or the release of the MRGCD's allocation of SJC Project water, and is also influenced by seepage into the groundwater system, groundwater interception by riverside drains, return flows to the river, and other basin depletions such as open-water evaporation, riparian evapotranspiration, and groundwater pumping. All of these factors are variable over time. Analyses must consider whether water being diverted would have been there and available for diversion if the MRGCD were not operating.

2. Historical Setting of MRG Water Use and Development

Complicating the analysis is that the "proposed action" is actually an ongoing condition, while the "no action" alternative represents an unknown condition. Diversions for irrigated lands in the MRG have been occurring at, or greater than, present levels for several centuries. No living human has ever seen the Rio Grande during a time when it was not experiencing anthropogenic modification, and associated water depletions. In order to estimate the effects to species of the proposed action, one must be able to determine what conditions might occur in the absence of those proposed actions. A history of water use and development sets the stage for understanding pre-MRGCD conditions in the MRG, and are essential for examining the effects of MRGCD operations on the species. The following passages are quoted from "Report of the Chief Engineer", Burkholder, 1928.

> "The middle Rio Grande Valley in New Mexico is probably one of the oldest irrigated areas in the United States. Long before the first exploration of the Spaniards in 1539, the indians in this valley were irrigating their lands, and traces of ancient canals are found in many localities."
>
> "Antonio de Espejo, writing of the Rio Grande valley as seen by him about 1582, says in his "relaciones", "They (the Indians) have fields of maize, beans, gourds, piciete in large quantities which they cultivate like the Mexicans. Some of the fields are under irrigation, possessing very good diverting ditches, while others are dependent upon the weather."
>
> "Archeologists and historians differ widely in their estimates of these earlier inhabitants. Benavidez says that the Rio Grande valley was quite densely populated, one "city" alone having 3000 inhabitants. Other investigators think his estimates exaggerated, but there is positive proof of the existence of a number of towns or "pueblos", and it is thought that a very conservative estimate of their population would be something like 25,000 people."
>
> "If they cultivated one acre of land per inhabitant (which is about the present area cultivated per capita on some of the pueblo grants), there must have been about 25,000 acres of cultivated land in the valley prior to the coming of the Spaniards."

The Spanish period saw rapid growth of irrigated agriculture in the MRG through the 17th, 18th, and 19th centuries. "As each community was settled it built its own irrigating ditch or "acequia", since all of these settlements were agricultural communities, dependent upon irrigation, without which no crops could be grown in this country" (Burkholder, 1928)

A report to the NMISC (A report on the Irrigation Development and Water Supply of the Middle Rio Grande Valley, N.M., as it relates to the Rio Grande Compact, Hedke, 1924) included the following table (Table H1. MRG Irrigation Development):

	Middle Rio Grande Developments				
Time of Construction	Number of Ditches	Second Feet Capacity	1910 Irrigation	Additional Possible	Total Under Ditch (Acres)
Ancient and very old…..	15	405	11100	7830	18930
Old…..	40	946	20285	25815	46100
About 1700…..	2	40	1300	1300	2600
Before 1800…..	6	221	4500	7400	11900
Before 1850…..	5	143	3000	5350	8350
To 1880…..	6	184	3500	10000	13500
To 1910…..	5	197	1535	21885	23420
Totals…..	79	2145	45220	79580	124800

(This table is given by Mr Hedke as a summary of an investigation made in 1910 by Mr. H.W. Yeo of the United States Reclamation Service, at present State Engineer of New Mexico)

Table H1. MRG Irrigation Development

Table H1 indicates that collectively the early acequias had the ability to divert over 2000 cfs. Even in the earliest Spanish period, and possibly the Pueblos before that, there were irrigation canals in the MRG capable of diverting more water than at times naturally entered the MRG. Table H1 shows a continual expansion of acreage "under ditch" over time, culminating in the late 19th century. Unfortunately, this led to "much duplication of effort and waste of water" (Burkholder, 1928). Irrigated agriculture in the MRG valley reached its greatest extent around 1880, then began a rapid decline, to around 45,000 acres (Table H2). In addition to the development of irrigated agriculture upstream of the MRG in Colorado, which reduced the flow of water to the MRG, a principal cause of the reduction in irrigated acreage was increasing water table through the MRG. The increased water table was in large part due to the acequias themselves, as postulated by the following passage:

> "Many of the ditches in the Rio Grande valley have been diverting water for 200 years without restraint or regulation and have doubtless contributed to the rising water table of the lands through which they pass" (Burkholder, 1928)

The following Table H2 Progress of Irrigation Development in the MRG Valley (Burkholder, 1928, based on State of New Mexico, 1918 Drainage Survey, Yeo) illustrates the expansion and reduction of irrigated agriculture in NM.

Progress of Irrigation Developments in the Middle Rio Grande Valley					
Time Up to	Number of Ditches	Second Feet Capacity	Acres Under Development	Acres failed	Remarks
1600	22	537	25555		Indian development
1700	61	1445	73580		Indian with Spanish
1800	70	1808	100380		Above with Spanish grants
1850	80	2099	123315		Ntural increase
1880	82	2145	124800		Transcontinental traffic and civil war demand, completed developments
1896	71	1779	50000	74800	Due to short water supply, rising water table, Railroad supply competition and railroad labor demand
1910	79	2121	45220	79580	further shortage and further rising water table
1918	65	1957	47000	77800	War period
1925	60	1850	40000	84800	estimated present condition (assumed added in 1926)

Table H2: Progress of Irrigation Developments in the MRG Valley

The reduction in irrigated acreage in the late 19th century did not bring about a reduction in depletion of water. Irrigated agricultural land was replaced by seeped lands, alkali sacaton, salt grass, or swamp, all continuing to deplete water. In 1926-27, over 90,000 acres in the MRG valley were classified as non-irrigated, but consuming water (saltgrass: 48,603 acres, bosque: 37,821 acres, swamp and lake: 3,324 acres.

The MRG Basin is characterized by an extensive riparian forest, high temperatures, low humidity, shallow water, high water surface area, and abundant sunshine. Naturally occurring depletions are known to be very high, accounting for over 40% of all water consumption between Cochiti and Elephant Butte reservoirs. With the notable exception of the City of Albuquerque's treated wastewater, there are essentially no perennial tributary inflows to the MRG. "South of the mouth of the Rio Chama there is no dependable source of runoff. A few small local areas of high precipitation exist in the Sandia and Manzano mountains east and south of Albuquerque, but they do not produce perennial streams flowing as far as the Rio Grande" (Burkholder, 1928). River drying is expected during dry periods even with no diversions (Flanigan 2004).

Construction of the MRGCD works began in 1927 to remedy the "large loss of water" (Burkholder, 1928) then occurring in the MRG. In addition to the seepage and evaporative losses being incurred through the MRG, upstream water supply was of concern as evidenced by the following passages:

> "About 70% of the annual flow of the river occurs during the spring rise, while during the late summer the river is frequently dry as far up as Albuquerque. In

> the lower end of the valley water shortage is frequent and acute. Consequently reservoir storage is imperative to regulate the flow of the river and to make water available at the ditch headings during the entire irrigating season.

And:

> "The water supply is frequently inadequate for all the lands south of Albuquerque. In 1926 the river was dry at Belen for nearly sixty days during the season of greatest demand. At San Marcial the river is dry an average of about thirty-nine days each year."

The USGS has maintained a gauge at Otowi (Rio Grande at Otowi Bridge, near San Ildefonso, NM, USGS 08313000), above the MRG valley, since 1896 (with seven missing or incomplete years between 1906 and 1919). This presents 111 years of approximate inflows to the MRG for consideration. The Otowi record does not reflect inflow from the Rio Jemez, which can provide a substantial contribution to spring runoff flow, particularly in the March-April time period, but generally should not have a large influence on peak spring inflow, or minimum summer flow. The Otowi record also does not reflect precipitation inputs to the MRG from ephemeral tributaries. Examination of minimum summer flows at the Otowi gauge (Figure H1) suggests drying of the Rio Grande has been an extremely common occurrence over the period of record of the Otowi gauge. Flows at Otowi less than 300 cfs have been recorded in 52 of 111 years. At this inflow level to the MRG, drying is possible in the Albuquerque reach even with no agricultural consumption of water in the MRG, and almost a certainty from the vicinity of Isleta dam southwards. Flows at Otowi less than 400 cfs have been recorded in 86 of the 111 years, suggesting it is unlikely that flow would have reached San Acacia dam, even in the absence of agricultural use. In only 3 of those 111 years are inflows high enough that continuous flow throughout the MRG would be assured in the absence of agricultural use, or local rain inflows. Again quoting from Burkholder, "In late summer there is a shortage of irrigation supply almost every year".

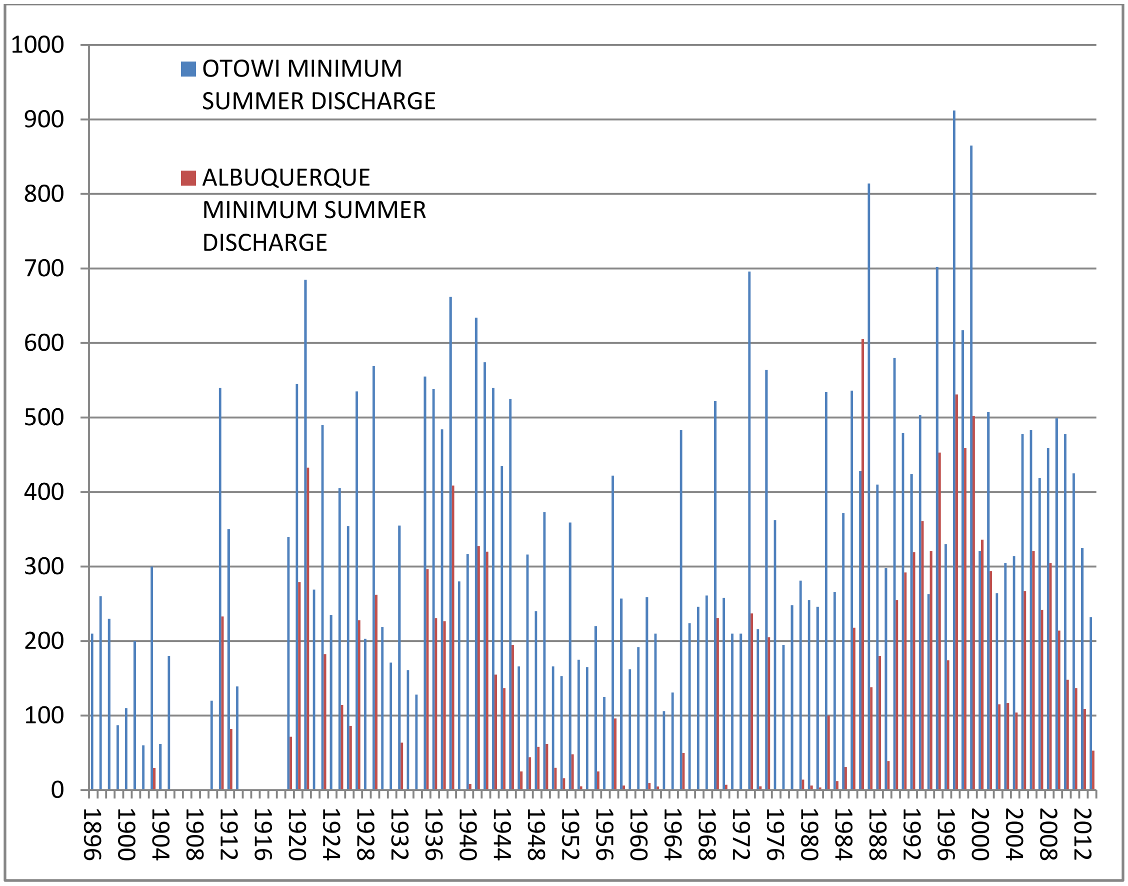

Figure H1. Recorded Minimum Summer discharge at Otowi, 1896-2013, and corresponding flow at Albuuqerque (1942-present recorded, 1896-1941 estimated)

Figure H1 also includes recorded summer minimum flows at Albuquerque gauge (near the middle of the Albuquerque reach, Rio Grande at Albuquerque, USGS 08330000) from 1942 to present. For this analysis, flow prior to 1942 was artificially generated by comparing the functional relationship between flow at Otowi and flow at Albuquerque for 6 different times of the year (2 month periods). This allows the critical Albuquerque record to be extended back to 1896, providing at least a rough estimate of the conditions the species likely experienced over the past century of changes to the Rio Grande. Notable is that flow below 100 cfs (considered the "drying" threshold for Albuquerque reach) occurred in only one year (1989) between 1984 and 2013. Prior to 1985, drying was a common condition in the Albuquerque Reach.

