6. Effects Analysis

"Effects of the action" refers to the direct and indirect effects of the Proposed Action on listed species or critical habitat together with the effects of other activities that are interrelated or interdependent with that action. These effects are considered along with the environmental baseline to determine the overall effects on the species (50 CFR Part 402.02). For purposes of this BA, effects on listed species and designated critical habitat are analyzed for the full suite of Proposed Water Management Actions as well as individually, where possible, for the discrete actions.

This section presents an evaluation of the hydrologic effects of the Proposed Water Management Actions and the predicted effects that those would have on the listed species. Reclamation and its non-Federal partners propose to continue water operations as described in section 3. Reclamation has deemed that the effects of these Proposed Water Management Actions can best be presented through a combination of analyses.

These include:

- Assessment of the composition (in terms of the source of water, and whether the water has been stored in a reservoir) of the flows that provide supply to the MRG; as well as the distribution of uses of that water;

- Evaluation of the total, aggregate impacts of Reclamation and non-Federal Proposed Water Management Actions without the use of Supplemental Water (Proposed Water Management Action). The model runs used assume operation of the facilities to meet the flow targets as defined by the 2003 BiOp. These actions are not part of the Proposed Action but were necessary to define the operations for the model.

- Action-by-action analysis of the relative effects of individual components of the Proposed Water Management Actions, to the extent practical, through the comparison of a simulation with those actions to a simulation in which those actions did not occur. Individual components of the Proposed Water Management Actions that were evaluated in the action-by-action analysis include:

    - Reclamation's operations at Heron Dam.

    - Actions by Reclamation and the MRGCD related to the operation of El Vado Dam.

- MRGCD's surface water diversions and associated water management actions.

- An assessment of the effectiveness of proposed conservation measures of Reclamation and the MRGCD in offsetting the aggregate impacts.

6.1 Approach, Tools, and Methods for Hydrologic Analysis

Reclamation performed the hydrologic analyses that support this effects analysis using a combination of hydrologic modeling and analytical computations. The URGWOM was used for the majority of the analyses. URGWOM is, a computational, rule-based, water operations computer model that simulates physical processes and operations of facilities in the Rio Grande Basin in New Mexico. URGWOM has been developed through an interagency effort and is constantly being refined. It is the only model available that can perform the needed analyses at a daily time-step and can make computational estimates of river drying. URGWOM individually tracks water allocated for specific uses, and Reclamation has used this capability to isolate the effects of individual actions evaluated in the action-by-action portion of this effects analysis.

Reclamation completed the simulations, as well as the analytical computations that support the modeling, using five 10-year synthetic hydrologic sequences developed with reference to paleo-climate data to represent the range of past hydrologic variability in the MRG Basin. The hydrologic sequences represent hydrologic conditions for which total annual flow at Otowi gage has a 10, 30, 50, 70, and 90% chance of being exceeded (higher exceedence curve represents drier conditions). Reclamation, in cooperation with the Population and Habitat Viability Assessment workgroup of the Collaborative Program, developed these sequences to capture the full range of variability in the hydrology and climate that have been experienced over the past 604 years, as captured in tree-ring records (Roach 2009; appendix 1). These sequences represent a range of hydrologic conditions that might reasonably be expected to occur during the time period associated with this BA.

The sequences were developed through a statistical sorting of the hydrologic years contained in the 604-year reconstruction (Gangopadhyay and Harding 2008, appendix 1). From the years within the reconstruction, 1,000 10-year sequences were constructed. The sequences of years were corrected to ensure that the year-to-year transitions were consistent with those in the hydrologic record but were otherwise randomly composed. For each of these sequences, the total flow past Otowi gage over the 10 years was calculated and compared to the range of 10-year total flows for the full set of 1,000 sequences. The five sequences for which the total flow past Otowi gage over the 10-year period was closest to having a 10, 30, 50, 70, and 90% chance of exceedence among the full suite of sequences (i.e., for the 90% sequence, 90% of the sequences had more water flowing past Otowi gage over the 10-year period than flowed past the gage in this sequence) were selected as the sequences for which Reclamation would analyze the impacts of the Proposed Water Management Actions in this BA. Each year in a selected sequence was then matched to the actual year in the URGWOM record (1975–2007) with the most similar total flow past Otowi gage, and that year's daily hydrologic record was used to distribute the total annual flow to daily flow for the modeled year.

It should be noted that these sequences were developed based on the total flow past Otowi gage, which is upstream of the MRG. The flow past Otowi gage is a good indicator of the total snowmelt runoff in a given year but does not fully reflect the strength of the summer monsoons, particularly in years for which summer moisture is distributed disproportionately downstream of Otowi gage. However, the years contained in the URGWOM record reflect a range of monsoon conditions. Since actual years in the 1975–2007 period are used in the simulations as representations for hypothetical years in the sequences, the monsoon volumes in the sequences are paired with flows past Otowi gage as they have been in recent years.

Figure 59, below, provides a comparison of the hydrologic conditions, as depicted by the distribution of flows at Otowi Bridge, in the five synthetic hydrologic sequences against the mean of those experienced under baseline conditions for this BA.

The distribution of flows at Otowi Bridge experienced during the baseline period (2001–2011) is within the envelope of flows defined by the five hydrologic sequences. Except among the very lowest flows (percent chance of exceedence 95–100%, for which the baseline and synthetic sequences are all in approximate alignment), baseline conditions fall between the two driest synthetic sequences, those with a respective 70 and 90% chance of exceedence.

The modeling analyses presented in this section do not consider the potential impacts of climate change on water resources and on Reclamation’s water operations, since Reclamation’s work evaluating the likely future impacts of climate change in the MRG Basin is not yet complete. However, the inclusion of the range of hydrologic variability, as determined from the 604-year tree ring analysis, serves as a proxy for quantitative climate-change analysis, in that it allows for consideration of a wider range of hydrologic variability than has been experienced during the period for which flows have been monitored. Past and current climatic conditions are described in Section 5, Environmental Baseline. A more detailed discussion of the current and potential impacts of climate change is contained in Section 7, Cumulative Effects Analysis.

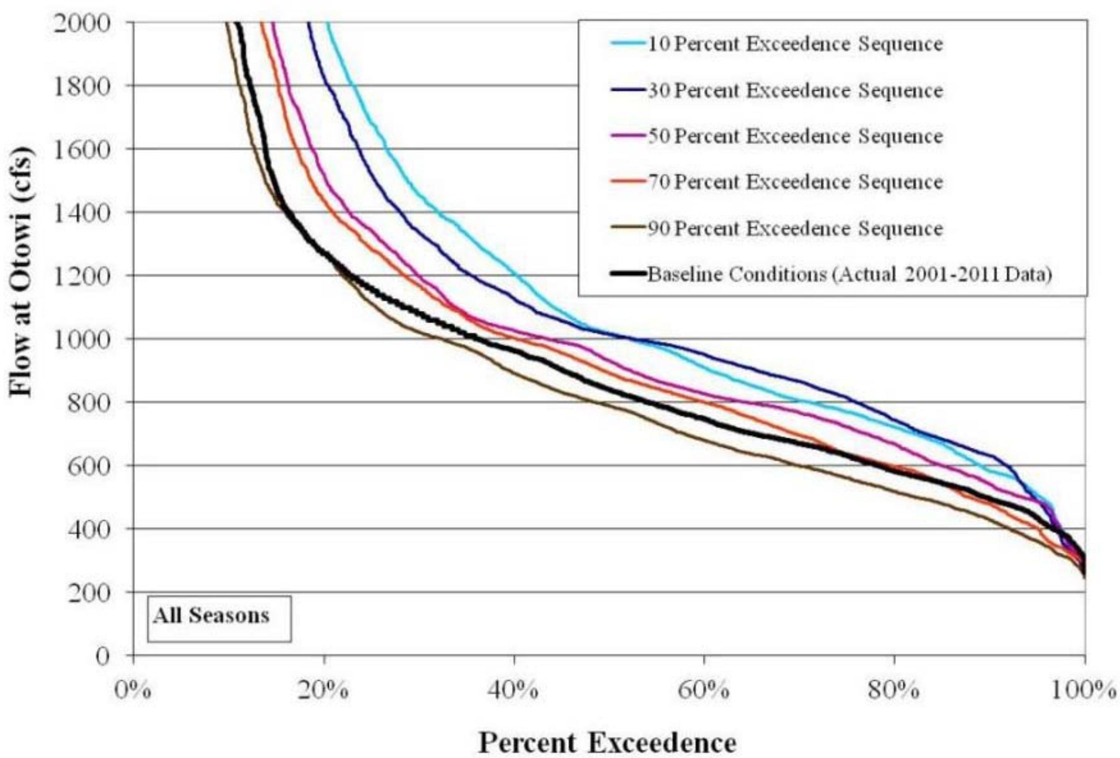

Figure 59. Comparison of flows at the Otowi Bridge for the Proposed Water Management Actions under the five hydrologic sequences against baseline conditions.

In the action-by-action analysis, Reclamation analyzed the discrete impacts of individual actions by utilizing model runs for the Proposed Water Management Actions, and sequentially turning off specific actions, so that the model runs without a particular action could be compared to model runs with that action, and the difference between the two could be assessed. Please note that the Proposed Action model runs also include the interrelated and interdependent actions of the Corps and State Letter Water releases as described in 3.2.1.

The combined impacts on river flows of the Proposed Water Management Actions and the impacts of individual actions in the action-by-action analysis are presented through several graphical methods, including box-and-whisker plots, which characterize ranges of variation in flows as the result of particular actions, and flow exceedence curves, which present flows, or differences in flows, that result from particular actions against total flow. The flow exceedence curves represent the percentage of time that a given river flow is equaled or exceeded. The majority of the curves were assembled using the results for all of the five hydrologic sequences, so they represent 50 years of simulation results and a broad range of historic hydrologic variability. They can be used to interpret the chance of occurrence of overbank flows as well as the chance of river drying.

6.1.1 Model Uncertainty and Refinements to Support Hydrologic Analysis

The URGWOM model realistically simulates water management scenarios through the Rio Grande/Rio Chama system to Cochiti Reservoir based on past gage data, expected runoff volumes, and reservoir operating rules. However, the outputs from the URGWOM model become appreciably less certain for locations downstream from Cochiti Dam. This is due to a highly complex interaction of consumptive uses and ground water exchange into and out of the river. In recent years, significant effort has gone into calibrating the URGWOM model to better reflect MRG conditions, and it is improved. Still, calibration has only been possible against observed conditions, and the No Action condition, in which none of the Proposed Water Management Actions are being performed, has not occurred since before flow monitoring began. Because of this lack of knowledge about the No Action condition, the model is unlikely to accurately reflect the extent and duration of river drying. Therefore, the extent of river drying under the No Action condition has been assessed and compared to the extent of river drying under the Proposed Water Management Actions using an analytical spreadsheet model developed by the MRGCD.

Because of the uncertainty in the degree of river drying under the No Action condition, graphs are provided in this effects analysis that present the difference in flows between model runs. These graphs depict the effects of proposed actions in terms of relative changes to flow rather than the absolute flows. Also, additional analyses have been performed using a spreadsheet model developed by the MRGCD to compare the drying, as well as high flows, under the Proposed Water Management Actions relative to the No Action condition. The results of these computations are provided in tabular form. The PHVA workgroup of the Collaborative Program and Reclamation, in coordination with the URGWOM Technical Team (an interagency team of modelers who have been working together to create and refine the URGWOM model), have made significant enhancements to URGWOM the planning module and to URGWOM’s representation of the rules that govern operational policy in this basin to support the modeling efforts presented in this BA. These include refinements and corrections to the model as well as the incorporation of new processes, such as the ABCWUA drinking water project and the Buckman Direct Diversion. A full data management interface (DMI) was established in URGWOM to allow model inputs to be set efficiently for all simulations, and spreadsheet tools were set up to facilitate postprocessing and review of results from all the completed model runs. These enhancements were made both prior to and during the modeling efforts to support this BA. The list includes enhancements made in response to comments received on the first draft of this BA, which was distributed to members of the water management community on August 18, 2011. The current configuration of the URGWOM planning model and the refinements made to it as part of this process are summarized in the URGWOM modeling report presented in appendix 7.

An analysis has been completed to develop appropriate initial conditions for reservoir storage and account status to use in BA model runs. These initial conditions reflect conditions as of December 31, 2011, and are described in appendix 4.

6.1.2 Approach for Analysis of Effects to Listed Species

URGWOM hydrologic modeling represents Reclamation's best understanding of the hydrologic effects that may occur due to the Proposed Water Management Actions. Effects to the species are evaluated using this modeling and species information presented in the baseline. Additional modeling is presented in this section as needed to better understand conditions that may affect listed species.

Environmental conditions and water management decisions within the MRG are correlated both spatially and temporally and, thus, are not independent of each other. Several levels of effects to the listed species are considered in this BA. Any action that may cause mortality of an individual is considered "likely to adversely affect" even if the long-term indirect effects are likely to be beneficial. Population level effects are more difficult to predict and are presented using the best available information for each species. It is anticipated that a silvery minnow population viability model (PVA) may be available to develop the biological opinion that can give a better resolution of the management actions effects on long-term viability of silvery minnow in the MRG.

The only currently viable population of Rio Grande silvery minnow exists within the project area described within this document. Due to the lack of any interaction with other populations of silvery minnow, actions that occur within this area have direct ramification to the species existence. Timing and magnitude of discharge and geomorphic trends through the MRG are key factors driving population levels. Proposed Water Management Actions may affect spring runoff, magnitude, and duration of summer drying as well as winter flows. These hydrologic parameters affect each life stage of silvery minnow (spawning, larval development, juvenile, and adult survival), as well as habitat availability and quality and water quality. There is evidence presented both by population monitoring and preliminary PVA analysis that suggests that successful recruitment of silvery minnow is strongly linked to the magnitude and duration of spring runoff, with population increases coinciding with the inundation of overbank habitats supporting larval development. Drying of the river, which occurs mainly during summer and fall months, causes mortality for silvery minnow.

The MRG currently supports a large proportion of the total population of the endangered flycatcher when compared range wide. Water operations can have both positive and negative effects on flycatchers and the vegetative habitat they find suitable. In general, actions that promote overbank flooding or maintain moist soil conditions during territory establishment (approximately May 10‾June 15) are beneficial for flycatchers and vegetative health. Suitable flycatcher habitat typically only remains suitable for a short amount of time (5 to 15 years depending on environmental conditions) when vegetation composition and structure are within a certain age class. For this reason, flycatchers depend on an ever changing environment where vegetation has the opportunity to continuously over mature in some areas and regenerate and reach maturity in other areas.

There are currently two populations of Pecos sunflower in the MRG. The La Joya population is mainly affected by actions that would change the delivery of water to the La Joya SWA. The Rhodes population is in the flood plain of the river and would be affected by actions that change the incidence of overbank flows in the San Acacia Reach. There is no critical habitat associated with the MRG for Pecos sunflower. Pecos sunflower effects are consolidated in section 6.3.3, while silvery minnow and flycatcher effects are presented with each action.

As previously mentioned in the Status and Distribution section of this analysis, the interior least tern can be considered a vagrant on the MRG, and no interior least tern nesting has been recently documented (Service 1995). According to the Recovery Plan from the Service in 1990, the only documented breeding along the Rio Grande takes place in Texas, and the only documented breeding within the State of New Mexico can be found on the Pecos River (Service 1990); similar conclusions are drawn in the complete range-wide survey collected in 2005 (Lott 2006). Due to the low potential for occurrence and that the interior least tern likely only would be present infrequently and/or temporarily (i.e., during migration), the interior least tern likely would not be affected by the project; and no further analysis will be completed on behalf of the species.

6.1.3 Continuation of Geomorphic Trends

The reductions in peaks, increased low flow duration due to water use within the basin, and reduced sediment supply from in place dams has altered the geomorphology of the MRG from a wide, active channel to a narrow, stabilized system. The historic pattern was characterized by large, high energy flows, which reworked sections of the river and flood plain, removed vegetation, supplied sediment, and may have relocated the main channel laterally to lower elevations. This pattern resulted in a wide, braided, sandy channel that was well connected to the flood plain.

The current condition, with lower peak discharges, allows vegetation to establish that, in turn, causes the channel to narrow and become more simplified with little within-channel habitat diversity. In reaches where sediment supply is low, the river has become disconnected from the flood plain and is less likely to inundate the flood plain than in the historical condition. Generally, areas that have high sediment load and low sediment transport have a greater connectivity to the flood plain and provide more complex habitat at all flows; however, these sections are also more prone to intermittency due to the perched nature of the channel causing the flow to go subsurface.

The Proposed Water Management Actions are not anticipated to have trend-reversing effects on the geomorphology within the MRG. The river is expected to continue to trend towards a narrower, more simplified channel. Channel degradation downstream from Cochiti Dam is expected to continue and to extend further downstream. Currently, the designated safe discharge from Cochiti Dam is 7,000 cfs; and significantly larger discharges would be needed to reverse the geomorphic trends. Habitat restoration and river maintenance activities have had some impact on this trend but have not been performed on a large enough scale to return the river to predevelopment conditions. These restoration projects also will require periodic maintenance to function as designed.

6.2 The Composition of Middle Rio Grande Flows

This section breaks down sources of water providing flows to the MRG at Cochiti Dam as well as of water used to meet the MRGCD diversion demand for the Six MRG Pueblos, the MRGCD's non-Indian irrigators, and the BDANWR. These breakdowns indicate the original sources of the water (native versus. non-native), whether or not the water has been stored (natural flow versus released from storage), and the use or fate of the water (diverted for beneficial use or delivered to Elephant Butte). These breakdowns were developed from URGWOM simulations performed for this BA and present these water sources and fates for each of the five synthetic hydrologic sequences.

The breakdowns of the sources and fates of water that are presented in this section represent the range of 10-year average hydrologic conditions that are likely to be encountered under stable climatic conditions as well as the degree of variability of these conditions in individual years. These breakdowns provide an indication of the scale of the effect of upstream water management actions presented in this BA as well as the degree to which changes to these actions can affect flow conditions in the MRG.

Natural flow, which constitutes the majority of MRG flows, is comprised of natural flow from the main stem, unregulated tributary inflows, and native water from the Rio Chama that has been bypassed from storage at El Vado Dam. The natural flow bypassed at El Vado may be regulated at Abiquiu or Cochiti Dams and still maintains its designation as natural flow for this analysis.

The analysis also shows native water released from storage at El Vado Reservoir and non-native SJC Project water. Native water released from storage at El Vado Reservoir includes:

- Water stored during times in which native inflow to El Vado exceeded irrigation demand, and in which Article VII restrictions under the Rio Grande Compact are not in effect.

- Water stored in El Vado during times in which Article VII restrictions under the Rio Grande Compact are in effect to meet the irrigation requirements of the lands of the Six MRG Pueblos with prior and paramount water rights.

- Water stored in El Vado during times in which Article VII restrictions under the Rio Grande Compact are in effect, but storage is allowed in equal exchange for delivery credits by New Mexico to Texas that have been relinquished under the terms of the Rio Grande Compact. Water has been stored at El Vado under this process in the past decade by agreement (i.e., EDWA) between the State of New Mexico, the MRGCD, Reclamation (for its Supplemental Water Program), and New Mexico municipalities. The EDWA s only a result of initial conditions, not additional relinquishments or allocations.

SJC Project water includes water released from Heron Reservoir to meet the needs of 16 SJC project contractors, including ABCWUA and the MRGCD, as well as water leased by Reclamation under its Supplemental Water Program. SJC Project water may be released to meet contractors' needs or may be released as "Letter Water," to offset the impacts of ground water pumping. SJC Project water released from Heron may be temporarily stored or reregulated at El Vado, Abiquiu, or Cochiti Reservoir and still be presented as SJC Project Water for this analysis. SJC Project water maintains its identity until it is fully depleted within the State of New Mexico.

6.2.1 The Composition of River Flow at Cochiti Dam

To better understand water management in the MRG. it is important to first understand the composition of water under various conditions. This section shows the average percentage contributed by each source of water that provides flows at Cochiti Dam (table 13) and the average uses or fates of that water over a calendar year for the five hydrologic sequences used in this effects analysis. The first three rows of this table (shown in blue) indicate that, on average, about 90% of the water in the MRG is composed of the natural flow in the Rio Grande system, consisting of native water of the Rio Grande and its tributaries that has not been stored for beneficial use at a Reclamation reservoir. Of that 90%, over 32% is used to meet MRGCD's irrigation demand, and the rest is conveyed to Elephant Butte Reservoir to support New Mexico's compliance under the Compact. Releases of native water from El Vado (shown in green, in the second block of rows) total an average across the calendar year of only 3% of the flow out of Cochiti Dam, including native storage, storage for irrigation of lands with prior and paramount water rights, and relinquished credit water under the Rio Grande Compact ("EDWA water"). SJC Project water (shown in purple, in the third block of rows) makes up an average of just over 7% of the flow out of Cochiti Dam. Table 14 presents the percentage of the total flow that goes to the major SJC Project contractors—MRGCD and ABCWUA—as well the portion that is used to supplement river flows under Reclamation's Supplemental Water Program. Flow to other contractors that do not lease their contracted water to the Supplemental Water Program is negligibly small.

Table 13. Composition of river flows below Cochiti Dam as percent: calendar year

	Wetter →									*Drier*	
WATER SOURCE OR USE	**10%-Exceedence Sequence**		**30%-Exceedence Sequence**		**50%-Exceedence Sequence**		**70%-Exceedence Sequence**		**90%-Exceedence Sequence**		**Avg**
Natural Flow of Rio Grande System	**90.8**		**89.6**		**90.5**		**90.1**		**89.2**		**89.8**
Diverted to meet MRGCD and BDA Demand		23.4		27.0		31.0		33.5		37.5	32.3
Delivered to Elephant Butte		67.4		62.6		59.5		56.6		51.7	57.6
El Vado Releases	**4.3**		**4.1**		**2.7**		**2.7**		**2.4**		**3.0**
Native Storage		3.5		3.2		1.1		0.8		0.1	1.3
Prior and Paramount, for demand		0.1		0.1		0.2		0.2		0.4	0.2
Prior and Paramount, unused, evacuated		0.2		0.2		0.7		0.9		1.0	0.7
EDWA (MRGCD)		0.3		0.3		0.4		0.4		0.5	0.4
EDWA (Reclamation)		0.2		0.3		0.3		0.3		0.4	0.3
SJC Project Water	**4.9**		**6.4**		**6.9**		**7.2**		**8.4**		**7.2**
MRGCD		1.4		2.4		2.6		2.5		3.4	2.7
ABCWUA Diversion		2.7		3.1		3.5		3.7		3.8	3.5
Supplemental Water Program		0.8		0.8		0.8		1.1		1.1	1.0

Table 14 depicts the composition of flows, by percentage, which makes up the supply used to meet the MRGCD diversion demand over the calendar year. The water diverted by the MRGCD is used to meet the needs of the Six Middle Rio Grande Pueblos as well as the MRGCD's non-Indian irrigators. Diverted water that remains at the end of the MRGCD's system is delivered to the BDANWR. The MRGCD estimates this delivery to be 40,000–60,000 acre-feet per year, most of which is passed through the refuge and returned to the LFCC. The actual volumes associated with the MRGCD's diversion demand are provided in appendix 5, by month and by diversion structure.

The composition of the water that is used to meet the diversion demand of the MRGCD differs somewhat from the composition of water at Cochiti Dam but shows the same general character in which most the water is supplied by the natural flow of the Rio Grande and its tributaries. Additionally, 79% of the diversion requirement at the MRGCD's four main stem diversions (Cochiti Dam and Angostura, Isleta, and San Acacia Diversion Dams, but not the LFCC diversions) is met by natural flows of the Rio Grande system, consisting of native flows not stored at El Vado Reservoir and over which Reclamation has no control. Only 5.9% of water diverted at these four main stem MRGCD diversions is composed of Reclamation's releases of Rio Grande water from storage at El Vado Reservoir. Reclamation's SJC Project releases account for approximately 6.7% of the MRGCD's irrigation demand. The remainder of the MRGCD's irrigation demand (as defined by the irrigation demand curves used in the URGWOM model (appendix 5) remains unmet.

Table 14. Composition of the diversion demand of the MRGCD, as percent: calendar year

	Wetter →									*Drier*	
WATER SOURCE OR USE	**10%-Exceedence Sequence**		**30%-Exceedence Sequence**		**50%-Exceedence Sequence**		**70%-Exceedence Sequence**		**90%-Exceedence Sequence**		**Avg**
Natural Flow of Rio Grande System	**78.8**		**80.8**		**82.0**		**79.3**		**74.5**		**79.2**
Releases from Storage	**12.0**		**8.4**		**6.3**		**4.9**		**4.0**		**5.9**
Native Storage		10.1		6.5		2.9		1.3		0.1	2.7
Prior & Paramount, for demand		0.3		0.3		0.5		0.4		0.8	0.5
Prior & Paramount, unused, evacuated		0.6		0.6		1.9		2.1		2.1	1.7
EDWA (MRGCD)		1.0		1.0		1.0		1.0		1.0	1.0
MRGCD SJC Project Water	**4.8**		**7.2**		**6.8**		**5.9**		**6.8**		**6.7**
Deficit	**4.4**		**3.5**		**4.9**		**9.9**		**14.7**		**8.2**

Table 15 shows sources of flow and uses or fates of water for the five hydrologic sequences during the snowmelt runoff season (March–July). A comparison of table 14 to table 16 shows that the proportion of the flow out of Cochiti that consists of the natural flow of the Rio Grande system is higher during the snowmelt runoff season than in the year overall. This is because, during the snowmelt runoff season, natural flow typically provides more than sufficient water to meet the irrigation demand; and, therefore, releases of native water in storage or SJC Project water are usually not needed to meet demand (native water is usually being stored in El Vado during this period). Some releases of native water from El Vado and SJC Project water occur during this period, particularly in the later part of this period in years for which the runoff ends before July, but the amount is lower than during the year overall.

Table 16 shows the composition of flows out of Cochiti Dam during the later part of the irrigation season, after the snowmelt runoff is complete (August–October). During this period, the use of stored native water and SJC Project water is at its maximum. However, even during this period, over 79% percent of the flow is composed of natural flow.

Table 15. Composition of River Flows below Cochiti Dam as percent: runoff season (March–July)

	Wetter →									*Drier*	
WATER SOURCE OR USE	**10%-Exceedence Sequence**		**30%-Exceedence Sequence**		**50%-Exceedence Sequence**		**70%-Exceedence Sequence**		**90%-Exceedenc e Sequence**		**Avg**
Natural Flow of Rio Grande System	**94.1**		**92.8**		**93.3**		**91.6**		**89.7**		**91.8**
Diverted to meet MRGCD and BDA Demand		24.8		28.2		32.9		36.1		43.1	35.1
Delivered to Elephant Butte		69.3		64.6		60.3		55.5		46.6	56.8
El Vado Releases	**2.2**		**1.6**		**2.1**		**1.8**		**2.4**		**2.0**
Native Storage		1.6		0.9		0.8		0.4		0.1	0.5
Prior and Paramount, for demand		0.1		0.1		0.2		0.3		0.5	0.3
Prior and Paramount, unused, evacuated		0.0		0.0		0.2		0.1		0.5	0.2
EDWA (MRGCD)		0.3		0.1		0.5		0.5		0.7	0.5
EDWA (Reclamation)		0.3		0.4		0.4		0.5		0.6	0.5
SJC Project Water	**3.7**		**5.7**		**4.7**		**6.6**		**7.9**		**6.2**
MRGCD		1.2		2.8		1.5		2.7		3.7	2.7
ABCWUA Diversion		1.4		1.9		2.2		2.2		2.6	2.2
Supplemental Water Program		1.1		0.9		1.1		1.7		1.6	1.3

Table 16. Composition of river flows below Cochiti Dam as percent: late (postrunoff) irrigation season (August–October)

	Wetter →									*Drier*	
WATER SOURCE OR USE	**10%-Exceedence Sequence**		**30%-Exceedence Sequence**		**50%-Exceedence Sequence**		**70%-Exceedence Sequence**		**90%-Exceedence Sequence**		**Avg**
Natural Flow of Rio Grande System	**72.1**		**77.2**		**75.6**		**81.9**		**82.5**		**79.3**
Diverted to meet MRGCD and BDA Demand		51.2		54.3		59.7		69.4		67.2	62.7
Delivered to Elephant Butte		20.9		23.0		15.8		12.5		15.3	16.6
El Vado Releases	**17.3**		**12.7**		**8.3**		**8.0**		**5.5**		**8.6**
Native Storage		14.5		9.7		3.9		2.1		0.0	3.9
Prior and Paramount, for demand		0.1		0.1		02		0.1		0.5	0.2
Prior and Paramount, unused, evacuated		1.2		1.2		3.7		5.2		4.3	3.6
EDWA (MRGCD)		0.9		1.7		0.5		0.7		0.7	0.9
EDWA (Reclamation)		0.5		0.0		0.0		0.0		0.0	0.0
SJC Project Water	**10.7**		**10.1**		**16.1**		**10.0**		**12.0**		**12.1**
MRGCD		4.6		3.5		10.3		5.0		7.1	6.5
ABCWUA Diversion		5.4		5.2		5.0		4.9		3.9	4.8
Supplemental Water Program		0.7		1.4		0.8		0.1		1.0	0.9

The tables presented thus far in this section depict average conditions over 10-year periods for a variety of hydrologic conditions. Table 17 displays the degree to which these conditions can vary in individual years, based on the volume of the natural flow and the availability of water stored in reservoirs from previous years. The largest component of natural flow would occur in a year for which the initial reservoir storage is small and the natural flow is large. In the modeled year for which these conditions are most extreme, the percentage of MRG flows made up of natural flow of the Rio Grande system is 95.2%. In this high-natural-flow year, the component of MRG flow that is made up of water that had been stored in El Vado is 3.0%, and the component made up of SJC Project water is 1.8%. The largest contribution of stored and non-native water would be in a year with large initial reservoir storage and a small natural flow. In the modeled year for which these conditions are the most extreme, the percentage of MRG flows made up of natural flow is only 74.0%. In this low-natural-flow year, the component of MRG flow that is made up of water that had been stored in El Vado is 9.8%, and the component made up of SJC Project water is 16.2%.

Table 17. Composition of river flows below Cochiti Dam, as percent: range of variability for individual years

WATER SOURCE OR USE	Individual Year with Small Reservoir Storage and Large Natural Flow	Individual Year with Large Reservoir Storage and Small Natural Flow
Natural Flow of Rio Grande System	95.2	74.0
Diverted to meet MRGCD & BDA Demand	17.1	38.8
Delivered to Elephant Butte	78.1	35.2
El Vado Releases	3.0	9.8
Native Storage	1.8	6.5
Prior & Paramount	0.0	2.4
EDWA (MRGCD)	0.8	0.0
EDWA (Reclamation)	0.4	0.9
SJC Project Water	1.8	16.2
MRGCD	0.1	5.8
ABCWUA Diversion	1.7	6.9
Supplemental Water Program	0.0	3.6

6.3 Comparison of Hydrologic Conditions with and Without the Proposed Water Management Actions

This section compares modeled hydrologic conditions under the Proposed Water Management Actions to modeled hydrologic conditions in the absence of those actions (referred to as the "No Action" condition in this section, for convenience). The Proposed Water Management Actions do not include Reclamation's Supplemental Water Program, which is evaluated separately as a conservation measure in section 6.5. Both conditions have been modeled and evaluated using the five synthetic hydrologic sequences described in section 6,1. In the simulations of the Proposed Water Management Actions, Reclamation operates Heron Dam to provide SJC Project water to its contractors. Reclamation, in coordination with the MRGCD, stores native water in El Vado Dam and releases that water as needed to meet MRGCD diversion demand, and the MRGCD operates its MRG diversions. In the simulation of the No Action condition, these operations are turned off in the model. However, MRGCD irrigation demand is not turned off. Therefore, if water is available to the irrigation network, such as from interior and riverside drains, that water will be used to meet irrigation demand if it can be delivered to the turnout without being diverted from the river. The flow targets set by the 2003 BiOp are used as operating rules for all model runs. Additionally, through 2013, the Corps can deviate its operations of Cochiti Dam to enhance the timing and shape of the spring hydrograph in the MRG, an interrelated and interdependent action to this BA, which is turned on in all model runs (see table 30).

