7. Cumulative Effects Analysis

Cumulative effects are effects of future non-Federal (State, local governments, or private) activities on endangered and threatened species or critical habitat that are reasonably certain to occur within the action area of the actions subject to consultation. This cumulative effects analysis considers those non-Federal activities that may occur in the foreseeable future. The effects of non-Federal actions included in this BA as proposed actions and analyzed in the direct and indirect effects sections are not included in the cumulative effects analysis.

The following section shows a potentially dire water supply outlook for the MRG: the climate is projected to become warmer and dryer; population growth is projected to increase; and the current demand for water in the MRG outstrips the variable supply. Therefore, water management in the MRG will only become more challenging.

7.1 Future Changes in Climate and Hydrology

In future years, more pronounced changes are anticipated in the climate in the MRG Basin, including greater increases in average temperature, earlier snowmelt runoff, and even greater hydrologic variability. Projected changes in the climate and hydrology of this region were summarized in the Secure Water Report (Reclamation 2011), which Reclamation recently published and delivered to Congress, as required by the 2009 Secure Water Act. The projections summarized in that report were developed from the World Climate Research Programme Coupled Model Intercomparison Project3 (WCRP CMIP3) climate projections, which were bias-corrected and spatially downscaled to this region (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections). The results suggest that average temperatures throughout the Rio Grande Basin may increase steadily during the 21st century. The basin-average mean-annual temperature is projected to increase by 5–6 °F during the 21st century (figure 91). The range of annual variability widens through time.

There is significant disagreement among the climate projections regarding the likely change in annual precipitation over the region. However, the combined mean from numerous projections suggests that mean-annual precipitation, averaged over the MRG Basin may gradually decrease during the 21st century. The projections also suggest that annual precipitation in the MRG Basin will remain quite variable over the next century (figure 91). The character of precipitation within the MRG Basin is expected to change in such a way that there are more frequent rainfall events and less frequent snowfall events.

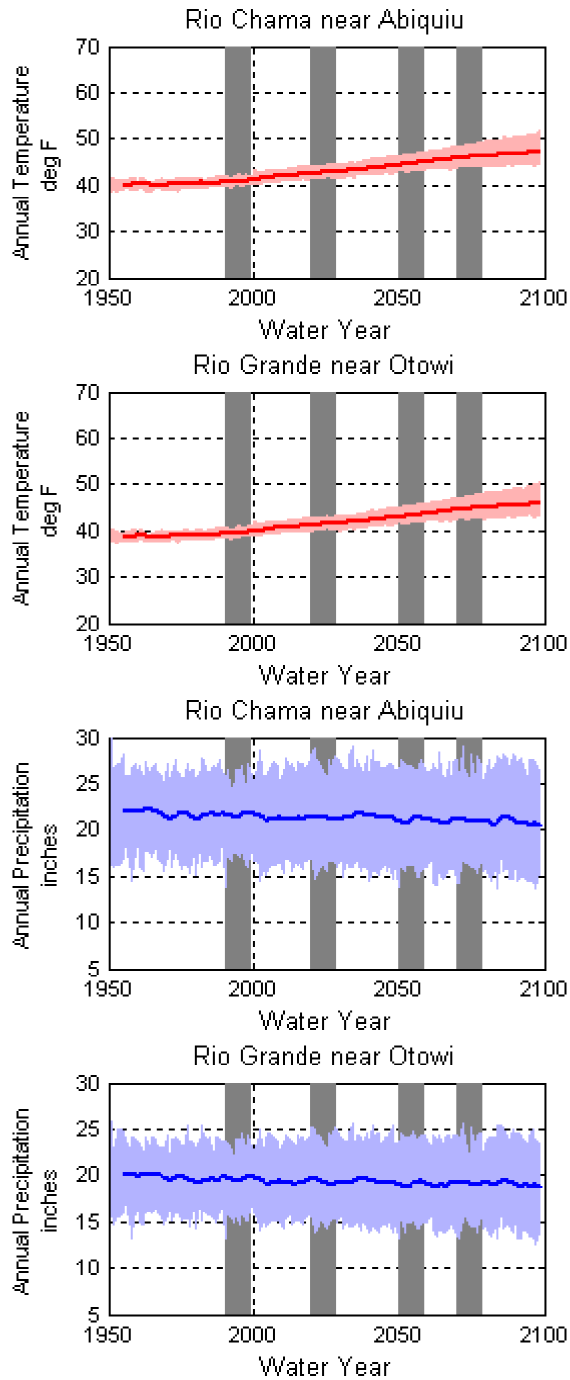

Figure 91. Simulated annual climate averaged over Rio Grande sub-basins.