Figure H2 presents the peak annual inflow to the MRG at Otowi recorded since 1896, along with peak flow at Albuquerque (recorded from 1942 onwards, artificially generated prior to that time). Some very large peak inflows are recorded up until 1942, interspersed with very low peak inflows. After 1942, peak inflows only rarely exceed 10,000 cfs at Otowi. El Vado dam and reservoir was completed in 1935, but as discussed elsewhere, that facility can only regulate flows on the Rio Chama, and impacts only a small percentage of water contributing to peak discharges through the MRG. Changes in operations and infrastructure on the mainstem of the Rio Grande, probably far upstream of the MRG are likely responsible for this change. The impact of Cochiti Reservoir in the mid 1970's is detectable in the Albuquerque record, with flows being "capped" at less than 8700 cfs, and a much larger gap occurring in flows at Otowi and Albuquerque post-construction. Figure H2 also illustrates the "feast or famine" nature of peak spring flows to the MRG, with years tending to be either low, or relatively high.

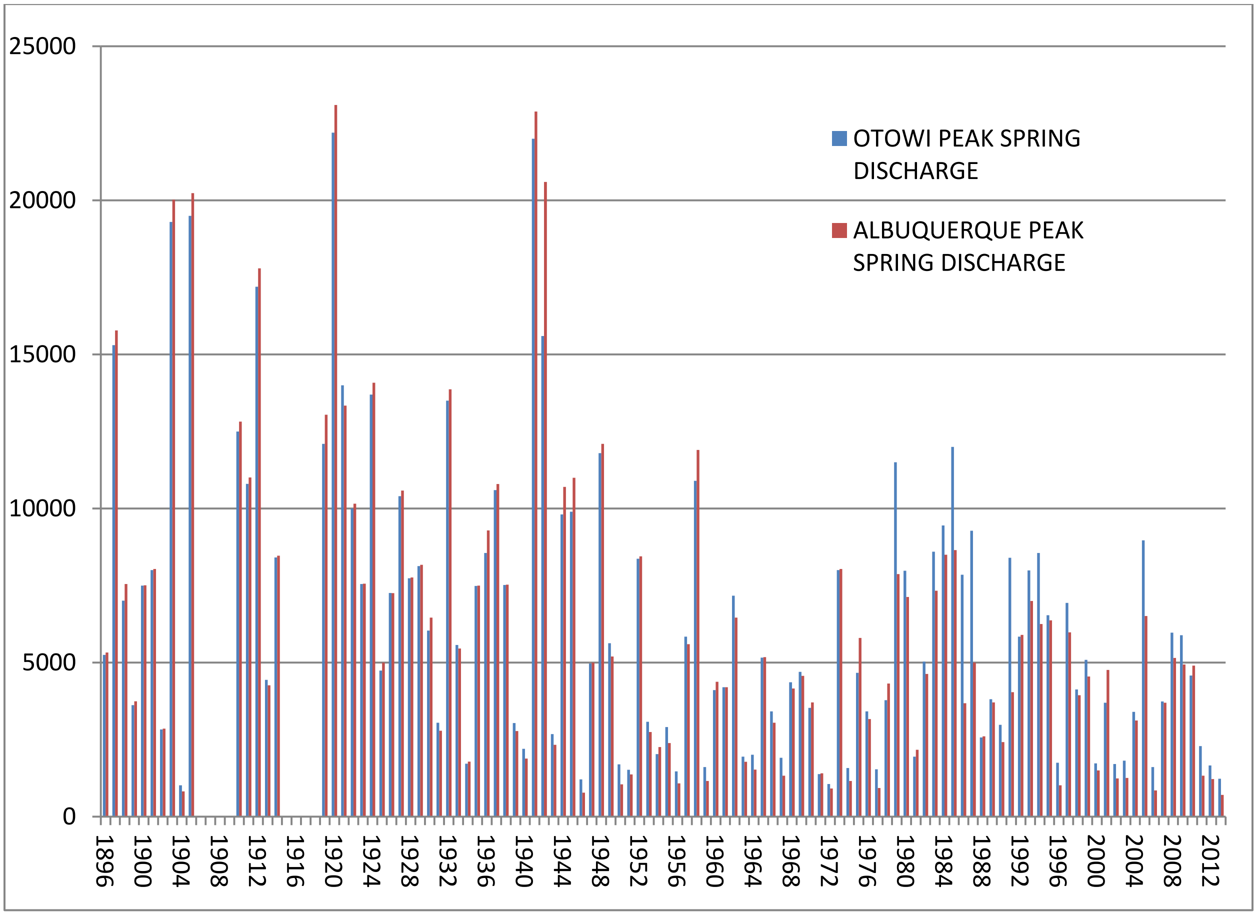

Figure H2. Recorded Peak spring discharge at Otowi, 1896-2013, and corresponding peak discharge at Albuquerque (1942-present recorded, 1896-1941 estimated)

3. Methodology

Analyses of the hydrologic impacts of MRGCD operations have been performed using output from the URGWOM simulations performed to support this BA, which are based on five, 10-year paleoclimate-based hydrologic sequences, i.e., 10%, 30%, 50%, 70%, 90% exceedance with 10% being the wettest sequence, that represent the range of variability experienced within the MRG over the past 604 years. A simple spreadsheet model takes model output and uses it to estimate rates of flow likely to occur through the MRGCD, as described at the end of this Appendix in the *Flow Model Documentation* section. Available flow downstream of each Diversion Dam was derived by analyzing the estimated agricultural, riparian, and evaporative losses (ET Toolbox values as shown in MRGCD model), along with the typical diversion rates for specific dams (MRGCD model), at specific times of year. Agricultural depletions and diversions can be switched on, off, or partially occurring to analyze the effects of diversion dam operation. In this spreadsheet model, flow remaining below diversion dams can subsequently be depleted on a per–mile basis, based on approximate rates of flow (*Flow Model Documentation* section of this Appendix) that have been observed to keep specific river reaches flowing.

Resolution of flow changes into an effect on the listed species requires separate approaches for the spring high-flow period, and the summer/fall low-flow period. The spreadsheet model evaluates the high-flow and low-flow periods as follows:

- For the high-flow period, the effect on species is evaluated in terms of flow threshold values at which key biological functions (spawning/recruitment for RGSM, nest establishment for SWFL) are expected to occur. Duration (in number of days) that the threshold flow value is exceeded is also considered. For RGSM, the difference in the number of years that the flow and duration thresholds are met, with or without diversion dam operation, can be evaluated.

- For the summer/fall low flow period, the effect on species is determined by the change in potential river miles of habitat available for use by the species resulting from depletion of water by agricultural crops made possible by diversion dam operation, as well as the localized effects of diversion immediately below dams. Drying is considered both on a reach-by-reach basis, and the percentage of the total critical habitat that is affected. Analysis of drying using the spreadsheet model also includes a comparison of the number of years that drying can be expected to occur with or without diversion dam operation.

The effect of diversion is subtly different within each of the four MRGCD divisions, and each requires separate examination. These individual examinations are presented in the *Results and Discussion* section.

4. Results and Discussion

4.1 Hydrologic Impacts

4.1.1 Cochiti Dam and the Cochiti Reach

The MRGCD originally constructed a small diversion dam near Cochiti Pueblo, to supply its Cochiti Division, in 1934. In 1969, the Corps initiated construction of a large flood control dam and reservoir at the same location and with the same name. This structure was completed by 1975, replacing the function of the original MRGCD diversion works with canal intakes located in the outlet works of the Corps' Cochiti Dam.

The MRGCD diversion at Cochiti Dam supplies water to canals on the east and west sides of the Rio Grande. Total capacity of these canals is 271 cfs. However, the Cochiti Division is not fully developed, and the canals are not operated to maximum capacity. Actual **diversion rates at Cochiti Dam have typically been around 200 cfs, with a maximum of about 230 cfs.** Diversions at Cochiti Dam remain relatively constant throughout the irrigation season, except during periods of high rainfall, when surface inflows into the canals creates risk of flooding, or during shortage periods when water is not available for normal operation.

The MRGCD operation of the diversion works in Cochiti Dam reduces the flow immediately below Cochiti Dam by about 200 cfs. During spring runoff (April 15 to June 15), natural flows entering the MRG valley can range between 750 and 7200 cfs, and the diversion of water by the MRGCD at Cochiti Dam has a potential impact of reducing flows below the dam by as much as 27% (200/750), or as little as 3% (200/7200). During the summer/fall low-flow period (June 16 to October 31), natural flows entering the MRG valley (excluding short-term rainfall events) can range from 25 to 700 cfs, and the diversion of water by the MRGCD at Cochiti Dam has the effect of reducing flows below the dam by as much 100% (complete drying), or as little as 29 %.

The reductions in flow caused by diversion at Cochiti Dam have the impact described above only immediately below Cochiti Dam. For the remainder of the Cochiti reach, and downstream reaches, the impact of Cochiti diversion is moderated by flows from irrigation drain outfalls and wasteways, which return a portion of the diverted water, to the Rio Grande. Based on the spreadsheet model used for this analysis, the impact of MRGCD operations in Cochiti reach can range from between about 30 to 120 cfs, depending on climate and time of year. The overall maximum impact of the Cochiti reach during the spring runoff is thus to reduce flows by as much as 16% (120cfs/750cfs) or as little as 2% (120 cfs/7200cfs). For the summer/fall low flow period, the overall impact on the Cochiti reach is a potential maximum reduction of flows by as much as 100% (rare, 3 out of the 50 modeled years), to as little as 17%. In half of all years, the maximum impact of Cochiti diversions on flows in the Cochiti reach has been 25% or less. The spreadsheet model shows that, as expected, the most significant reduction occurs when natural flows entering the MRG valley are least, and irrigation demand is highest.

When natural flows fall below levels needed to supply water to all diversion dams, MRGCD requests Reclamation to release stored water from El Vado Reservoir. Since Cochiti Dam is the first MRGCD diversion point, and represents a small percentage of the total MRGCD service area, virtually all stored water released from El Vado can be expected to pass downstream of Cochiti Dam, and therefore, releases from El Vado have the net impact of increasing flows through the Cochiti reach to higher levels than they would be without both the releases from storage and the diversions. Figure H3 illustrates the impact of release by Reclamation and the MRGCD of stored water from El Vado Reservoir (including SJC water) to increase flows entering the MRG, and how these releases generally increase minimum inflows by an amount sufficient to counter any depletions caused by MRGCD diversions below Cochiti Dam.