There are effects to both high flow and low flow conditions within the MRG from the Proposed Water Management Action when compared to a No Action scenario. Figure 60 presents a comparison of the modeled duration of continuous high flows at Central Avenue under the Proposed Water Management Actions, relative to the No Action condition. This figure shows that, on average, the Proposed Water Management Actions decrease the length of time that the spring snowmelt runoff peaks persist in the MRG. For example, there is a 4-day difference between the duration of flows exceeding 3,000 cfs and a 10-day difference in the duration of flows exceeding 1,000 cfs under the Proposed Water Management Actions relative to the No Action condition. This change is due to both diversion of flows and storage of water at El Vado. The difference is more pronounced in the Isleta Reach decreasing the duration at 3,000 cfs by 6 days and 1,000 cfs by over 20 days. The COE deviation program is included through 2013 in the model runs for both Proposed Action and No Action scenarios. The deviation is not likely to change the total flow volume but may extend the number of days that flow remains above a threshold level.

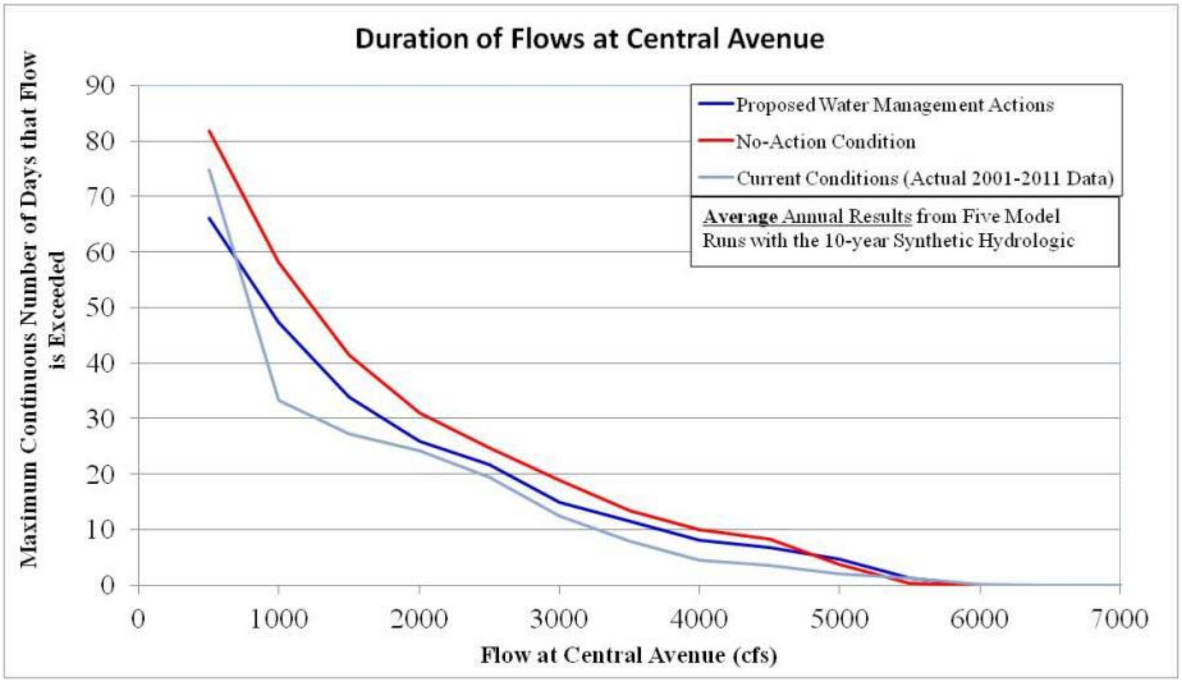

Figure 60. Comparison of the duration of continuous days of high flow under the Proposed Water Management Actions, relative to the No Action condition, at Central Avenue gage, Rio Grande, New Mexico, in the 500- to 7,000-cfs range.

The effect is more pronounced during lower flows. Figure 61 provides a summary of the impact of the Proposed Water Management Actions on flows in the MRG, relative to the No Action condition, at key locations within the MRG, including the Albuquerque/Central Avenue gage, downstream from Isleta Diversion Dam, downstream from San Acacia Diversion Dam, and at San Marcial, from July 1 to October 31. Each colored bar shows the combined effects on flows of both Federal and non-Federal actions in the Proposed Water Management Actions, including operation of Heron Dam under the SJC Project, Operation of El Vado Dam, and MRGCD diversions, at these key locations. It shows that the Proposed Water Management Actions result in lower flows across the normal range of flows at this location.

This effect is concentrated in the irrigation season. The difference between the Proposed Water Management Actions and the No Action condition during the nonirrigation season is very small. The model runs and the spreadsheet analysis presented here indicate that Proposed Water Management Actions likely will result in additional days of river drying. The relative differences between modeled flows under the Proposed Water Management Actions and the No Action persist downstream through the remaining reach of the MRG.

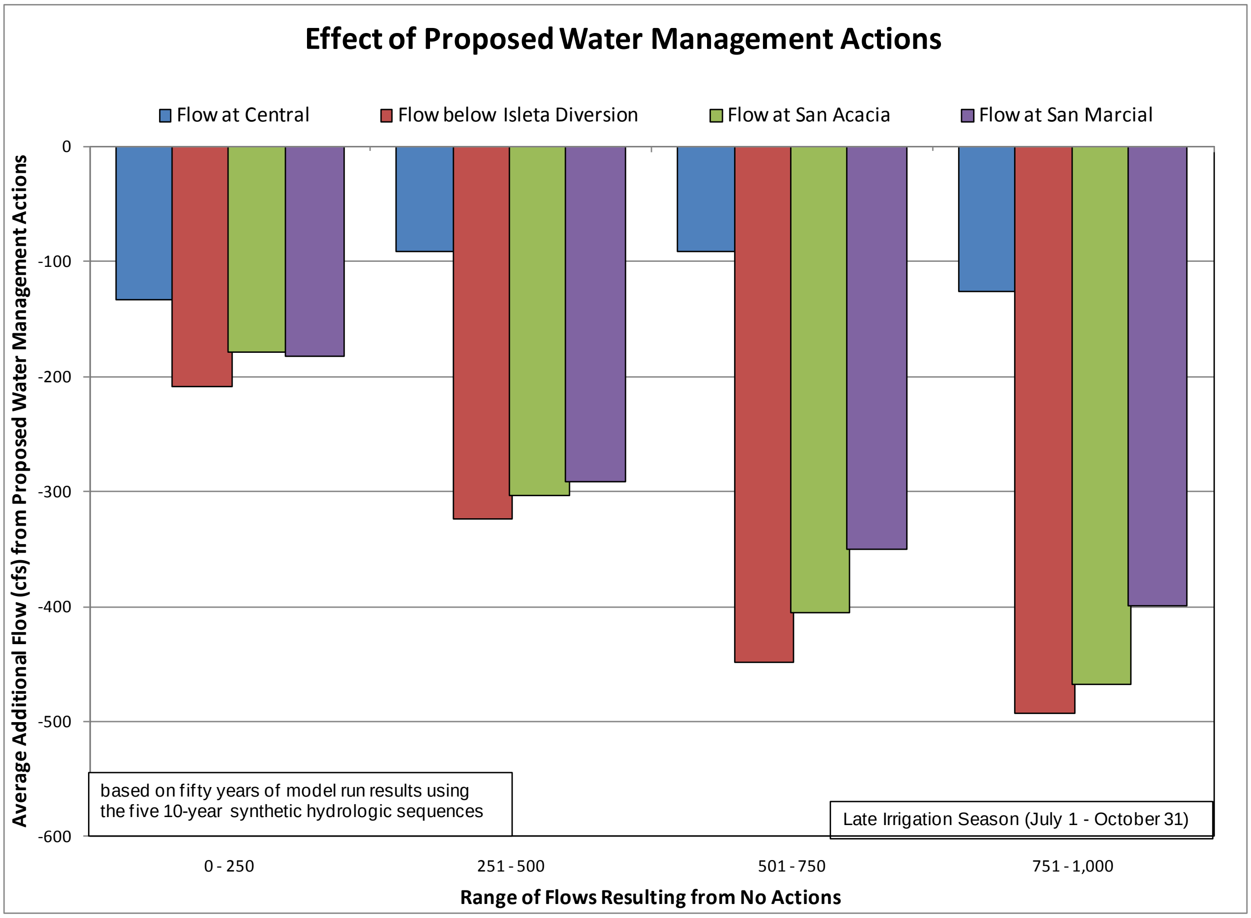

Figure 61. Change in modeled flow under the Proposed Water Management Actions to flow modeled under the No Action condition over the calendar year.

As explained in section 6.1.1, the portrayal of the No Action condition in URGWOM is subject to considerable uncertainty, since this condition has not been monitored in the MRG, and, therefore, the model has not been calibrated to this condition. Therefore, an additional computational tool, a mass-balance-based spreadsheet model developed in MS Excel by the MRGCD (described in appendix 10) has been employed for evaluation of the No Action condition and comparison of this condition to the flow conditions under the Proposed Water Management Actions.

The premise of the spreadsheet model is that a certain flow enters each reach, and the amount leaving that reach is determined by subtracting the known depletions in that reach from that inflow. 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. As noted above, some reaches are aggregated for consideration, which eases the difficulty in accounting for these complicating factors. The spreadsheet model depends on an input of the flow expected to enter the MRG from the outlet works of Cochiti Reservoir. This input value is derived from the previous URGWOM modeling for various conditions.

The spreadsheet model then uses estimates of agricultural, riparian, and open water depletions from Reclamation's "ET Toolbox," plus a ground water component in the Albuquerque area, to estimate flows arriving at four key points in the MRG; Central Avenue gage in Albuquerque, below Isleta Dam, San Acacia Gage, and San Marcial Gage. Flows at these points are evaluated in terms of number of years of successful spawn/recruitment condition during each run (Central Avenue only), days of major drying over the course of the run, days of intermittency over the course of the run, number of years during the run in which major drying occurs, and number of years during the run in which some intermittency occurs (table 18).

Table 18. The following thresholds were specified as output criteria for table 19

	Spawn Flow/Duration	Major Drying	Intermittency
Central Avenue	3,000 cfs/7 days	10 cfs	100 cfs
Below Isleta Dam		30 cfs	100 cfs
San Acacia Gage		10 cfs	200 cfs
San Marcial Gage		10 cfs	50 cfs

The spreadsheet model also includes a user-adjustable factor that specifies agricultural consumption. This allows for full agricultural consumptive use to occur in the model under the Proposed Water Management Actions, 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 ground water accretion in MRGCD drains. The factor specified for a given reach is dependent on whether the drain flows in that reach can be used for irrigation, or must return to the river.

Table 19 presents a summary of the days of minnow spawning flows, intermittency, and river drying that are projected under the five hydrologic sequences used for this effects analysis for the Proposed Water Management Actions and the No Action condition. The third column of tables compares the two conditions and, therefore, presents an assessment of the impact of the Proposed Water Management Actions on these conditions, based on the spreadsheet model. Please note that the column headers for the Central Avenue location differ from those for the other key locations.

No Action

Central Ave.	Sequence	Less than 100 cfs Days	Less than 100 cfs Years	Spawn (YRS) 3000cfs/7dys
Wetter	10%	31	4	8
↑	30%	23	4	6
	50%	16	3	6
↓	70%	34	4	6
Drier	90%	47	3	3
	All (50 yrs)	151	18	29

Below Isleta Dam Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	39	5	127	6
30%	25	4	68	4
50%	16	3	71	3
70%	40	4	141	4
90%	64	3	261	8
All (50 yrs)	184	19	668	25

Blw SanAcaciaDam Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	276	7	668	9
30%	175	6	460	8
50%	186	5	597	9
70%	277	4	640	10
90%	447	6	831	10
All (50 yrs)	1361	28	3096	46

Blw SanMarcial Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	683	10	765	10
30%	547	8	618	9
50%	670	10	730	10
70%	723	10	787	10
90%	824	10	900	10
All (50 yrs)	3447	48	3800	49

Proposed Action

Central Ave.	Sequence	Less than 100 cfs Days	Less than 100 cfs Years	Spawn (YRS) 3000cfs/7dys
Wetter	10%	122	2	8
↑	30%	95	3	6
	50%	139	3	5
↓	70%	258	4	6
Drier	90%	411	5	3
	All (50 yrs)	1025	17	28

Below Isleta Dam Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	779	9	985	9
30%	673	9	880	10
50%	907	10	1127	10
70%	1008	10	1208	10
90%	1187	10	1373	10
All (50 yrs)	4554	49	5573	49

Blw SanAcaciaDam Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	705	9	1092	10
30%	656	9	1046	10
50%	818	10	1266	10
70%	944	10	1391	10
90%	1097	10	1486	10
All (50 yrs)	4220	48	6281	50

Blw SanMarcial Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	907	10	980	10
30%	853	10	914	9
50%	1030	10	1122	10
70%	1155	10	1228	10
90%	1224	10	1296	10
All (50 yrs)	5169	50	5540	49

Impact (Proposed Action minus No Action)

Central Ave.	Sequence	Less than 100 cfs Days	Less than 100 cfs Years	Spawn (YRS) 3000cfs/7dys
Wetter	10%	91	-2	0
↑	30%	72	-1	0
	50%	123	0	-1
↓	70%	224	0	0
Drier	90%	364	2	0
	All (50 yrs)	874	-1	-1

Below Isleta Dam Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	740	4	858	3
30%	648	5	812	6
50%	891	7	1056	7
70%	968	6	1067	6
90%	1123	7	1112	2
All (50 yrs)	4370	30	4905	24

Blw SanAcaciaDam Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	429	2	424	1
30%	481	3	586	2
50%	632	5	669	1
70%	667	6	751	0
90%	650	4	655	0
All (50 yrs)	2859	20	3185	4

Blw SanMarcial Sequence	Drying Days	Drying Years	Intermittency Days	Intermittency Years
10%	224	0	215	0
30%	306	2	296	0
50%	360	0	392	0
70%	432	0	441	0
90%	400	0	396	0
All (50 yrs)	1722	2	1740	0

Table 19. Comparison of the occurrence of spawning flows, river intermittency, and river drying under the Proposed Action relative to the No Action Condition over 10-year period. Criteria for this table are outlined in table 18.

The analysis at the Central Avenue Gage location includes an assessment of the number of years in which silvery minnow spawning flows are achieved, which is designated for purposes of this analysis as 3,000 cfs for 7 consecutive days. This analysis shows that, as has been indicated previously in this analysis, the Proposed Water Management Actions have a negligible impact on the spawning flows. The spreadsheet model projects a difference of one year in fifty for the achievement of spawning flows, from 29 out of 50 years under the No Action condition to 28 out of 50 years under the Proposed Water Management Action.

The spreadsheet model projects a significantly larger difference in the number of years in which intermittency and drying occur with and without the proposed action. This is as expected, since the Proposed Water Management Actions include irrigation diversions from the river. The Proposed Water Management Action results in a change in the number of days with flows below 100 cfs at Central Avenue is projected to be about 5% of the total number of days. This translates to over 75% of intermittency at Central Avenue being attributable to the Proposed Water Management Action (table 20). The larger impact is downstream of Isleta Diversion Dam where the Proposed Water Management Actions cause over 90% of the drying, a change from drying several days per year to drying about 25% of days.

Table 20. Proportion of predicted river drying and intermittency attributable to Proposed Water Management Action downstream from various gages on the Rio Grande

	Upstream River Gage			
Sequence	Central	Isleta	San Acacia	San Marcial
Major Drying		<10 cfs	<30 cfs	<10 cfs
10%		95.0%	60.9%	24.7%
30%		96.3%	73.3%	35.9%
50%		98.2%	77.3%	35.0%
70%		96.0%	70.7%	37.4%
90%		94.6%	59.3%	32.7%
Intermittency	<100 cfs	<100 cfs	<200 cfs	<50 cfs
10%	74.6%	87.1%	38.8%	21.9%
30%	75.8%	92.3%	56.0%	32.4%
50%	88.5%	93.7%	52.8%	34.9%
70%	86.8%	88.3%	54.0%	35.9%
90%	88.6%	81.0%	44.1%	30.6%

6.3.1 Effect of Proposed Water Management Actions on Silvery Minnow

The Proposed Water Management Actions can decrease the length of time that spring snowmelt runoff peaks persist in the MRG. This indicates that the Proposed Action may have a negative effect on the development of silvery minnow eggs and larvae by reducing the time in which high flows inundate overbank habitat. The difference in the mean number of days that would be expected at each discharge level increases as the peak flow decreases. Thus, in years with high overbank potential (flows greater than 3,000 cfs at Albuquerque) there is a less noticeable decrease in high flows than in those years with minimal snowmelt. The relationship of October catch rates of silvery minnow and number of days greater than 3,000 cfs (figure 16), revealed that, since 1993, only 1 year with fewer than 30 days with discharge greater than 3,000 cfs had a mean October catch rate greater than five fish per 100 square meters (m^2). A linear regression of this relationship indicates an approximate change in mean October CUPE by two fish per 100 m^2 for every 5 days change in spring discharge > 3,000 cfs.

Table 21. Relationship of mean October CPUE with number of days with discharge greater than 3,000 cfs in May and June from figure 17

Yr	Mean October CPUE (#/100 m^2)	# Days Discharge >3,000 cfs (May and June)	Graph Value (Figure 16)
1993	11.8	59	1.9
1994	12.6	60	2.0
1995	26.8	61	2.3
1996	1.4	0	0.7
1997	13.6	43	2.2
1999	6.3	30	1.3
2000	0.4	0	0.3
2001	0.9	2	0.4
2002	0.1	0	0.1
2003	0.0	0	0.0
2004	0.9	0	0.4
2005	37.3	57	2.9
2006	1.3	0	0.6
2007	10.8	10	1.7
2008	8.3	46	1.6
2009	15.5	34	2.2
2010	1.2	19	0.6
2011	1.2	0	0.5

The Corps deviation program is included through 2013 in the model runs for both Proposed Action and No Action scenarios. The deviation is not likely to change the total flow volume but may extend the number of days that flow remains above a threshold level, which could benefit silvery minnow. There is little difference between the Proposed Water Management Actions and the No Action condition for the duration of flows over 5,000 cfs, which are the flows that are high enough to alter the channel; so the Proposed Water Management Actions have little direct effect on current silvery minnow habitat features within the MRG. However, the Proposed Water Management Actions do provide low summertime flows, which allow vegetation growth and, therefore, contribute to channel narrowing and simplification. This indirect effect is compounded by the lack of channel-resetting high flow events due to flood control operations by the Corps at Cochiti Dam. There is a complex relationship between sediment transport and silvery minnow habitat. Generally, areas that have high sediment load and low sediment transport have a greater connectivity to the flood plain and provide more complex habitat at all flows; however, these sections are also more prone to intermittency due to the perched nature of the channel causing the flow to go subsurface. These processes are described in detail in the River Maintenance Part II. Depending on their operation, diversion dams may interrupt sediment downstream transport and cause degradation within the channel.

In addition to the high flow duration, October catch rates are related to the onset of low flow conditions (figure 17). The early onset of low flows is negatively related to the recruitment of silvery minnow. Modeling predicts that the Proposed Action increases the likelihood that low flow conditions begin earlier in the year (indicated by 200 cfs at San Marcial) (figure 62). Modeling runs of the Proposed Action also indicate that the duration of low flow conditions and drying are increased under the Proposed Action as compared to the No Action scenario (table 19). In the modeled scenarios, there is increased probability of drying in all reaches with the Proposed Action as compared to the No Action scenario. Increased drying is likely to adversely affect silvery minnow, especially juvenile and adults during summer and fall timeframes.

The Proposed Action may increase winter flows during the transfer of water to Elephant Butte after the irrigation season. This is considered to have little effect on silvery minnow since the flow levels tend to be sufficient and stable during winter. Stable water conditions should allow minnow to remain in a single overwinter habitat without having to expend energy seeking out new suitable habitats as flows change. Higher flows also may provide some amount of thermal stability during times of extremely low air temperatures. A summary of the effects of the Proposed Water Management Actions on silvery minnow is presented in table 22.

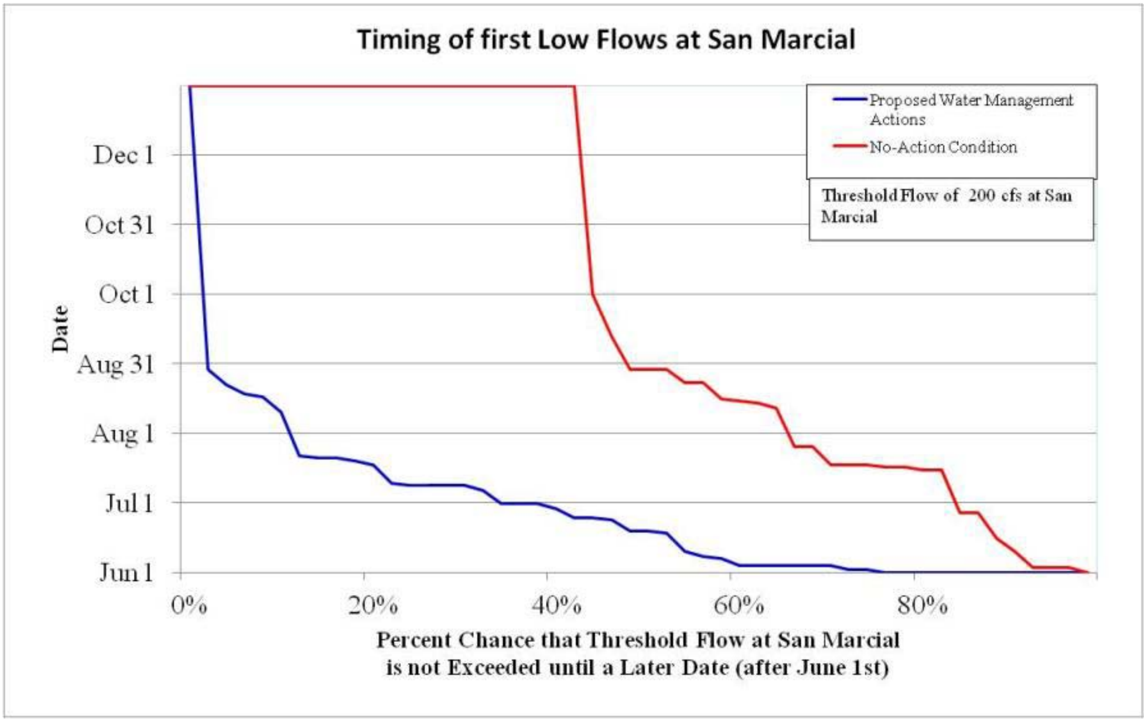

Figure 62. Comparison of the timing of the first low flows at San Marcial under the Proposed Water Management Actions to flows under the No Action condition, after June 1.

Table 22. Summary of the effect of the full Proposed Water Management Actions on the life history elements and critical habitat PCEs of silvery minnow. Table 19. Effect of Proposed Water Management Actions (3.2 and 3.3) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Spring (March–June)	The Proposed Action will cause a small decrease in the magnitude and duration of runoff in the MRG. This decrease is anticipated to be minor. The duration of inundation of overbank habitats is related to spawning and recruitment of silvery minnow. **Direct and Indirect – *The Proposed Water Management Actions are likely to adversely affect silvery minnow*** recruitment due to the decreased magnitude and duration of spring runoff.				There is little information on how spring flows are related to adult survival of silvery minnow. The anticipated minor changes in the spring hydro-graph from the Proposed Water Management Actions ***are not likely to directly or indirectly adversely affect adult silvery minnow.***

Table 22. Summary of the effect of the full Proposed Water Management Actions on the life history elements and critical habitat PCEs of silvery minnow. Table 19. Effect of Proposed Water Management Actions (3.2 and 3.3) on life history elements and PCEs of silvery minnow (continued)

	Spawning	Eggs	Larval	Juvenile	Adult
Summer (June–Sept)			The Proposed Water Management Actions are anticipated to cause decreased summer and fall flows and drying as compared to the No Action scenario. Both low flows and drying are likely to cause mortality of silvery minnow. Thus, **Direct and Indirect – *The Proposed Water Management Actions are likely to adversely affect silvery minnow during summer and fall periods.***		
Fall (Sept–Nov)					
Winter (Dec–Feb)					Water releases for SJC Project contractors generally occur in November and December. These releases provide higher flows through the MRG, which are of sufficient amount and generally stable. **Direct and Indirect – *The Proposed Water Management Actions are not likely to adversely affect winter survival of adult silvery minnow.***
Critical Habitat PCE's					
Hydrologic Regime					
A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.	The Proposed Action has no effect on the duration of channel resetting, habitat forming flows (> 5,000cfs) but does set the base flow levels that also continues the long-term geomorphic trends within the MRG, which is trending towards a narrower, more simplified channel due to vegetation encroachment. There are indirect as well as interrelated and interdependent effects on silvery minnow critical habitat from the storage and release of water from reservoirs which changes sediment transport capacity and disrupts of peak flows. There is ***no direct effect to silvery minnow critical habitat but indirect effects include long-term vegetation encroachment within the channel, which may adversely affect silvery minnow critical habitat.***				
Presence of a diversity of habitats for all life history stages					

Table 22. Summary of the effect of the full Proposed Water Management Actions on the life history elements and critical habitat PCEs of silvery minnow. Table 19. Effect of Proposed Water Management Actions (3.2 and 3.3) on life history elements and PCEs of silvery minnow (continued)

	Spawning	Eggs	Larval	Juvenile	Adult
Sufficient flows from early spring (March) to early summer (June) to trigger spawning	Silvery minnow are known to spawn with very small flow increases. However, the Proposed Action may result in a minor decrease in high flows especially in years with limited spring runoff; ***this may have direct and indirect effects but is not likely to adversely affect critical habitat for spawning of silvery minnow.***				
Flows in the summer (June) through fall (October) that do not increase prolonged periods of low or no flow		The Proposed Action increases the likelihood of low flow periods and drying in the MRG as compared to No Action. **Direct and Indirect –** ***The Proposed Action is likely to adversely affect silvery minnow critical habitat by increasing the duration of low flow and drying within the MRG.***			
Constant winter flow				Water releases for SJC Project contractors generally occur in November and December. These releases provide higher flows through the MRG that are of sufficient amount and generally stable. **Direct and Indirect –** ***Actions are not likely to adversely affect winter critical habitat.***	

Table 22. Summary of the effect of the full Proposed Water Management Actions on the life history elements and critical habitat PCEs of silvery minnow. Table 19. Effect of Proposed Water Management Actions (3.2 and 3.3) on life history elements and PCEs of silvery minnow (continued)

	Spawning	Eggs	Larval	Juvenile	Adult
Unimpounded stretches of river with a diversity of habitats and low velocity refuge areas					
River reach length	Currently, diversion dams are in place; no new cross channel structures are proposed. The actual length of wetted river within each reach changes depending on channel sinuosity. Sinuosity changes depending on geomorphology and discharge levels. Sinuosity of the thalweg may increase during low flows that increase the length of the river but also may promote vegetation growth on point bars within the river channel. The lack of flood stage flows also changes the potential that the river will move outside its current channel. The Proposed Action ***is not likely to adversely river reach length.***				
Habitat "Quality" in each reach and refugial habitats.	Habitat quality in each reach is dependent on the structure and diversity of available habitat. Channel trends throughout the MRG are towards a more simplified channel due to vegetation encroachment. Base flow levels from the proposed actions drive the vegetation encroachment within the channel. The quantity of suitable habitat within each reach also changes at different flows, this relationship is not linear in most sections of the river and is dependent on channel shape. The Proposed Action ***may have indirect effects that adversely affect silvery minnow critical habitat***.				
Substrate of sand or silt					
Substrates of predominantly sand or silt	The Proposed Action is not likely to affect the current trend of substrate coarsening in the Cochiti Dam and Angostura Reaches or deposition within the lower reaches. Much of the sediment in the MRG is introduced from tributary flows that are largely unregulated. The presence and operation of diversion dams within critical habitat interrupts sediment transport and may affect the substrate size downstream from the structures. Direct and Indirect – The Proposed Action ***is likely to adversely affect substrate composition within silvery minnow critical habitat.***				
Water quality					
Temp >1˚ - <30˚C.	Water temperature, DO, and pH within the MRG may be affected during low flow conditions, especially in intermittent areas. ***Direct and Indirect – The Proposed Action is likely to adversely affect water quality due to increased low flow periods.***				
DO > 5 mg/L					
pH (6.6-9.0)					
Other Contaminants	Drain and irrigation return water has the potential to have poor water quality, but recent studies (Buhl 2011) found no biologically significant levels of contaminants in the tested wasteway water. The Proposed Action reduces the amount of water that is available to dilute contaminants that are introduced to the river from outside sources. This lack of dilution may have ***indirect effects but is not likely to adversely affect silvery minnow***.				

6.3.2 Effect of Proposed Action on flycatcher.

Currently, the suitable habitat within the project area that would be affected by the Proposed Action include areas in the upper end of Cochiti Reservoir in the Otowi to Cochiti Dam Reach; from just south of Albuquerque to the Isleta Diversion Dam, Isleta Diversion Dam to Rio Puerco, and Rio Puerco to San Acacia Reaches; and from the BDANWR to RM 73 (just south of the BDANWR) in the Arroyo de las Cañas to San Antonio Bridge, San Antonio Bridge to River Mile 78 and River Mile 78 to River Mile 62 Reaches (reach boundaries are described in the River Maintenance section). Areas that are not on the list likely will not reach suitability in at least the next 10 years based on vegetation trends in the last 10 years and/or the depth to ground water is likely too deep to encourage new growth of native-dominated vegetation communities. An extensive effort beyond water operations would be required to establish flycatcher suitable habitat in those areas.

Above Cochiti Reservoir, other factors influence hydrology and flycatcher habitat such as water coming in from tributaries, reservoir storage, and beaver activity that maintains ponded areas of water within the Cochiti Reservoir delta. Into the future, flycatcher habitat in this area is predicted to remain well within the 50 meter distance to water and have saturated soils associated with flycatcher preference to establish territories and conditions suitable for vegetation health and recruitment. This prediction is based on historic flows observed at the Otowi Bridge gage over the last 10 years.

The area from the confluence of the Rio Grande and the Rio Chama to Otowi Bridge is proposed critical habitat for flycatchers; however, that area would not be affected by the Proposed Action because MRGCD's water diversions do not take place this far north. Additionally, due to the 1,800-cfs channel capacity on the Rio Chama below Abiquiu Reservoir, flows from the Chama alone would make little impact on the occurrence of recruitment or overbank flows in the MRG.

Overbank flooding events tend to attract flycatchers and lead to territory establishment. These events also contribute to vegetation health, seedling establishment, and insect prey base abundance. The methodology described in the following paragraphs was used in an effort to determine the relative change in the potential for overbank flooding due to the decrease in high flow periods from the Proposed Water Management action.

The one-dimensional modeling from the River Maintenance Part 2, Most Likely Strategies and Methods by Reach Attachment uses the a value of 4,700 cfs as an indicator for predicting overbank flows. The 2-year return rate of 4,700 cfs was modeled to predict the frequency of when an overbank flooding event would occur. For example, a value is over 1 signifies a higher frequency of overbank flows at lower discharge than 4,700 cfs. Values under 1 signify lower frequency of overbank flows. This modeling effort does not include overbank flows on islands; therefore, it is likely an overestimate of the flows required to inundate those areas. Table 23 describes the modeling value for overbank flows in each reach related to a discharge of 4,700 cfs.

Overbank discharge values were less than 1 in most reaches, signifying that more than 4,700 cfs would be needed for overbank flows with the exception of areas in the BDANWR. Because the Arroyo del las Cañas to San Antonio Bridge and San Antonio Bridge to River Mile 78 Reaches had overbank discharge values over 1, flows less than 4,700 cfs would trigger an overbank flooding event. A recent Colorado State University study determined actual overbank flows occur at a discharge of 1,400 cfs for that reach.