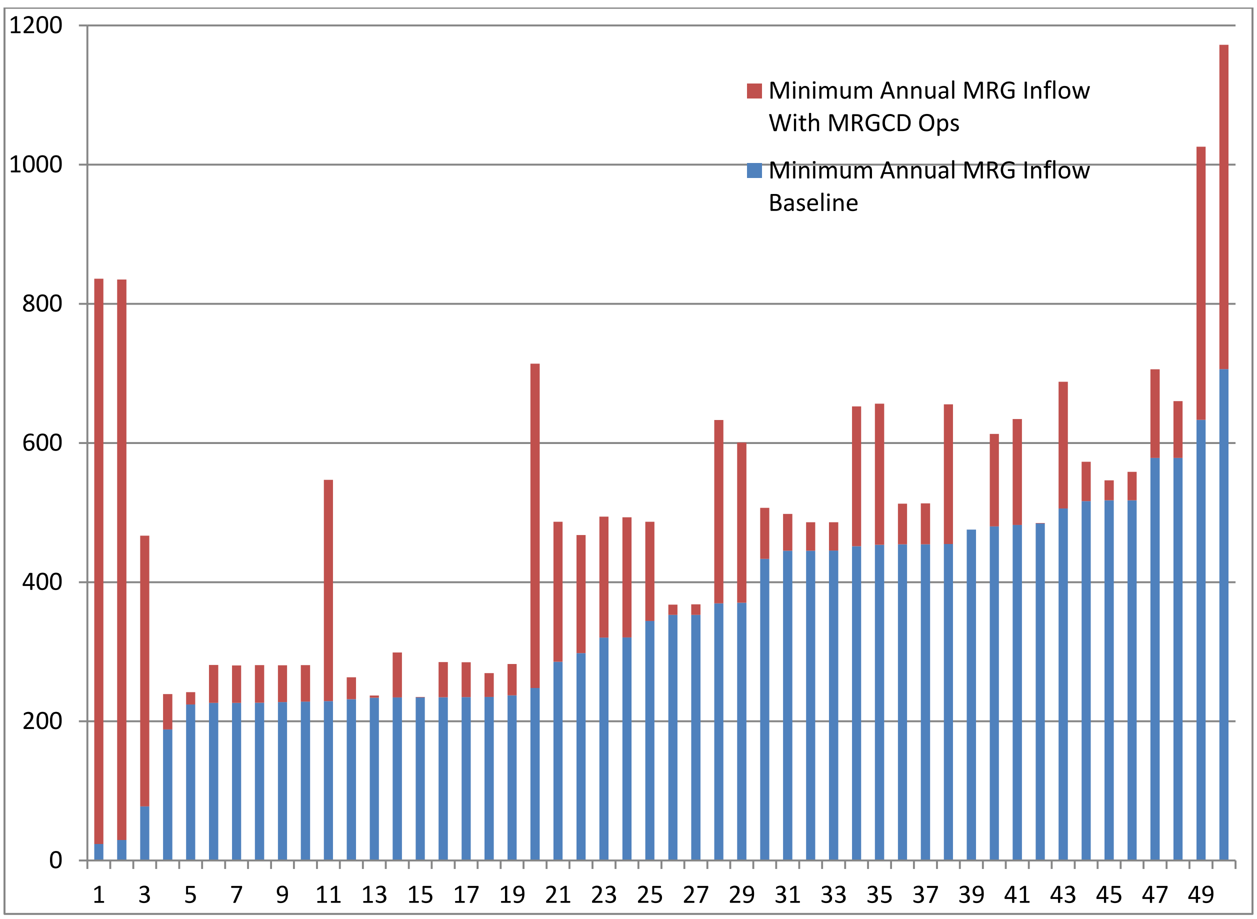

Figure H3. Impacts of stored water released from upstream reservoirs

During the winter months, when the MRGCD is not operating to divert water at Cochiti Dam, there is no hydrologic impact from the MRGCD's actions. MRGCD diversions at Cochiti Dam have no appreciable impact on water quality.

4.1.2 Angostura Diversion Dam and the Albuquerque reach

The MRGCD originally constructed Angostura Diversion Dam, a low cross-river weir, in 1934. Because of its design, Angostura Dam maintains a relatively constant upstream water level, throughout the year, and regardless of how gates are adjusted. The MRGCD adjusts two sluice gates to fine tune elevation and pass sediment and debris through the structure. One to four intake gates are operated to divert water into the Albuquerque Main Canal, with a capacity of 400 cfs. Actual diversion rates at Angostura Dam typically are about 300 cfs, with a maximum of about 350 cfs. Diversion rates at Angostura are varied in response to time of year, rainfall, and irrigation demand.

MRGCD operation of Angostura Dam potentially reduces flow below Angostura Dam by up to about 300 cfs. During spring runoff, natural flow arriving at Angostura Dam can range between **630 and 6800 cfs,** and the diversion of water by the MRGCD at Angostura dam has a potential impact of reducing flows below the dam by as much as 48% (300cfs/630cfs, or as little as 4% (300cfs/6800cfs). During the summer/fall low flow period, natural flows arriving at Angostura Dam (excluding short-term rainfall events) can range from 0 to 630 cfs, and the diversion of water by the MRGCD has an impact of reducing flows below the dam by as much as 100% (complete drying), or as little as 48 %.

The reductions in flow caused by diversion have the impact described throughout most of the Albuquerque reach. Under normal operating conditions, the MRGCD does not return unused flow to the Rio Grande until the downstream-most two miles of the Albuquerque reach, just above the Isleta Diversion dam. A notable exception is the Corrales area, which returns water from two drains and a wasteway in about the middle of the reach. However, Corrales return flows are relatively small, representing only about 10% of the typical diversion. The overall impact on the Albuquerque reach during the spring runoff is thus to reduce flows by as much as 43%, or as little as 4%. For the summer/fall low flow period, the overall impact of MRGCD diversions on flow the Albuquerque reach is a potential maximum reduction of naturally occurring flows by as much as 100%, to as little as 43%.

However, just as with Cochiti reach, when natural flows are low enough to produce drying in the Albuquerque reach, MRGCD relies on release of water stored in El Vado reservoir, as well as its contracted SJC Project water, to increase flows, with the goal of delivering sufficient water to downstream diversions. When this occurs, the impact to Albuquerque reach from MRGCD operation is reversed, and by delivering water to Isleta dam for diversion, flows through the reach are often higher than would occur without the combined impact of releases from storage and diversion at Angostura. The incidence of drying in the Albuquerque reach caused by MRGCD operation is thus moderated by the release of stored water.

Without MRGCD operations, the Albuquerque reach would be expected to experience risk of drying (defined as flows less than 100 cfs at the Albuquerque gauge) in 36% to 40% of all years. Under the proposed action (normal MRGCD operation), the model simulations indicate that the Albuquerque reach would experience drying (less than 100 cfs at Albuquerque) in 30% to 42% of all years. When MRGCD is in normal operation and drying is not occurring, flows through the Albuquerque reach may be higher than they otherwise would be, due to movement of water released from storage at El Vado Reservoir to Isleta dam.

During the winter months, when the MRGCD is not operating to divert water at Angostura Dam, there is no hydrologic impact from diversion operations.

Angostura Dam serves as an impassable barrier to fish movement in an upstream direction, and may discourage downstream movement of fish, requiring them to pass either through sluice gate openings, or over the weir crest. However, operation of the dam to divert water has no effect on fish passage in either direction. Operation of the dam to divert water has no appreciable impact on water quality.

4.1.3 Isleta Diversion Dam and the Isleta Reach

The MRGCD originally constructed Isleta Diversion Dam, a cross-river gated structure, in 1934. Because of its design, Isleta Dam allows for adjustment of upstream water level, relative to downstream elevation, producing an elevation change of about 4.3 feet. When not being used to divert water, the gates at Isleta Dam are lifted from the water allowing upstream and downstream levels to equalize. The MRGCD adjusts two sluice gates to fine tune elevation and pass sediment and debris through the structure. One to seven intake gates are operated to divert water to canals on both sides of the RG, with a total capacity of 1000 cfs. Actual diversion rates at Isleta Dam typically are limited to about 800 cfs. Diversion rates at Isleta Dam are varied in response to time of year, rainfall, and irrigation demand.

The MRGCD operation of Isleta Dam has a potential impact of reducing the flow below Isleta Dam by up to about 800 cfs. During spring runoff, peak natural flow arriving at Isleta Dam can range from less than 300 cfs to over 6500 cfs. Diversion of water by the MRGCD at Isleta Dam can have an impact on flows of as much as 100%, or as little as 12%. When considered with the consumptive use and bypassed return flows in the upstream divisions (0-150 cfs), MRGCD operation may reduce peak spring flows below Isleta Dam as much as 100% (full drying) or as little as 15%. However, only a small number of the years analyzed (16%) have spring flow arriving at Isleta Dam below the threshold at which diversion would be expected to produce drying below Isleta Dam. The remaining years (84%) in the analyzed sequences have spring flows of sufficient magnitude that MRGCD operation reduces flows by less than 50%. A majority (52%) of all years in the sequences experience less than a 25% reduction in spring runoff, again demonstrating a general pattern of feast or famine for the MRG.

During the summer/fall low-flow period, natural flows entering the MRG valley (excluding short-term rainfall events) can commonly range from about 25 to 800 cfs. The depletion of water within the Cochiti and Albuquerque reaches both by natural causes and agricultural uses, can approach an equivalent of about 400 cfs, leaving 0 to about 400 cfs arriving at Isleta Dam. Diversion requirements at Isleta Dam are typically up to about 800 cfs, so the hydrologic impact of Isleta dam operation is commonly to divert all remaining flow from the RG during the summer/fall low flow period.

However, there often is not sufficient water natural inflow to the MRG to overcome riparian and evaporative losses to Isleta Dam and still deliver the required flow for diversion. In 40% of all modeled years, there are expected to be periods of time during which no natural flow arrives at Isleta Dam. In the absence of significant precipitation inputs in the MRG (which are unpredictable), this would be expected to result in complete drying of the Rio Grande from just upstream of Isleta Dam all the way to Elephant Butte. As discussed for Cochiti Dam, a few of these years (6%) represent extremely low flows, also likely to result in drying well upstream of Isleta Dam possibly to portions of the Cochiti reach.

However, during low-flow periods, the MRGCD requests that Reclamation release water from native storage in El Vado Reservoir, or water from the MRGCD’s SJC Project account, to deliver the required flow for diversion at Isleta Dam. The net effect of this release of water from storage accompanying the diversion of water is an increase in flows through the upstream reaches (Cochiti and Albuquerque) to Isleta Dam. MRGCD diverts all of this released water at Isleta Dam. In years in which natural flow does not reach Isleta Dam (40% of modeled years), there is no hydrologic impact from the operation of Isleta Dam, since diversions are supported by storage releases. In years when natural flow is high enough to reach Isleta Dam, but not San Acacia Dam (18% of modeled years), there are variable impacts on the Isleta reach due to the operation of Isleta Dam. In years when natural flow is high enough to reach San Acacia Dam, but not San Marcial (34%), there are variable impacts on the San Acacia reach due to the operation of Isleta Dam. In 4% of modeled years, the operation of Isleta Dam has an impact on flows arriving at San Marcial.

During the winter months, when the MRGCD is not operating to divert water at Isleta Dam, there is no hydrologic impact from MRGCD operations. Isleta Dam serves as a variably permeable barrier to fish passage when in operation. When gates are lowered to provide operating head to divert water, fish are unlikely to be able to pass through the structure in an upstream direction, except during periods of unusually high flow. During the winter months Isleta Dam gates are lifted from the water, allowing fish passage upstream, and sediment passage downstream. The operation of Isleta Dam to divert water prevents fish passage for 8 to 9 months of each year.

Operation of Isleta Dam to divert water likely has an impact on downstream water quality, specifically on water temperature, and particularly during the summer/fall low-flow period, when up to 100% of the natural flow may be diverted. As with the quantity of water diverted, the greatest impacts occur when natural flows are low, and in such circumstances the operation of El Vado or Heron Dams to deliver additional water to Isleta Dam for diversion has an impact of providing water to Isleta Dam that would not have been there otherwise.

4.1.4 San Acacia Diversion Dam and the San Acacia Reach

The MRGCD originally constructed San Acacia Diversion Dam, a cross-river gated structure, in 1934. Because of its design, San Acacia Dam allows for adjustment of upstream water level, relative to downstream elevation, producing an elevation change of about 7.5 feet. When not being used to divert water, the gates at San Acacia Dam are lifted from the water. The MRGCD adjusts a single weir gate at the north end of the dam to fine tune elevation, and at times to maintain desired flow rates downstream of the structure. A second weir gate controls flow to the intake for the Socorro Main Canal, with a capacity of 265 cfs. Actual diversion rates at San Acacia Dam have typically been up to 265 cfs. Diversion rates at San Acacia Dam are varied in response to time of year, rainfall, and irrigation demand.

The impact of MRGCD operation of San Acacia Dam is to reduce the flow below San Acacia Dam by up to 265 cfs. During spring runoff, peak natural flow arriving at San Acacia Dam can range from 0 to over 5000 cfs. Diversion of water by the MRGCD at San Acacia Dam has a potential impact of reducing peak flows by as much as 100% or as little as 5%. Spring runoff flows at the low end of this range are rare within the years modeled. Return flows resulting from Isleta Dam operation typically equal or exceed diversions at San Acacia Dam, so there is no additional impacts to spring runoff from San Acacia Dam operation.