Table 23. Modeled predictions of overbank flooding at 2-year return rate of 4,700 cfs

Reach	Inundation Value
Angostura Diversion Dam to Isleta Diversion Dam	0.76
Isleta Diversion Dam to Rio Puerco	0.70
Rio Puerco to San Acacia Diversion Dam	0.53
Arroyo del las Cañas to San Antonio Bridge	1.74
San Antonio Bridge to River Mile	3.36
River Mile 78 to River Mile 62	0.53

Hydraulic modeling indicates a small change in the overbank flooding potential in all reaches due to the Proposed Action (figures 63, 64, and 65) using the Proposed Action with no Supplemental Water sequence and during the early irrigation season that covers the period of flycatcher territory establishment. There would be a difference of between 1 to 3 days of overbank flows in all reaches from Albuquerque to RM 62 with the exception of the area from Arroyo del las Cañas to River Mile 78 when comparing the Proposed Action to No Action (table 24). This difference is likely inconsequential for flycatcher, considering that these areas often require more than the 4,700 cfs for flooding, and areas where flycatchers occupy are typically along the rivers' edge and within the 50-meter distance to water where 94% of flycatcher nests are located.

Table 24. Effects of the Proposed Water Management Action compared to No Action and the difference in potential days of overbank flooding events during early irrigation season and flycatcher territory establishment. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with Proposed Action	Number of days flows reach 4,700 cfs with Proposed Action	Percent of the time flows reach 4,700 cfs with No Actions	Number of days flows reach 4,700 cfs with No Actions
Central	10.20%	12	11.30%	14
San Acacia	7.10%	9	10.00%	12
San Marcial	3.10%	4	4.40%	5

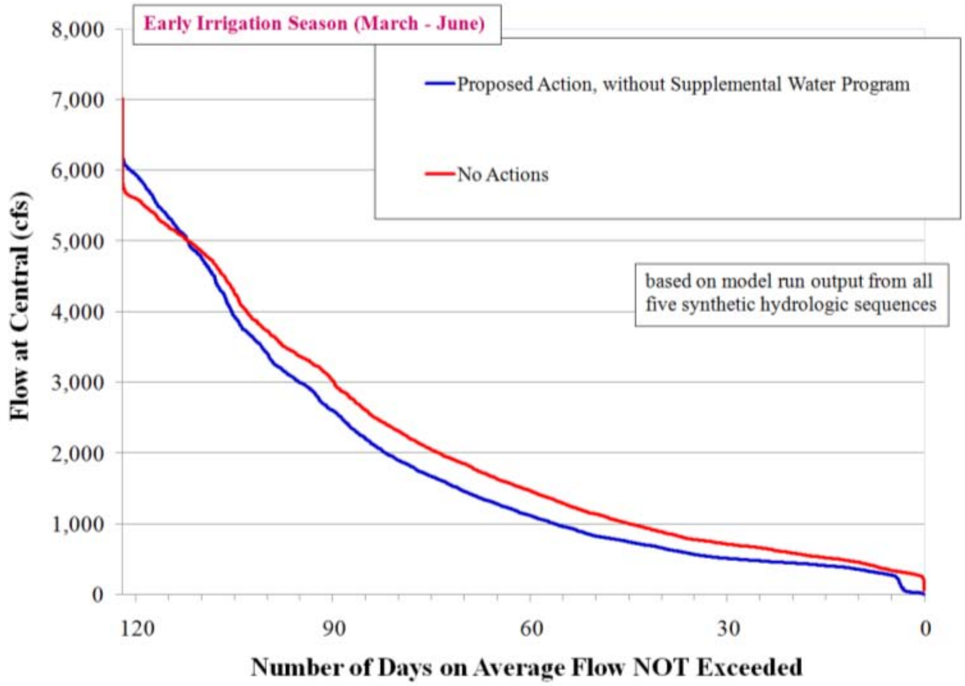

Figure 63. Relative comparison of modeled flows at Central gage considered Proposed Action with no Supplemental Water Program compared to No Action during the flycatcher territory establishment period.

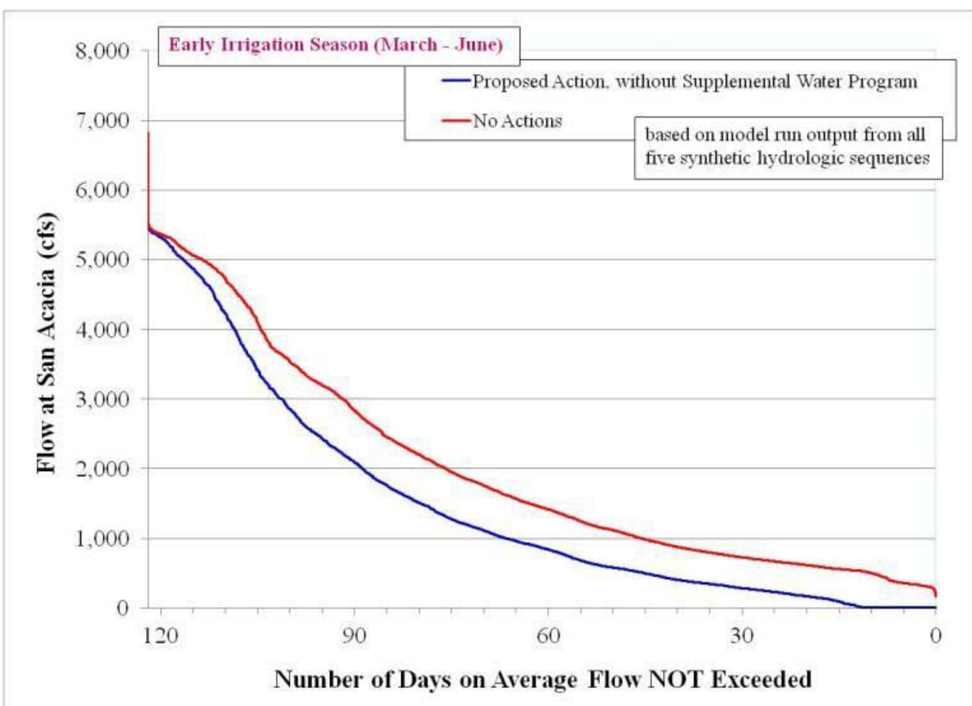

Figure 64. Relative comparison of modeled flows at San Acacia gage considered Proposed Action with no supplemental water program compared to No Action during the flycatcher territory establishment period.

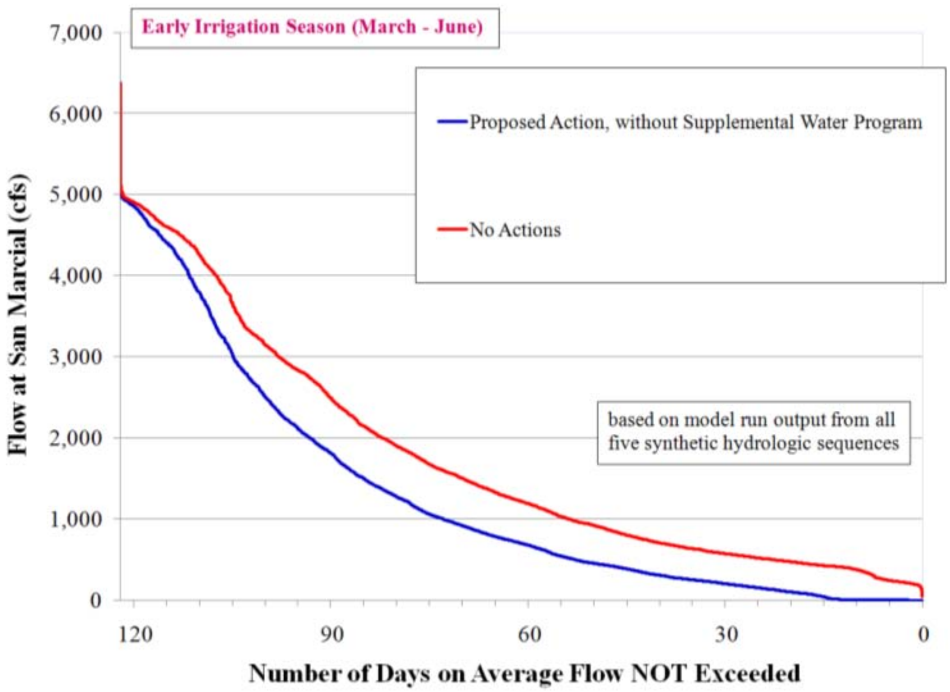

Figure 65. Relative comparison of modeled flows at San Marcial gage considered Proposed Action with no Supplemental Water Program compared to No Action during the flycatcher territory establishment period.

Hydrologic modeling for the late irrigation season from July to October indicate a small decrease in water but relatively minor differences between the No Action versus Proposed Action scenarios (table 25).

Table 25. Effects of the Proposed Water Management Action compared to No Action and the difference in potential days of overbank flooding events during late irrigation season and flycatcher nesting period. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with Proposed Action	Number of days flows reach 4,700 cfs with Proposed Action	Percent of the time flows reach 4,700 cfs with No Actions	Number of days flows reach 4,700 cfs with No Actions
Central	1.8%	2	2.2%	3
San Acacia	1.8%	2	2.4%	3
San Marcial	1.7%	2	2.3%	3

For the Arroyo del las Cañas to RM 78 reach, modeled flow at the San Acacia gage was analyzed with the Proposed Action at the 1,400 cfs required for inundation within the BDANWR area. According to calculations, this area would meet overbank flows 45.0% of the time in the No Action sequence and 36.3% or

44 days in the Proposed Action sequence (table 26). This 10-day difference would be more substantial when compared to the other reaches but territories within this area are found along the river and are typically within 50 m of water as long as the river is wet which would be the majority of time in the March-to-June time period.

Table 26. Effects of the Proposed Water Management Action compared to No Action and the difference in potential days of overbank flooding events during early irrigation season and flycatcher territory establishment in the reaches from Arroyo del las Cañas to RM 78.

Gage Location	Percent of the time flows reach 1,400 cfs with Proposed Action	Number of days flows reach 1,400 cfs with Proposed Action	Percent of the time flows reach 1,400 cfs with No Actions	Number of days flows reach 1,400 cfs with No Actions
San Acacia	36.30%	44	45.00%	55

The modeling results for the late irrigation season from July–October at the San Acacia gage results indicate a 5-day difference in potential overbank flooding during that time period (table 27). Though this time period is less important in regard to territory establishment, it is important for vegetative health and nest success during July and August. If vegetation declines in value for flycatchers during this time period, their nests would be more visible and subject to predation due to decreased foliage cover. Table 28 presents a summary of the effects of Heron and El Vado Dam operations and MRGCD diversions on flycatchers in the MRG.

Table 27. Effects of the Proposed Water Management Action compared to No Action and the difference in potential days of overbank flooding events during late irrigation season and flycatcher nesting period in the reaches from Arroyo del las Cañas to RM 78.

Gage Location	Percent of the time flows reach 1,400 cfs with Proposed Action	Number of days flows reach 1,400 cfs with Proposed Action	Percent of the time flows reach 1,400 cfs with No Actions	Number of days flows reach 1,400 cfs with No Actions
San Acacia	6.2%	8	10.5%	13

Table 28. Effect of Proposed Action on life history elements and PCEs of flycatchers

Life History Element	**Migration** (April–June and July–September)	**Arrival to Territories/ Territory Establishment/Nest Building** (May–July)	**Egg Laying/ Incubation/ Nestling/ Fledgling** (June–August)
Breeding Season (April–September)	The Proposed Action would ***not likely adversely affect*** flycatcher stopover locations during migration because flycatchers will use habitat that is less suitable during this time and farther away from water sources.	The Proposed Action may ***indirectly affect flycatcher habitat on a negligible level***. Because the Proposed Action, when compared to No Action, would ***decrease the potential of overbank flooding and decrease the overall water available for vegetation***, this could cause a decline in territory recruitment and canopy cover/plant health/seed establishment and ***could potentially adversely affect flycatcher habitat,*** particularly in periods of drought. However, it should be noted that the decrease in water between the two scenarios is a relatively small amount.	Territory recruitment at this stage is no longer an issue as flycatchers are more invested in their territories and less likely to abandon nests should conditions dry or decline in value. However, if vegetation does not have adequate water resources, canopy cover likely will decrease, and predation and/or parasitism likely would be more prevalent. Because the Proposed Action would result in less water in the system, there would be an increased possibility of vegetation not having adequate water to maintain health and, thus, ***would adversely affect flycatcher habitat and potential nest success***, again particularly in times of drought.
Critical Habitat PCES			
Riparian Vegetation	Riparian habitat in a dynamic successional environment to be used for nesting, foraging, migration, dispersal, and shelter. Dense tree or shrub vegetation in close proximity to open water or marsh areas. With a decrease in the water amount reaching flycatcher suitable habitat patches, the Proposed Action could ***potentially adversely affect flycatcher riparian vegetation***.		
Insect Prey Populations	A variety of insect prey populations found in close proximity to riparian flood plains or moist environments. The minimal difference between the No Action and the Proposed Action ***may affect, not likely to adversely affect the insect prey populations***. It is also important to note that a dry river does not impact insect populations when ponded water and adjacent drains are present.		

6.3.3 Effect of Proposed Action on Pecos Sunflower

In the Middle Rio Grande, the Pecos sunflower is presently known to exist within the La Joya Waterfowl Area of the NMDGF Ladd S. Gordon Waterfowl Complex. This is one of the largest populations of *H. paradoxus*, consisting of 100,000 to 1,000,000 plants. This unit is 854 acres (346 ha) in Socorro County, New Mexico. This population is located about 7 mi (11 km) south of Bernardo within Socorro County near the confluence of the Rio Grande and the Rio Puerco. The La Joya population is bounded to the west by I-25 and to the east by the Unit 7 Drain. The plants exist entirely within the managed area of the NMDGF wildlife area. Ponds, springs, and wetted soils are features within the La Joya Unit that strongly influence the presence and distribution of Pecos sunflower. Both ground water and managed water create these wet features where Pecos sunflower is found. The interaction between these is complex and not well understood (NMDGF 2007). One or all three may be a source of water for the Pecos sunflower, possibly to varying degrees at different times of the year. Water is delivered to this area via the Unit 7 Drain and the La Joya drain which is part of the “former state drain system.”

In recent years, the maintenance of the drains has been limited. In the past, Reclamation performed maintenance on portions of the drains that was largely funded by the State. Currently, the responsibility for O&M of the drains is under consideration. Effects of maintenance are discussed in the River Maintenance section. Reclamation’s Water Management actions (operation of Heron and El Vado) mainly extend the supply of water available for diversion during irrigation season and have little or no effect on the Pecos sunflower in the Middle Rio Grande (table 29). Water delivered through the MRGCD system to manage the Ladd S. Gordon Waterfowl Complex for migratory waterfowl habitat is beneficial to preserve wetland habitat for *H. paradoxus*. Parts of the riverside drains also function as conveyance channels during the irrigation season, causing drain stage to be above the water table. Therefore, riverside drains either can lose or gain water from the aquifer system depending on the drain stage and drain bed altitude relative to the water table. The ground water modeling by USGS (Bartolini and Cole 2002, McAda and Barroll 2002) indicate that ground water elevation in the region near the sunflower population has been generally steady in recent history. There is no designated critical habitat for Pecos sunflower in the Middle Rio Grande.

Infestations of exotic plant species continue to destroy or degrade desert wetlands and riparian areas. High densities of saltcedar (*Tamarix* sp.), Russian olive (*Elaeagnus angustifolia*), and perennial pepperweed (*Lepidium latifolium*) can have adverse impacts to cienegas. Saltcedar and Russian olive trees transpire considerable amounts of water from shallow water tables, which could reduce water available for Pecos sunflower. These invasive species also create an over story canopy that reduces light in the understory and further degrades Pecos sunflower habitat. Perennial pepperweed reduces species diversity in cienegas and space otherwise available for Pecos sunflowers. The Pecos sunflower habitat management plan identifies their strategy to control exotic plants within the wildlife area (NMDGF 2007).

Table 29. Effects of Proposed Water Management Actions on Pecos sunflower within the Middle Rio Grande, New Mexico

Proposed Actions	Effect on Pecos Sunflower
	Direct and Indirect – Flow from drains and return channels provide water to maintain wetland conditions suitable for Pecos sunflower and, therefore, is beneficial to the species. ***The delivery of water is beneficial to Pecos sunflower.*** Actions that decrease the potential for overbank flooding in the area of the Rhodes population ***may indirectly adversely affect Pecos sunflower***.
Reclamation's Proposed Actions	**Effect on Pecos Sunflower**
Heron Dam and Reservoir	The sunflower population is supported from MRGCD drain and return water. The difference in the hydrograph from the operation of Heron Dam and SJC Project water is negligible and only provides roughly 7% of the total water diverted by MRGCD. Heron Dam operations have very limited effect on high flows that would be needed to inundate the Rhodes population. **Direct and Indirect** – No effect on Pecos sunflower.
El Vado Dam and Reservoir	The sunflower population is supported from MRGCD drain and return water. Storage and release of water from El Vado does not have a noticeable impact on the amount of water available to the Pecos sunflower population. El Vado operations may decrease the potential for overbank flooding on a negligible level, the effect is only noticeable during years that main stem Rio Grande flows are low and overbank flows are not present . **Direct and Indirect** – *Not likely to affect Pecos sunflower*.
Non-Federal Proposed Actions	**Effect on Pecos Sunflower**
MRGCD Diversion Operations	
Operation of Diversion Dams and Returns	**Direct and Indirect** – Flow from drains and return channels provide water to maintain wetland conditions suitable for Pecos sunflower and, therefore, is beneficial to the species. ***The delivery of water through MRGCD drains is beneficial to Pecos sunflower at La Joya SWA.*** MRGCD diversions decrease the water within the River and the frequency of overbank flows. This decrease ***may adversely affect Pecos sunflower*** within the flood plain of the Rio Grande.

The newly established Rhodes population is likely to be affected by water operations only during high flow conditions. The area did inundate during the winter of 2011 due to an ice dam forming in the area. It is unknown what the inundation level that is needed to provide water. There are no effects to the population during base flow conditions.

6.4 Action-by-Action Analysis of Effects of Components of the Proposed Water Management Actions

6.4.1 Approach to Action-by-Action Analysis

In the action-by-action portion of this hydrologic effects analysis, effects of individual actions are parsed out from the overall effect of the Proposed Water Management Actions to identify the relative effect of each discrete action, to the extent practical. The effect of each action is evaluated by comparing a condition in which that action does not occur. The analyses presented in this section distinguish the relative impacts of the discrete actions and, therefore, can contribute to developing and evaluating potential mitigative alternatives and additional conservation measures.

Reclamation's action-by-action analysis differentiates the effects of the following management actions:

- Reclamation's releases from Heron Reservoir at the request of project contractors, under the SJC Project.
- Storage of water in and release of water from El Vado Reservoir, by Reclamation and in coordination the MRGCD.
- MRGCD operations of the MRG diversion structures to provide flows to MRGCD irrigators, including the Six MRG Pueblos, and tail water to the Bosque del Apache National Wildlife Refuge.

The simulations included in the action-by-action analysis are summarized in table 30. The second row in this table explains how the comparisons between runs are used to determine the impact of each discrete action. The runs are compared sequentially in a step down approach, from the full suite of actions on the right to the No Action condition on the left. The effects of Reclamation's Heron Dam operations under the SJC Project are simulated by comparing the Proposed Water Management Actions to a run that simulates only Reclamation's El Vado Dam operations and MRGCD diversions. The effects of El Vado Dam operations under the MRG Project are determined by comparing simulations of El Vado Dam operations and MRGCD diversions to a set of simulations of MRGCD diversions of the natural flow, but no El Vado Dam operations.

Table 30. Summary of water operations included in each action-by-action model run

Across: Action-by-Action Model Runs Down: Modeled Operations	No Actions	MRGCD Diversions only	El Vado Dam Operations and MRGCD Diversions (No SJC Project Operations)	Proposed Water Management Actions	Proposed Water Management Actions and Reclamation's Supplemental Water Program
	Compare with next scenario to evaluate impact of MRGCD diversions; compare with 4th column to evaluate impact of all actions	Compare with next scenario to evaluate impact of El Vado Dam operations	Compare with Proposed Action to evaluate impact of Heron Dam operation	Compare with next scenario to evaluate impact of Reclamation's Supplemental Water Program	Conservation measure evaluation
Heron Dam Operations					
Reclamation leases					X
LFCC Pumping					X
San Juan-Chama Project diversions				X	X
Heron waivers				X	X
MRGCD SJC Project storage at El Vado				X	X
ABCWUA storage at Abiquiu, diversions, and Letter Water delivery				X	X
SJC Combined-account storage at Abiquiu, and Letter Water delivery				X	X
Refilling of Cochiti Recreation Pool				X	X
Maintenance of target flows				X	X
El Vado Dam Operations					
Prior and paramount water storage at El Vado			X	X	X
Release of prior and paramount water according to daily demand schedule			X	X	X
Storage of unused allocation of Emergency Drought Water (MRGCD and Supplemental Water Program)			X	X	X
Rio Grande Storage at El Vado			X	X	X
Release Rio Grande water from El Vado for the MRGCD demand			X	X	X
El Vado reregulation for the channel capacity below El Vado			X	X	X

Table 30. Summary of water operations included in each action-by-action model run (continued)

Across: Action-by-Action Model Runs / Down: Modeled Operations	No Actions	MRGCD Diversions Only	El Vado Dam Operations and MRGCD Diversions (No SJC Project Operations)	Proposed Water Management Actions	Proposed Water Management Actions and Reclamation's Supplemental Water Program
MRGCD Diversions					
Diversions for MRGCD non-Indian irrigators		X	X	X	X
Diversions for Pueblos		X	X	X	X
Other Operations					
Cochiti Deviations (years one and two)	X	X	X	X	X

And finally, the effects of the MRGCD diversions are determined by comparing the simulation of the MRGCD diversions only to a run that includes none of the Federal or non-Federal Proposed Actions. The effects of the Proposed Water-Management Actions, in total, are evaluated by comparing the Proposed Water-Management Actions simulation to the simulation of the "No Action" condition.

Figures 66 through 69 summarize of the range of impacts of the discrete actions evaluated in this action-by-action analysis under low flow conditions during the late irrigation season, the period most likely to have river intermittency and drying. As discussed above, in these graphs, the impacts of discrete actions are evaluated through comparing sequential steps in the stepped-down sequence of URGWOM simulations presented in table 30. The vertical axis on these plots depicts the difference in flow that results from the action being evaluated, in comparison to a situation in which that action is not performed. The gray boxes on these "box and whisker plots" show the middle 50% of impacts.

These plots show that, during low flow conditions in the late irrigation season, Heron and El Vado Dam operations each provide a small, but occasionally significant, increase in flow. The impacts are largest at Central Avenue, and progressively smaller at Isleta, San Acacia, and San Marcial. MRGCD diversions decrease flows in times of low flow conditions, which increases with distance downstream, due to the cumulative effects of diversions on river flows. The impact of the combined Proposed Water Management Actions, shown in the final box and whisker, represents the impact of the discrete actions combined. The combined Proposed Water Management Actions have a consistently negative impact on low flows.

At Central Avenue (figure 66), the positive impacts of Heron Dam operations on low flows during the late irrigation season are typically (the middle 50%) between zero and 60 cfs, and the impacts of El Vado Dam operations are typically between zero and 240 cfs. The downward impacts on flows of MRGCD diversions are typically between 200 and 300 cfs at Central Avenue, and the total impact of the Proposed Action typically ranges from 180–240 cfs.

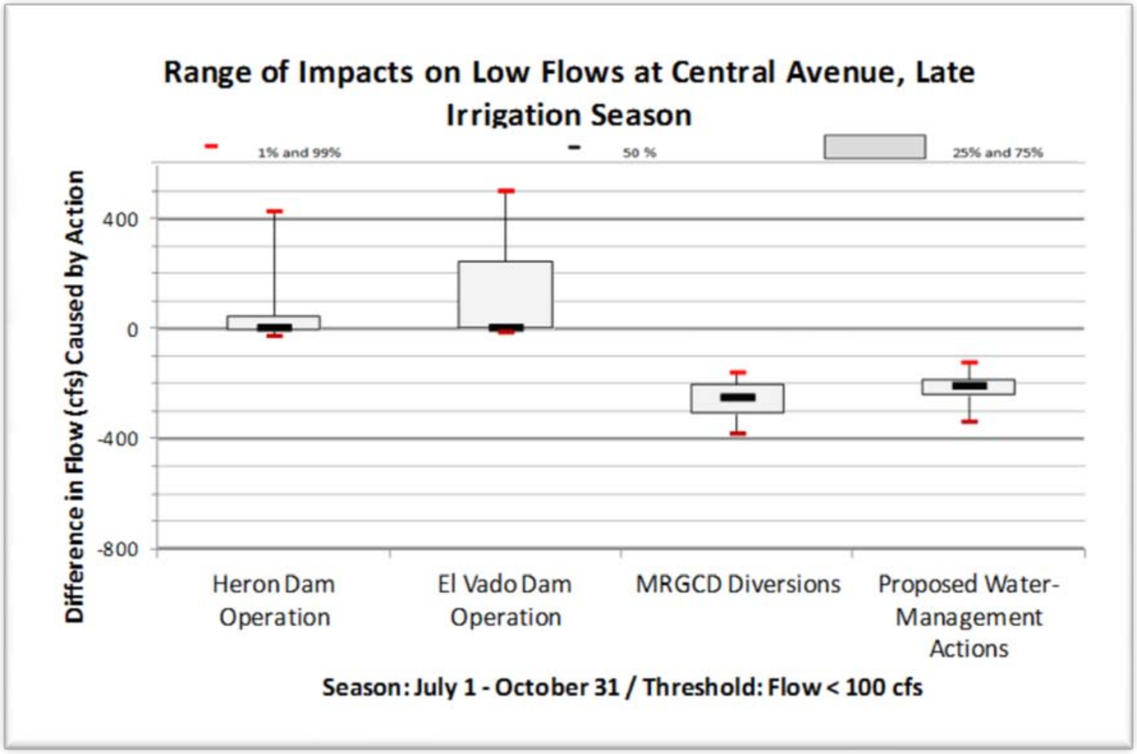

Figure 66. Range of impacts for the step down comparison of discrete actions on low flows at the Central Avenue Gage in Albuquerque during the post-runoff season.

Downstream of Isleta Diversion (figure 67), model results show a smaller positive impact from Heron and El Vado Dam operations on low flows during the late irrigation season and a larger negative impact from MRGCD diversions, typically between 380–520 cfs. Therefore, the combined effects of discrete actions, represented by the Proposed Water Management Actions, also cause a negative effect during low flows.

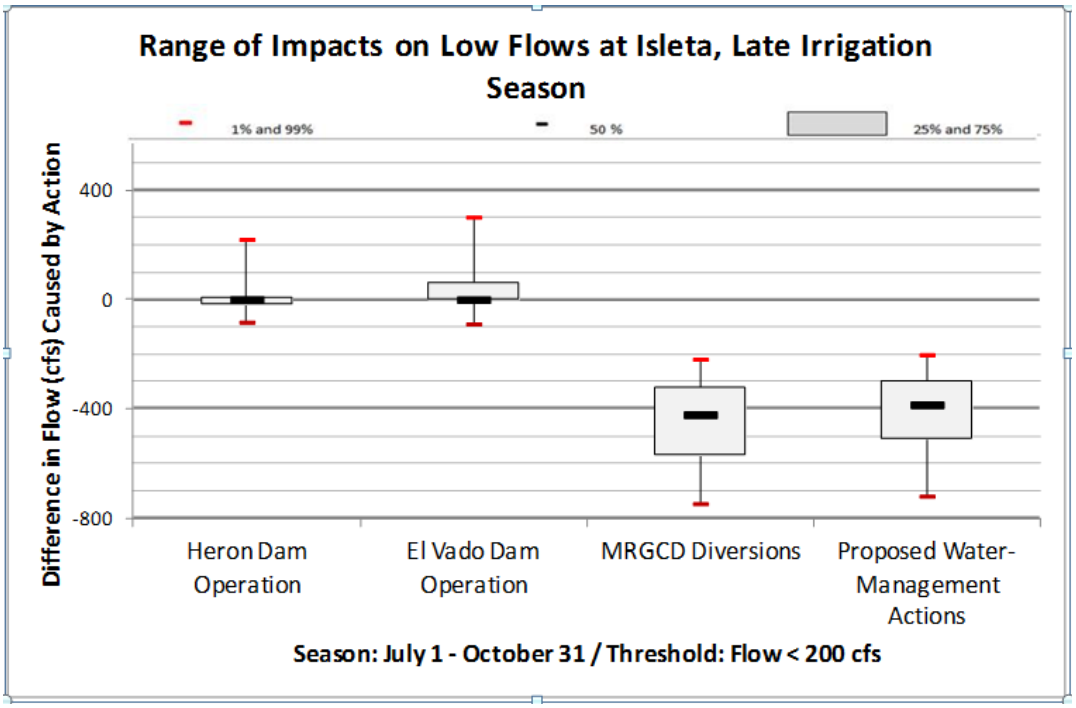

Figure 67. Range of impacts for the step down comparison of discrete actions on low flows downstream of the Isleta Diversion Dam during the post-runoff season.

Downstream of San Acacia Diversion (figure 68), this trend, in which the positive impact of Heron and El Vado Dams on flow is lessened, and the negative impact on flows of MRGCD diversions is increased due to the cumulative effect of upstream diversions, continues. However, the differences between the effects downstream of Isleta Diversion and those downstream of San Acacia Diversion are small because there is relatively little water diverted at San Acacia.

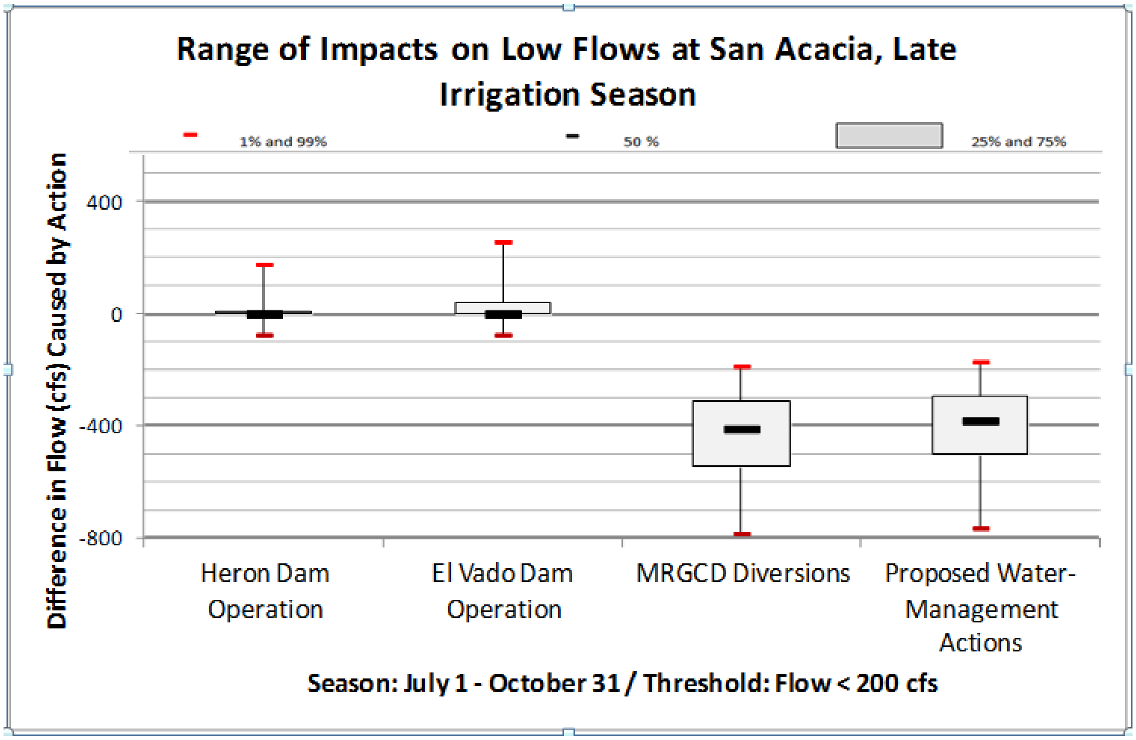

Figure 68. Range of impacts for the step down comparison of discrete actions on low flows downstream of the San Acacia Diversion Dam during the postrunoff season.