During the summer/fall low-flow period, natural flows entering the MRG valley (excluding short-term rainfall events) can range from 25 to 750 cfs. Naturally occurring and uncontrolled depletions (evaporation and riparian consumption) throughout the MRG upstream of San Acacia Dam can reach the equivalent of about 400 cfs. In the absence of any MRGCD diversion and use of water, in less than half (46%) of all modeled years are natural flows sufficient to reach San Acacia Dam throughout the year. In only 7 years (14%) does sufficient natural flow arrive at San Acacia to overcome evaporative and riparian losses below San Acacia Dam and cause flow to reach San Marcial.

When MRGCD is in normal operation for diversion and use of water, flow arrives at San Acacia Dam with slightly more frequency, 27 of 50 modeled years (54%). This is due to return flow from Isleta Dam diversions being delivered to San Acacia Dam. Although most of the return flow may be routed through the west side drain system, and this has been generally done since about 2000, a portion is still delivered through the lower end of the Isleta reach to San Acacia Dam. When operating to divert water in this situation, MRGCD diversions from the river at San Acacia Dam are normally less than is being returned from the upstream diversion.

A temporary exception can occur because the San Acacia Dam is situated downstream of two significant, but ephemeral, tributaries, the Rio Puerco and the Rio Salado. Inflows from these tributaries occasionally make up a large portion of the flow of the Rio Grande that reaches San Acacia Dam. At these times, operation of San Acacia Dam may have large impact on flows in the San Acacia reach. However, flows in these tributaries are normally short-duration events. When MRGCD is in normal operation, whether diverting at San Acacia Dam or relying on delivery to Socorro Division via the drain system, the presence of water in the canal adjacent to the river has an impact by increasing flow below San Acacia Dam. For a distance of about 9 miles, the Socorro Main canal (and other District channels) and the LFCC is above the elevation of the river. The river accretes leakage from these channels, functioning as a drain, and tends to not fully dry. In the absence of normal MRGCD operation, this reach of the RG would be expected to dry when river inflows were not occurring, but is incidentally maintained when MRGCD delivers water for irrigation use in the Socorro Division. Thus, in the 50 modeled years, there is a 4-year decrease in the number of years in which this 9-mile portion of the San Acacia reach is expected dry. As with Isleta Dam operation, there is a change in the pattern of wet/dry in the San Acacia reach, from extremes under the No Action condition, to more consistency with proposed action.

During the winter months, when the MRGCD is not operating to divert water at San Acacia Dam, there is no hydrologic impact from operation of this diversion dam.

When in operation to divert water, San Acacia gates are lowered, preventing passage of fish in an upstream direction, and discouraging passage in a downstream direction. During the winter months, or times of no diversion, gates are lifted from the water, and would allow fish passage upstream and downstream. However, the incised nature of the river downstream of San Acacia Dam creates a situation in which fish are unlikely to pass upstream through the structure, regardless of gate position. The proposed action, to operate San Acacia Dam to divert water, thus does not have an effect on upstream fish passage. The operation of San Acacia Dam to divert water may discourage downstream fish passage.

The operation of San Acacia Dam may affect water quality (temperature), but due to the relative magnitude of flow, time of year, and rates commonly diverted, is unlikely to have a significant impact.

4.1.5 Impacts above the MRG

In the process of being conveyed from El Vado Reservoir to Isleta Dam, water released from storage to supply MRGCD diversion dams may have impacts to river reaches above the MRG. This water must incur loss from evaporation and riparian consumption just as the natural flow does, and the release from El Vado must be larger than that required for diversion at Isleta Dam. This has an impact of partially offsetting natural (evaporation, riparian consumption) and anthropogenic (acequia diversions, groundwater pumping) river depletions that are not part of the Proposed Action. An impact of summer/fall operation of MRGCD diversion dams is to increase flows in the Rio Chama from El Vado to the confluence with the Rio Grande, and in the Rio Grande from the confluence to Isleta Dam. Various activities on the Rio Chama in particular are dependent on this impact. Natural flows on the Rio Chama may fall to single digit levels in the absence of rain, and therefore are often not sufficient to support the native and introduced fisheries on the Rio Chama, nor the recreational activities (commercial and private boating and sport fishing) that occur on the reach from El Vado to Abiquiu. Diversions for historic acequias occur below Abiquiu Dam. These acequias, some of which date to the early 17th century, cannot function efficiently or effectively when flows are less than 100cfs, so the delivery of water for MRGCD Diversion dams provides an important benefit for these water users above the MRG.

4.2 Effects of Diversion Dam Operation on RGSM

The effects of operation of the diversion dams on RGSM are primarily indirect, related to the withdrawal of water. Removing a portion of the flow results in a changed habitat condition downstream of each diversion dam, and the water that is consumed within the District, rather than returned to the river at wasteways, has a cumulative impact on flows in the river downstream of the diversion point, including in downstream MRGCD divisions. However, those effects are highly variable, as described above, depending on time of year, physical location (dam and reach), and magnitude of naturally occurring flow.

For the purposes of this analysis, a flow of 2500 cfs or greater at the Albuquerque gauge, occurring for at least 7 consecutive days between April 15 and June 15 of each year is considered the minimum necessary to provide habitat conditions necessary for successful spawning and recruitment of RGSM. Effects of diversion dam operation are evaluated in terms of how they change the annual frequency of occurrence of minimum required spawning and habitat conditions. The values used (2500 cfs, 7days) are based on past recommendations of the Minnow Action Team (ad hoc working group of the Collaborative Program), guided by recommendations and research conducted by the PVA workgroup (Goodman, Miller) and the USACE (Porter).

Operation of diversion dams to divert water for the MRGCD has a minor indirect effect on RGSM during the spring spawning and reproduction period. Flows of magnitude and duration required for successful spawning and recruitment in the Albuquerque reach (>2500 cfs) occur in 64% of modeled years in the No Action condition. With operation of the diversion dams as described by the Proposed Action, the occurrence of these conditions is 58% of modeled years, a reduction of 6%.

4.2.1 Overall Effects, Spring Spawning and Recruitment Conditions

There is likely an indirect effect of reduction of the total extent of available spawning and recruitment habitat resulting from the MRGCD Proposed Action. At lower flows (<2500 cfs at Central Avenue), when spawning and recruitment conditions are not optimal, the diversion of water does not appreciably change the wetted area of available habitat. When overbanking flows are achieved, diversion of water reduces the extent of available overbank habitat for RGSM. When flows are high, they tend to be considerably higher than the threshold at which overbank flow occurs (>2500 cfs at Central Avenue), and so the diverted (and consumed) water represents a relatively smaller percentage of total flow. In the case of Isleta Dam, the largest diversion, and what might be considered the "worst case", typical diversion rates represent about 15% of the average peak flow, when overbanking conditions exist. The range is from 23% to 11%. However, reduction on extent of suitable spawning and recruitment habitat is unlikely to be linear, and remains impossible to quantify at present, in part because considerable uncertainty remains as to what conditions constitute suitable spawning and recruitment habitat.

4.2.2 Overall Effects, Summer/Fall Low Flows

The effect of water diversion on available summer/fall habitat during periods of typically lower flow is evaluated by the presence or absence of habitat potentially usable by RGSM. It cannot be ascertained in the model results whether RGSM actually occupy any particular location in the MRG, but if the model shows flowing water is not present at a location, then that location is not capable of being used by RGSM. The MRG contains approximately 172 miles of river channel which may potentially be utilized by RGSM. For purposes of this analysis, the river is evaluated in 1-mile segments. The presence of water throughout the year in any particular mile is considered evidence of suitability as habitat for RGSM. The absence of water in any particular mile, for any duration, is considered evidence of unsuitability of that mile as RGSM habitat. Thus, the change in total river miles wet or dry in a year, from No Action to Proposed Action is assumed to represent the effect on RGSM. Although RGSM may possibly re-utilize previously dried miles after flows return, it is assumed they will not until the following winter or spring, so this approach represents a conservative "worst case" evaluation of the effects to RGSM during the summer/fall low flow period.

Figure H4 represents the extent of potential drying (defined here as no flow) which may be expected under the No Action scenario. Each row represents the annual extent of continuous flow (blue) or river drying (brown) over 172 miles of MRG river from Cochiti Dam to the Low Flow Conveyance Outfall Channel, for one of the modeled years. The 50 rows represent all 50 years modeled, in sequence, and by % chance of exceedance for each sequence as labeled in the left column. The "wettest" sequences are at the top, with "driest" sequence at bottom. The graphic clearly shows the pattern of feast or famine with extreme drying in a few years (3), and continuous flow throughout the MRG in a few more years (7). The remaining years experience some intermediate level of drying, with flows receding to above Isleta Dam in many years (21). This pattern is consistent with accounts of no water for irrigation frequently being unavailable below Albuquerque in pre-MRGCD times. An important consideration for the effects analysis is that under the No Action condition, no 10 year sequence contains more than 4 years in a row with habitat maintained downstream of the Albuquerque gauge. This suggests that RGSM populations which currently exist in the lower reaches of the MRG might not be able to persist under the No Action condition.

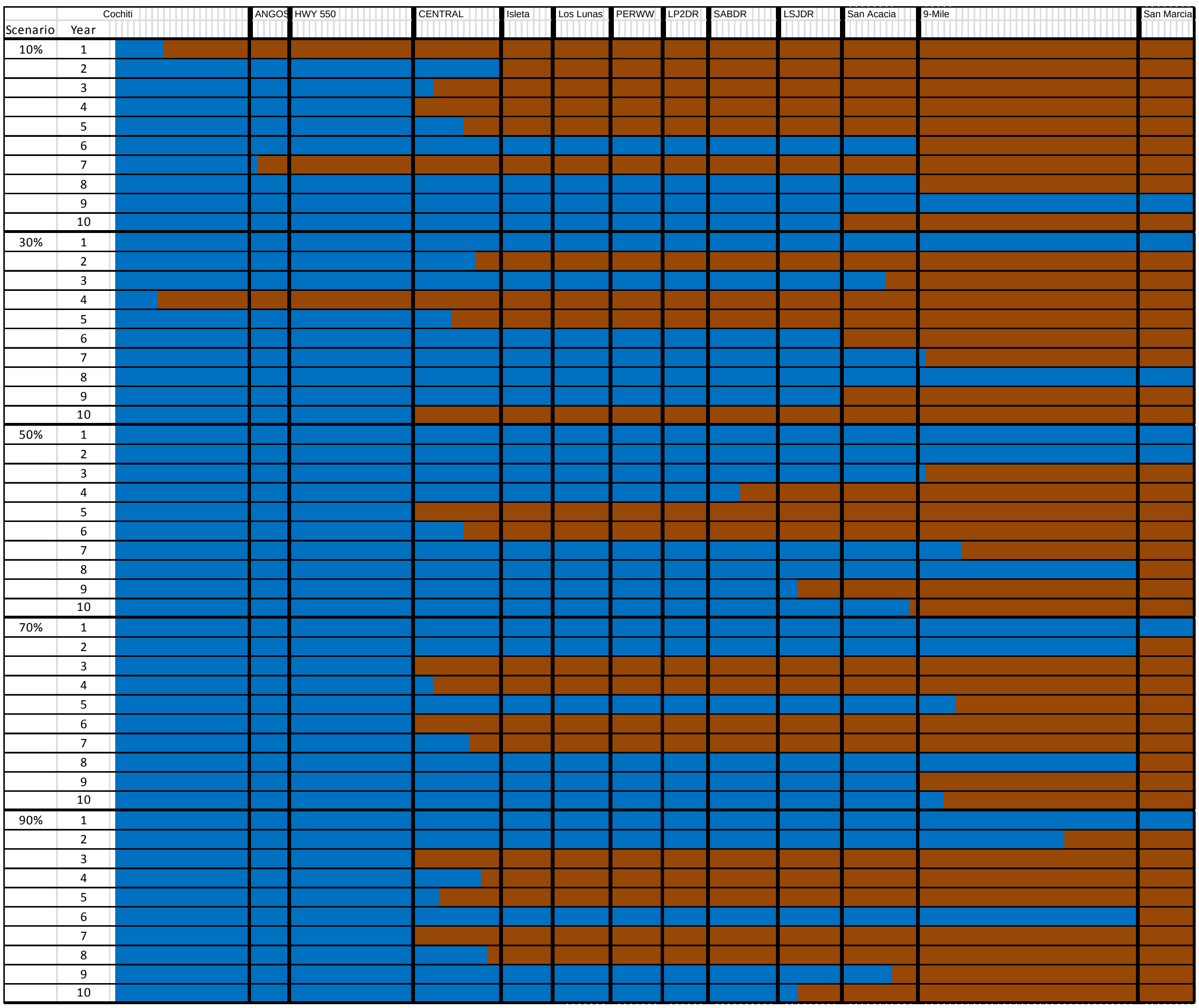

Figure H4. Extent of drying possible under No Action condition, 50 modeled years

Figure H5 presents a similar graphic demonstrating the effects to RGSM habitat expected to result from the Proposed Action. This graphic clearly shows the influence of regulated reservoir releases being available in many, though not all, years. The release of stored water associated with irrigation deliveries, along with return flows, acts as a stabilizing influence on extent of habitat. While the overall total extent of available habitat for all 50 years is reduced by about 6% (an average of 10.4 miles every year), the delivery of water through the MRG tends to moderate the extremes of the No Action condition. Most notably, habitat is maintained to Isleta Dam in 5 additional years, and the occurrence of extreme drying upstream of Central Avenue is eliminated. Also of interest is the increase in dependability of habitat in the lower end of the Isleta reach, between Belen and San Acacia. This is a relatively recent phenomenon, only occurring since about 2000, and apparently is due to increased use of drains to deliver water to San Acacia Dam for irrigation purposes, and an associated reversal of gradient between drains and river. The increased use of drains by MRGCD occurred in response to increased metering and understanding of water management, precipitated by drought and reduced water supply, and was not intended to assist the RGSM. However, the associated beneficial effect to extent of RGSM habitat appears to be a useful side effect.