At San Marcial, which is downstream of the MRGCD and the BDANWR (Figure 68), the positive impact on flows of Heron and El Vado Dam operations is very small. The negative impact of diversions is also decreased, due to return flows, especially from the BDANWR. At this location, the cumulative negative impact on low flows of the Proposed Water Management Actions is 200 to 400 cfs.

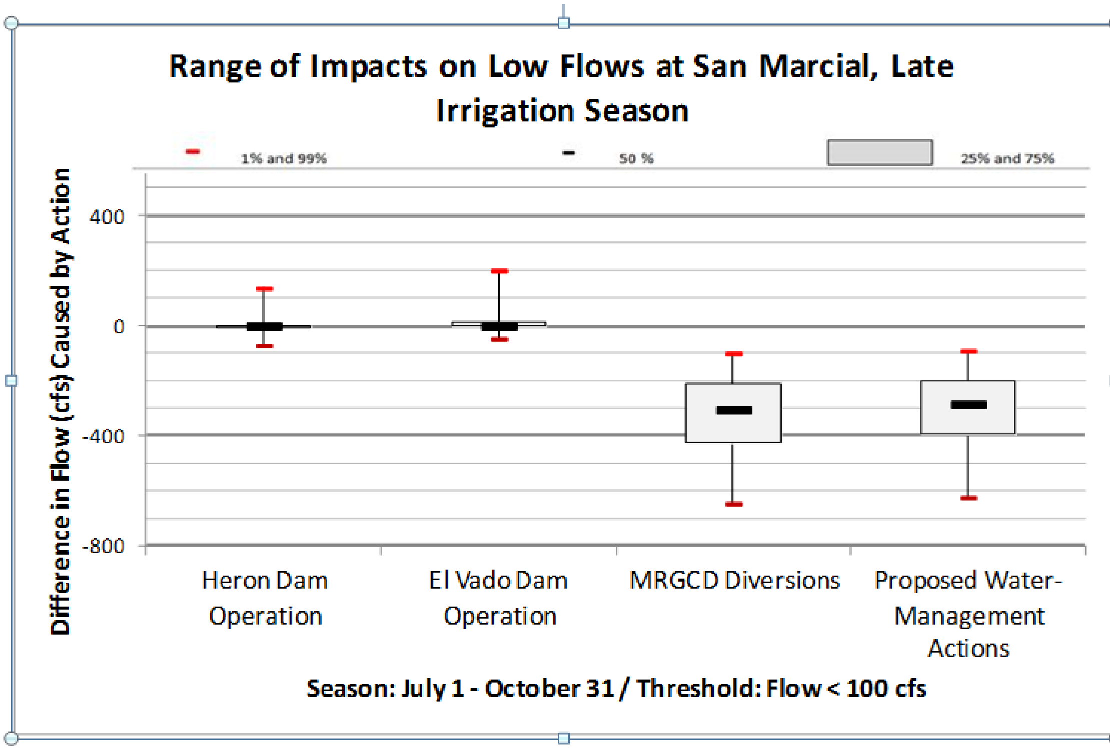

Figure 69. Range of impacts for the step down comparison of discrete actions on low flows at San Marcial during the postrunoff season.

Table 31 summarizes the average impacts of the discrete actions at the key locations presented in the plots. In this table, the impacts are depicted as positive (increasing flows in the low flow range) or negative (decreasing flows when flows are already low), and near zero (less than 20 cfs), minor (20 cfs to less than 50 cfs), or major (greater than 50 cfs). The patterns of impact are essentially the same as has been described for the "box and whisker" plots. However, the average impact of Supplemental Water on low flows downstream from Isleta has been characterized as "major" due to the influence of Supplemental Water released to comply with continuous flow requirements.

Table 31. Qualitative assessment of average impact on low flows in the Middle Rio Grande.

Location	Season	Supplemental Water	Heron Dam Operation	El Vado Dam Operation	MRGCD Diversions	Proposed Water-Management Actions	Threshold Flow
							(cfs)
Central Avenue Gauge	Early Irrigation	minor (+)	major (+)	major (+)	major (-)	major (-)	100
Downstream of Isleta Diversion Dam		major (+)	~0	~0	major (-)	major (-)	200
Downstram of San Acacia Diversion Dam		minor (+)	~0	~0	major (-)	major (-)	200
San Marcial Floodway Gauge		major (+)	~0	~0	major (-)	major (-)	100
Central Avenue Gauge	Late Irrigation	~0	major (+)	major (+)	major (-)	major (-)	100
Downstream of Isleta Diversion Dam		~0	~0	minor (+)	major (-)	major (-)	200
Downstram of San Acacia Diversion Dam		~0	~0	minor (+)	major (-)	major (-)	200
San Marcial Floodway Gauge		~0	~0	~0	major (-)	major (-)	100
	Legend	50	to	1000	major (+)		
		20	to	49.99	minor (+)		
		-19.99	to	19.99	~0		
		-49.99	to	-20	minor (-)		
		-1000	to	-50	major (-)		

Further details on the impacts of each of the discrete actions are provided in the following sections.

6.4.2 Effects of Heron Dam Operations under the SJC Project

6.4.2.1 Approach to the Analysis of Reclamation's Actions under the SJC Project

URGWOM runs were used to evaluate Reclamation's Heron Dam operations under the SJC Project. In this analysis, Reclamation's Heron Dam operations include deliveries to all contractors, whether or not those contractors have completed ESA consultations for the delivery and use of their SJC Project water. Entities that have separate ESA consultations for their use of SJC Project water include the city of Santa Fe and Santé Fe County (for the Buckman Direct Diversion Project) and ABCWUA (for the Albuquerque Drinking Water Project).

Without Reclamation's release of SJC Project water from Heron Reservoir, the MRGCD would not have access to its annual allocations of SJC Project water, and the ABCWUA would not have supplies for its drinking-water diversion project. Also, no deliveries would be made to offset evaporative losses from the Cochiti Recreation Pool, and there would be no "Letter Water" deliveries to offset impacts of ground water pumping on MRGCD irrigators and the Compact.

As shown on table 32 (shown later in this discussion) and described above, the effects of Reclamation's Heron Dam operations are evaluated by comparing a simulation of the Proposed Water Management Actions to a simulation of when the only aspects of the Proposed Water Management Actions that are included are El Vado Dam operations and MRGCD diversions (i.e., Heron Dam operations are turned off). The simulations when Heron Dam operations are turned off specify no importation of water from the San Juan Basin, no new allocations of SJC Project water to contractors, and no releases of SJC Project Water at Heron Dam.

Note that under the initial conditions for these model runs, some SJC Project water is already in storage by the MRGCD, the ABCWUA, and other contractors at El Vado and Abiquiu Reservoirs. For the analysis, these stored waters are used to meet standard demands, but no new SJC Project water is available once these supplies are depleted. All SJC Project water initially in Heron Reservoir is retained and gradually evaporates. In general, these runs do not include the Supplemental Water Program that is evaluated as a conservation measure. Supplemental Water available under initial conditions is used as long as supply lasts, but no additional SJC Project water is made available for lease to the Supplemental Water Program.

6.4.2.2 Effects of Reclamation's Heron Dam Operations under the San Juan-Chama Project

Reclamation's operations of Heron Dam under the SJC Project result in augmented flows below Cochiti Dam as a result of ABCWUA deliveries to its surface-water diversion and MRGCD deliveries of its SJC Project water allocation to irrigators in the MRG. While increased flows are evident below Cochiti Dam and at Central Avenue, much of the additional flow is diverted at the ABCWUA diversion or at MRGCD diversions at Cochiti, Angostura, or Isleta.

Figure 70 compares flows below Cochiti Dam and the Cochiti diversions with and without Reclamation's operations of Heron Dam. Both curves summarize hydrologic conditions compiled from all of the synthetic hydrologic sequences. This comparison indicates that Heron Dam operations increase flows during low flow periods downstream from Cochiti Dam as a result of the additional supply for ABCWUA and MRGCD irrigators.

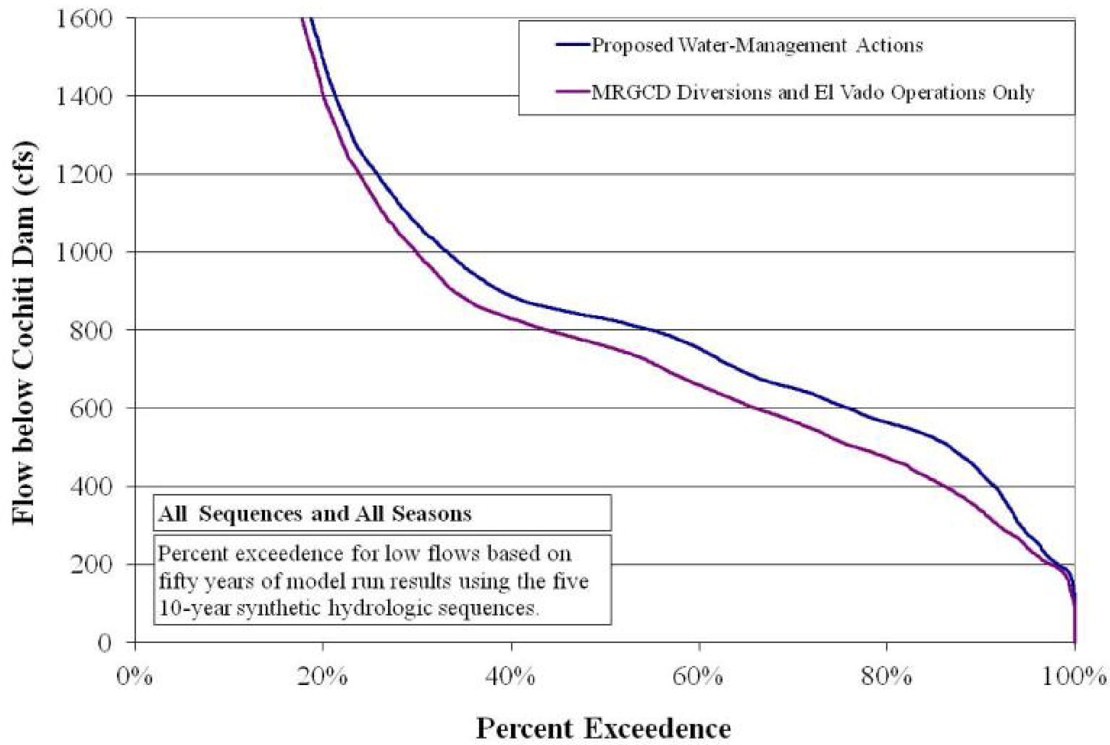

Figure 70. Relative effect of the Heron Dam operations on flows downstream from Cochiti Dam and Diversion.

Figure 71 shows that the benefit of flow augmentation by SJC Project water is less pronounced at the Central Avenue gage, since this gage is located downstream from the ABCWUA's diversion for its drinking water project and, therefore, does not get the benefit of flows of SJC Project water to that diversion. The benefit of Reclamation's Heron Dam operations at Central Avenue is due to the MRGCD's SJC Project water deliveries to Isleta diversion. This graph does not indicate a significant incidence of drying at the Central Avenue gage with or without Reclamation's Heron Dam operations.

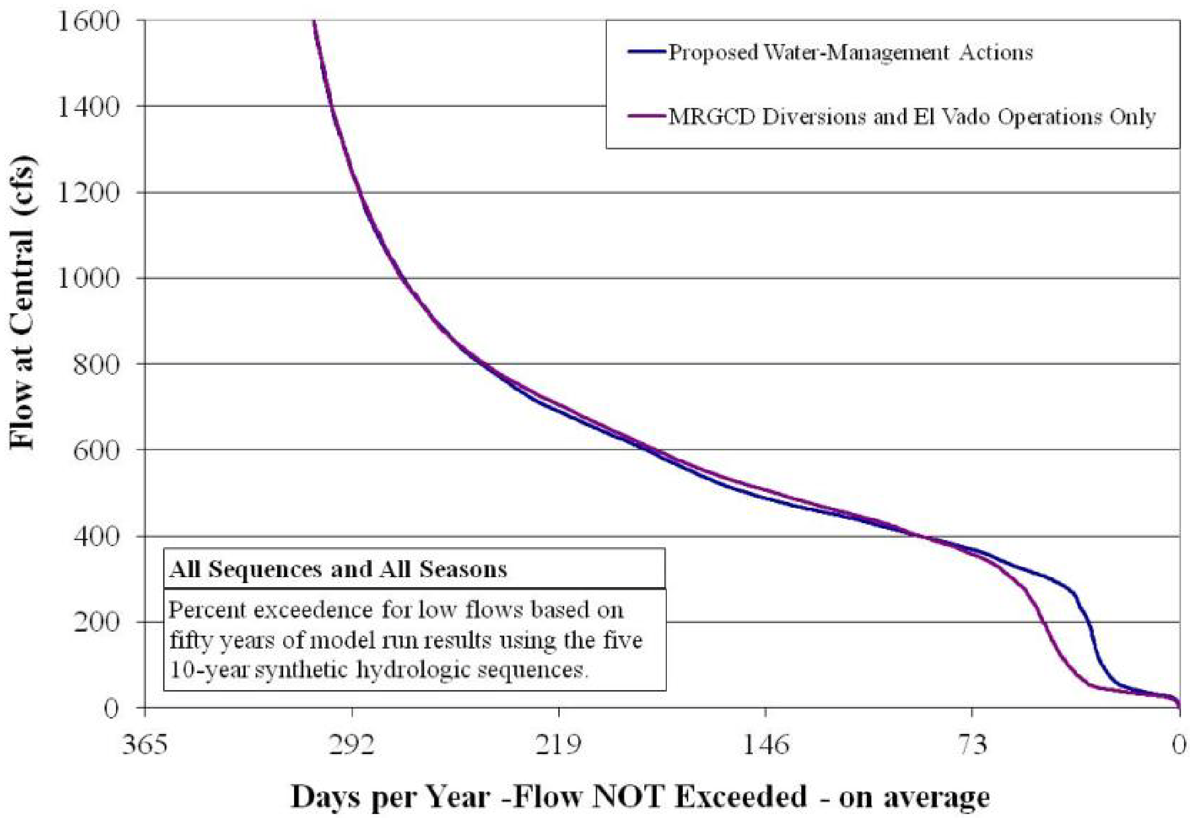

Figure 71. Relative impact of the Heron Dam operations at the Central Avenue gage.

The positive impacts of SJC Project water are most apparent during dry conditions when the MRGCD has depleted its native supplies and is operating using SJC Project water. MRGCD's use of SJC Project water, which constitutes an average of about 7% of its diversions (including Letter Water allocated to the MRGCD), helps to reduce the amount of time that MRGCD is in shortage operations. Since there is a greater chance of critically low flows in the Albuquerque and Isleta Reaches during shortage operations, Reclamation's SJC Project operations help to maintain flows in these reaches during critical periods. Flow exceeds 300 cfs more frequently with Heron Dam operations than without. Hence, SJC Project releases increase flows at Central Avenue during times of shortage.

Other uses of SJC Project water, such as that by Santa Fe's Buckman Direct Diversion or the Cochiti Recreation Pool, are upstream of Cochiti Dam and do not affect flows in the MRG. Many contractors use their SJC Project water to provide an offset to MRGCD irrigators and the Compact for depletions caused by ground water pumping, as administered by the Office of the State Engineer's Letter Water program. Letter Water deliveries to the MRGCD typically are stored in El Vado Reservoir and used to supplement MRG irrigation along with the remainder of the MRGCD's SJC Project allocation. Letter Water deliveries to the Compact typically are released in the winter. SJC Project releases are not of sufficient magnitude to significantly impact the size of the spring snowmelt runoff peak in the MRG.

Downstream from the Isleta Diversion Dam, there is essentially no difference in flows between simulations with and without Heron Dam operations, since Isleta Diversion Dam is the furthest-downstream point of diversion for any significant amount of SJC Project water.

6.4.2.3 Effect of Heron Dam Operation on Silvery Minnow

Prior to reaching the upstream boundary of silvery minnow critical habitat, there are three major dams (El Vado, Abiquiu, and Cochiti) downstream from Heron Dam. The importation of SJC Project water provides more water to meet MRG water demands. Model results indicate that SJC Project water delivered during low flow periods of the irrigation season is detectable in the MRG until Isleta Diversion Dam and may help maintain continuous flow within the Angostura Reach. There are very few detectable geomorphic or water quality effects within silvery minnow critical habitat from the operation of Heron Dam. Table 32 presents the effects of Heron Dam operation on the life history elements and critical habitat PCEs of silvery minnow. Delivery of Letter Water to Elephant Butte may have a more noticeable effect downstream during the late fall and winter.

Figures 72 and 73 show the stepped down effects of the various components of the Proposed Water Management Actions on two of the most important elements for silvery minnow recruitment, the magnitude and duration of spring high flows and the timing of the onset of low flow conditions. There is little impact from Heron Dam operation on the magnitude and duration of high flow events. There is also little impact on the timing of the onset of low flows. The Supplemental Water Program, which is not considered in this graph, helps manage the recession of runoff.

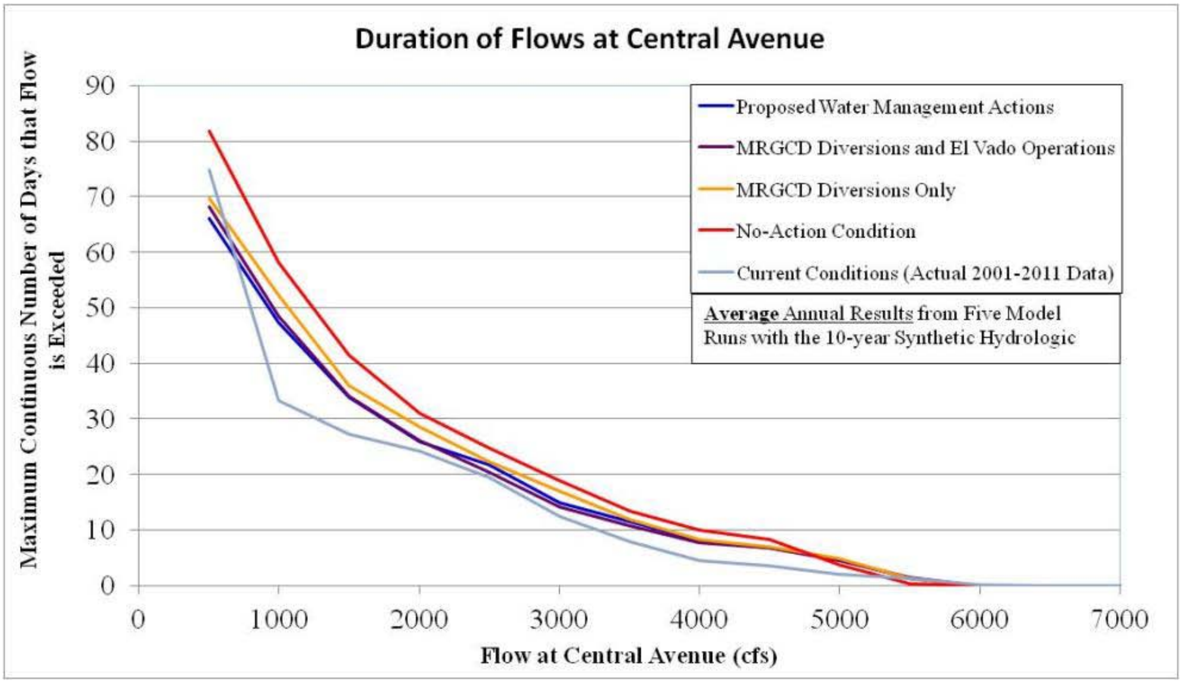

Figure 72. Modeled average annual results of maximum number of continuous high flow days from five model runs with the 10-year synthetic hydrologic sequences at San Acacia gage, Rio Grande, New Mexico.

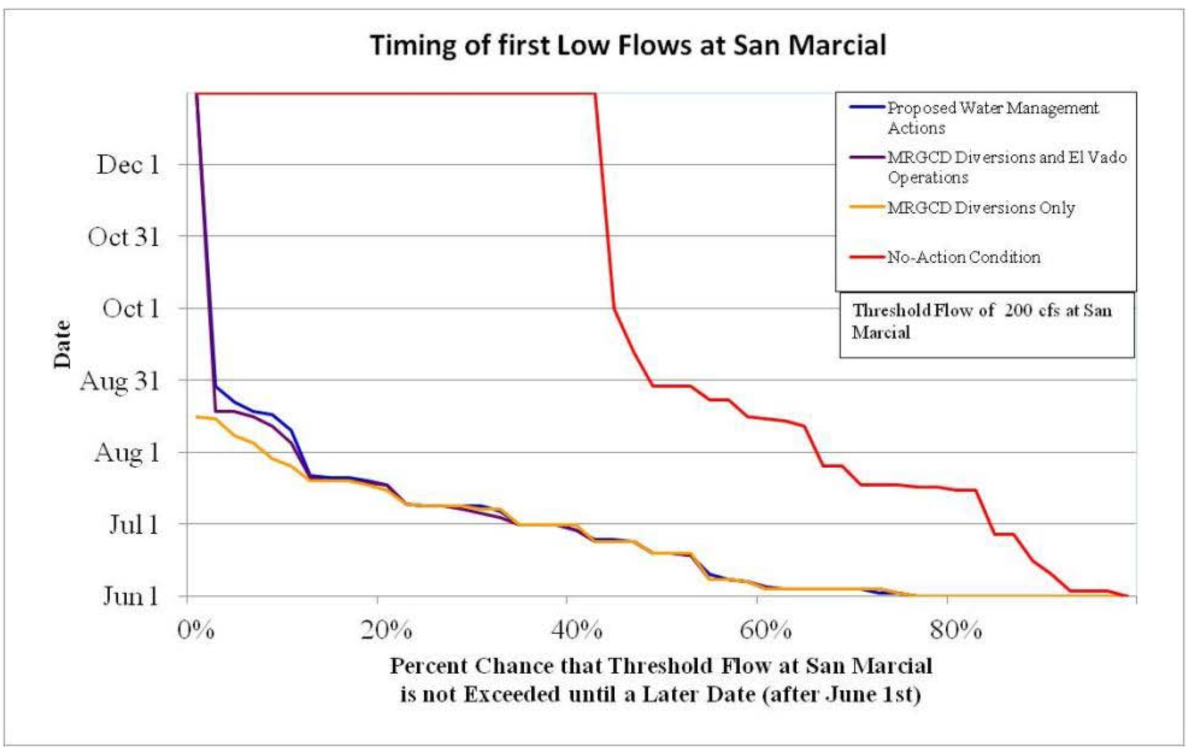

Figure 73. Modeled average annual results of the relative percentage of time low flow (< 200 cfs) begins prior to June 1 at San Marcial gage, Rio Grande, New Mexico from five model runs with the 10-year synthetic hydrologic sequences.

Table 32. Effect of Heron Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

<table>
<tr><th></th><th>Spawning</th><th>Eggs</th><th>Larval</th><th>Juvenile</th><th>Adult</th></tr>
<tr><td>Spring (April–June)</td><td colspan="3">Timing of the Rio Chama peak spring runoff does not normally coincide with the Rio Grande peak. Channel capacity of the Rio Chama below Abiquiu is limited. The anticipated effect on the hydrograph within occupied habitat during spring runoff is minor. Direct and Indirect – Heron operations are not likely to adversely affect silvery minnow spawning or recruitment.</td><td></td><td>The anticipated effect on the hydrograph within occupied habitat during spring runoff is minor. Direct and Indirect – Heron operations are not likely to adversely affect adult silvery minnow.</td></tr>
<tr><td>Summer (June–Sept)</td><td></td><td></td><td colspan="3" rowspan="2">Heron Dam operations increase flows during low flow periods below Cochiti Dam till Isleta Diversion Dam. Much of this water is utilized at the ABCWUA diversion. Model runs indicate that this water helps maintain perennial flow within the Angostura Reach. Thus, Direct and Indirect – Heron Dam operations are beneficial to silvery minnow during summer and fall periods.</td></tr>
<tr><td>Fall (Sept–Nov)</td><td></td><td></td></tr>
<tr><td>Winter (Dec–March)</td><td></td><td></td><td></td><td></td><td>Water releases for contractors generally occur in November and December. These releases provide higher flows through the MRG that are of sufficient magnitude and generally stable. Direct and Indirect – Operations are not likely to adversely affect winter survival of adult silvery minnow.</td></tr>
</table>

Table 32. Effect of Heron Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Critical Habitat PCEs					
Hydrologic Regime					
A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.	***Direct and Indirect – Heron Dam operations are not likely to adversely affect*** the hydrology and maintenance of silvery minnow habitats within the MRG. There may be some beneficial effects due to decreased chances of drying in the Angostura Reach.				
Presence of a diversity of habitats for all life history stages		There is ***not likely to be an adverse effect*** on geomorphology or silvery minnow habitats in the MRG from Heron Dam operations. Vegetation encroachment and channel narrowing caused by water delivery is anticipated to be negligible.			
Sufficient flows from early spring (March) to early summer (June) to trigger spawning	Timing of the Rio Chama peak spring runoff does not normally coincide with the Rio Grande peak. Channel capacity of the Rio Chama below Abiquiu is limited. There is little effect on the hydrograph within occupied habitat during spring runoff. **Direct and Indirect –** ***Operations are not likely to adversely affect silvery minnow critical habitat for spawning.***				
Flows in the summer (June) through fall (October) that do not increase prolonged periods of low or no flow	Heron Dam operations increase flows during low flow periods below Cochiti Dam. Much of this water is utilized at the ABCWUA diversion. Model runs indicate that this water helps maintain perennial flow within the Albuquerque Reach. Thus, **Direct and Indirect–** ***Heron Dam operations are beneficial to silvery minnow critical habitat during summer and fall periods*****.**				

Table 32. Effect of Heron Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Constant winter flow				Water releases for contractors generally occur in November and December. These releases provide higher flows through the MRG that are of sufficient magnitude and generally stable. **Direct and Indirect – *Heron operations are not likely to adversely affect winter critical habitat.***	
Unimpounded stretches of river with a diversity of habitats and low velocity refuge areas					
River reach length	The actual length of wetted river within each reach changes depending on channel sinuosity. Low flow conditions are supplemented by the operation of Heron Dam. Sinuosity changes depending on geomorphology and discharge levels. Sinuosity of the thalweg may increase during low flows and increases the length of the river but also may promote vegetation growth on point bars within the river channel. The operation of Heron Dam ***is not likely to adversely river reach length.***				
Habitat "quality" in each reach and refugial habitats.	Habitat quality in each reach is dependent on the structure and diversity of available habitat. Channel trends throughout the MRG are towards a more simplified channel due to vegetation encroachment. Base flow levels from the proposed actions drive the vegetation encroachment within the channel. The quantity of suitable habitat within each reach also changes at different flows; this relationship is not linear in most sections of the river and is dependent on channel shape . The Proposed Action ***may have indirect effects that adversely affect silvery minnow critical habitat***.				
Substrate of sand or silt					
Substrates of predominantly sand or silt	Heron Dam is on Willow Creek, a small tributary of the Rio Chama. El Vado, Abiquiu, and Cochiti Dams capture sediment downstream prior to water entering critical habitat. There is ***no effect*** on sediment transport in the MRG from Heron Dam operations.				
Water quality					
Temp >1˚ - <30 ˚C DO > 5 mg/L pH (6.6-9.0)	Water temperature, DO, and pH within the reservoir are not likely to have any effect on these parameters within critical habitat. However, increased water availability in the MRG during low flow periods is likely to maintain water quality within the described range. **Direct and Indirect – *Heron Dam operations are beneficial to silvery minnow critical habitat during summer and fall periods.***				
Other contaminants	All chemical parameters were well below levels of concern in Heron; however there is a listing for mercury in fish tissue. It is unknown how contaminants in this reservoir affect water quality in critical habitat, but it is likely a minor factor. **Direct and Indirect – *Heron Dam operations are not likely to affect silvery minnow critical habitat.***				

6.4.2.4 Effect of Heron Dam Operation on Flycatcher

The effect of Heron Dam operation on flycatchers is minimal and results in an increased amount of water in the river at times of lowest flows which may help maintain and establish vegetation. However, Heron Dam operations essentially have no impact on overbank flow conditions that are essential for flycatcher recruitment. Figures 74 and 75 display those model results comparing Central to San Marcial gages during the flycatcher territory establishment period. The result of minimal difference between actions is also evident in the late irrigation season.

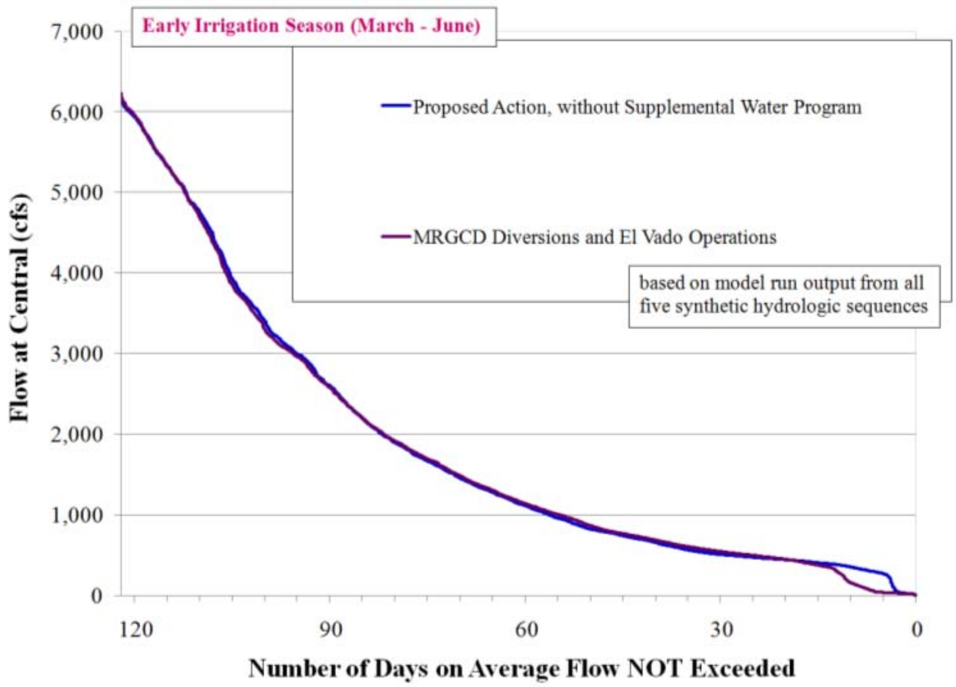

Figure 74. Relative comparison of flows at Central gage considered Proposed Action with no Supplemental Water Program compared to MRGCD diversions and El Vado Operations during the flycatcher territory establishment period.

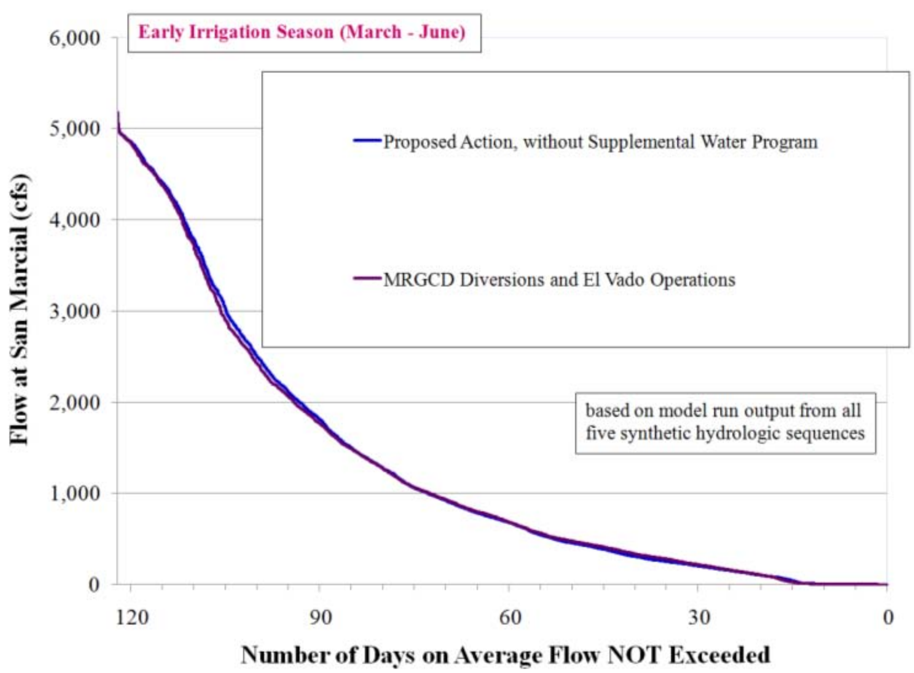

Figure 75. Relative comparison of flows at San Marcial gage considered Proposed Action with no Supplemental Water Program compared to MRGCD diversions and El Vado operations during the flycatcher territory establishment period.