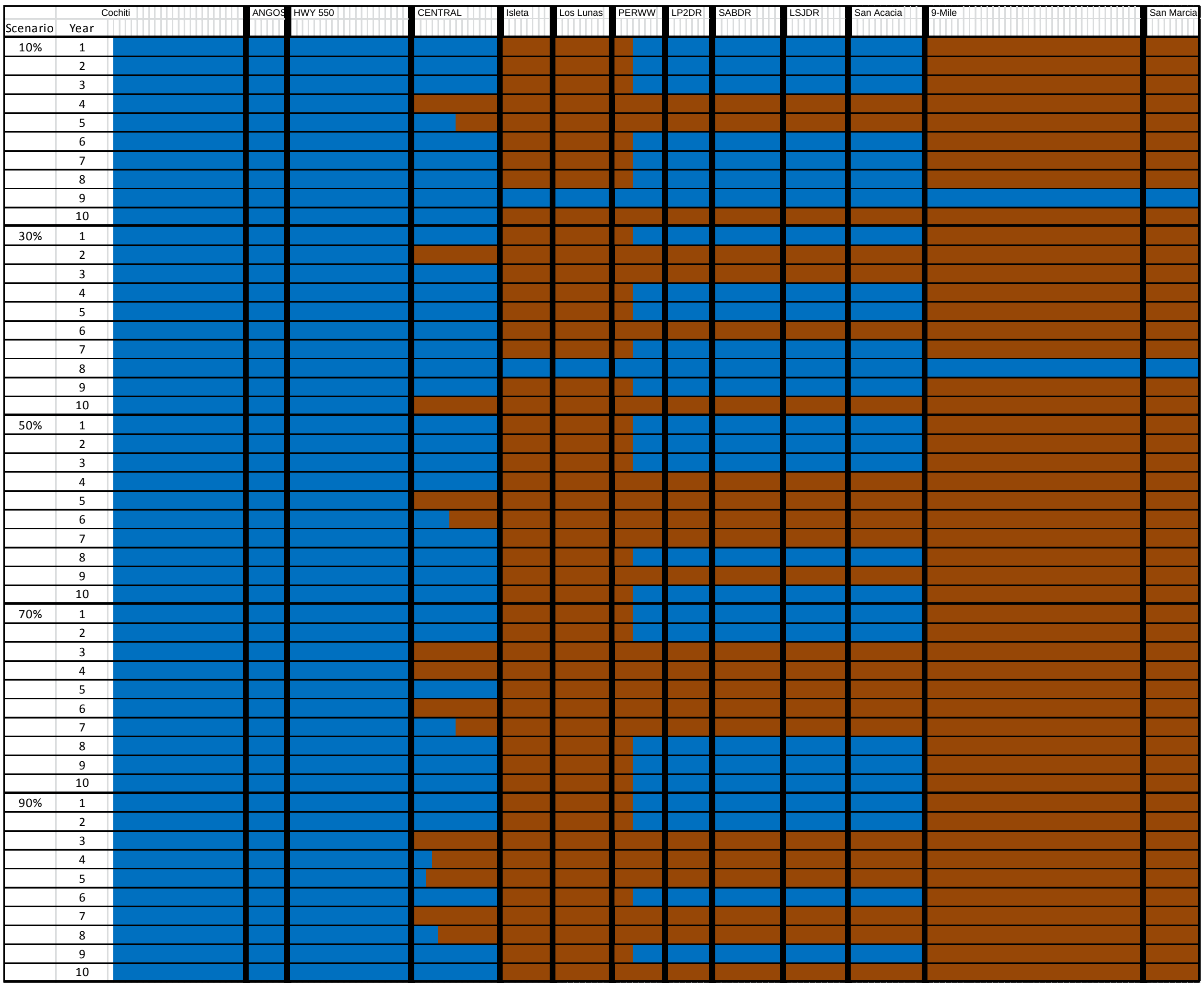

Figure H5. Extent of drying possible under the Proposed Action condition, 50 modeled years

The preceding analysis describes the overall effect on RGSM habitat. Each diversion dam operation is examined separately as well, to describe any local effects, and to give an idea of the contribution of each dam and reach to the overall.

4.2.3 Effects by Reach

4.2.3.1 Cochiti Dam and Cochiti Reach

Operation of Cochiti Dam to divert water for the MRGCD has an insignificant effect on RGSM in the Cochiti Reach during the spring spawning and reproduction period. Diversion of water does not change the frequency of annual occurrence of conditions in Cochiti Reach believed to be required for spawning and reproduction (>2,500 cfs at Central). Any change in the wetted area of available habitat for RGSM spawning and recruitment is likely so small as to immeasurable. Furthering this conclusion is that under present conditions, RGSM in the Cochiti Reach are believed to either be extirpated, or present only in exceedingly small numbers, thus operation of Cochiti Dam is not likely to adversely affect RGSM reproduction in this reach.

Operation of Cochiti Dam makes possible the consumptive use of water equivalent to about 70 cfs and therefore the impact of water consumed in the Cochiti reach would shift upward by about 70 cfs the release required to initiate overbank flooding in downstream reaches. This represents less than a 3% increase in the required inflow to the MRG valley. Due to the feast or famine nature of spring runoffs through the MRG, low water years tend to be far below the level where successful spawning and recruitment flows are expected. Conversely, years in which spawning and recruitment conditions are met tend to be much higher than the minimum required inflow, so that diversion of water does not change the frequency of occurrence of the desired conditions.

During the remainder of the species life cycle, the effect of operation of Cochiti Dam to divert water for the MRGCD depends on whether the MRGCD is under normal operations, with El Vado releases available to supplement natural flow, or more limited operations. Under normal MRGCD operations after the spring runoff, operation of Cochiti Dam decreases flows by about 200 cfs at the upstream end of the Cochiti Reach, returning about 130 cfs by the downstream end of the reach. Dam releases into the river are typically between about 400_and 1000cfs. Due to the incised nature of the river through the Cochiti Reach and the cobble substrate resulting in poor habitat for the silvery minnow, this change in flow (20% to 50%) has no significant effect on the wetted area of available habitat, or on water quality conditions for RGSM, nor does it lead to river drying within the Cochiti Reach.

As noted above, irrigation operations within the Cochiti Reach result in a net removal of approximately 70 cfs from downstream reaches, affecting available habitat there.

Although release of water from Cochiti Reservoir has an impact to water quality below the dam, operation of Cochiti Dam to divert water is unlikely to have any significant effect to other PCEs for RGSM.

4.2.3.2 Angostura Dam and Albuquerque Reach

Operation of Angostura Dam to divert water for the MRGCD has an indirect effect on RGSM during the spring spawning and reproduction period. Flows of magnitude and duration required for successful spawning and recruitment in the Albuquerque reach (≥2500 cfs) occur in 64% of modeled years. With operation of Angostura Dam, the occurrence of these conditions is 58% of modeled years, a reduction of 6%.

Under normal operation, Angostura Dam has only minor indirect effect on RGSM habitat during the remainder of the species life cycle within the Albuquerque reach. Naturally occurring flows, in combination with normal water operations (augmented flow when necessary) entering the MRG valley are typically greater than water withdrawals, as the MRGCD is operating to deliver water to Isleta Dam for diversion. Flows expected to result in drying in the Albuquerque reach may be expected to occur in 36% to 40% of years under the No Action condition. With operation of Angostura Dam to divert water along with releases, drying in the Albuquerque reach may be expected in 30% to 42% of years. Under normal operating conditions, diversion of water at Angostura Dam has limited influence on the the wetted area of available habitat, or on water quality conditions for RGSM, nor does it lead to river drying within the Albuquerque reach. The use of water made possible by Angostura Dam (and upstream diversions) may decrease the available extent of habitat for RGSM below Isleta Dam in some years, but this decrease is commonly offset by release of water from storage.

Habitat for RGSM may be slightly enhanced by the proposed action, due to movement of water to downstream locations for diversion.

There are unlikely to be any measurable effects to other PCEs for RGSM resulting from Angostura Dam operation. Because Angostura Dam inflow originates from a reach believed to have zero, or extremely small numbers of RGSM, Angostura Dam is expected to have no effect on RGSM due to incidental egg, larvae, or adult entrainment. Passage in an upstream direction through Angostura Dam is believed to not be possible for a fish with the physical characteristics of the RGSM and the nature of the Angostura Dam structure. Operation of Angostura Dam thus has no effect on RGSM distribution (river connectivity).

4.2.3.3 Isleta Dam and Isleta Reach

Operation of Isleta Dam to divert water for the MRGCD may have indirect effects on RGSM during the spring spawning and reproduction period. Isleta Dam has larger hydrologic impact than upstream operations, but flooding in the Isleta Reach occurs at lower discharges (approximately 2000 cfs) than upstream reaches. Frequency of conditions deemed necessary for RGSM spawning and recruitment are unchanged by the proposed action.

Operation of Isleta Dam has significant indirect effect on RGSM habitat during the remainder of the species life cycle within the Isleta reach. Because the MRGCD operates only to deliver water in the river channel as far as Isleta Dam, when releasing from storage the effect of Isleta Dam operation on the Isleta Reach is wholly dependent on natural MRG inflow. In 56% of years, operation of Isleta Dam has no effect on RGSM habitat either because natural inflow to the MRG is insufficient to maintain any habitat below Isleta dam (42% of years), or natural flow is sufficient to maintain habitat throughout the Rio Grande below Isleta Dam (14% of years). In the remaining 34% of years operation of Isleta Dam has variable effect on extent of habitat available to RGSM (see Figures H4 and H5 above)

The effect of Isleta Dam operation is an average reduction of habitat available to support RGSM populations of 6% annually, or about 10.4 miles. Isleta Dam operation changes the distribution of habitat available for RGSM throughout the MRG, as shown in Figures H4 and H5. The movement of water to and through the MRG, and the regulation of drain structures, associated with diversion and use of water results in additional loss of habitat in some areas, but preservation of habitat in other areas downstream from Isleta dam.

RGSM may pass in either direction through Isleta Dam when gates are lifted from the water. Gates must be lowered, partially or fully, to allow diversion at Isleta Dam for about 8.5 months of each year. During this time, fish passage in an upstream direction is unlikely to be possible for RGSM, and made less likely in a downstream direction. Thus, the operation of Isleta Dam has the effect of reducing potential RGSM movement between the Isleta and Albuquerque reaches by 71% of the year.