It is also important to review information from the hydrological effects section. Due to the 1,800-cfs channel capacity on the Rio Chama below Abiquiu Reservoir and the normal release schedule from Heron Reservoir, Heron Dam operations for the SJC Project have essentially no impact on the occurrence of recruitment or overbank flows in the MRG.

There is a minimal difference in potential overbank flooding occurrence during early irrigation season due to the operation of Heron Dam (table 33). This difference is largely inconsequential, especially when considering that these areas often require even more than the 4,700 cfs for flooding, and areas where flycatchers occupy are typically along the rivers' edge and, thus, within the 50-meter distance to water where 94% of flycatcher nests are located. For late irrigation season, from July–October, this comparison indicates no difference in the potential days of flooding (table 34).

Table 33. Effect of Heron Dam operation on the potential days of overbank flooding events during early irrigation season and flycatcher territory establishment. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with all Proposed Actions	Number of days flows reach 4,700 cfs with all Proposed Action	Percent of the time flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions
Central	10.20%	12	9.8%	12
San Acacia	7.10%	9	6.8%	8
San Marcial	3.10%	4	2.2%	3

Table 34. Effect of Heron Dam operation on the potential days of overbank flooding events during late irrigation season and flycatcher nesting period. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with all Proposed Actions	Number of days flows reach 4,700 cfs with all Proposed Action	Percent of the time flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions
Central	1.8%	2	1.7%	2
San Acacia	1.8%	2	1.7%	2
San Marcial	1.7%	2	1.7%	2

For the reach below San Acacia gage, modeling indicates that the Proposed Action would meet the 1,400 cfs required for inundation within the BDANWR area and would meet overbank flows 36.1% of the time in the MRGCD diversions and El Vado operations sequence and 36.3% in the Proposed Action sequence. There would be no difference in potential overbank flows by Heron Dam operations (table 35). For late irrigation season, from July–October, there is a very small increase in the probability of 1,400-cfs flows at the San Acacia gage due to the operation of Heron Dam. These results indicate minimal difference in potential overbank flooding during that time period (table 36). Table 37 presents a summary of the effects of Heron Dam operations on flycatchers in the MRG.

Table 35. Effect of Heron Dam operation on the potential days of overbank flooding events during early irrigation season and flycatcher territory establishment in the reaches from Arroyo del las Cañas to RM 78

Gage Location	Percent of the time flows reach 1,400 cfs with all Proposed Actions	Number of days flows reach 1,400 cfs with all Proposed Actions	Percent of the time flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions
San Acacia	36.30%	44	36.1%	44

Table 36. Effect of Heron Dam operation on the potential days of overbank flooding events during late irrigation season and flycatcher nesting period in the reaches from Arroyo del las Cañas to RM 78

Gage Location	Percent of the time flows reach 1,400 cfs with all Proposed Actions	Number of days flows reach 1,400 cfs with all Proposed Actions	Percent of the time flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions
San Acacia	6.2%	8	5.8%	7

Table 37. Effect of Heron Dam operations on life history elements and PCEs of flycatchers

Life History Element	**Migration** (April–June and July–September)	**Arrival to Territories/ Territory Establishment/Nest Building** (May–July)	**Egg Laying/ Incubation/ Nestling/ Fledgling** (June–August)
Breeding Season (April to September)	The Proposed Action would **not likely adversely affect** flycatcher stopover locations during migration because flycatchers will use habitat that is less suitable during this time and farther away from water sources.	The Proposed Action may ***indirectly affect flycatcher habitat on a negligible level***. Because the Proposed Action when compared to MRGCD Diversion and El Vado Dam Operation would ***increase flows in the river.*** At times of lower flows, it would ***minimally increase the overall water available for vegetation*** and could cause an increase in plant health. This ***could potentially and beneficially affect flycatcher habitat,*** particularly in periods of drought. This action would not affect the potential for overbank flows and likely would have no affect on territory recruitment. However, it should be noted that the increase in water between the two scenarios is a relatively small amount.	Territory recruitment at this stage is no longer an issue as flycatchers are more invested in their territories and less likely to abandon nests should conditions dry or decline in value. However, if vegetation does not have adequate water resources, canopy cover likely will decrease and predation and/or parasitism likely would be more prevalent. Because the Proposed Action would result in a little more water in the system, there would be an decreased possibility of vegetation not having adequate water to maintain health and, thus, ***would beneficially affect flycatcher habitat and potential nest success,*** again particularly in times of drought.
Critical Habitat PCES			
Riparian Vegetation	Riparian habitat in a dynamic successional environment to be used for nesting, foraging, migration, dispersal and shelter. Dense tree or shrub vegetation in close proximity to open water or marsh areas. With an increase in the water amount reaching flycatcher suitable habitat patches, the Proposed Action could ***potentially beneficially affect flycatcher riparian vegetation***.		
Insect Prey Populations	A variety of insect prey populations found in close proximity to riparian flood plains or moist environments. The minimal difference between the No Action and the Proposed Action ***would have no affect the insect prey populations***. It is also important to note that a dry river does not impact insect populations when ponded water and adjacent drains are present.		

6.4.3 Analysis of Effects of El Vado Dam Operations Under the Middle Rio Grande Project

6.4.3.1 Approach to Analysis of Effects of the Operation of El Vado Dam Under the Middle Rio Grande Project

Impacts of El Vado Dam operations were evaluated comparing URGWOM simulations of the Proposed Water Management Actions of when Heron Dam operations are turned off to another set of URGWOM simulations of when both Heron Dam operations and El Vado Dam operations are turned off.

In the runs for which El Vado Dam operations are shut off, native inflows are not stored for use within the MRGCD. SJC Project water is not stored for use by MRGCD water rights holders when native Rio Grande flows drop below demand. MRGCD non-Indian irrigators would have available any native and SJC Project water present in El Vado Reservoir under initial conditions, but no additional native and SJC Project water would be stored beyond that required to meet prior and paramount water needs.

6.4.3.2 Effects of El Vado Dam Operations under the Middle Rio Grande Project

Operation of El Vado Dam and Reservoir involves storage of water from the Rio Chama during springtime peak flows, and calls for and use of that stored water in the MRG in times of low flow. El Vado Dam operations, therefore, result in decreased peak flows on the Rio Chama and decreased in flows in the MRG associated with the Rio Chama runoff peak, which generally occurs prior to the main stem spring runoff peak. These actions also result in an increase in flows in the Rio Chama and the MRG during low flow periods, primarily in the summer.

Figure 76 compares flows at the Central Avenue gage for two sets of model simulations: one including El Vado Dam operations and one without these actions. The difference between the two curves on figure 76 indicates the effects on flows at Central Avenue of El Vado Dam operations. Storage at El Vado Reservoir results in a small (about 5-day-per-year) decrease in the number of days with flows above 800 cfs but also causes a minor increase in the number of days per year that flows are above 100 cfs at Central Avenue.

In most years, operation of El Vado Dam does not significantly affect the spring runoff peak in the Rio Grande, since these operations affect the flows on the Rio Chama, and the Rio Chama spring runoff peaks are typically earlier in time and smaller than those on the main stem Rio Grande. In the rare years in which the Rio Chama spring runoff peaks coincide with the main stem runoff peaks, El Vado Dam operations have a greater effect; however, the effects of the Rio Chama runoff are still limited due to the 1,800-cfs channel capacity on the Rio Chama below Abiquiu Reservoir. Therefore, El Vado Dam operations have a minimal impact on the peak spring discharges in the MRG.

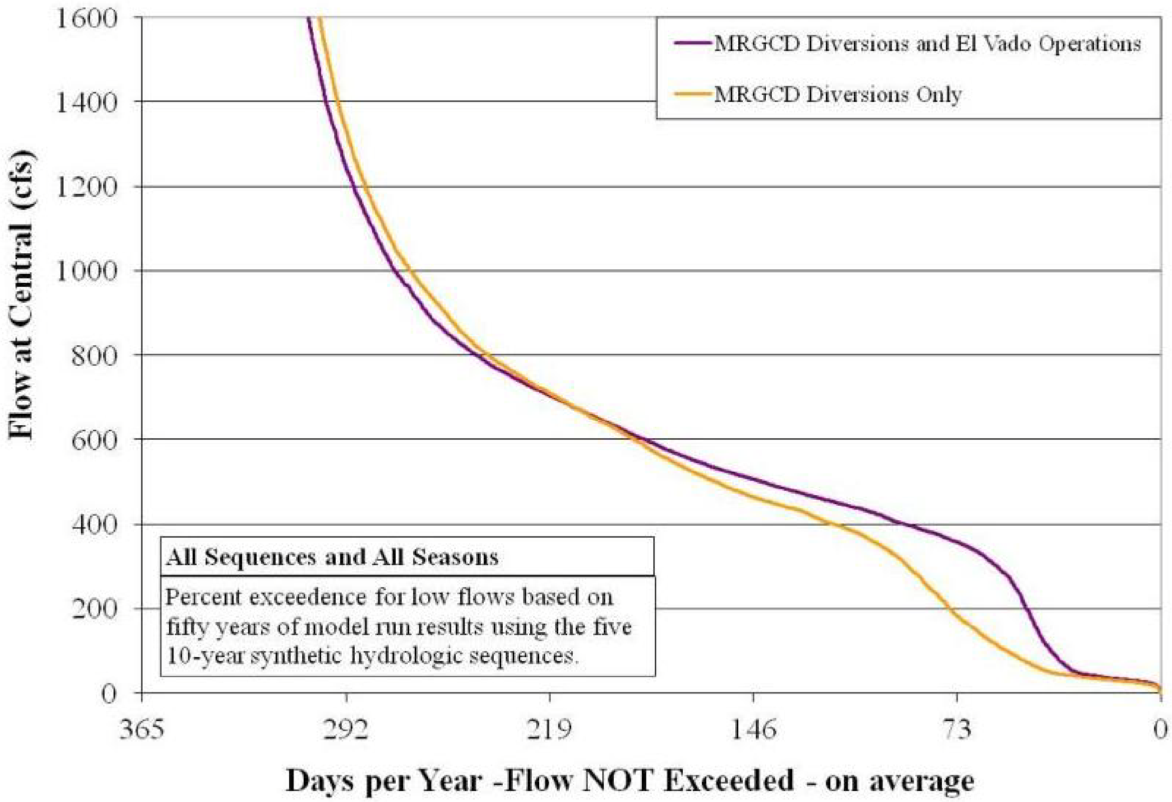

Figure 76. Relative comparison of flows at Central Avenue gage with and without El Vado operations, for the calendar year.

Reclamation releases available water from storage in El Vado Reservoir at the request of the MRGCD to meet the MRG irrigation demand during periods when the natural flow is insufficient to meet these demands. This release of stored water reduces the occurrence of critically low flows and drying, especially in the Cochiti Dam and Albuquerque Reaches, and increases river flows during those periods. This effect may be evident even when Article VII restrictions under the Compact are in effect, since under Article VII restrictions, native water that was stored at El Vado Reservoir prior to the initiation of Article VII restrictions may still be released.

Model results indicate that river drying in the reaches downstream from Isleta Diversion Dam would occur with or without El Vado Dam operations. However, without El Vado Dam operations, river drying in the MRG would be more frequent and more prolonged, especially during times when the daily MRGCD irrigation demand cannot be met by the natural flow of the river. These effects are magnified in the lower reaches of the MRG. Without the release of stored water from El Vado Reservoir, model results indicate that the MRGCD would be in shortage operations, where MRGCD has no storage water to meet demand for some portion of almost every irrigation season. During shortage operations, diversions at Angostura typically are increased to allow the limited river flow to be used as efficiently as possible and ensure that water is delivered to the Six MRG Pueblos, and to non-Indian irrigators as well if sufficient water is available. Under shortage operations, river drying could be expected in the Albuquerque Reach as well as in the Isleta and San Acacia Reaches. Without El Vado Dam operations, river drying would be expected to increase below the Isleta Diversion Dam, as shown in figure 77.

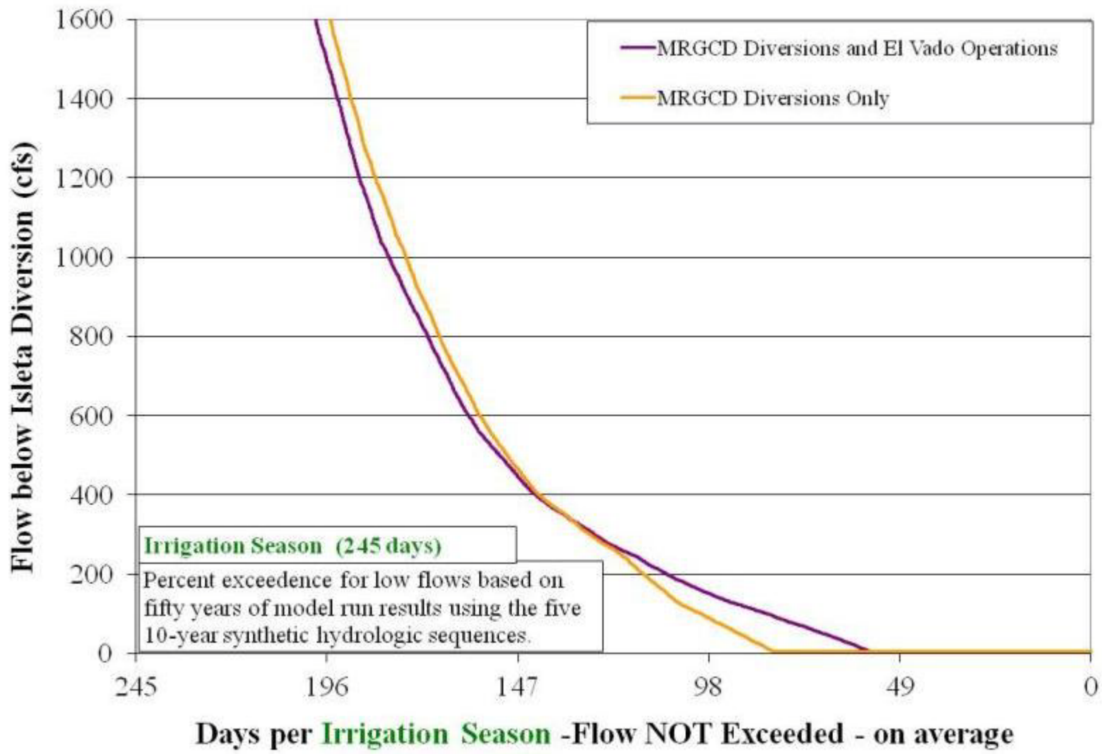

Figure 77. Relative comparison of flows below Isleta Diversion during the irrigation season with and without El Vado operations.

The effect on flows of Reclamation's El Vado Dam operations is less in the San Acacia Reach, downstream from the MRGCD's downstream-most diversion point from the Rio Grande. Still, due to return flows to the river and variations in demand, model simulations indicate that Reclamation's El Vado Dam operations decrease the duration of river drying below San Acacia Diversion, as indicated by the flow exceedence curves in figure 78.

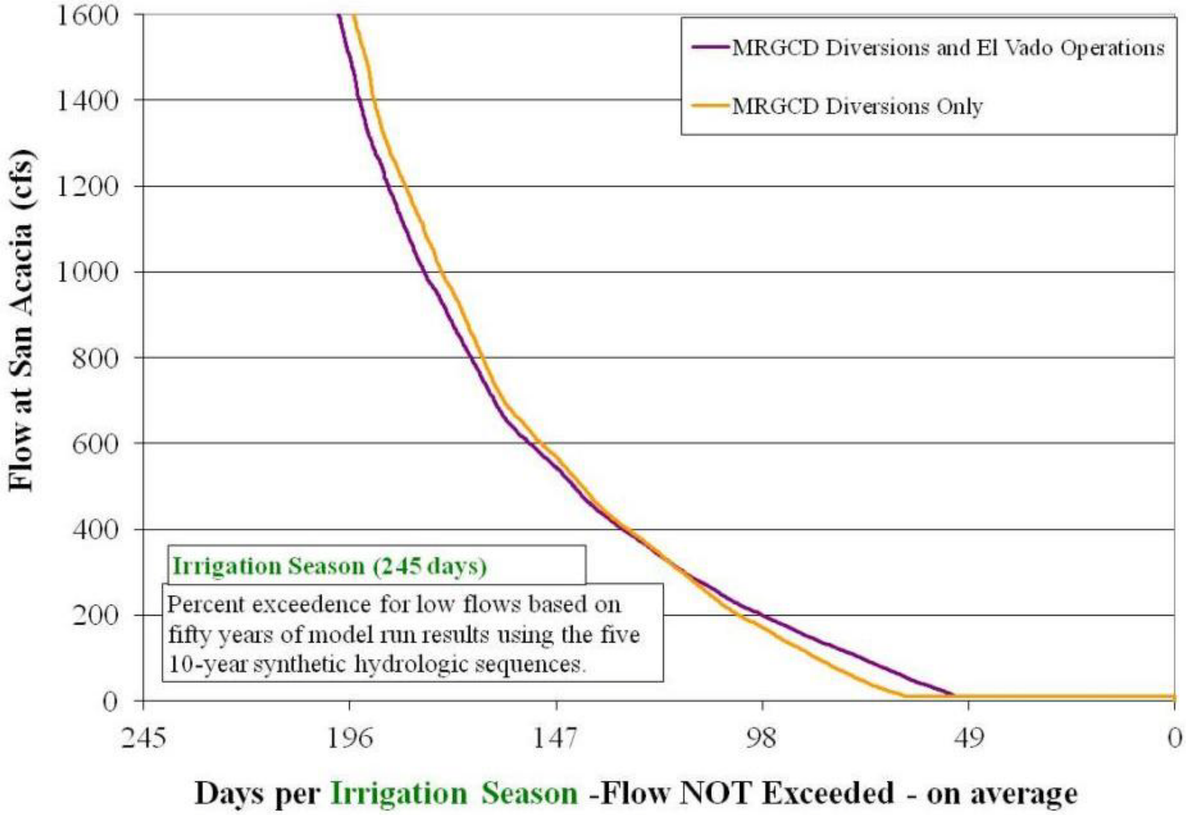

Figure 78. Relative comparison of flows downstream from San Acacia Diversion during the irrigation season, with and without El Vado operations.

6.4.3.3 Effects of El Vado Dam Operations on Silvery Minnow

The modeled effects of El Vado Dam indicate that the storage of springtime peak flows from the Rio Chama causes a slight decrease in the duration and magnitude of spring flows within silvery minnow habitat. The decrease in duration is more noticeable when springtime discharge is low to moderate (less than 4,000 cfs at Central Gage). The modeled difference in the magnitude of discharge during runoff caused by El Vado storage is less than 200 cfs. This stored water is later released for irrigation purposes. The release of this water decreases the duration of drying that would be predicted without this management action below Isleta Dam and San Acacia Dam.

There are two major dams between El Vado Dam and the upstream boundary of silvery minnow critical habitat. Any effects to sediment transport caused by operation of El Vado are masked by Abiquiu and Cochiti Dams. Additionally, the effect of operations on other geomorphic trends within occupied habitat is minor due to the limited difference in high flows from operations. Similar to Heron, El Vado water quality surveys in 2007 determined that all physical and chemical parameters were well below levels of concern except for dissolved oxygen. This report questioned the low DO readings and thought it might be due to equipment malfunction. Regardless, the low DO in El Vado is unlikely to have effects down into silvery minnow critical habitat.

El Vado has recently had positive microscopy test results for quagga mussels though the presence has not been confirmed. The long-term indirect effects downstream from potential quagga mussel establishment in El Vado are difficult to predict for the MRG. Quagga mussels do not appear to be increasing to any extent in the Ohio and Mississippi Rivers, even after being present in these rivers for over a decade. In contrast, numbers in the Colorado River system have continued to increase since the quagga mussel was first reported (Nalepa 2008). It is predicted that high levels of suspended sediment and high inorganic: organic particle ratios may limit, or possibly prevent, mussel expansion in the main stem portions of the Colorado River (Kennedy 2007). However, changes in water quality (i.e., dissolved nutrients, phytoplankton, and zooplankton) in infested reservoirs may impact food web structure or trophic linkages in the downstream riverine ecosystem. A summary of the effects of El Vado Dam on silvery minnow is presented in table 38.

Table 38. Effect of El Vado Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

<table>
<tr><th></th><th>Spawning</th><th>Eggs</th><th>Larval</th><th>Juvenile</th><th>Adult</th></tr>
<tr><td>Spring (April–June)</td><td colspan="3">Timing of the Rio Chama peak spring runoff does not normally coincide with the Rio Grande peak. Channel capacity of the Rio Chama below Abiquiu is limited. During most years, there is limited effect on the hydrograph within occupied habitat during spring runoff. This effect is more pronounced in years with low runoff conditions in the Rio Grande drainage. Though the impact on silvery minnow spawning and recruitment is anticipated to be minor, the Direct and Indirect effects of El Vado operations are likely to adversely affect silvery minnow spawning and recruitment.</td><td></td><td>There is little information on how spring flows are related to adult survival of silvery minnow. The small differences in the spring hydrograph from El Vado operations are not likely to (directly or indirectly) adversely affect adult silvery minnow.</td></tr>
<tr><td>Summer (June–Sept)</td><td></td><td></td><td colspan="3" rowspan="2">El Vado Dam releases increase flows during low flow periods below Cochiti Dam to Isleta Diversion Dam. The majority of this water is diverted by MRGCD at their diversions. Model runs indicate that this water helps maintain perennial flow within the Albuquerque Reach and decreases drying in the Isleta Reach. Thus, Direct and Indirect – El Vado Dam operations are beneficial to silvery minnow during summer and fall periods.</td></tr>
<tr><td>Fall (Sept–Nov)</td><td></td><td></td></tr>
</table>

Table 38. Effect of El Vado Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Winter (Dec–March)					Water releases for contractors and Compact deliveries generally occur in November and December. These releases provide higher flows through the MRG, which are of sufficient magnitude and generally stable. **Direct and Indirect –** ***El Vado operations are not likely to adversely affect winter survival of adult silvery minnow.***
Critical Habitat PCES					
Hydrologic Regime					
A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.	***Direct and Indirect – El Vado Dam operations are not likely to adversely affect the hydrology and maintenance of silvery minnow habitats within the MRG.*** There may be some beneficial effects due to decreased chances of drying in the Angostura and Isleta Reaches during low flow periods.				
Presence of a diversity of habitats for all life history stages		There is ***no direct effect*** on geomorphology or silvery minnow habitats in the MRG from El Vado Dam operations. Water delivery with low base flow levels may have long-term impacts by encouraging vegetation encroachment and channel narrowing and ***indirectly, may likely adversely affect critical habitat***.			

Table 38. Effect of El Vado Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Sufficient flows from early spring (March) to early summer (June) to trigger spawning	Timing of the Rio Chama peak spring runoff does not normally coincide with the Rio Grande peak. Channel capacity of the Rio Chama below Abiquiu is limited. There is little effect on the hydrograph within occupied habitat during spring runoff. **Direct and Indirect – *El Vado operations are not likely to adversely affect silvery minnow critical habitat for spawning*.**				
Flows in the summer (June) through fall (October) that do not increase prolonged periods of low or no flow	El Vado Dam releases increase flows during low flow periods below Cochiti Dam. The majority of this water is diverted by MRGCD at their diversions. Model runs indicate that this water helps maintain perennial flow within the Albuquerque Reach and decreases drying in the Isleta Reach. **Direct and Indirect – *El Vado Dam operations are beneficial to silvery minnow critical habitat during summer and fall periods*.**				
Constant winter flow				Water releases for contractors generally occur in November and December. These releases provide higher flows through the MRG that are of sufficient magnitude and generally stable. **Direct and Indirect – *El Vado operations are not likely to adversely affect winter critical habitat for silvery minnow.***	
Unimpounded stretches of river with a diversity of habitats and low velocity refuge areas					
River reach length	Currently, diversion dams are in place; no new cross channel structures are proposed. The actual length of wetted river within each reach changes depending on channel sinuosity. The sinuosity changes depending on geomorphology and discharge levels. Sinuosity of the thalweg may increase during low flows that increases the length of the river but also may promote vegetation growth on point bars within the river channel. The lack of flood stage flows also changes the potential that the river will move outside its current channel. The Proposed Action ***is not likely to adversely river reach length.***				

Table 38. Effect of El Vado Dam operation (3.2.1) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Habitat "quality" in each reach and refugial habitats.	Habitat quality in each reach is dependent on the structure and diversity of available habitat. Channel trends throughout the MRG are towards a more simplified channel due to vegetation encroachment. Base flow levels from the Proposed Actions drive the vegetation encroachment within the channel. The quantity of suitable habitat within each reach also changes at different flows, this relationship is not linear in most sections of the river and is dependent on channel shape. The Proposed Action ***may have indirect effects that adversely affect silvery minnow critical habitat***.				
Substrate of sand or silt					
Substrates of predominantly sand or silt	Abiquiu and Cochiti Dams capture sediment downstream from El Vado prior to delivered water reaching critical habitat. There is ***no effect*** on sediment transport in the MRG from El Vado Dam operations.				
Water quality					
Temp >1˚ - <30 ˚C DO > 5 mg/L pH (6.6-9.0)	Water temperature, DO, and pH within El Vado Reservoir are not likely to have any effect on these parameters within critical habitat. However, increased water availability in the MRG during low flow periods is likely to maintain water quality within the described range. **Direct and Indirect – *El Vado Dam operations are beneficial to silvery minnow critical habitat during summer and fall periods*.**				
Other contaminants	All chemical parameters were well below levels of concern in El Vado; however recent quagga mussel tests indicate that mussels may be present. It is unknown how quagga mussels in this reservoir may affect water quality in Critical Habitat but establishment within the main stem seems unlikely. **Direct – *El Vado Dam operations are not likely to affect silvery minnow critical habitat.* Indirect – *El Vado Dam operations are not likely to affect silvery minnow critical habitat* due to the unknown impacts from quagga mussels and unlikely establishment of mussels in the main stem.**				

6.4.3.4 Effect of El Vado Dam Operation on Flycatcher

Model results indicate a very minor change when comparing El Vado Dam operations with MRGCD diversions compared with MRGCD diversions alone. The main difference is noticed during the late irrigation season and farther north where the El Vado Dam operations maintain a more water within the channel during low flows (figure 79) and may beneficially supply additional ground water to support vegetation. Conversely, earlier in the season, by storing additional water in El Vado Reservoir when the river is experiencing higher flows, this action has a negative impact on the potential for overbank flows though El Vado operations alone have a very minimal impact on the occurrence of recruitment or overbank flows in the MRG.

Hydraulic modeling predicts on average that there is a minimal difference in potential for overbank flooding occurrence during early irrigation season for El Vado Dam operations. This difference is largely inconsequential, particularly when considering these areas often require even more than the 4,700 cfs for flooding, and areas where flycatchers occupy are typically along the rivers’ edge and, thus, within the 50-meter distance to water where 94% of flycatcher nests are located (table 39). The same comparison for the late irrigation season from July–October using the MRGCD diversion and El Vado Dam operations sequence indicates no difference in the potential days of flooding (table 40).

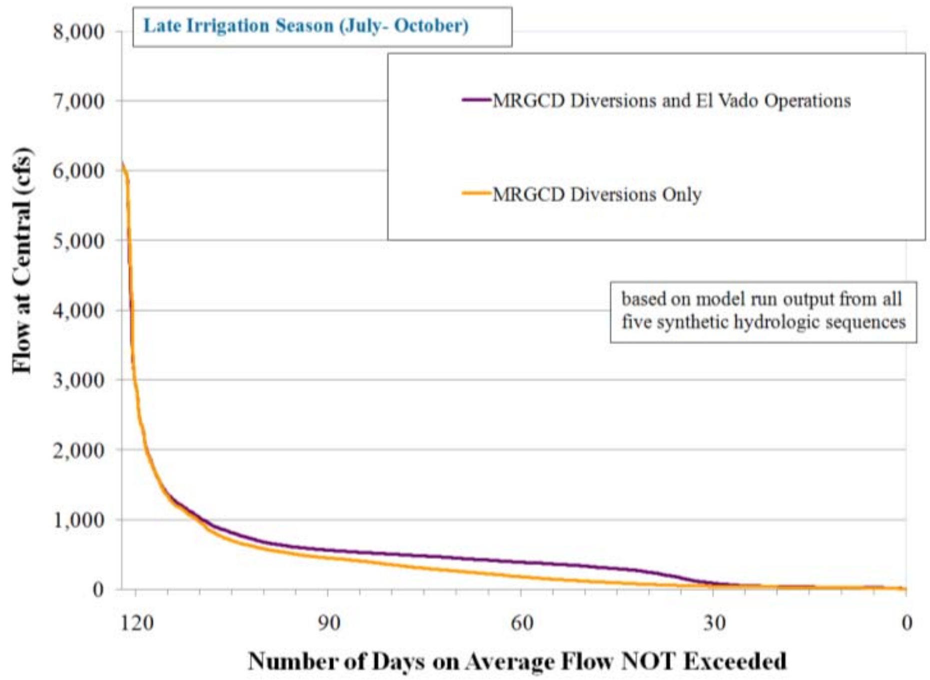

Figure 79. Relative comparison of flows at Central Avenue gage with and without El Vado operations during the flycatcher breeding period.

Table 39. Effect of El Vado Dam operation on the potential days of overbank flooding events during early irrigation season and flycatcher territory establishment. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions	Percent of the time flows reach 4,700 cfs with MRGCD diversions only	Number of days flows reach 4,700 cfs with MRGCD diversions only
Central	9.8%	12	10.4%	13
San Acacia	6.8%	8	7.2%	9
San Marcial	2.2%	3	2.9%	4

Table 40. Effect of El Vado Dam operation on the potential days of overbank flooding events during late irrigation season and flycatcher nesting period. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 4,700 cfs with only El Vado Dam operation and MRGCD diversions	Percent of the time flows reach 4,700 cfs with MRGCD diversions only	Number of days flows reach 4,700 cfs with MRGCD diversions only
Central	1.7%	2	1.8%	2
San Acacia	1.7%	2	1.7%	2
San Marcial	1.7%	2	1.7%	2

For the reach below the San Acacia gage where 1,400 cfs, required for inundation within the BDANWR area, would meet overbank flows 36.1% of the time with MRGCD diversions and El Vado operations sequence and 39.0% of the time with MRGCD diversions alone sequence (table 41). This 4-day difference would be more substantial than other reaches, but territories within this area are found along the river and are typically within 50 m of water as long as the river is wet, which would be the majority of time in the March–June time period.

Table 41. Effect of El Vado Dam operation on the potential days of overbank flooding events during early irrigation season and flycatcher territory establishment in the reaches from Arroyo del las Cañas to RM 78

Gage Location	Percent of the time flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions	Percent of the time flows reach 1,400 cfs with MRGCD diversions only	Number of days flows reach 1,400 cfs with MRGCD diversions only
San Acacia	36.10%	44	39.0%	48

From July–October at the San Acacia gage, flows would be approximately 1,400 cfs for 7 out of 123 days or 5.8% of the time in the MRGCD diversions alone sequence, or 7 days and 5.8% of the time with MRGCD diversions and El Vado Dam operations. These results indicate no difference in potential overbank flooding during that time period (table 42).

Table 42. Effect of El Vado Dam operation on the potential days of overbank flooding events during late irrigation season and flycatcher nesting period. This includes the reaches from Arroyo del las Cañas to RM 78.

Gage Location	Percent of the time flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions	Number of days flows reach 1,400 cfs with only El Vado Dam operation and MRGCD diversions	Percent of the time flows reach 1,400 cfs with MRGCD diversions only	Number of days flows reach 1,400 cfs with MRGCD diversions only
San Acacia	5.8%	7	5.8%	7

A summary of the effects of El Vado Dam on flycatchers is presented in table 43.

Table 43. Effect of El Vado Dam operations on life history elements and PCEs of flycatchers

	Migration (April–June and July–September)	**Arrival to Territories/ Territory Establishment/Nest Building** (May–July)	**Egg Laying/ Incubation/ Nestling/ Fledgling** (June–August)
Breeding Season (April–September)	The Proposed Action would **not likely adversely affect** flycatcher stopover locations during migration because flycatchers will use habitat that is less suitable during this time and farther away from water sources.	The Proposed Action may ***indirectly affect flycatcher habitat on a negligible level***. Because the El Vado Dam operation would decrease the potential of overbank flooding but would increase the water available to vegetation at times of lower flows, overall, this would increase the potential for vegetation health, and ***could potentially beneficially affect flycatcher habitat,*** particularly in periods of drought. The benefit of maintaining the vegetative health outweighs the potential of initial territory recruitment via overbank flooding, particularly because most flycatcher habitat is along the river and within 50 meters of water anyway. However, it should be noted that the decrease in water between the two scenarios is an extremely small amount.	Territory recruitment at this stage is no longer an issue, as flycatchers are more invested in their territories and less likely to abandon nests should conditions dry or decline in value. However, if vegetation does not have adequate water resources, canopy cover will likely decrease and predation and/or parasitism would likely be more prevalent. Because the Proposed Action would result in a little more water in the system at times of low flows and increased plant stress, there would be an decreased possibility of vegetation not having adequate water to maintain health and, thus, ***would beneficially affect flycatcher habitat and potential nest success,*** again particularly in times of drought.

Table 43. Effect of El Vado Dam operations on life history elements and PCEs of flycatchers

	Migration (April–June and July–September)	**Arrival to Territories/ Territory Establishment/Nest Building** (May–July)	**Egg Laying/ Incubation/ Nestling/ Fledgling** (June–August)
Critical Habitat PCES			
Riparian Vegetation	Riparian habitat in a dynamic successional environment to be used for nesting, foraging, migration, dispersal and shelter. Dense tree or shrub vegetation in close proximity to open water or marsh areas. With an increase in the water amount reaching flycatcher suitable habitat patches, the Proposed Action could ***potentially beneficially affect flycatcher riparian vegetation***.		
Insect Prey Populations	A variety of insect prey populations found in close proximity to riparian flood plains or moist environments. The minimal difference between the No Action and the Proposed Action ***would not affect the insect prey populations***. It is also important to note that a dry river does not impact insect populations when ponded water and adjacent drains are present.		

6.4.4 Hydrologic Effects Analysis of Non-Federal Proposed Action: MRGCD Diversions

The MRGCD diverts water for its irrigation works at Cochiti Dam and operates diversion structures at Angostura, Isleta, and San Acacia. The MRGCD typically diverts and delivers water from March 1–October 31 each year, although in recent years, delivery of irrigation water to the Six MRG Pueblos has continued through November 15. Diversions impact river flows up to the capacity of MRGCD diversions, or until the river dries. River flows are subsequently augmented, especially in the Albuquerque and Isleta Reaches, by return flows from drains and MRGCD wasteways.

Irrigation demand correlates closely with climatic conditions and the physiologic properties of agricultural crops. Demand is highest during the months of May, June, and July, tapering off in August and September. From March through mid-June, natural flows in the Rio Grande are generally greater than MRGCD consumptive needs. Therefore, during this early part of the irrigation season, much of the water diverted by the MRGCD is returned directly to the Rio Grande through wasteways and drains in the Cochiti Dam, Albuquerque, and Isleta Reaches. However, after the end of the spring snowmelt runoff, naturally occurring flows often drop precipitously and are generally less than the consumptive needs of the MRGCD. During the peak growing season, most water diverted is consumed by crops, and return flows are minimal.

At this time, the MRGCD augments the natural flow of the Rio Grande, up to its consumptive needs, with releases of stored water from El Vado Reservoir. The tail water from MRGCD diversions is delivered to the Bosque del Apache National Wildlife Refuge.

6.4.4.2 Approach for Analyzing Impacts of MRGCD Diversions

In the next step of this action-by-action analysis, MRGCD diversions for non-Indian irrigators and the Six MRG Pueblos were removed from the model, and the model was run without MRGCD diversions, El Vado Dam operations, and Heron Dam operations. The results of these runs, for the five hydrologic sequences, were then compared to the previous set of runs, in which El Vado Dam operations and Heron Dam operations were turned off, but MRGCD diversions were still operating. The comparison provides an assessment of the effects of the MRGCD diversions on river flows.

There are no historical data for years in which there were no diversions during the irrigation season; and, therefore, URGWOM is not calibrated for these conditions. For this reason, the model is not able to accurately predict river drying under these conditions. Analyses based on past river flows have suggested that river drying still would be expected during dry periods even with no diversions (Flanigan et al. 2004). However, Reclamation's modeling analyses suggest that this drying likely is mitigated by return flows to the river from riverside and interior drains. Under the No Action condition, this water would be returned to the river and would not be diverted for irrigation further downstream. The amount of anticipated drying under the No Action scenario is presented in table 19 using an adjusted methodology.

Because of the uncertainty in the degree of river drying under the modeled No Action condition, graphs are provided in this effects analysis that present the difference in flows between model runs. These graphs depict the effects of proposed actions in terms of relative changes to flow, rather than the absolute flows. In this draft, the original graphs, which present a comparison of the flows with and without the Proposed Action being evaluated, also are presented. MRGCD diversions were simulated in the URGWOM planning model according to a set of demand curves for each diversion, which was developed by the MRGCD in cooperation with the NMISC. These demand curves are provided in appendix 5.

6.4.4.3 Hydrologic Effects of MRGCD Diversions

Figure 80 presents a relative comparison of the flows that could be expected downstream from Cochiti Dam with and without MRGCD diversions during the irrigation season. Figure 81 presents this comparison through flow exceedence curves for the URGWOM simulation with the MRGCD diversions operating and for the No Action condition. The difference between the two lines indicates the relative impact of the diversions at Cochiti Dam. At times when the flow of the river downstream from Cochiti Dam are 200 cfs with the diversions operating, approximately 130 cfs of additional flow could be expected, on average, if the diversions were not operating. Similarly, at times when flows are above 100 cfs with irrigation diversions operating, model runs indicate approximately a 75- to 150-cfs increase could be expected below Cochiti Dam and the Cochiti diversions if the MRGCD diversions were not operating. This graph shows these differences for the irrigation season. There is essentially no impact of MRGCD diversions during the nonirrigation season.

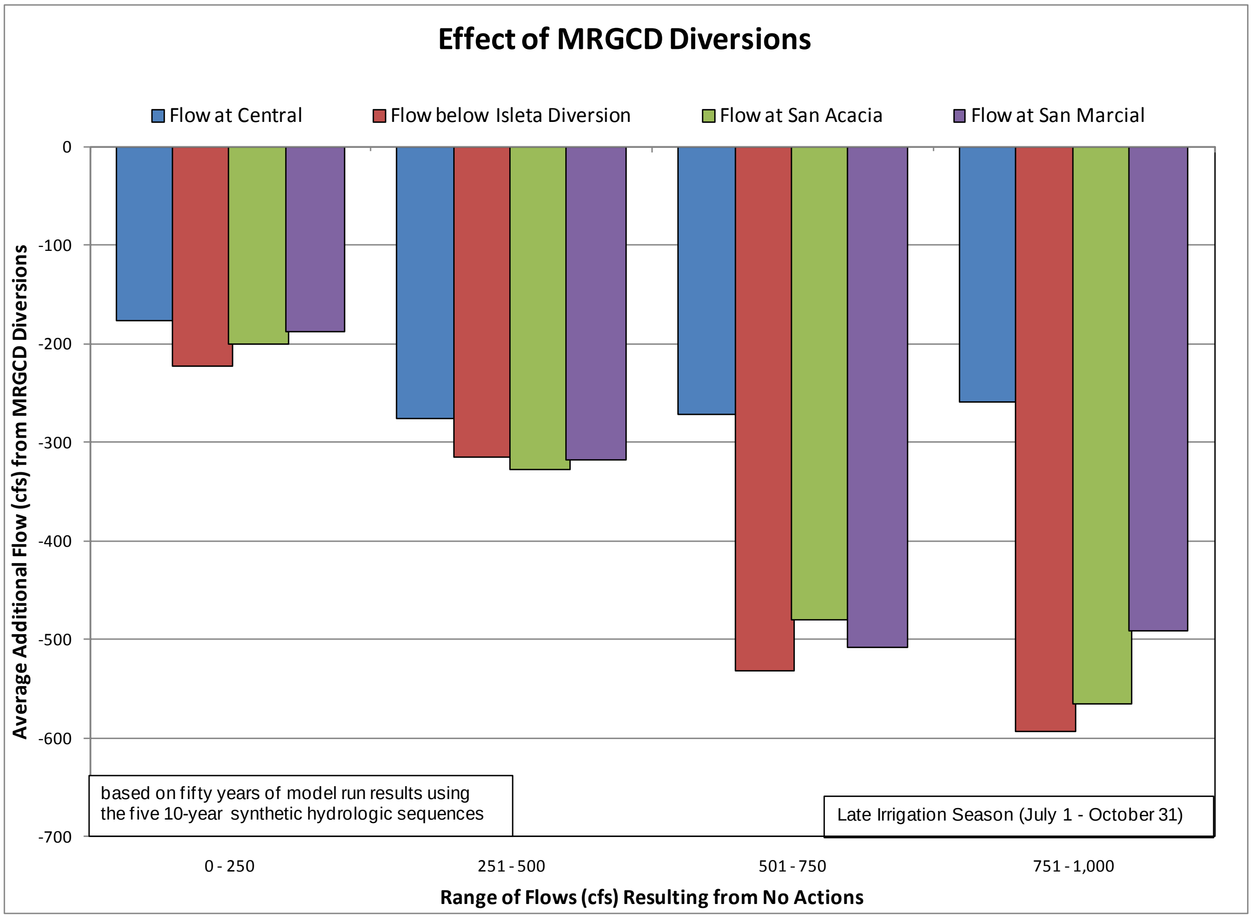

Figure 80. Flow reductions resulting from MRGCD diversions during low flow conditions, late irrigation season.

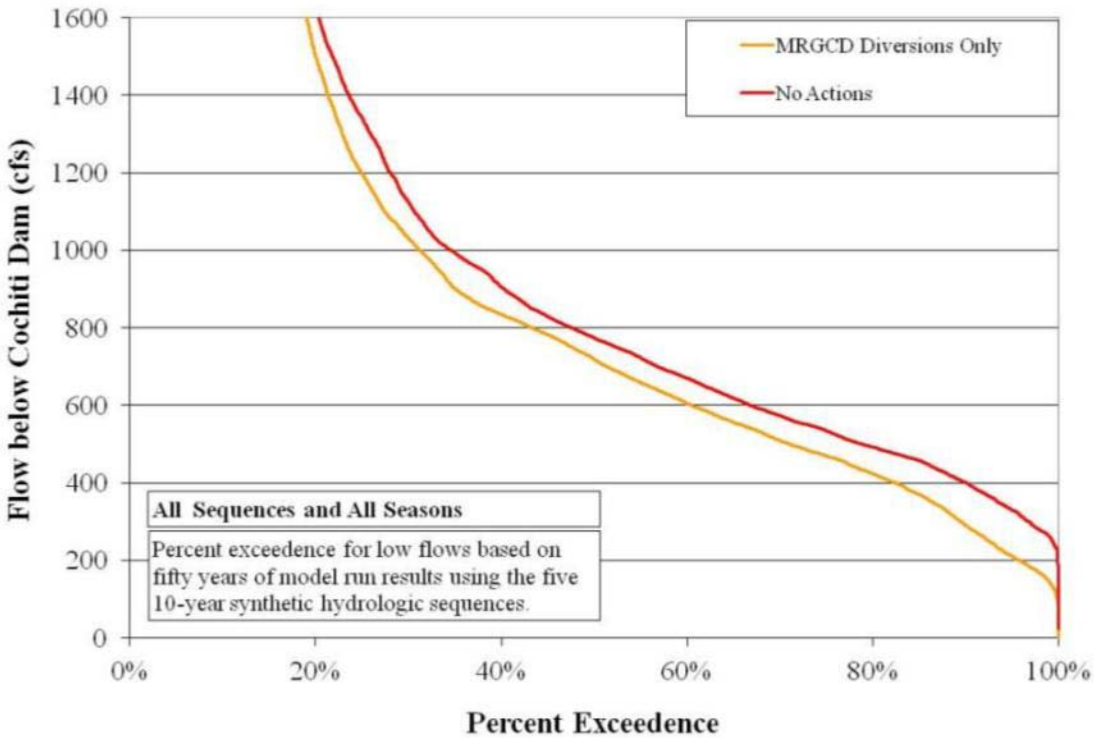

Figure 81. Relative comparison of flows downstream from Cochiti Dam with and without MRGCD diversions, for the calendar year.

Figure 82 compare the flows at the Albuquerque/Central Avenue gage with and without MRGCD diversions. The additional flows without MRGCD diversions are more significant at Central Avenue than they are downstream from Cochiti Dam and Diversion, since the river at Central Avenue is impacted by the diversions at Angostura in addition to the diversions at Cochiti. However, due to return flows from the Cochiti Division, the difference is not equal to the total of the diversions at Cochiti and Angostura. Without MRGCD diversions, flows at Central Avenue could be 200 cfs higher at most flows. When the flows with MRGCD diversions are between 100 and 500 cfs, the difference is larger—additional flows of up to 300 cfs could be expected if the Cochiti and Angostura Diversions were turned off. These conditions could reflect times in which the MRGCD is in shortage operations, and diversions at Angostura are increased to ensure delivery of water to the MRG Pueblos.

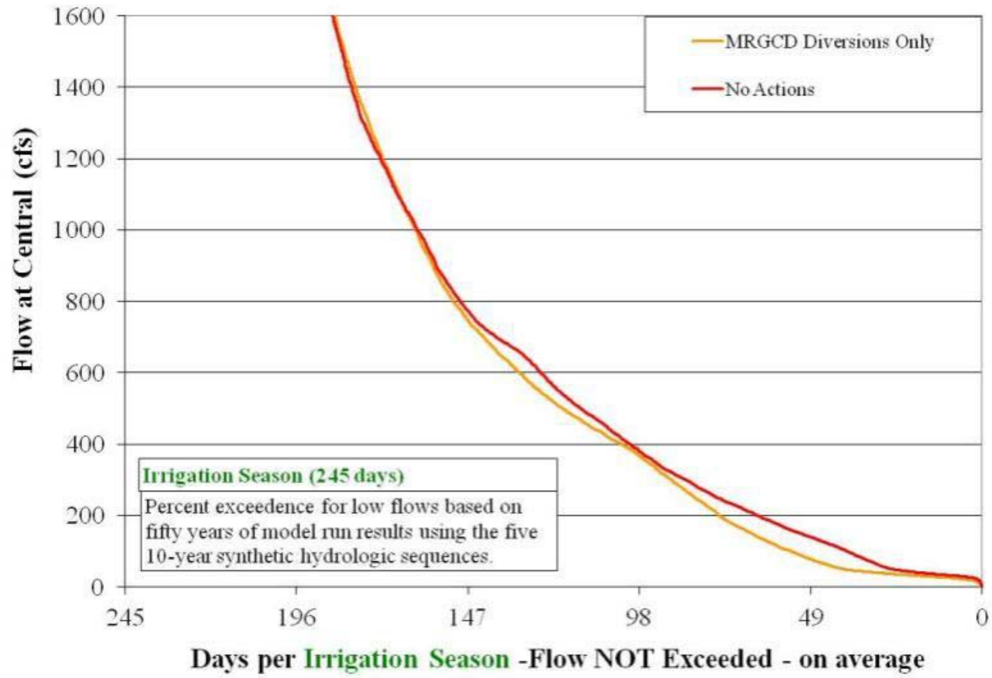

Figure 82. Relative effect of MRGCD diversions at the Central Avenue gage during the irrigation season.

Modeling indicates that additional flows are expected below San Marcial during the irrigation season if the MRGCD diversions were turned off. Below the Isleta Diversion structure, the additional river flows that could be expected without MRGCD diversions are typically in the range of 500 cfs. The additional river flow that could be expected below the San Acacia Diversion and at San Marcial would be between 400–500 cfs. The expected additional flows are lower at the locations downstream from the San Acacia Diversion due to conveyance losses. It is important to note that these differences are only apparent during the irrigation season. During the nonirrigation season, when the diversions would not be operating anyway, there is no effect from turning them off.

6.4.4.4 Qualitative Evaluation of the Effects of MRGCD's Proposed Actions

As quantified in section 6.2, the MRGCD diverts a large portion of all water moving to and through the MRG. In the process, its operations have distinct and measurable effects on water flow and distribution and, therefore, on the habitat of the listed species. MRGCD effects may be positive or negative and, in some cases, may be both depending on the timing of events.

6.4.4.4.1 MRGCD Operations

The operation of the MRGCD mimics the predevelopment pattern in which springtime floods are spread across the flood plain and a gradual drying out of the flood plain follows through the summer and fall. Though this process is now artificially controlled, and depletions have been shifted from natural vegetation to agricultural crops, water consumption occurs within the historic flood plain of the river.

The cycling (or recycling) of water throughout the MRGCD results in a pattern of dry and wet areas. Near points of diversion, the Rio Grande is typically drier. Further downstream, return flows are collected, and ground water levels generally increase. 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 ground water levels tend to overcome evaporative/riparian loss and produce additional wet areas in the river. This pattern simulates the predevelopment 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 ground water, to the LFCC. Reclamation then pumps this water, as required and available, from the LFCC back to the Rio Grande to support species habitat.

The MRGCD's diversions from the Rio Grande during the baseline period were about 350,000 AFY. These proposed diversions are significantly lower than the amount diverted in previous decades, and the reduced diversions help to increase flow below diversion dams at times when natural flow is greater than MRGCD demand. When natural flow is less than MRGCD demand, these reduced diversions decrease the requirement for augmentation through releases from El Vado Reservoir. This, in turn, has the effect of conserving MRGCD's supply, prolonging the time during which MRGCD is in normal operation. Normal MRGCD operation decreases the need for Supplemental Water for listed species. In addition, the reduced diversions result in smaller MRGCD releases from storage, which, in turn, results in a decreased need for water to be replaced into storage. This minimizes the impact of springtime storage in El Vado on Rio Grande flows.

As discussed in section 3, Reclamation operates El Vado Reservoir in coordination with the MRGCD. El Vado Dam operations include storage, bypass of natural flows, and release of stored water. The effect of the storage operation is to reduce the magnitude and/or duration of runoff flow on the Rio Chama. Storage may occur, and flows may be reduced, at any time of the year, but typically storage takes place between April 15–June 1. Due to the Corps' re-regulation at Abiquiu Reservoir and limited channel capacity below Abiquiu Dam, the influence of storage at El Vado on peak MRG discharge typically is minimized. Abiquiu channel capacity and the Corps' re-regulation also may moderate the impact of El Vado Reservoir storage on the duration of high spring flows in the MRG.

The release of stored water from El Vado, when requested by MRGCD, affects the Rio Grande during periods of low natural Rio Grande flow. When natural flow is insufficient to meet irrigation demand, the MRGCD relies on stored water from El Vado to augment natural flow. At times, natural flow above Cochiti Reservoir can be quite small (< 150 cfs), and virtually all water movement to and through the MRG may be due to release of stored water. The routing of this water increases flow between upstream reservoirs on the Rio Chama and MRGCD diversion structures. Typically, the increased flow extends downstream to the Isleta Diversion. At times, water is routed as far downstream as San Acacia and, therefore, keeps the Isleta Reach of the river wet. More typically, water used for irrigation in the San Acacia Reach is diverted at Isleta and routed to the San Acacia division via irrigation infrastructure rather than through the river.

While there can be exceptions when naturally occurring flow is very near or equivalent to MRGCD demands, in general, the effect of storage and release from El Vado is to moderate the MRG flows. The snowmelt runoff volumes are slightly reduced, while the extent of drying is considerably reduced. In the case of drying, the effect is not felt below San Acacia Dam, since MRGCD requests releases of water only up to its needs, and return flows from Socorro Division are delivered to the LFCC and the BDANWR instead of the Rio Grande.

Another effect of storage and release of water from El Vado is the reduced need for Supplemental Water for listed species. MRGCD's movement of water to its diversion points in the MRG increases the flow in the river to those points, so that Supplemental Water releases are not required to keep those reaches wet (although Supplemental Water still may be needed to support flows downstream from the diversion points). MRGCD may reduce diversions or cease calling for the release of water from El Vado Reservoir before the scheduled end of the irrigation season to save water for subsequent irrigation seasons, resulting in carryover storage in El Vado. Carryover storage increases the likelihood that the MRGCD will be in full operation during the subsequent irrigation season(s), decreasing Supplemental Water requirements in the future, although it may increase Supplemental Water requirements during the current season.

6.4.4.4.2 MRGCD Water Diversions and Returns

As detailed in section 6.1.3, the water that the MRGCD diverts consists of natural flows of the Rio Grande and its tributaries, native Rio Grande water released from El Vado Reservoir, and imported water from the SJC Project. The MRGCD's permit with the NMOSE, as well as the Compact, allows MRGCD to divert up to 100% of the available natural flow in the MRG.

The MRGCD's diversions from the Rio Grande have the effect of reducing river flows. During times of high flows, the effect may be slight. During times of lower flow, the effect may be significant and may lead to additional river drying.

During those low water times, Reclamation, in coordination with the MRGCD, releases stored water from El Vado Reservoir (if available) to augment the natural flow of the Rio Grande to the level required for MRGCD diversion works to function. This normally results in continuous flow in the MRG from Cochiti Dam to Isleta Diversion Dam.

The MRGCD can serve all of its irrigators downstream from the Isleta Diversion Dam at times when there is no flow in the river to the San Acacia Diversion Dam by recycling return flows from the Belen Division. Under these conditions, while the effect of MRGCD diversion is to reduce flow, it reduces flow from a rate that would be considerably less, possibly zero, in the absence of releases from El Vado (Flanigan, 2004). Flows from MRGCD drains and wasteways have the positive effect of increasing Rio Grande flow in the reaches downstream from the outlets.

The MRGCD follows shortage operations at times when the natural flow is insufficient to meet the full irrigation demand, and there is not sufficient water in storage at El Vado to make up the difference, or the MRGCD chooses not to release available water in storage to make up the shortfall, but to preserve supplies for the following year. At these times, diversions occur only for the needs of the lands with prior and paramount water rights on the Six MRG Pueblos. During such times, the effect of MRGCD diversions is to reduce flow, possibly to zero, below the Diversion Dams.

MRGCD's diversions (and diversions for the BDANWR) from the LFCC may potentially conflict with Reclamation's LFCC pumping program (a component of the Supplemental Water Program) during low flow periods. As discussed in section 3, the MRGCD is comprised of four divisions, and the physical layout of the MRGCD has an effect on water movement in the MRG. Each division begins with a diversion point (the Diversion Dam). The upper three divisions return excess water directly to the Rio Grande. The lower most division returns its excess water to the BDANWR and the LFCC.

Cochiti Dam and the MRGCD's three diversion dams effectively separate the MRG into four distinct river reaches, through which water and fish can move downstream but not upstream. Cochiti and Angostura Diversion Dams form barriers to the upstream migration of fish. Isleta Diversion Dam, on the other hand, may only be a partial migration barrier depending on the elevation of the checked upstream surface and the gate settings. Channel incision directly below the San Acacia Diversion Dam has caused a more complete separation of the upstream and downstream reaches at that location.

The re-use of water into and out of MRGCD canals has the effect of reducing flow in the Rio Grande below the Diversion Dams but increases the flow where return flows are discharged. Management of the MRGCD in four distinct divisions decreases the total amount of water required by the MRGCD to operate its system significantly below the amount that would be required if the MRGCD had only a single diversion point. The recycling of carriage water adds efficiency to system operation and decreases the amount of water that Reclamation and the MRGCD must release from storage to support irrigation. Carriage water re-use can increase carryover storage, which increases the proportion of time during which MRGCD is in normal operation and, therefore, decreases the amount of time that the river must be kept wet through the release of Supplemental Water by Reclamation.

6.4.4.5 Effects of MRGCD Water Management Actions on Silvery Minnow

The main source of water for MRGCD diversions is natural flow Rio Grande water (section 6.2). Smaller amounts of the water used for MRGCD operations come from storage at Abiquiu and El Vado Reservoirs and SJC project water. The first diversion of water is taken at Cochiti Dam. In most years, the amount of water diverted at Cochiti Dam is less than or similar to the amount diverted at the Angostura Dam (figure 36). The majority of the diversions occur at Isleta Dam. Only a small fraction is taken from San Acacia Dam. In model runs, the impact of diversions is more noticeable in the downstream reaches below Isleta Diversion Dam.

During spring runoff, duration of peak flows is decreased due to MRGCD diversions. Model runs predict that operations decrease the number of continuous days that discharge exceeds 3,000 cfs on an average of 2 days at Central, 6 days below Isleta and San Acacia Dams, and 3 days at San Marcial. The difference is more pronounced at lower flow thresholds. Model runs indicate that diversions also cause low flow conditions in the lower river (i.e., < 200 cfs at San Marcial) to begin at an earlier date (figure 73). The number of high flow days and date of onset of low flow have a strong relationship to October CPUE of silvery minnow.

Similarly, the number of low flow days and drying that are predicted for each reach is increased by diversion operations. Low flow conditions that may be expected to have drying are predicted in all reaches with the MRGCD diversion only scenario. The modeled mean number of days annually that flow is less than 100 cfs in the Angostura Reach increases by over 40 days with MRGCD diversions. Drying can cause direct mortality for silvery minnow due to desiccation or being stranded into isolated pools with low water quality. There is some evidence that if flows are decreased gradually, many silvery minnow can move with the water and find refugial habitats. Low flow conditions also put silvery minnow at greater risk of predation since the amount of cover that is offered by deeper water is decreased. Sediment transport is minimal during extremely low flow periods, thus, visibility is high, and fish are concentrated. Additionally, poor water quality conditions and other stressors may reduce body condition for those fish that survive in isolated pools, which may have indirect effect to their survival later in the year.

Both the decrease in peak flow and lower base flows that are present with diversion operations have effects to the geomorphic condition of silvery minnow habitat. The current geomorphic trends of vegetation encroachment and channel simplification are driven by high flows and base flow conditions. The MRG has often developed a two-stage channel, which is large enough to reflect the common high flows and, then inside, that is a smaller channel that reflects the common low flows. This is also evident in habitat specific studies that indicate that, under current conditions, habitat availability for silvery minnow does not increase linearly with flow increases (Bovee 2008). Decreases in peak flows and lower base flows result in a reduction in available wetted habitat at both stages in the MRG. The diversion dams also alter sediment transport as well as the ability of the river to move within the flood plain, which affects habitat quality for silvery minnow.

Irrigation season typically runs March 1–October 31; Pueblo deliveries may continue through November 15. Impacts from diversions are not present during the winter since irrigation is shut down. There are impacts due to the presence of the diversion year round. San Acacia and Angostura Dams are thought to be complete barriers to upstream fish passage. Barriers may have long-term genetic effects on the population by preventing upstream movement of fish. There is likely a population level effect as well, especially in the uppermost reaches when population levels of silvery minnow are low and much of the reproductive effort is lost to downstream reaches. There is some thought that Isleta Dam may be passable by silvery minnow under certain gate configurations. Silvery minnow of all life stages may become entrained into the irrigation system, especially as eggs and larvae. The magnitude of entrainment in the past several years has been minor due to MRGCD modifying its operations during peak egg production periods; this is proposed to continue as a conservation measure. Outflows from drains may provide some refuge for silvery minnow during low flow periods or areas of low velocity habitat during high flows.

The summary of MRGCD effects is presented in table 44.

Table 44. Effect of operation of MRGCD diversions (3.3.1) on life history elements and PCEs of silvery minnow

	Spawning	Eggs	Larval	Juvenile	Adult
Spring (April–June)	The duration and magnitude of spring runoff in the MRG is decreased by MRGCD operations. The decrease to the duration of inundation of overbank habitats, which is related to spawning and recruitment of silvery minnow, is anticipated to be minor. Eggs and larvae may be entrained into the irrigation system; but with modified management during peak egg production, this is expected to be minor. **Direct and Indirect – *Operation of diversions is likely to adversely affect silvery minnow spawning and recruitment.***				There is little information on how spring flows are related to adult survival of silvery minnow. Decrease in the spring hydrograph from MRGCD operations is anticipated to be minor. Adult entrainment into the irrigation system is likely rare. ***Direct and Indirect – The operation of diversions are not likely to adversely affect adult silvery minnow.***
Summer (June–Sept)			MRGCD diversions increase the number of low flow days and drying especially in the Isleta and San Acacia Reaches. Drying can cause mortality in silvery minnow, put them at risk for predation, and may reduce their fitness when concentrated for long periods in isolated pools. Releases from drains and outfalls may provide areas of refuge for silvery minnow during low flow periods. **Direct and Indirect – *Diversions are likely to adversely affect silvery minnow in summer and fall periods.***		
Fall (Sept - Nov)					
Winter (Dec–March)					MRGCD does not divert water in the winter. **Direct – *Diversions have no direct effect to winter survival of adult silvery minnow.*** **Indirect – Body condition of fish may be reduced going into winter months due to increased low flow periods.**

Table 44. Effect of operation of MRGCD diversions (3.3.1) on life history elements and PCEs of silvery minnow (continued)

	Spawning	Eggs	Larval	Juvenile	Adult
Critical Habitat PCES					
Hydrologic Regime					
A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats.	***Direct and Indirect – Diversions are likely to adversely affect the hydrology and maintenance of silvery minnow critical habitat within the MRG***. The current geomorphic trends of vegetation encroachment and channel simplification are driven by high flows and base flow conditions. There is little effect from MRGCD diversions on the duration and magnitude of channel altering flows (> 5,000 cfs). Increased low flow periods due to diversion operations reduces available wetted habitat. The formation of a two-stage channel within the MRG set by the high and low flow condition causes habitat availability for silvery minnow to not increase linearly with flow increases and is set to base flow levels. Drain outfalls may provide backwater and refuge habitats.				
Presence of a diversity of habitats for all life history stages					
Sufficient flows from early spring (March) to early summer (June) to trigger spawning	Silvery minnow are known to spawn with very small flow increases. However, the Proposed Action may cause minor decreases in high flows, especially in years with limited spring runoff; **Direct and Indirect – MRGCD *operations are not likely to adversely affect silvery minnow critical habitat for spawning of silvery minnow.***				
Flows in the summer (June) through fall (October) that do not increase prolonged periods of low or no flow	MRGCD diversions increase the number of low flow days and drying especially in the Isleta and San Acacia Reaches. Releases from drains and outfalls may provide areas of refuge for silvery minnow during low flow periods. **Direct and Indirect – *MRGCD operations are likely to adversely affect silvery minnow critical habitat during summer and fall periods.***				

Table 44. Effect of operation of MRGCD diversions (3.3.1) on life history elements and PCEs of silvery minnow (continued)

	Spawning	Eggs	Larval	Juvenile	Adult
Constant winter flow					MRGCD diversions are not operated during the winter. **Direct and Indirect –** ***MRGCD operations are not likely to adversely affect winter critical habitat for adult silvery minnow.***
Unimpounded stretches of river with a diversity of habitats and low velocity refuge areas					
River reach length	San Acacia and Angostura Dams are thought to be complete barriers to upstream fish passage. There is some thought that Isleta Dam may be passable by silvery minnow under certain gate configurations. ***Diversion Dams directly adversely affect river reach length within critical habitat***. The sinuosity changes depending on geomorphology and discharge levels. Sinuosity of the thalweg may increase during low flows, which increases the length of the river but also may promote vegetation growth on point bars within the river channel. The lack of flood stage flows also changes the potential that the river will move outside its current channel. The Proposed Action ***is not likely to indirectly adversely river reach length.***				
Habitat "quality" in each reach and refugial habitats.	Ongoing geomorphic trends will continue under the current operations. The formation of a two-stage channel within the MRG set by the high and low flow condition causes habitat availability for silvery minnow to not increase linearly with flow increases and is set to base flow levels. Drain outfalls may provide backwater and refuge habitats. Drying within the San Acacia and Isleta Reaches decreases habitat quality and quantity. Habitat quality in each reach is dependent on the structure and diversity of available habitat. Channel trends throughout the MRG are towards a more simplified channel due to vegetation encroachment. Base flow levels from the Proposed Actions drive the vegetation encroachment within the channel. The quantity of suitable habitat within each reach also changes at different flows; this relationship is not linear in most sections of the river and is dependent on channel shape. The Proposed Action ***may have indirect effects that adversely affect silvery minnow critical habitat***. ***Diversions are likely to adversely affect habitat quality within the reaches of critical habitat***.				
Substrate of sand or silt					
Substrates of predominantly sand or silt	Diversion Dams alter sediment transport within the MRG. The ongoing trends will continue within the reaches above and below Diversion Dams. ***Diversions are likely to adversely affect sediment transport within critical habitat***.				
Water quality					
Temp >1˚ - < 30 ˚C DO > 5 mg/L pH (6.6-9.0)	Water temperature, DO, and pH within the MRG may be affected during low flow conditions especially in intermittent areas. **Direct and Indirect – The operation of Diversions is likely to adversely affect water quality due to increased low flow periods.**				
Other contaminants	Drain and irrigation return water has the potential to have poor water quality, but recent studies (Buhl 2011) found no elevated levels of contaminants in the tested wasteway water. River water entering the irrigation canal system can carry high nutrient concentrations, but concentrations of nitrate, ammonium, and phosphate re-entering the river from these tributary return flows are consistently low (Zeglin and Dahm 2006). The operation of MRGCD diversions reduces the amount of water that is available to dilute contaminants that are introduced to the river from outside sources. This lack of dilution may have ***indirect effects but is not likely to adversely affect silvery minnow.***				

6.4.4.6 Effect of MRGCD Water Management Actions on flycatcher.

Within the MRG, there is a decrease in the amount of water in the river brought on by diversions. This decreases in the possibility of overbank flooding, and increases the potential for drying the river. This action also has the potential for affecting ground water levels that would have impacts to native vegetation health. Figures 83–86 demonstrate the relative difference between the predicted flow exceedence curves with MRGCD diversions and in the No Action scenario at Central and San Marcial.