Due to the presence of RGSM eggs, larvae, and adults, upstream of Isleta Dam, operation of Isleta Dam may have direct effects on RGSM through incidental entrainment of individuals and eggs into irrigation canals. Habitat conditions immediately upstream of Isleta Dam are probably not preferred habitat for RGSM by the concrete intake bays within a few feet of the structure, which may help to minimize any incidental entrainment of adult RGSM. However RGSM eggs and larvae are carried with the flow, and lack the ability to selectively avoid canal intakes. The magnitude of this effect is assumed to be directly proportional to the percentage of flow diverted during the spring high flow period when eggs and larvae are likely to be present. This may range from as low as 0%, assuming unsuccessful spawning in low flow years, to as high as 40% when flows are just high enough for a successful spawn. As peak flows increase, the relative proportion of entrainment decreases again to about 12%. In recent years, sampling for eggs in canals supplied by Isleta Dam has detected entrainment of eggs, but in a lower proportion than would be expected based solely on flow. This may indicate the design of canal intake works incidentally tends to discourage the entrainment of eggs. Adult RGSM have been collected in irrigation canals originating from Isleta Dam, but in exceedingly small numbers.

Due to the magnitude of diversion relative to total flow, operation of Isleta Dam is expected to have a greater effect on water quality than other diversion dams. However, this effect is relatively small except when flows are very low. When naturally occurring flows are very low, operation of Isleta Dam may have effects to the PCE of water of sufficient quality (primarily temperature) to support RGSM. In general, however, the PCE of water of sufficient quantity is more critical, and this effect has already been described and quantified.

4.2.3.4 San Acacia Dam and San Acacia Reach

Operation of San Acacia Dam to divert water for the MRGCD has minor indirect effect on RGSM during the spring spawning and reproduction period. Overbank flooding in the San Acacia Reach occurs at lower discharges (≥1500 cfs) than upstream reaches, and water removed by San Acacia Dam represents as much as 18% of the required flow. However, San Acacia Dam generally diverts less water than is returned to the RG from upstream diversion dam operation. When taken collectively with upstream operations, the effect on required flows for RGSM spawning and recruitment does not change due to San Acacia Dam operation.

The operation of San Acacia Dam may have indirect effects to RGSM through changes in available habitat during the summer/fall low flow period. In 68% of years, operation of San Acacia Dam has no effect on RGSM habitat either because natural inflow to the MRG is insufficient to maintain any habitat below San Acacia Dam (54% of years), or natural flow is sufficient (with diversions occurring) to maintain habitat throughout the Rio Grande below San Acacia Dam to San Marcial (14% of years). In the remaining 32% of years, operation of San Acacia Dam has variable effect on extent of habitat available to RGSM (see Figures H4 and H5 above for the Proposed Action condition)

A potential exception may occur under certain upstream low-flow conditions, when ephemeral tributaries near San Acacia Dam may supply water for diversion when naturally occurring flows entering the MRG at the beginning of the Cochiti reach are insufficient to reach San Acacia Dam. This is a common condition in many years, and San Acacia Dam operation may be judged under these conditions to be reducing available RGSM habitat in proportion to the available flow. However, these flows tend to be short duration, and the San Acacia Reach still generally experiences periods of no arriving flow in these years. Only in a case where timing of these ephemeral tributary inflows was such to counter the absence of any naturally arriving flows in a year would there then be an effect to available habitat for RGSM. Although this is a possibility, it is probably a very rare circumstance, defying any practical attempt to estimate or model.

Due to existing river conditions downstream from San Acacia Dam, passage in an upstream direction through San Acacia Dam is believed to not be possible for a fish with the physical characteristics of the RGSM and due to the nature of the dam structure. Fish passage in a downstream direction is possible, and probably does occur. However, operation of the dam does not change the possibility of passage in either direction, and there are no effects to RGSM associated with river connectivity due to the operation of San Acacia Dam.

Due to the presence of RGSM eggs, larvae, and adults, upstream of San Acacia Dam, operation of San Acacia Dam may have direct effects on RGSM through incidental entrainment of individuals and eggs into irrigation canals. Habitat conditions immediately upstream of San Acacia Dam are probably not preferred habitat for RGSM by the concrete intake bays within a few feet of the structure, which may help to minimize any incidental entrainment of adult RGSM. However, RGSM eggs and larvae are carried with the flow, and lack the ability to selectively avoid canal intakes. The magnitude of this effect may considered to be directly proportional to the percentage of flow diverted during the spring high flow period when eggs and larvae are likely to be present. This may range from as low as 0%, assuming unsuccessful spawning in low flow years, to as high as 18% when flows are high enough for a successful spawn, but not extremely high. As peak flows in a year increase, the relative proportion of entrainment decreases again to about 5%. In recent years sampling for eggs entrained in canals by San Acacia Dam has detected entrainment of eggs, but in a lower proportion than would be expected based solely on flow, possibly indicating the design of canal intake works tend to incidentally discourage the entrainment of eggs. Adult RGSM have been collected in irrigation canals originating from San Acacia dam, but in exceedingly small numbers.

4.3 MRGCD Return Flow Facility Operation

4.3.1 Hydrologic Impact of MRGCD Return Flow Facility Operation

The MRGCD must routinely divert more water than is required for consumptive use by crops. This additional water, often referred to as “carriage water,” is a common and necessary component of gravity-fed irrigation systems worldwide. While carriage water also incurs consumptive use (by definition) through evaporation, consumption by riparian vegetation along irrigation canals, and seepage to groundwater, which is pumped and consumed by other users, the majority becomes return flow. Return flow can take a variety of paths back to the Rio Grande. Some simply passes down the length of a canal and returns directly to the Rio Grande through a wasteway. Some canals, farm ditches, and fields discharge surface water directly to MRGCD drains. Some water seeps from canals or from field applications to become groundwater flow, for interception by MRGCD drains, to once again become surface flow. Flow recovered in the MRGCD drains may be discharged back to the Rio Grande or be recycled to another canal.

The Rio Grande (when flowing) also contributes groundwater flow. Due to the generally aggrading/avulsing nature of the Rio Grande in the lower reaches of the MRG, the river is typically perched above the surrounding floodplain. Although in recent years, the river has been experiencing increased channel narrowing and incision, surface water elevation in the active channel remains substantially higher than surrounding lands outside the flood control levees in some areas. Sediments of the channel and floodplain area are commonly sand, with high permeability, interspersed with clay and silt layers. These sediments offer high horizontal conductivity, and variable vertical conductivity depending on presence or absence of clay layers. Combined with a relatively steep hydraulic gradient away from the river and towards the historic floodplain (now almost completely occupied by urban and agricultural development), the result is an extremely “leaky” river. MRGCD drains intercept this leakage, returning it to the river channel, or in some cases directing it back to the MRGCD delivery system, from which it can be used for irrigation. Drain operation does not cause the river to leak, but instead intercepts natural leakage before it can surface at some low-lying location away from the river channel, where it would then evaporate or be consumed by vegetation. Drain operation allows directed control of river leakage. Drains were a principal component of both the MRGCD and MRG Project, satisfying downstream users that flows delivered to them through the Rio Grande would increase, and allowing additional MRG consumptive uses to be developed from savings of large incidental evaporative losses that river leakage was then incurring.

After interception of either river leakage or agricultural returns by drains, MRGCD drain operation directs this water to locations where it can be returned to the Rio Grande, or delivered into to irrigation canals for delivery to water users. Drain flow is highly variable with changing hydraulic head differential. Control structures near discharge points from drains act to establish groundwater elevation control. Gradients to drains increase during high flow periods (from the river side), or high rainfall or irrigation periods (from the field side), causing increased flow rates in drains, but in general very little regulation of drain inflow occurs.

Regulation occurs at the outflow end, where MRGCD operates numerous structures, by adjusting control gates installed in the structures, to return water to the Rio Grande. During the irrigation season, a portion of flow may be returned to the Rio Grande, or routed into downstream drains or canals for use in delivery to agricultural lands. During the off-season, drain operation generally returns all flow to the Rio Grande.

One hydrologic impact of MRGCD drain and wasteway operation is to collect and deliver flow diverted from the river, and not consumptively used by agricultural crops, to a desired location and thus reducing the incidental loss of water to evaporation or evapotranspiration. The location can be the Rio Grande channel, or it can be an irrigation canal. This impact is variable over the course of the year, and with flows in the river. During the winter months when no diversions are occurring, return flow from agricultural lands continues, but the impact becomes quite small by December. During the early portion of the irrigation season, return flow impacts often are large. Between 50-90% of water diverted by MRGCD diversion dams, enters drains (and wasteways) between March and mid-May. When flows begin to rise during spring runoff, drain accretions rise as well. Especially in years of large spring runoff, MRGCD has difficulty getting rid of all the water entering its return-flow channels, and attempts to return flows to the river as quickly as possible. During the summer, when natural flows decline and Reclamation and the MRGCD are releasing storage from El Vado, return flows are recycled into irrigation canals where possible, although some return flow continues to be directed back to the Rio Grande. At the end of the irrigation season, late September through October, return flows rise again as consumptive use of water tapers off, typically culminating in a “burst” of water returned to the river as canals are emptied for the winter.

Another hydrologic impact of drain operation is to collect and return intercepted groundwater seepage which originates from the Rio Grande. This impact counters the natural tendency of the Rio Grande to leak to surrounding lands. This impact occurs year-round, influenced primarily by stage (relative elevation) of water in the RG compared to surrounding lands/drain channels, and secondarily by interception of groundwater by riparian vegetation. River leakage to drains generally increases during the winter, because higher winter flows in the river produce higher hydraulic gradient, drains structures are unchecked lowering the drain water surface, and riparian consumption between the river and drains ceases to take a portion of the subsurface flow. The impact of drains is substantial through the winter and early spring, as well as during the spring runoff when flows are large. When natural flows recede after spring runoff, and riparian vegetation (the cottonwood/willow “Bosque” along the RG) consumptive use becomes high, and impact of the drains to return intercepted groundwater becomes substantially less.

Due to operation of the drains, and adjustment of control gates, there are several reaches of the RG through the MRG where the hydraulic gradient from river to drain becomes reversed under low flow conditions, and the river channel intercepts seepage from nearby drains. Under these circumstances, the hydrologic effect of drain operation is to increase flows in the river, or eliminate any additional leakage from the RG.

4.3.2 Effects of MRGCD Return Flow Facility Operation on Minnow

MRGCD wasteways are simply the ends of canals, and are normally separated from the RG by some sort of regulating structure. Due to a difference in water surface elevation, RGSM are not expected to pass upstream through these structures, and are believed to not normally inhabit irrigation canals. Thus, there are not likely to be significant effects to RGSM from wasteway operation.

RGSM may inhabit the RG near wasteway discharge points. In these cases, there may be indirect effects to RGSM from MRGCD wasteway operation. The effect is to increase flow from what would otherwise be present. Wasteway discharges are typically small, representing only a small increase in flows. In some locations, wasteway discharges can enter an area of the river experiencing very low flow, and in this case there may be significant effect of the wasteway operation to RGSM, and this effect is believed to be entirely beneficial.

There may also be potential effects to water quality from MRGCD wasteway operation. Wasteway discharge is typically water diverted from some point upstream, which has not been delivered. Its quality is unlikely to be altered in any way, except that being conveyed in a narrower, deeper, and faster moving channel, it will have experienced less evaporative and heating influence than the source water, so when discharged is likely to be slightly cooler and less salty than the river.

MRGCD drains receive surface water inflow, groundwater inflow from agricultural areas, and groundwater inflow from the RG. Discharge points from drains are separated from the river with control structures which may generally vary water surface elevations. At times these structures may prevent upstream passage of RGSM, but under other operating conditions may allow passage. RGSM are known to inhabit MRGCD drains, although it may not be considered preferred habitat. Thus there are likely to be direct effects from drain outfall operation.

RGSM may inhabit the RG near drain outfalls, and drain outfall channels, and there may be indirect effects to RGSM from MRGCD drain operation. The effect is to increase flow from what would otherwise be present. In some locations drain discharges can enter an area of the river experiencing very low flow, and in this case there may be a significant effect of the drain operation to RGSM, and this effect is believed to be entirely beneficial.

There may also be potential effects to water quality from MRGCD drain operation. Drain discharge originates from multiple sources, including potential contact with agricultural operations. It is likely to have different water conditions when compared with surface flow in the river. However, sampling to date has yet to indicate any occurrence of drain outfall water with water conditions outside of acceptable ranges for RGSM habitat.