Using the previously described analysis, it is predicted that, on average, MRGCD diversions would decrease overbank flooding by 1–3 days during the early irrigation season (March–June) when compared to No Action and would decrease in the overall water availability. This difference is minor, particularly when considering many areas often require more than the 4,700 cfs for flooding, and areas where flycatchers occupy are typically along the rivers' edge and, thus, within the 50-meter distance to water where 94% of flycatcher nests are located (table 45).

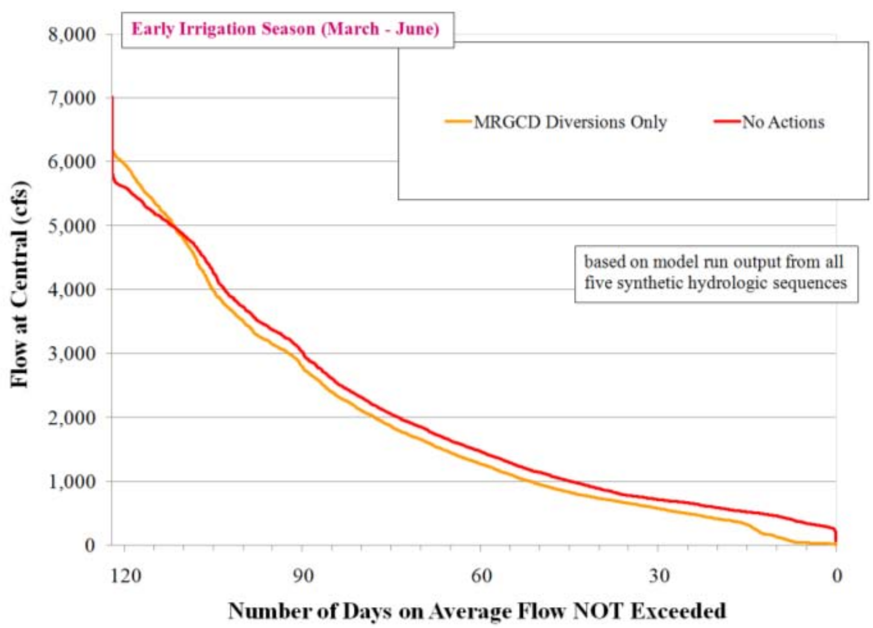

Figure 83. Relative comparison of modeled flows at Central gage considered Proposed Action of MRGCD diversions compared to No Action during the flycatcher territory establishment period.

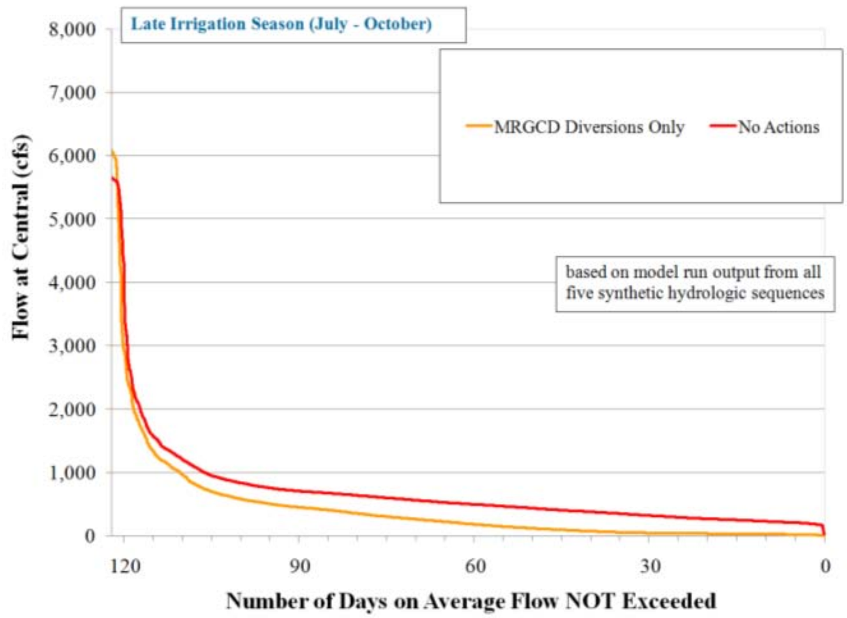

Figure 84. Relative comparison of modeled flows at Central gage considered Proposed Action of MRGCD diversions compared to No Action during the flycatcher breeding period.

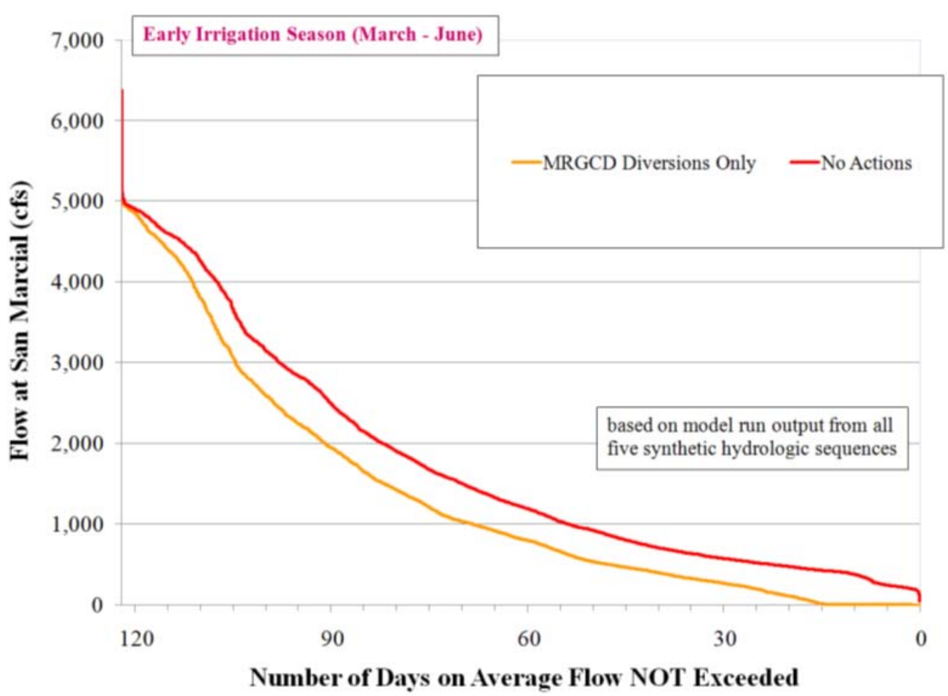

Figure 85. Relative comparison of modeled flows at San Marcial gage considered Proposed Action of MRGCD diversions compared to No Action during the flycatcher territory establishment period.

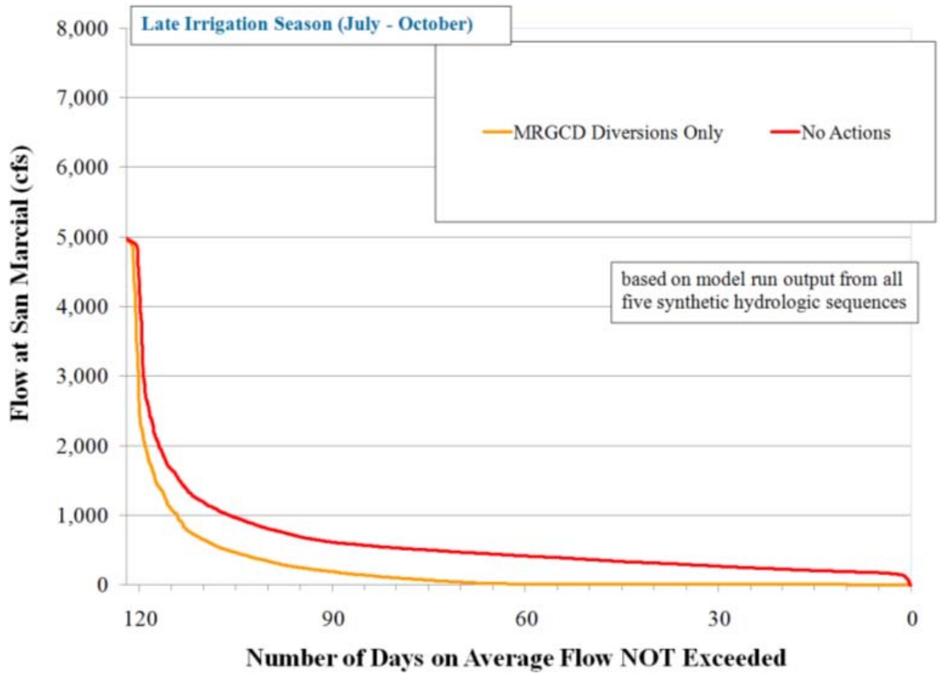

Figure 86. Relative comparison of modeled flows at San Marcial gage considered Proposed Action of MRGCD diversions compared to No Action during the flycatcher breeding period.

Table 45. Effect of MRGCD diversions on the number of potential days of overbank flooding events during early irrigation season (March–June) and flycatcher territory establishment. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with MRGCD diversions only	Number of days flows reach 4,700 cfs with MRGCD diversions only	Percent of the time flows reach 4,700 cfs with No Action	Number of days flows reach 4,700 cfs with No Action
Central	10.2%	13	11.30%	14
San Acacia	7.2%	9	10.00%	12
San Marcial	2.9%	4	4.40%	5

The same comparison but using results from the late irrigation season from July–October with No Action indicates flows would be approximately 4,700 cfs at the Central, San Acacia, and San Marcial gages 2% of the time. With MRGCD water management actions, the potential overbank flooding decreases slightly. There is not a significant difference between overbank flooding with the No Action versus the MRGCD action scenarios (table 46). For reaches below the San Acacia gage at the 1,400 cfs required for inundation within the BDANWR area, flows under the Proposed Action would meet overbank flows 45% of the time in the No

Action sequence and 39% of the time in the MRGCD diversions alone sequence. This 7-day difference would be more substantial when compared to the other reaches (table 47). The time period during late irrigation from July–October at the San Acacia gage indicates a 6-day difference in flows above 1,400 cfs and potential overbank flooding. Though this time period is less important in regard to territory establishment, it would be important for vegetative health and nest success during July and August (table 48). Table 49 presents a summary of the MRGCD Water Management Actions on flycatchers.

Table 46. Effect of MRGCD diversions on the number of potential days of overbank flooding events during late irrigation season (July–October) and flycatcher nesting period. This includes all reaches from Albuquerque to RM 62 with the exception of the reaches near the BDANWR.

Gage Location	Percent of the time flows reach 4,700 cfs with MRGCD diversions only	Number of days flows reach 4,700 cfs with MRGCD diversions only	Percent of the time flows reach 4,700 cfs with No Action	Number of days flows reach 4,700 cfs with No Action
Central	1.8%	2	2.2%	3
San Acacia	1.7%	2	2.4%	3
San Marcial	1.7%	2	2.3%	3

Table 47. Effect of MRGCD diversions on the number of potential days of overbank flooding events during early irrigation season and flycatcher territory establishment for reaches from Arroyo del las Cañas to RM 78

Gage Location	Percent of the time flows reach 1,400 cfs with MRGCD diversions only	Number of days flows reach 1,400 cfs with MRGCD diversions only	Percent of the time flows reach 1,400 cfs with No Action	Number of days flows reach 1,400 cfs with No Action
San Acacia	39.0%	48	45.00%	55

Table 48. Effect of MRGCD diversions on the number of potential days of overbank flooding events during late irrigation season and flycatcher nesting period for reaches from Arroyo del las Cañas to RM 78

Gage Location	Percent of the time flows reach 1,400 cfs with MRGCD diversions only	Number of days flows reach 1,400 cfs with MRGCD diversions only	Percent of the time flows reach 1,400 cfs with No Action	Number of days flows reach 1,400 cfs with No Action
San Acacia	5.8%	7	10.5%	13

Table 49. Effect of MRGCD Proposed Action on life history elements and PCEs of flycatchers

	Migration (April-June and July–September)	**Arrival to Territories/ Territory Establishment/ Nest Building** (May–July)	**Egg Laying/ Incubation/Nestling/ Fledgling** (June–August)
Breeding Season (April–September)	The Proposed Action would **not likely adversely affect** flycatcher stopover locations during migration because flycatchers will use habitat that is less suitable during this time and farther away from water sources.	The Proposed Action may ***indirectly affect flycatcher habitat on a negligible level***. Because the Proposed Action, when compared to No Action, would decrease the potential of overbank flooding and decrease the overall water available for vegetation, this could cause a decline in territory recruitment and canopy cover/plant health/seed establishment and ***could potentially adversely affect flycatcher habitat,*** particularly in periods of drought. However, it should be noted that the decrease in water between the two scenarios is a relatively small amount.	Territory recruitment at this stage is no longer an issue as flycatchers are more invested in their territories and less likely to abandon nests should conditions dry or decline in value. However, if vegetation does not have adequate water resources, canopy cover likely will decrease and predation and/or parasitism likely would be more prevalent. Because the Proposed Action would result in less water in the system, there would be an increased possibility of vegetation not having adequate water to maintain health and, thus, ***could adversely affect flycatcher habitat and potential nest success,*** again particularly in times of drought.
Critical Habitat PCES			
Riparian Vegetation	Riparian habitat in a dynamic successional environment to be used for nesting, foraging, migration, dispersal, and shelter. Dense tree or shrub vegetation in close proximity to open water or marsh areas. With a decrease in the water amount reaching flycatcher suitable habitat patches, the Proposed Action could ***potentially adversely affect flycatcher riparian vegetation.***		
Insect Prey Populations	A variety of insect prey populations found in close proximity to riparian flood plains or moist environments. The minimal difference between the No Action and the Proposed Action ***may affect, not likely to adversely affect the insect prey populations***. It is also important to note that a dry river does not impact insect populations when ponded water and adjacent drains are present.		

6.5 Evaluation of Conservation Measure – RIP

The conservation measure presented to offset effects of the described Proposed Actions of Reclamation and MRGCD as well as other participants is the formation of a RIP. The associated implemention of actions that assist in the recovery of the species and provide compliance with Sections 7 and 9 of the ESA for water development and water management related activities in the MRG.

The objectives of the RIP are to:

- Promote the conservation and contribute to the recovery of the endangered species in the Program area.
- Assist in attainment of Endangered Species Act compliance for all parties with the concurrence of the Service.
- Encourage water development and management activities consistent with State and Federal laws and mandates.

For the purposes of the RIP and Section 7 consultations, it is assumed that:

1. The RIP will produce a list of actions that can be implemented to assist in the recovery of the species.
2. The funding will be available to implement these actions.
3. Participants will take appropriate steps to implement those actions.
4. Actions will be implemented in accordance with the developed schedule.

Once the RIP is implemented, annual work plans will be developed that will define specific projects and commitments of participants. The Service will determine if sufficient progress towards recovery is achieved for the Program on an annual basis and if progress toward recovery has been sufficient for the Program to serve as a reasonable and prudent alternative or measure.

The Draft Action Plan identifies specific actions and tasks that the RIP will undertake to alleviate jeopardy and strive toward recovery of the listed species in the Program area. The actions described address many of the threats described in the recovery plans for silvery minnow and willow flycatcher (Service 2010, Service 2002). Table 50 summarizes actions as described in the draft of the action plan (appendix 8) and the associated threats that would be addressed by these actions. The development of alternative water management strategies will be contained in the Water Management Plan (WMP) for the middle Rio Grande (MRG). The WMP will be a companion plan to the RIP Action Plan and Long Term Plan, and will contain the suite of water management tools available to meet the needs of listed species and water users.

Table 50. Description of actions outlined in draft RIP Action Plan and threats addressed by these actions

Action	Description of RIP Action	Threats Addressed
Silvery Minnow		
1.1	Create habitat for spawning and larval rearing	• Prevention of overbank flooding. • Altered preferred habitat. • Reduced flows, which may limit the amount of preferred habitat and limit dispersal of the species. • Confined flood flows. • Establishment of stabilizing vegetation. • Elimination of meanders, oxbows, and other components of historic aquatic habitat. • Reduction of inundated floodplain areas where young can develop. • Geomorphological changes to the river channel.
1.2	Provide spring-time hydrologic (flow) conditions sufficient to produce minnow spawning and larval fish survival	• Risk of 2 consecutive below-average flow years, which can affect short-lived species. • Altered flow regimes. • Prevention of overbank flooding. • Altered preferred habitat. • Stored spring runoff and summer inflow, which would normally cause flooding. • Reduced flows, which may limit the amount of preferred habitat and limit dispersal of the species. • Reduction of inundated floodplain areas where young can develop. • Confined flood flows.
2.1	Provide viable wetted habitats during summer and fall that can be shown to improve survival and recruitment of minnow during main channel drying events.	• Annual dewatering of a large percentage of the species' habitat. • Risk of 2 consecutive below-average flow years, which can affect short-lived species. • Increase in contaminant concentrations during low flows, which may exacerbate other stresses. • Altered flow regimes. • Prolonged summer low flow. • Reduced flows, which may limit the amount of preferred habitat and limit dispersal of the species.

Action	Description of RIP Action	Threats Addressed
2.2	Provide hydrologic (flow) conditions in summer, fall, and winter to support survival in all years.	• Annual dewatering of a large percentage of the species' habitat. • Risk of 2 consecutive below-average flow years, which can affect short-lived species. • Increase in contaminant concentrations during low flows, which may exacerbate other stresses. • Altered flow regimes. • Prolonged summer low flow. • Reduced flows, which may limit the amount of preferred habitat and limit dispersal of the species.
2.3	Increase reach boundary connectivity.	• Fragmented habitat. • Prevention of species' dispersal.
3.1	Plan and evaluate minnow propagation and augmentation program.	• Reduced population numbers and potential loss of genetic diversity. • Risk of 2 consecutive below-average flow years, which can affect short-lived species.
3.2	Develop, support, and maintain propagation and rearing facilities for minnow.	• Reduced population numbers and potential loss of genetic diversity. • Risk of 2 consecutive below-average flow years, which can affect short-lived species.
3.3	Rear and maintain minnow in captivity.	• Reduced population numbers and potential loss of genetic diversity. • Risk of 2 consecutive below-average flow years, which can affect short-lived species.
3.4	Augment wild populations as necessary.	• Reduced population numbers and potential loss of genetic diversity. • Risk of 2 consecutive below-average flow years, which can affect short-lived species.
4.1	Identify and prioritize specific science activities that address overall Program goals.	Prioritizing management actions.
4.2	Conduct minnow research critical to the RIP.	Prioritizing management actions.
4.3	Determine the viability of minnow populations.	Prioritizing management actions.
4.4	Develop and implement monitoring programs with sufficient reliability, precision, and accuracy for RIP needs.	Prioritizing management actions.
4.5	Establish and maintain a Database Management System for RIP needs.	Prioritizing management actions.

Action	Description of RIP Action	Threats Addressed
5.1	Support the development of additional wild self-sustaining populations of minnow.	• Reduced population numbers and potential loss of genetic diversity. • Risk of 2 consecutive below-average flow years, which can affect short –lived species.
5.2	Rear and maintain minnow in captivity in order to augment wild populations as necessary (Actions 3.3 and 3.4).	• Reduced population numbers and potential loss of genetic diversity. • Risk of 2 consecutive below-average flow years, which can affect short-lived species.
Willow Flycatcher		
1.1	Create habitat conducive to territory establishment and nesting success.	• Habitat loss and modification. • Changes in abundance of other species. • Vulnerability of small populations.
1.2	Create hydrologic conditions conducive to territory establishment and nesting success.	• Habitat loss and modification. • Changes in abundance of other species. • Vulnerability of small populations.
2.1	Assess, identify, and prioritize specific science activities that address overall Program goals.	Prioritizing management actions.
2.2	Conduct flycatcher research critical to the RIP.	Prioritizing management actions.
2.3	Determine the viability of flycatcher populations.	Prioritizing management actions.
2.4	Develop and implement monitoring programs with sufficient reliability, precision, and accuracy for RIP needs.	Prioritizing management actions.
2.5	Incorporate flycatcher data into the RIP Database Management System.	Prioritizing management actions.
3.1	Support the development of other populations of flycatcher.	• Vulnerability of small populations.
Rip Management Elements		
1.1	Facilitate Program planning and management.	Prioritizing management actions.
1.2	Provide ongoing Program management.	Prioritizing management actions.
1.3	Implement priority Program projects.	Prioritizing management actions.

The following sections present an evaluation of specific conservation measures that have been proposed by Reclamation and MRGCD to offset the impacts of MRG water operations that will be incorporated into the RIP. Conservation measures analyzed for this BA include Reclamation's Supplemental Water Program and the conservation measures of the MRGCD under the Environmental Baseline, which the MRGCD has proposed to continue under a new consultation as well as several new measures. Additional conservation measures have been proposed by MRGCD, the details of which are currently being coordinated between Reclamation and MRGCD. Theses additional proposed measures are attached in appendix 9.

6.5.1 Reclamation's Supplemental Water Program

Reclamation's Supplemental Water Program, as proposed, and its effectiveness in offsetting the impacts of Reclamation's Proposed Action and those of Reclamation's non-Federal partners have been evaluated through URGWOM modeling. Reclamation's Supplemental Water Program is intended to benefit the listed species and includes the following actions:

- Supplemental water acquisition.
- Storage of acquired water in Rio Chama reservoirs and release to benefit listed species and assist in compliance with flow requirements.
- SJC Project storage waivers for contractors who have agreements to lease water to Reclamation (if there is a benefit to the United States).
- Pumping and conveyance of water from the LFCC to the Rio Grande.

Reclamation expects the water available for lease from all sources to decline from the average of 28,990 AFY that has been available under the 2003 BiOp to an average of 13,050 AFY over the 10-year analysis period for this BA. The primary source of water in the Supplemental Water Program is Reclamation's lease of annual water allocations from willing SJC Project contractors. However, SJC Project water available for lease has decreased because SJC Project contractors, including the ABCWUA (which has historically provided the largest amount of SJC Project lease water to the Program), are using more of their water for its intended purpose. The water that was available over the past decade also included significant amounts of credit water relinquished under the Compact and leased to Reclamation by the State of New Mexico under the terms of the Conservation Water Agreement and Emergency Drought Water Agreement.

Reclamation's model runs include 38,696 AF of EDWA water available for storage and lease to the Supplemental Water Program at the beginning of the 10-year analysis period. This number includes 19,196 AF of Emergency Drought Water for ESA in storage as an initial condition plus an unused allocation for storage of an additional 19,500 AF. However, the analysis does not assume that any additional credit relinquishment water becomes available. Reclamation continues to seek more water for its Supplemental Water Program.

6.5.1.1 Approach to Analysis of Reclamation's Supplemental Water Program

To evaluate the effectiveness of the Supplemental Water Program as a conservation measure, model simulations of the Proposed Water Management Actions and the Supplemental Water Program have been compared to simulation of the Proposed Water Management Actions without the Supplemental Water Program. Also, the simulations that include the Supplemental Water Program were performed using two sets of companion runs—one using the available supply of Supplemental Water and one using a hypothetical unlimited supply of Supplemental Water. In the model runs, the Supplemental Water is used to meet the flow requirements of the 2003 BiOp. In both sets of runs, there is no prioritization to the releases of Supplemental Water; if a release is needed to meet the flow requirements, the water is released until the Supplemental Water supply runs out.

6.5.1.2 Analysis of the Supplemental Water Program

The Supplemental Water Program provides water to support the habitat requirements of listed species in the MRG during periods of low flows, when the flow augmentation provided by the release of irrigation water from El Vado Dam and the operation of the San Juan-Chama Project is insufficient to maintain flow or meet flow targets. The Supplemental Water Program delays and decreases the duration of drying, which decreases mortality of silvery minnow and may have some impact on maintaining vegetation for flycatchers. The impact of this Supplemental Water varies from year to year depending on the type of water year and the amount of Supplemental Water available. The modeling runs for the use of Supplemental Water used the 2003 BiOp requirements as an example of how the water can be used to augment flows in the system and benefit the species.

The following graph breaks down the modeled uses of water acquired, stored, and released from upstream reservoirs under the Supplemental Water Program (figure 87) to meet 2003 BiOp requirements. Please note that no water is used in the model to control rates of drying after river rewetting, since this was not a BiOp requirement (and is typically performed through gradual ramp-up of MRGCD diversions). Reclamation is not proposing to continue these operations under the current Proposed Action but this information may guide the prioritization of Supplemental Water use into the future.

Traditionally, the largest use of Supplemental Water has been to maintain flows of 100 cfs or greater at the Central Avenue Gage. Water to meet this target is typically released after the recession from the spring snowmelt runoff, typically after June 15. The second largest use was to maintain continuous flows during the early irrigation season, between March 1 and June 15. The impact of both of these categories of releases can be seen at Central Avenue.

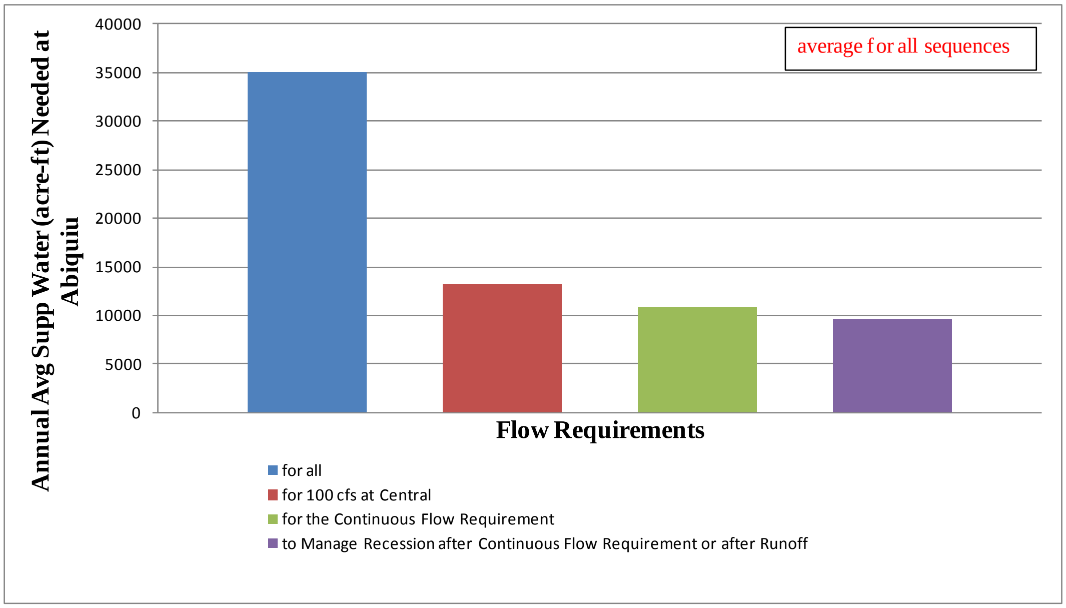

Figure 87. Uses of Supplemental Water in URGWOM simulations.

Figure 88 is a "box and whisker" plot that summarizes the impact of the Supplemental Water Program on flows at the Central Avenue Gage during the entire irrigation season, March 1–October 31. These impacts have been broken down according to ranges of low flows that would occur without the Supplemental Water Program, 0–100 cfs, 101–200 cfs, and 201–300 cfs, respectively. The impact of the Program, as indicated by the grey box, which shows the 25–75% range of probability, is primarily positive in these ranges. The "whiskers" in this plot show some apparent negative impacts in the lowest-probability portions of the distributions. These effects result from time lags and operational rules within URGWOM and do not indicate any real likelihood of negative impacts from the Supplemental Water Program. The "boxes" indicating the middle 50% show the greatest impact of the Supplemental Water Program, up to 50 cfs, in the range of flows 101–200 cfs during the irrigation season. The whiskers also show a low probability of flows below 200 cfs being supplemented by an additional flow of greater than 250 cfs.

Downstream of Central Avenue in Albuquerque, the Supplemental Water Program has the greatest impact during the early irrigation season, March 1–June 15. This period represents the time in which the 2003 BiOp has required continuous flows in the MRG during dry years. As defined in the 2003 BiOp, during dry years, benefits of Supplemental Water are not realized after June 15 in lower reaches that do not have flow targets, since Supplemental Water will, by agreement with the MRGCD, be diverted for irrigation at the dam below the downstream-most flow targets.

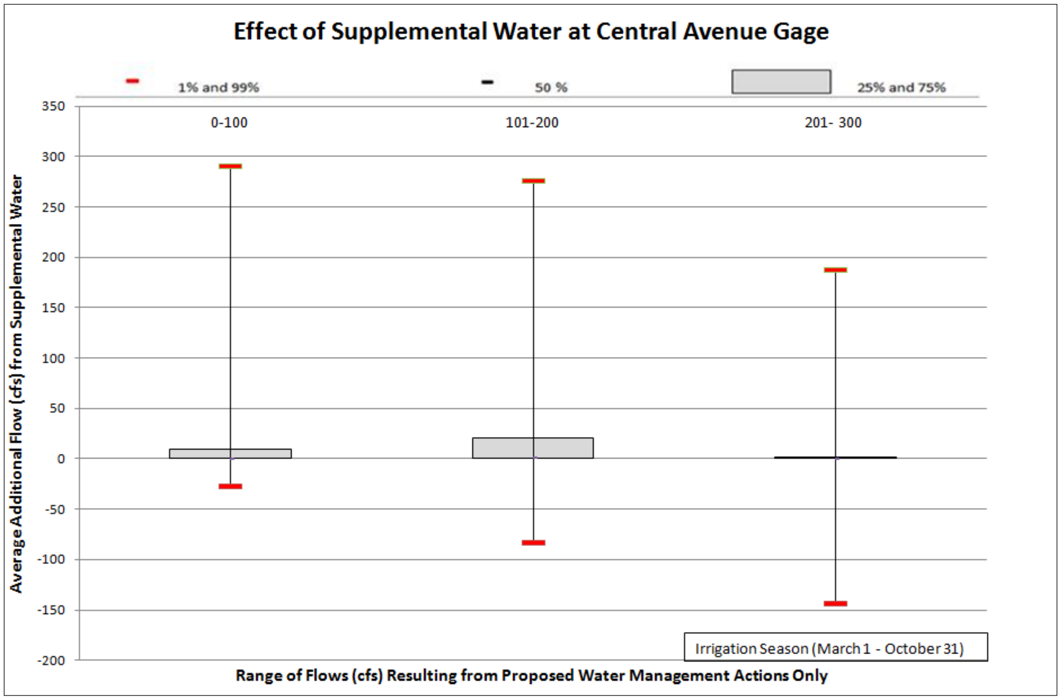

Figure 88. Impact of Supplemental Water on flows of 300 cfs or less at the Central Avenue Gage as compared to the Proposed Action.

Figure 89, below, presents the additional flow provided by the Supplemental Program at key locations downstream of Central Avenue (Isleta, San Acacia, and San Marcial) during this time period. These curves show that, at these locations, the greatest impacts of Supplemental Water, including release of water from upstream reservoirs and pumping from the LFCC to the river, is at the lowest flows, generally when flows would be below about 120 cfs. The Supplemental Water Program provides up to 80 cfs of additional flow at each of these locations under these conditions.

Figure 90 presents the impact of Supplemental Water on low flows during the early irrigation season at these same locations, Isleta, San Acacia, and San Marcial, in the form of a “box and whisker” plot, as was used to display the impact of Supplemental Water at Central Avenue. These probability distributions were created by filtering for days with flows below thresholds for each reach in which downstream drying might be expected. The grey boxes, which indicate the middle 50% of probabilities, show a consistent benefit of the Supplemental Water Program of up to 130 cfs at Isleta, 15 cfs at San Acacia, and 115 cfs at San Marcial. The benefits at Isleta and San Acacia are primarily provided by releases from upstream reservoirs. The benefits at San Marcial are primarily provided by pumping from the LFCC to the river.

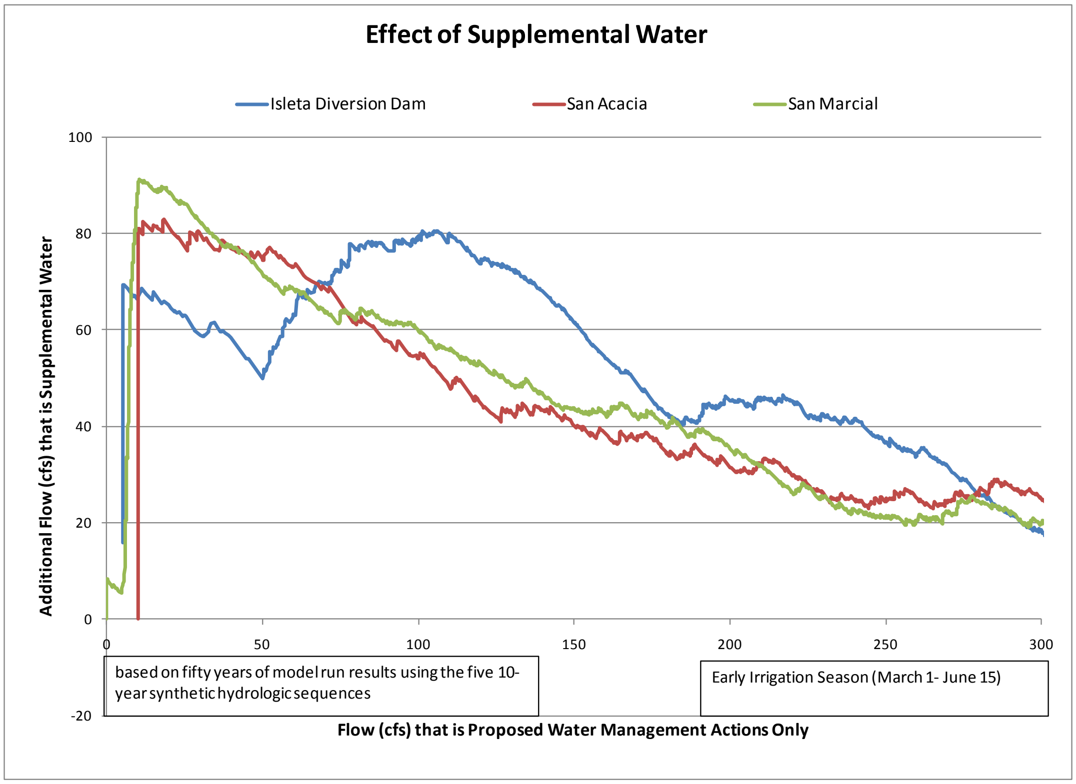

Figure 89. Graph showing the impact of Supplemental Water on flows of 300 cfs or less at Isleta, San Acacia, and San Marcial as compared to the Proposed Action.

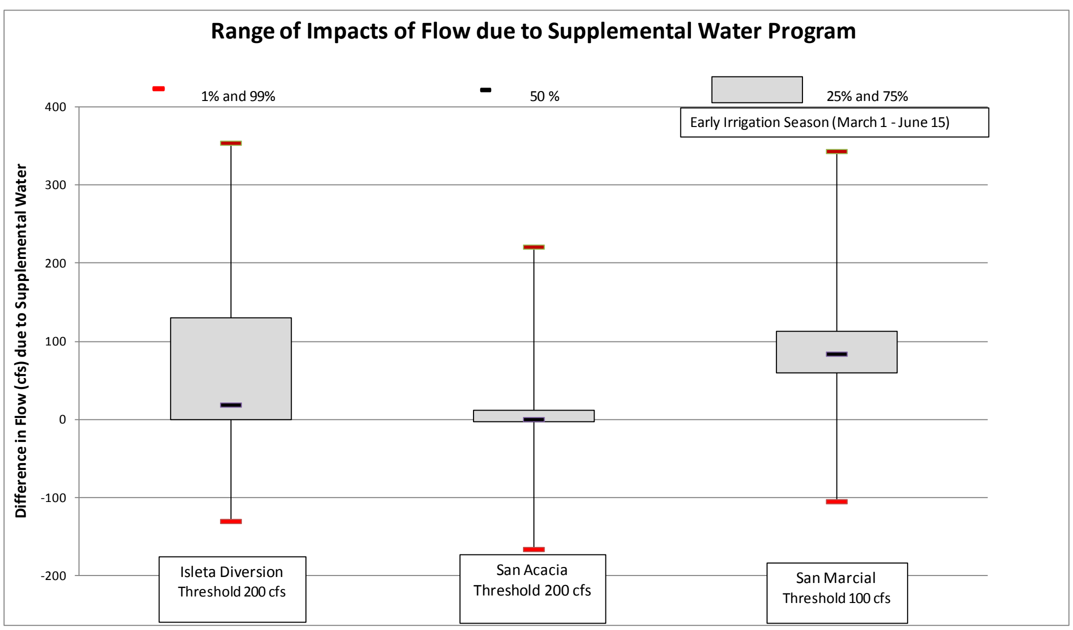

Figure 90. "Box and whisker plot" showing the impact of Supplemental Water on low flows at Isleta, San Acacia, and San Marcial during the early irrigation season compared to the Proposed Action.

The need for Supplemental Water can be very high at times when MRGCD is in shortage operations. Under these shortage operations, diversions at Angostura are increased to meet the remaining water needs of the Pueblos, as far south as Isleta. Increased diversions at Angostura yield higher flows to the Albuquerque Drain that outfall to the river just above the Isleta diversion and are re-diverted there as they are available. Diversions at both Isleta and San Acacia continue as water remains available; but under these shortage operations, water is not specifically conveyed to these diversion structures.

During MRGCD shortage operations, ABCWUA would be using ground water to meet drinking water needs. When the MRGCD is in shortage operations, it typically increases Angostura Diversions, which results in greater potential for river drying in the Albuquerque Reach. Under these conditions, water released from storage under Reclamation's Supplemental Water Program is the primary source for flows in the river and habitat for the silvery minnow. The SJC Project water released under Reclamation's Supplemental Water Program, as available, further helps to reduce river drying when MRGCD is in shortage operations. Water from the Supplemental Water Program also contributes to a reduction in drying of the Isleta and San Acacia Reaches.

In the San Acacia Reach, the frequency and duration of river drying also would be increased by the lack of Reclamation's program of pumping water from the LFCC to the river. Without these pumping operations, increased river drying can be expected below each pump site. River drying would occur more often by 8% of the time (33 more days per year on average).

Recruitment and overbank flows in the MRG occur based on hydrologic conditions, but it should be noted that Supplemental Water is likely not of sufficient volume to provide recruitment or overbank flows and has not been modeled for these purposes. Cochiti deviations have the potential to significantly help to increase the frequency of recruitment or overbank flows. Without deviations, it is possible that overbank flows would not occur at all within the next 10 years under conditions represented by the driest hydrologic sequence. Under the wettest hydrologic sequence, up to 4 years without overbank flows could be expected.

6.5.2 Effects of the MRGCD's Proposed Conservation Measures

ESA compliance is a requirement of MRG Project operations; and through inclusion in this BA, the MRGCD recognizes the need to continue to cooperate with Reclamation to perform joint future compliance efforts and to conserve water for use during drought years. As part of a broader Water Management Plan among the water managers, as included in the RIP Action Plan, the MRGCD will negotiate a water management agreement with Reclamation, which will include planning for all types of water years. One of the major elements will include development of a Drought Management Pool that will be "last to use" to assist in managing the system for both irrigation and in-river conditions during critically dry years. This section presents hydrologic and biological analyses of the flow-related conservation measures proposed by Reclamation's non-Federal partner, the MRGCD, to the extent that these measures lend themselves to such analysis. The conservation measures evaluated in this section include measures that were undertaken by the MRGCD under the 2003 BiOp as well as proposed new measures.

6.5.2.1 Measures to Enhance Coordination

Though it is difficult to quantify, these measures provide an invaluable tool for water managers and biologists who ultimately reduce the overall take of the species by ensuring that water operations are coordinated efficiently with the larger group. Additionally access to the river for species monitoring and management activities, such as fish salvage, also reduce the take numbers and aid in information gathering.

6.5.2.2 Water Management Related Measures

1. *Maintenance of Perennially Wetted Habitat Through Releases from Drain Outfalls and Wasteways*

As a general practice, the MRGCD will manage its diversions and return flows to the Rio Grande in a way that supports new habitat areas and other designated sites, consistent with tasks identified in the RIP Action Plan and in the MRGCD's Water Management Agreement with Reclamation. The MRGCD will identify key target areas where water can be returned, especially during critically dry periods, to maintain wetted habitat for silvery minnow when drying is occurring elsewhere in the river.

Under this conservation measure, the MRGCD will deliver water to drain outfalls and wasteways to better meet the needs of RGSM. These releases will provide discrete wetted sections that will serve as refugia for RGSM, with possible Southwestern willow flycatcher benefit. This conservation measure will include the following elements:

- During critical, low water periods, the MRGCD will manage the release rates for consistency to create refugial habitat.

- As needed, and in coordination with Reclamation and the Service, the MRGCD will manage these returns flows to assist the Service with its RGSM rescue efforts.

- Details (timing, locations, quantity of water) of these releases will be described in the RIP Action Plan and in the MRGCD's Water Management Agreement with Reclamation.

- This action could increase wetted habitat for silvery minnow during critical low flow periods, which would decrease mortality of silvery minnow. This action may also help maintain vegetation for flycatcher.

2. Maintenance of Wetted Habitat Downstream from Diversion Structures

Under certain conditions, by mutual agreement, and contingent on water being physically present, MRGCD will take actions to maintain a small discharge, not to exceed 8 cfs (normal gate leakage) downstream from both the Isleta Diversion Dam and the San Acacia Diversion Dam. It is estimated that, in the Isleta Reach, this amount of water could maintain approximately 200 yards of wetted habitat. In the San Acacia Reach, channel degradation below the dam has made the river better able to maintain water. Ground water inflow also occurs at this location. Therefore, the dam leakage likely will provide a greater length of wetted habitat, potentially up to a quarter of a mile. Ground water inflow may continue the wetted habitat further downstream.

3. Management of Diversions During Peak Egg Production To Minimize Incidental Entrainment of Silvery Minnow Eggs.

As needed, and in coordination with Reclamation and the Service, the MRGCD will minimize or temporarily suspend diversions during periods of peak egg production to minimize incidental entrainment of eggs and larvae into irrigation canals. This measure has been successful in the past at minimizing egg entrainment. Few eggs are collected during monitoring within the canal system.

4. Acceptance of Conveyance Losses for Supplemental Water

Under the 2003 BiOp, the MRGCD accepted conveyance losses of Supplemental Water. The MRGCD proposes to continue this practice under a new consultation. This conservation measure includes the following elements:

- During normal MRGCD operations, MRGCD will convey Reclamation’s Supplemental Water as far as the Isleta Diversion Dam without incurring any consumptive losses. MRGCD will bear all losses to Reclamation Supplemental Water through Cochiti and Angostura Reaches.

- MRGCD will divert Reclamation’s Supplemental Water as necessary at the Diversion Dams, leaving an equivalent amount of native Rio Grande water undiverted, if necessary, to meet flow targets. This water accounting exercise provides that the Supplemental Water Program’s SJC Project water is fully consumed within the MRG, which is consistent with the intent of the SJC Project to provide for beneficial use of Colorado River water in New Mexico.

- During normal MRGCD operations, the MRGCD will allow a flow of native Rio Grande water equivalent to 50% of Reclamation's Supplemental Water arriving at Isleta Diversion Dam to pass through the San Acacia Diversion after an appropriate time delay. The MRGCD will bear a variable portion of losses to Reclamation's Supplemental Water, dependent on rates of flow and time of year.

In exchange for bearing the losses to Reclamation's Supplemental Water, Reclamation has, over the past 15 years, allowed the MRGCD to divert for irrigation all water remaining in the river downstream from the downstream-most flow target. This feature is also part of the proposed conservation measure under this new consultation. The following analysis compares the amount of water that the MRGCD provides to the Supplemental Water Program to the amount that the MRGCD receives from the Program. This analysis is based on the 2003 BiOp flow targets, which are used in the modeling analyses as example flow targets.

If the amount of water in the Supplemental Water Program is sufficient to meet the flow targets throughout the year (as it has been over the past decade), modeling analyses indicate that this exchange leads to a contribution from MRGCD of about 5% of the total Supplemental Water Released. This situation is broken down below in table 51, as determined from URGWOM simulations of Proposed Water Management Actions with an Unlimited Supply of Supplemental Water.

Table 51. Simulation of Proposed Water Management Actions with Unlimited Supply of Supplemental Water

		Isleta (for 100 cfs at Central dry-year summer flow target)			San Acacia (for continuous flow for average- and wet-year flow requirements)		
Sequence (10-year)	*Additional* Supplemental Water Released under Proposed Action over 10 years.	Supplemental Water Losses Covered by MRGCD	Additional Diversions with Supplemental Water	Net Impact on MRGCD	Supplemental Water Losses Covered by MRGCD	Additional Diversions with Supplement al Water	Net Impact on MRGCD
10 perc	239,712	35,871	15,367	20,504	-1,276	810	-2,086
30 perc	274,430	46,158	13,542	32,616	2,898	1,273	1,626
50 perc	187,087	21,245	17,056	4,189	2,879	1,152	1,727
70 perc	324,494	39,688	30,619	9,069	12,271	2,089	10,182
90 perc	385,282	47,250	43,649	3,601	16,227	2,924	13,304
min	187,087	21,245	13,542	3,601	-1,276	810	-2,086
avg	282,201	38,042	24,047	13,996	6,600	1,650	4,950
max	385,282	47,250	43,649	32,616	16,227	2,924	13,304
total	1,411,005	190,212	120,233	69,979	32,999	8,248	24,752
Total as Percent of Additional Supplemental Water Released		13%	9%	5%	2%	1%	2%

In most years of most sequences of URGWOM simulations of the Proposed Water Management Actions, Reclamation does not have sufficient Supplemental Water to make it through the year. Therefore, the MRGCD provides water to the Program through its acceptance of conveyance losses, but it does not receive the benefit of the use of Supplemental Water for irrigation during periods for which drying is allowed in the Isleta and San Acacia Reaches, since at those times, the Program is usually out of water. Therefore, in the simulations of the Proposed Water Management Actions with the projected supply of Supplemental Water, the exchange results in a contribution from the MRGCD of about 22% of the total amount of Supplemental Water released, as is shown in table 52.

Table 52. Simulation of Proposed Water Management Actions with projected supply of Supplemental Water

		Isleta (for 100 cfs at Central dry-year summer flow target)			San Acacia (for continuous flow for average and wet year flow requirements)		
Sequence (10 years)	Supplemental Water Released under Proposed Action over 10 years	Supplemental Water Losses Covered by MRGCD	Supplemental Water Diverted by MRGCD	Net Impact on MRGCD	Supplemental Water Losses Covered by MRGCD	Supplemental Water Diverted by MRGCD	Net Impact on MRGCD
10 perc	84,582	19,271	191	19,080	2,898	29	2,869
30 perc	84,198	27,497	2	27,495	6,213	-88	6,301
50 perc	70,919	14,140	1,158	12,981	428	313	116
70 perc	84,413	15,730	686	15,045	104	185	-81
90 perc	79,460	13,169	2,569	10,601	147	589	-442
min	70,919	13,169	2	10,601	104	-88	-442
avg	80,714	17,962	921	17,040	1,958	205	1,752
max	84,582	27,497	2,569	27,495	6,213	589	6,301
total	403,572	89,808	4,606	85,202	9,789	1,027	8,762
Total as Percent of Additional Supplemental Water Released		22%	1%	21%	2%	0%	2%

5. *Management of Diversions at Angostura Diversion Dam during MRGCD shortage and conservation operations*

During MRGCD shortage/conservation operations and when the ABCWUA has agreed to suspend diversions of native Rio Grande water, the MRGCD will reduce diversions at Angostura Diversion Dam to the minimum practical rate of flow required to meet irrigation demand within the Albuquerque division, as occurred during the fall of 2011. Diversion rates needed to serve the Albuquerque Division are typically less than 200 cfs. Any additional water available in the river will remain in the river as far as Isleta Diversion Dam.

6. Borrow/Payback during Travel Time for Supplemental Water

Under certain conditions, by mutual agreement and to prevent delay, when Reclamation has begun releasing Supplemental Water, but that water has not yet reached its intended destination, the MRGCD will assist Reclamation to achieve intended rates of flow at target locations. A simple analysis of this exchange of water indicates that, if 100 cfs is released from Abiquiu under the Supplemental Water Program and it takes 2 days for that water to reach Central Avenue, MRGCD would loan approximately 400 AF of water to the Supplemental Water Program to meet a target flow at Central Avenue. This provides more flexibility in water management and reduces take of silvery minnow.

6.6 Interrelated and Interdependent Actions

In addition to activities authorized, funded, or carried out by Federal agencies, Section 7 consultation regulations also require agencies to analyze the effects of interrelated and interdependent actions along with the direct and indirect effects of the proposed action. Interdependent actions are those having no independent utility apart from the Proposed Action (defined in 50 CFR §402.02). Interrelated actions are those actions that are part of a larger action and depend on the larger [proposed] action for their justification (defined in 50 CFR §402.02). The Proposed Action model runs also include the interrelated and interdependent actions of the Corps and the New Mexico State Engineer as described below (see table 53).

6.6.1 The Corps Actions Related to the SJC Project

Reclamation has determined that the following components of the Corps' actions are interrelated and interdependent with Reclamation's actions:

1. Storage of SJC Project water in Abiquiu Reservoir.
2. Use of SJC Project water to offset evaporation and other depletions occurring at the Cochiti Reservoir recreational pool.

6.6.1.1Storage for SJC Project Contractors at Abiquiu Reservoir

The Corps stores up to approximately 180,000 AF of SJC Project water in Abiquiu Reservoir pursuant to agreements with SJC Project contractors. The contractors take ownership of their SJC Project water upon release from Heron Dam by Reclamation and can elect to deliver this water to Abiquiu Reservoir for storage.

As discussed in the following Effects Analysis, the transport of SJC Project water within the Rio Grande Basin is beneficial to listed species and designated critical habitat because it increases both the discharge rate and volume above that of natural flow. Water stored by non-Federal entities in Abiquiu Reservoir also has been used, at their discretion, to offset ground water depletions or has been made available for purchase or lease by others, including Reclamation for its Supplemental Water Program. Reclamation expects these uses to continue in the future.

No listed species or designated critical habitat occurs between Heron Dam and Abiquiu Dam; therefore, the discretionary storage of SJC Project water in Abiquiu Reservoir will have no effect on the silvery minnow, flycatcher, or designated critical habitat of these species. The related release of such water—at the discretion of other entities—is benign or beneficial to the minnow, flycatcher, and their designated critical habitat. There is no effect on Pecos sunflower.

6.6.1.2 Use of SJC Project Water for Cochiti Recreation Pool Replacement Water

The Corps uses SJC Project water at the end of spring runoff and during the winter months to replace water that has evaporated from the Cochiti Recreation Pool. The elevation of the recreation pool increases approximately 1 to 1.5 feet with partial delivery of replacement water, and up to 3 feet after all replacement water is delivered in a given year. The Corps follows recommendations from a multi-agency biological advisory group to maximize the benefits of the replacement water to the wetlands in the delta area of Cochiti Lake (Allen et al. 1993). The use of water for the recreation pool does not change the hydrograph downstream from Cochiti Dam.

The Rio Grande silvery minnow does not occur between Heron Dam and Cochiti Lake, nor does designated critical habitat for this species.

Designated critical habitat for flycatcher does not occur between Heron Dam and Cochiti Lake. Flycatchers are known to use the river corridor upstream of Cochiti Lake during spring migration (Reclamation 2010) and are presumed to be similarly present during fall migration. The annual replenishment of evaporation losses at Cochiti Lake maintains existing riparian and wetland habitat immediately upstream of the permanent pool. Therefore, the use of recreation pool replacement water would have no effect on flycatcher. This action may have an indirect, beneficial effect by maintaining riparian habitat used by migrating flycatchers. There is no effect on Pecos sunflower.

6.6.2 The New Mexico State Engineer’s Actions Related to the SJC Project

For each ground water pumper with SJC pumper water that needs or chooses to release SJC Project water for offset, the NMOSE provides Reclamation with letters describing, the volume of SJC Project water that must be released by Reclamation or MRGCD and a deadline to do so. The depletions 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 depletions above and/or below the Otowi gage.

Depletions 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 MRGCD, which holds that water for release when needed to meet demand. As such, it provides an offset of the ground water pumping effects on the river system. Depletions that occur outside of the irrigation season are considered effects on Elephant Butte Reservoir. The required amount of SJC Project water is generally released to the Rio Grande in the winter for delivery to Elephant Butte Reservoir.

6.7 Summary Effects Analysis of Proposed Water Management Actions

6.7.1 Summary of the Effects of Reclamation's Actions

The analyses show that Reclamation's ability to affect the timing and distribution of flows in the MRG is extremely limited. Reclamation's actions affect only imported SJC Project water and the portion of the native flows of the Rio Chama, a tributary to the Rio Grande, that are stored in El Vado Reservoir. Reclamation has no ability to affect the flows of the Rio Grande main stem that comprise a strong majority of the flow in the MRG.

Although Reclamation's discretionary actions have limited impact on flows in the MRG, model simulations demonstrate that these limited influences are, on the whole, positive, as measured by the ability to maintain summertime flows in the MRG. Additionally, since Reclamation's storage of water in the springtime only diminishes flows of the Rio Chama in the reach between El Vado Dam and Abiquiu Reservoir, Reclamation's actions have very little influence on the size and timing of the spring snowmelt runoff. The primary spring runoff , which has been correlated with the spring spawn of the minnow, comes from the main stem of the Rio Grande and is larger, longer in duration, and later in time than the runoff from the Rio Chama. Flows on the Rio Chama are limited to 1,800 cfs by the Corp's flood control operations at Abiquiu Dam; and, therefore, the Rio Chama on its own, with or without operation of Reclamation's Projects, cannot cause a flow in the MRG of greater than 1,800 cfs.

The water that the MRGCD diverts consists of the natural flows of the main stem of the Rio Grande and its tributaries, as well as native Rio Grande water released from El Vado Reservoir and imported SJC water from Reclamation's SJC Project. About 90% of the flows in the MRG are composed of natural flow that is native to the basin and has not been regulated by reservoirs. These natural flows provide 79.2% of the MRGCD's diversion demand, which is used to meet the needs of the

Six MRG Pueblos, MRGCD irrigators, and BDANWR. Only 5.9% of the MRGCD diversion demand is met with water released from storage at El Vado Reservoir. Reclamation's operation of Heron Dam under the SJC Project accounts for approximately 6.7% of the MRGCD diversion demand.

6.7.2 Summary of the Effects of MRGCD's Water Management Actions

The MRGCD's permit from the New Mexico Office of the State Engineer to divert flows of the Rio Grande allows the MRGCD to divert up to 100% of the available natural flow in the MRG. The MRGCD has been diverting flows from the Rio Grande, to serve irrigated acreages at and above the current level since the early 1930s. The MRGCD system replaced a pre-existing, acequia-based diversion and irrigation system that had been in place for hundreds of years, with a maximum irrigated acreage of 180,000 acres in the late 1800s.

These diversions have the effect of reducing Rio Grande flows during the irrigation season. During times of high flows, the impact may be minor. During times of lower flow, the effect may be significant and may result in river drying. However, it should be noted that, in most years, the natural flow of the Rio Grande is insufficient to sustain riparian evapotranspiration and open water evaporation of the MRG, so that drying likely would occur in the absence of MRGCD diversions. During those times, MRGCD submits requests to Reclamation to release stored water from El Vado Reservoir (when available) to augment the natural flow of the Rio Grande to the level required for MRGCD diversion works to function. During full irrigation system operations, this results in continuous flow as far downstream as Isleta Diversion Dam. The MRGCD can supply irrigation water to all of its members with no flow downstream from the Isleta Diversion Dam, since the needs of the Socorro Division (otherwise served by the San Acacia Diversion Dam) can be met by return flows from the Belen Division, transported between divisions using the Unit 7 Drain, a State drain, as a conveyance.

The effect of MRGCD diversions is to reduce flow in the Rio Grande downstream from those diversions during the irrigation season. However, the effect of operations of El Vado Reservoir, which support these diversions, is to increase flows upstream of those diversions during the same time period. Significant river drying could still occur in the MRG without the combined effects of El Vado operations and irrigation diversions. Flows from MRGCD drains and wasteways can increase flows in critical reaches, especially in the Albuquerque and Isleta Reaches.

6.7.3 Summary of Effects on Silvery Minnow

The Proposed Action includes operation of Heron Dam, El Vado Dam, and MRGCD Diversion Dams as well as interrelated and interdependent actions of the Corps. The Proposed Action has adverse effects to spawning and recruitment due to decreased peak flows and juvenile and adult survival due to low flows and drying. There is little difference between the Proposed Action and No Action scenarios in the duration of flows high enough to have channel altering capacity, so there is little direct effect to current silvery minnow habitat features within the MRG.

Reclamation's Proposed Action is specific to storage and later release of water from SJC Project water from Heron Reservoir and native Rio Chama water from El Vado Reservoir. The water then passes through two other reservoirs, operated by the Corps, prior to reaching occupied silvery minnow habitat. Stored SJC Project water is released for contractors as additional water to the Rio Grande and is beneficial to the silvery minnow.

MRGCD operations of existing diversions have a more direct effect on silvery minnow by decreasing the amount of water in the river during irrigation season. The decrease of water in the river leaves less wetted habitat for silvery minnow at both high and low flows, and ultimately decreases the population size that inhabits the river. Additionally, diversion structures cause fragmentation of silvery minnow population and habitat.

A summary of the action by action analysis is listed below.

Reclamation's Operation of Heron Dam:

- Provides a potential benefit to silvery minnow and designated critical habitat by adding imported water to the system and decreasing the likelihood of summer drying especially in the Angostura Reach upstream of Isleta Diversion Dam.

Actions by Reclamation and MRGCD Related to the Operation of El Vado Dam:

- Limited decrease in duration and magnitude of spring peak flow in silvery minnow designated critical habitat may adversely affect silvery minnow spawning and recruitment.

- Provides a potential benefit to silvery minnow and silvery minnow designated critical habitat by releasing stored water later in the irrigation season and decreasing summer drying.

MRGCD's Water Management Actions:

- Diversions decrease the amount of water within the river during the irrigation season, which may adversely affect the silvery minnow and their designated critical habitat by reducing the amount of wetted habitat.

- Diversions also create barriers to upstream movement of fish and affect the geomorphology of the river, which is likely to adversely affect silvery minnow and their designated critical habitat.

- Flows from MRGCD drains and wasteways can increase flows in critical reaches, especially in the Albuquerque and Isleta Reaches.

6.7.4 Summary of Effects on Flycatcher

Overall, Reclamation's Proposed Actions of storage and release of water from Heron and the combined operation of El Vado Reservoirs by Reclamation and MRGCD is mainly beneficial or likely to not adversely affect flycatchers or flycatcher critical habitat. The MRGCD proposed actions, however, are generally more negative in nature as the process of diverting water within the river during irrigation season removes water from the river system where flycatchers establish territories. A summary of the action-by-action analysis is listed below:

Reclamation's Operation of Heron Dam:

- Provides a potential benefit to flycatchers and flycatcher designated critical habitat by decreasing summer drying.

Actions by Reclamation and MRGCD Related to the Operation of El Vado Dam:

- Provides a potential benefit to flycatchers and flycatcher designated critical habitat by decreasing summer drying.

MRGCD's Water Management Actions:

- Diversions decrease the amount of water available for riparian vegetation used by flycatchers, which may adversely affect the species and their designated critical habitat.

- These diversions also decrease the amount of potential inundation of overbank habitat, which has effects for territory establishment of flycatchers.

6.7.5 Summary of Effects on Pecos Sunflower

- The Proposed Action is beneficial to Pecos sunflower within the La Joya WMA due to delivery of water.

- Reclamation's Proposed Action is specific to storage and later release of San Juan Chama water from Heron is not likely to adversely affect Pecos sunflower.

- The combined Reclamation and MRGCD operation of El Vado Reservoirs that is specific to storage and release of water is not likely to adversely affect Pecos sunflower and may have some beneficial effects due to delivery of water to the La Joya Waterfowl Management Area.

- MRGCD activities have a direct effect on the Pecos sunflower through beneficial delivery of water to the La Joya Waterfowl Management Area.

- The newly established, Rhodes population may be affected by actions that decrease overbank flows such as storage and diversion of spring flows, but effects of the Proposed Action are minimal and not likely to adversely affect Pecos sunflower.

6.7.6 Summary of Effects of Conservation Measures.

Conservation measures have been developed to attempt to mitigate the effects of the described actions, especially by adding additional water to the river during low flow periods as well as the deviation program developed by the Corps to enhance high flow events. Other conservation actions will be more fully developed in the RIP. The RIP is intended to identify and implement actions that assist in the recovery of the species and provide compliance with Sections 7 and 9 of the ESA for water development and water management activities in the MRG. For the purposes of the RIP and Section 7 consultations, it is assumed that:

1. The RIP will produce a list of actions that can be implemented to assist in the recovery of the species.
2. The funding will be available to implement these actions.
3. Participants will take appropriate steps to implement those actions.
4. Actions will be implemented in accordance with the developed schedule.

The Service will determine if progress toward recovery has been sufficient for the Program to serve as a reasonable and prudent alternative or measure.