5. Flow Model Documentation

5.1 Introduction

The URGWOM model does a remarkably good job of simulating realistic water management scenarios through the Rio Grande/Rio Chama system to Cochiti Reservoir based on past gauge data, expected runoff volumes, and reservoir operating rules. However, the outputs from the URGWOM model become appreciably less certain once water passes below Cochiti Dam. This is due to a highly complex interaction of consumptive uses and groundwater exchange into and out of the river. The use of URGWOM to model MRG flows on a daily is not appropriate when attempting to evaluate both the No Action and Proposed Action conditions for Reclamation's 2015 MRG BA with respect to hydrologic impacts of MRGCD Diversions.

The No Action scenario to be modeled must be capable of showing the operation of reservoirs as they exist, and for any actions that are not part of the Proposed Action condition. The No Action condition must also demonstrate the range of flows expected through the MRG in the absence of the proposed actions, which below Cochiti Reservoir is the operation of MRGCD diversions for water delivery to agricultural consumers. Initial attempts using the URGWOM model were made by removing the "MRGCD Demand" or "MRGCD Diversion" from the consumptive use below Cochiti. However, these factors include some consumptive uses which would in fact continue under a No Action scenario. MRGCD "demand" includes riparian consumptive use, evaporation from the river itself, and seepage to aquifer recharge, all of which would logically be expected to continue in the absence of irrigation water diversion. Similarly, MRGCD "diversion" includes a component which is not consumptively used by agriculture, but instead returns to the river or drain system, where it is consumptively used by riparian vegetation, evaporates, or is lost to groundwater recharge.

A practical alternative was developed by assessing all depletions of water that could be expected to occur as water moves through the MRG, and removing only that portion of depletions associated directly with the Proposed Action. Values for MRG depletions were derived from Reclamation's ET Toolbox model (ETT). The ETT produces daily consumptive use values for agricultural, riparian, and open water consumptive use based on climate conditions and acreage extents. This allows for the effects of agricultural consumption related to the operation of MRGCD diversion dams to be removed for the No Action condition, and restored for the Proposed Action condition. Or perhaps more correctly, the use of ETT allows the effects of open water evaporation and riparian consumption to remain as consumptive demands upon the river under all conditions. As with any model, there are limitations to ET Toolbox. ETT does not contain a component for groundwater recharge, and this must be compensated for in another way. Prior to 2011, ET Toolbox riparian and agricultural values were based on a NMSU-modified Penman-Montieth equation (PM). The NMSU PM method tended to overestimate

MRG ET by about 30% (ref: Brower doc). For 2011, ETT adopted the more conservative FAO-56 PM method.

5.2 The Flow Model

To simulate MRG flows, a spreadsheet model was constructed (using MS Excel). The construction of this Flow Model (FM) is possible due to the geographic and hydrologic characteristics of the MRG. It has been said that the MRG is where the Rio Grande spreads itself out to dry. Most flow inputs to the Rio Grande occur upstream of the MRG. Most flow in the RG originates from winter snows, resulting in a pronounced and often dramatic increase in flows during the spring runoff period, and much lower flows the remainder of the year as base-flow from groundwater (also snow origin) drains from the high mountains. MRG hydrology is heavily dominated by depletion. As the RG enters the MRG area, its valley widens and its slope lessens. Tributary contributions within the MRG are limited to the Rio Jemez, and a number of arroyos which normally flow only during and immediately after precipitation events. Climatic conditions become harsher and open water evaporation increases. The broad valley supports an extensive riparian forest which consumes an appreciable percentage of the total flow. Groundwater pumping causes de-watering of both shallow and deep aquifers, which in turn causes the RG to leak water to recharge that use. And of course water is diverted from the RG, and delivered onto agricultural lands where it is consumed by agricultural use.

Within the MRG, the river system is neatly oriented north-south. It can be broken into “reaches” by creating east-west boundary lines. For URGWOM and ETT purposes, the MRG is separated into 8 distinct reaches. Not coincidentally, these reaches correspond closely with points of interest for water managers and for describing flow characteristics for the BA. Reaches are related to these flow points of interest as:

Reach 1-3: Cochiti Reservoir outflow to Central Avenue gauge (Albuquerque)
Reach 4: Central Avenue Gauge to Isleta Diversion dam
Reach 5-6: Isleta Diversion dam to San Acacia Diversion Dam
Reach 7: San Acacia Diversion dam to San Marcial Gauge dam
Reach 8: San Marcial Gauge to Elephant Butte Reservoir

All of these reaches experience consumptive use of water for agricultural and riparian evapotranspiration and open water evaporation, with the exception of Reach 8. Reach 8 includes effectively no agricultural use, but does have extensive riparian consumption. Reach 8 also includes a large amount of open water evaporation, highly variable due to the changing pool elevation of EB reservoir. For these reasons, and since the downstream end of Reach 8 is not a flow point of interest for the effects analysis, the FM does not include Reach 8.

The underlying and simple premise of the FM is that a certain flow enters each reach, and the amount leaving that reach is determined by subtracting the known depletions in that reach. The outflow from that reach then becomes the inflow for the next reach. There are complicating factors, primarily the interaction of water into and out of the drainage system, which require consideration. As noted above, some reaches are aggregated for consideration, which eases the difficulty in accounting for these complicating factors.

5.2.1 Model Inputs

The FM depends on an input of the flow expected to enter the MRG on a daily basis. This input value is the flow arriving at Cochiti Reservoir, derived from previous URGWOM modeling for the various conditions. The FM then uses ETT derived depletion estimates for agricultural, riparian, and open water depletions, plus a groundwater component in the Albuquerque area, to estimate flows arriving at four key points in the MRG; Central Avenue gauge in Albuquerque, below Isleta Dam, San Acacia Gauge, and San Marcial Gauge. The FM is prepared to accept 10-year sequences of flows (runs). Flows at these points are evaluated in terms of number of years of successful spawn/recruitment condition (user specified discharge/duration) during each run (Central Avenue only), the occurrence of flows (user specified) at key points expected to result in drying, and the number of years during the run in which major drying occurs.

The FM is constructed so that the user can readily specify (or modify) values to test for spawn/recruitment conditions, major drying, or intermittency. For the runs described by this document, the following conditions were specified:

	Spawn Flow/Duration	Major Drying
Albuquerque Reach	2500 cfs/7 days	100 cfs
Isleta Reach		150/85 cfs*
San Acacia Reach		150 cfs
At San Marcial		10 cfs

*different thresholds are specified due to return flow conditions under the Proposed Action runs

The FM also includes a user-adjustable factor to specify for agricultural consumption. This allows for full agricultural consumptive use to occur in the FM when considering Proposed Action runs, where it should be set to 1. However, for No Action runs, agricultural consumption may still occur in some areas even when no diversion for that purpose is occurring, due to groundwater accretion in MRGCD drains which directly enters canals, deep-rooted crops with direct groundwater access, and groundwater pumping. Reaches 1-3 contain no lands which can practically be served without diversions. A considerable portion of agricultural lands in Reach 4 can be served from drain accretions, and smaller agricultural users may switch to shallow private wells when canals are not available. While a lesser percentage can be served in Reach 5-6, the very large agricultural acreage in Reach 5-6 makes this an important component, and a number of large users have supplemental groundwater wells. In Reach 7, about a third of agricultural lands are expected to be served from drains, primarily MRGCD lands south of Socorro and on the Bosque del Apache NWR, and some large users have supplemental groundwater wells. The following factors are used for the No-Action conditions described here.

Reach 1-3:	0
Reach 4:	0.5
Reach 5-6:	0.25
Reach 7:	0.33

Should one wish to evaluate conditions if no agricultural consumption were to occur these values could all be set to zero, but this is an unrealistic condition and would require a "browning" of the entire MRG that is not contemplated by the Proposed Action, and is well beyond the capability of Reclamation and its BA partners to control.

5.2.1.1 ET DATA for Depletion Input

Agricultural/Riparian Evapotranspiration and Open Water Evaporation should be reasonably constant year to year, though will vary notably over the course of a year. It is practical and reasonable to establish ET/OW consumption curves (for our purposes, a series of steps, roughly describing a curve), similar to what have previously been used in the URGWOM model for MRGCD Demand and MRGCD Diversion. Such a curve is considerably less subjective than previous efforts, since reliable estimations of ET/evaporation may be produced from mathematical evaluation of known plant/water functional relationships with climate.

ETT values used as inputs in the FM are determined through a separate set of spreadsheets:

AG_ET_Corrected_2Week.xls
RIP_ET_Corrected_2Week.xls
OW_EVAP_Corrected_2Week.xls

Each of these worksheets contains 5 years (2007-2011) of daily values from ETT. An Average value for each day is produced from the five years. Then, the average values are used to determine the average for every 2-week period beginning Jan 1. Two small exceptions occur. The last period of the year includes 15 days. Later, when these values are input into the FM, in any leap-year modeled (2012, 2016) Feb 29 is given the same value as Feb 28. The use of the 2-week average was found to be necessary to produce a logical and evenly distributed "curve" for ET throughout the year, dampening out the effects of daily weather disturbances from seasonal climate. The five years chosen represent a fairly limited sample, and a longer record would clearly be desirable. However, ETT underwent significant changes from its inception in 2000 through 2005, and 2006 was an exceptional year due to record rains in the critical July-September period. For these reasons only the last 5 full years of ETT data were used to construct the agricultural, riparian, and open water consumptive use inputs. ETT daily values for years 2007-2010 are multiplied by 0.70 in the worksheet to adjust them to the FAO-56 method used in 2011.

5.2.1.2 MRGCD Diversions

Along similar lines, MRGCD diversions were also processed through an excel spreadsheet:

Diversions_Corrected.xls

In this worksheet, daily recorded values for 4- to 6-year periods were culled from MRGCD records. Various sets of years are available and may be selected by the user to represent different time periods. Selection of years followed similar logic as ETT data. The timeframe 1996-1999 was used for the Proposed Action/No Action comparison, since that period best represents MRGCD diversion operations at the time of species listing, with only minor modifications intended to specifically improve species conditions. The timeframe 2001-2004 may also be used, but represents some changes in MRGCD operation made for species, and 2003 and 2004 were years of short supply. The years 2007-2012 are selected as a good period to represent MRGCD diversion operation when analyzing effects of Offsetting Measures, since this reflects changes in operation made specifically to minimize effects to species. Data for the year 2000 is not complete. The year 2006 is atypical due to unusually high rainfall. The years 2013 and 2014 may be useful for future efforts, representing some intentional species operations around outfall locations, but both also were years of limited supply and this should be considered. At present, diversions for Cochiti and Angostura are not included in the FM. The FM handles those divisions as depletions and drain accretions only. Future revisions of the flow model will incorporate diversions at these upstream points.

5.2.1.3 Leakage to Groundwater

A value for seepage to groundwater use is also necessary, particularly for estimating flows through the Albuquerque reach of the river. While there are lesser groundwater withdrawals throughout the MRG, an initial estimate of this is done only for the ABCWUA withdrawal/return. Current evaluation of this by NMISC is approximately 60,000 AF/year. While the rate will vary somewhat throughout the year, this averages out to a steady loss form the river of about 80 cfs. This loss is spread throughout the Albuquerque area, and is complicated by the fact that ABQ makes a substantial contribution to river flow through its surface water treatment plant. At present this return flow is estimated to be about 70 cfs on average. While ABCWUA replaces nearly as much water as leaks from the river due to groundwater pumping, the return occurs midway through Reach 4, while loss happens throughout both Reaches 3 and 4. Flow at the lower end of Reach 3 is of concern for the BA, so this must be appropriately accounted for. Accordingly, a seepage loss of 40 cfs each has been assigned to Reaches 3 and 4, and an inflow of 70 cfs occurs in Reach 4, in an effort to accurately reflect flows at the end of each reach.

Other groundwater consumptive use is occurring in the MRG. Most notable would be Rio Rancho/Bernalillo area, the Albuquerque South valley area with its myriad of private domestic wells, and the Los Lunas/Belen area. These consumptive uses are clearly substantial, but nearly impossible to incorporate into the FM at this time. In the past, they have tended to be masked by agricultural operations, as agricultural deliveries have probably supplied a considerable portion of the recharge to offset consumption. More precise regulation and monitoring of agricultural supply in the future will probably lead to quantification of this water use, and eventually of its incorporation into models of this type. At present however, it should be noted by the users of the FM, that the model may tend to overestimate flow at critical measuring points due to this shortcoming. As with a number of other factors which cannot be fully defined in the FM, the overestimation should be consistent across all conditions, so values between conditions should remain comparable.

5.2.1.4 FM Relationships

As previously mentioned, the FM begins with an input value representing flow entering the MRG. This is supplied by the user from URGWOM model outputs for a particular condition to be modeled. The FM then depletes this flow by the aggregated depletions occurring in Reaches 1-3 for Riparian (col C), Open water (col D), Agricultural (Col E) and ABCWUA (Col F). These inputs are derived from the INPUT sheet in the workbook. Ag depletion is subject to whatever depletion factor is entered on col. AA on the INPUT sheet, and this is where ag depletions may be switched on/off, or adjusted for partial service from drain accretions. The end result is a rate of flow arriving at the outflow from Reach 3, equivalent to the Central Avenue gauge. The original FM did not distinguish between flow in floodway and drain. Recent changes to the FM incorporate a factor for river leakage, resulting in a certain portion of flow being in the drains.

The FM then processes Reach 4. In Reach 4, the flow at Central Avenue is depleted by Riparian (col H), Open water (col I), Agricultural (Col J) and ABCWUA (Col K). Then the MRG's largest tributary, the ABCWUA return flow, is added as an input to Reach 4 in col. L. This produces the flow arriving at Isleta dam (col M). Drain flow at this point is not critical, as most drain flow is returned just above the dam, and only minor flows (<10 cfs) bypass the structure on the west side of the RG. To arrive at the flow in the RG just below Isleta dam, the MRGCD diversion at Isleta Dam (col. N) is subtracted from available flow (col. M). A logical test is applied in Col. O, preventing diversion from exceeding available supply, and the resulting flow past Isleta Dam is then displayed in Col. O.

Moving downstream, aggregated depletions in Reaches 5 and 6 are deducted from the available water at Isleta Dam (Col M) for Riparian (col P), Open water (col Q), Agricultural (Col R), to produce the total available water arriving at San Acacia Dam (col S). Note that the depletions are applied to total available flow at Isleta, and not the flow in the floodway below Isleta Dam. Return flows are derived from diversion, less expected depletion, to the extent water is available to meet the diversion. An important recent update to the FM was a logical test to prevent diversion from exceeding water available.

At San Acacia Dam, the split of the flow arriving via the Unit 7 is determined through logic in Col. T, and then the Flow below San Acacia Dam is determined by subtracting both the MRGCD diversion at San Acacia (col. U) and the flow in the Unit 7 Drain. This has the practical effect of drawing the dividing line between Reach 6 and 7 just upstream of San Acacia Dam, but downstream of the point where Unit 7 drain can re-enter the floodway. The Logic in Col V results in Unit 7 returning to the floodway if MRGCD diversions are zero, or remaining out of the floodway and in the drain if MRGCD is diverting. Accretion to Unit 7 drain in reaches 5/6 are based on a percentage (7%) of flow in the floodway below Isleta dam, and 50% of the MRGCD Isleta diversion less agricultural depletions. The end result are realistic values for flows below San Acacia Dam (Col. V).

Reach 7 calculations in the FM involve subtracting depletions for Riparian (col W), Open water (col X), Agricultural (Col Y) from the total available water at San Acacia (col S) to produce the total available water arriving at San Marcial (col AA). As at San Acacia, the flow at San Marcial is then partitioned into the component in the LFCC (col AB) by assuming 30% of flow at San Acacia (col S) winds up as groundwater accretion to the LFCC, or MRGCD return flow. The flow in the floodway at the San Marcial Gauge (col AC) is then determined by subtracting the component of flow in the LFCC (col AB) from the total arriving at San Marcial (Col AA).

5.2.1.5 Output Analysis

The FM spreadsheet includes a sheet titled ANALYSIS. In this sheet, the values from the FLOW MODEL sheet are compared to user test conditions. The user adjustable conditions are set in the boxes across the top of the sheet, and this then produces number of days or years that particular condition is met in the model. For Central Avenue, user adjustable test conditions are in Column C, For Isleta Column K, for San Acacia Column S, and San Marcial Column AA. With a little consideration, the purpose and use of these test conditions should be readily apparent to the user.

5.2.1.6 Using the Flow Model

Any particular set of flow conditions should begin by opening the Flow_Model_10Year_Template file. This should then immediately be saved as a new file name identifying the flow scenario to be entered, preserving the unaltered template. The newly created file should then receive appropriate inputs. All inputs should be made in the INPUTS sheet. The primary input will be Column B, into which the flow entering the MRG below Cochiti Dam should be cut/pasted from URGWOM output. Columns in the INPUT sheet for depletions (Columns C-S) can be changed if necessary, but presumably will remain the same for the present. For Flow scenarios where MRGCD diversions are expected to operate no, additional changes are necessary. However, Columns T-U contain average MRGCD diversions for Isleta and San Acacia, so if a flow scenario includes no diversion for MRGCD, the values in these two columns should be replaced with 0's (check carefully, as the top of the columns always show zeros anyway). Finally, there are four values at the top of the sheet in column D which represent the percent of ag depletions which are to be met. The template contains values believed appropriate for the No Action (MRGCD not diverting) scenario. These are user adjustable, and for scenarios where MRGCD is expected to be in normal operation, these for values should all be set to “1” (100% ag depletions met).

Column Z in the INPUT sheet was included to simulate the effects of an additional water source in Reach 7. This was specifically considered so that the effects of supplemental pumping could be considered. In the absence of pumping, this column should include all zeros, or appropriate values if pumping is to be included. At present, it is simply added to the available flow arriving at San Marcial. No provisions for additional sources of water are included in the FM, though this could readily be done in the future if desired.

After providing the correct Input values, the user should switch to the ANALYSIS sheet. There, one can view the number of days, and the number of years in which the defined conditions are met. The conditions can be changed if desired. Two conditions are available, should one wish to compare the occurrence of more than one flow.

To evaluate the presence or absence of conditions believed likely to produce successful spawning, a logical test is provided for flow and duration between April 15 and June 15 of each year. The values used can be set in the same box as the flow conditions for Central Avenue. Initial values used were 2500 cfs, for a minimum of 7 days, based on conversations with Gary Dean at BOR and Mickey Porter at USACE. However the user is free to substitute any conditions they deem appropriate for a successful spawn. The logic in Col N starts a counter whenever the min flow is reached, which continues to increment every day the flow occurs. It resets to zero if the flow is not reached on a day, and a fresh count must start. Logic in Col O evaluates whether the count has reached the value specified for minimum duration, and if so writes a zero. Logic in Col P tests to see if the value in Col O is greater than zero in any year, indicating that successful spawn conditions were met.

5.2.1.7 Considerations to be aware of

Actual Cochiti Dam and Angostura Dam rates of diversions are not yet incorporated in the model. The FM only uses the depletions expected to result from those diversions. This could change the results when operating at very low inflows with no stored water. At higher natural inflow, and when MRGCD is releasing stored water for diversion at Isleta Dam, there should be no effect on FM output in the upper reaches.

The FM is does not incorporate potential rainfall inputs in the MRG. In this regard, the FM is a “worst case” analysis. Any rainfall inputs to the MRG will increase flows, and reduce the incidence of drying. Rainfall inputs tend to be unpredictable, and no reasonable methodology appeared to allow their inclusion. However, MRG rainfall inputs generally occur in the form of thunderstorms in the July-August period. These flows can and do contribute appreciable volume of water to the river system, however the duration is usually very brief, so while the number of days might be reduced, the drying condition for a year likely would not change. In other words in a particular year, the drying might change from 100 days to 90 days, or 40 days to 30 days, but the drying condition would still have been met in the year. Along the same lines as the earlier mentioned unquantifiable groundwater depletions, rainfall events should affect all No Action and Proposed Action the same way, so the relative difference between conditions should be comparable.

The influence of summer precipitation events is not completely absent from the FM. The URGWOM model incorporates summer precipitation inputs above the MRG. Also, rainfall events within the MRG and incorporated in the URGWOM model help to determine NM Compact deliveries, and by extension storage and release of water upstream from the MRG. While URGWOM cannot accurately predict daily flows at points in the MRG, it does well on annual inflow/outflow basis and thus does realistically simulate NM RGC status.

The FM contains no time-lag between physical points. A flow at Cochiti translates instantly into a flow at San Marcial. Of course this is not reality, but for the purposes of the FM, and especially since other factors (ag, riparian, ow, diversions) are entered into the model as averages over time, this is expected to give reasonable results. The FM could be easily time-lagged if desired, but it would introduce another layer of complexity to the spreadsheets, trying to keep up with which rows corresponded, and probably would not produce significantly better results.

Numbers in the model have not been rounded. Although the formatting is set to display only integer values, most numbers are floating point with many digits to the right of the decimal.

5.3 Drying Model (graphical representation of available habitat)

Efforts to prepare a BA for the MRG have been influenced by the difficulty translating hydrologic impacts of actions into effects on species. An offshoot of Flow Model development is a graphical representation of river drying for each year, making it possible to determine the effect of water operations on availability of habitat. While it remains uncertain what the biological effect to species may result from changes in habitat presence, absence, or distribution, this drying analysis allows a degree of quantification of changes to habitat that may result from the Proposed Action, and the corresponding Offsetting and Conservation Measures offered by the BA Partners.

To provide this graphical analysis, MRG habitat is considered as 172 miles of riverine habitat which may potentially be occupied by RGSM (or other aquatic species). This habitat begins immediately below Cochiti Reservoir (BOR river mile 232.6), and ends 8 miles below the San

Marcial stream Gauge (BOR river mile 60). For the purposes of the drying analysis, miles are counted from 1 to 172 in the downstream direction.

Flow inputs for the model are placed in Sheet 1, Col. C-I, Row 15-64, producing a table of 350 values derived from the flow model. At the top of this table, Sheet 1 also contains (Row 14) the expected minimum flow required to keep each segment from drying, divided by the segment length, resulting in a depletive factor.

The model itself occurs on Sheet 3. A logical test is performed at the beginning of each segment (col C, as an example) to determine whether the expected inflow from the downstream reach (Col D) is greater than zero (full flowing) and if so the entire reach length is placed in Col C. If the inflow to the downstream reach is zero, the reach length placed in Col C. is reduced by the % of inflow occurring divided by that required for full flow. Subsequent columns each represent individual miles of the reach. Cells in each of those subsequent columns divide the value in Col C by the reach mile that corresponds to that column. The result is a value either greater than, or less than, 1. A logical formatting test causes each cell to be colored blue if the value is greater than or equal to 1 indicating that mile is expected to remain wet, or brown if the value is less than 1 and inflow to the reach is not sufficient to keep that mile wet.

The process resets, using different reach lengths, inflow/outflows, and depletion rates at Central Avenue gauge (mile 49, Col BB); Isleta Dam (mile 63, Col BQ); San Acacia Dam (mile 116, Col DX); and San Marcial (mile 164, Col FV). There are different spreadsheets for the No Action and Proposed Action evaluations. In the Proposed Action spreadsheet additional logic is applied between Belen (mile 83) and the 9-Mile outfall (mile 128) to account for irrigation return flow and irrigation facility/river gradient reversal. This conditions the drying indication such that if sufficient water arrives at Isleta dam to allow normal MRGCD Belen Division operation, the lower 32 miles of the Isleta reach does not dry. Similarly, if sufficient water arrives at San Acacia to allow normal MRGCD Socorro Division operation, the upper 9 miles of San Acacia reach cannot dry.

The final output then becomes a graphical representation of the habitat expected to remain wet, and thus capable of being habitat for RGSM and other aquatic species throughout a year. Each row represents 172 miles of habitat over an entire year, arranged upstream (left) to downstream (right). Key flow or geographic demarcations are indicated by dark vertical lines.

Use of the drying model is simple. For any particular scenario to be examined, inflows to reaches are placed in sheet 1, Col C-I, in appropriate rows. Care should be taken to select the correct file (no diversion, or normal diversion). If changes in rules are desired by the user, these would be defined in sheet 1, row 14, where reach length and required full flow are defined. As with the Flow Model, the drying model represents a “worst case” view of drying, being based on minimum inflow to reaches expected to occur in any year. In many years there may be less drying than the models would indicate due to MRG rainfall inputs, local climate, or other factors. However, those would be expected to affect different scenarios in similar fashion, so the relative differences between different modeled scenarios should not be affected.