Warming is expected to diminish the accumulation of snow during the cool season (i.e., late autumn through early spring) and the availability of snowmelt to sustain runoff to the MRG during the warm season (i.e., spring through early summer). Although increases or decreases in cool season precipitation could offset or amplify changes in snowpack, it is apparent that the projected warming in the Rio Grande Basin tends to dominate projected effects. Snowpack decreases are expected to be more substantial over the lower-lying portions of the basin where baseline cool season temperatures are generally closer to freezing thresholds and more sensitive to projected warming. Changes in climate and snowpack within the MRG Basin will change the availability of natural water supplies. These changes may be to annual runoff or to runoff seasonality. For example, warming without precipitation change would lead to increased evapotranspiration from the watershed and decreased annual runoff. Increases or decreases in precipitation (either rainfall or snowfall) would offset or amplify the effect. Results suggest that annual runoff changes generally are consistent throughout the basin, although local variations associated with elevation and baseline climate are evident. For example, annual runoff reductions in the Rio Chama at Abiquiu, draining the northwestern reaches of the basin, are projected to be somewhat less than reductions found at river locations draining the northern and eastern portions of the basin. However, at all locations, decade-mean annual runoff is projected to steadily decline through the 21st century, responding to both slight decreases in precipitation and warming over the region (figure 92).

The seasonality of runoff also is projected to change in the MRG in such a manner that, over time, winter flows increase and spring flows decrease. Warming would be expected to lead to more rainfall and runoff, rather than snowpack accumulation, during the winter. Conceptually, this change would lead to increases in the December–March runoff and decreases in the April–July runoff. As can be seen on figure 92, this concept is supported by results for the December through March seasonal runoff in the Rio Chama at Abiquiu, as projected mean winter runoff increases for the 2020s, 2050s, and 2070s.

However, for the three locations shown on the Rio Grande (Rio Grande at Lobatos, Rio Grande near Otowi, and Rio Grande below Elephant Butte), mean seasonal runoff changes during December through March generally follow mean annual runoff changes, without this shift from April-through-July to December-through-March runoff. However, at all four of the locations shown on figure 92, mean April-through-July runoff is expected to decline; and these declines are expected to become greater in magnitude over the course of the 21st century.

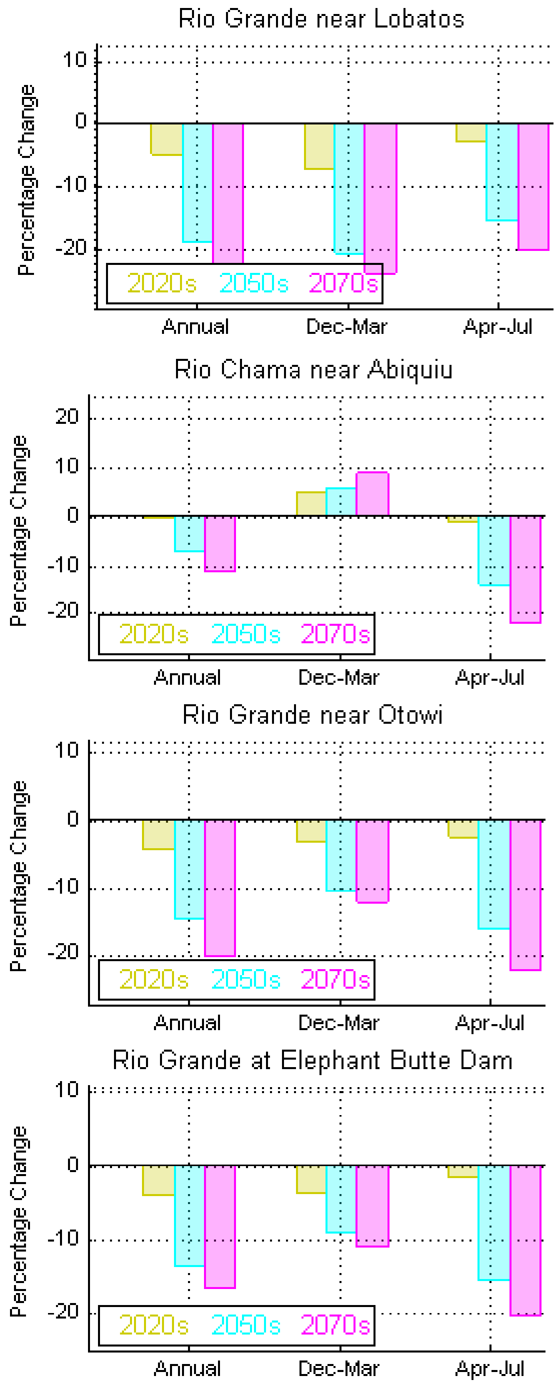

Figure 92. Simulated changes in decade-mean runoff for several sub-basins in the Rio Grande Basin.

Changes in the magnitude of flood peaks also are expected in the MRG (table 53), although there is less certainty in the analysis of these types of acute events than there is for changes in annual or seasonal runoff. Annual maximum week runoff (the maximum weekly average flowrate) and minimum week runoff (the minimum weekly average flowrate), as metrics of acute runoff events (figure 93), indicate that annual maximum week runoff may gradually decline during the 21st century. Results are generally consistent across the sub-basins shown. These results suggest that future flood events in the Rio Grande may be smaller in magnitude than those experienced in the 1990s, although the streamflow variability is expected to continue to be large. These changes have implications for flood control and ecosystem management. However, it is important to note that there is a high degree of variability among model simulations suggesting there is a high degree of uncertainty in this flood metric.

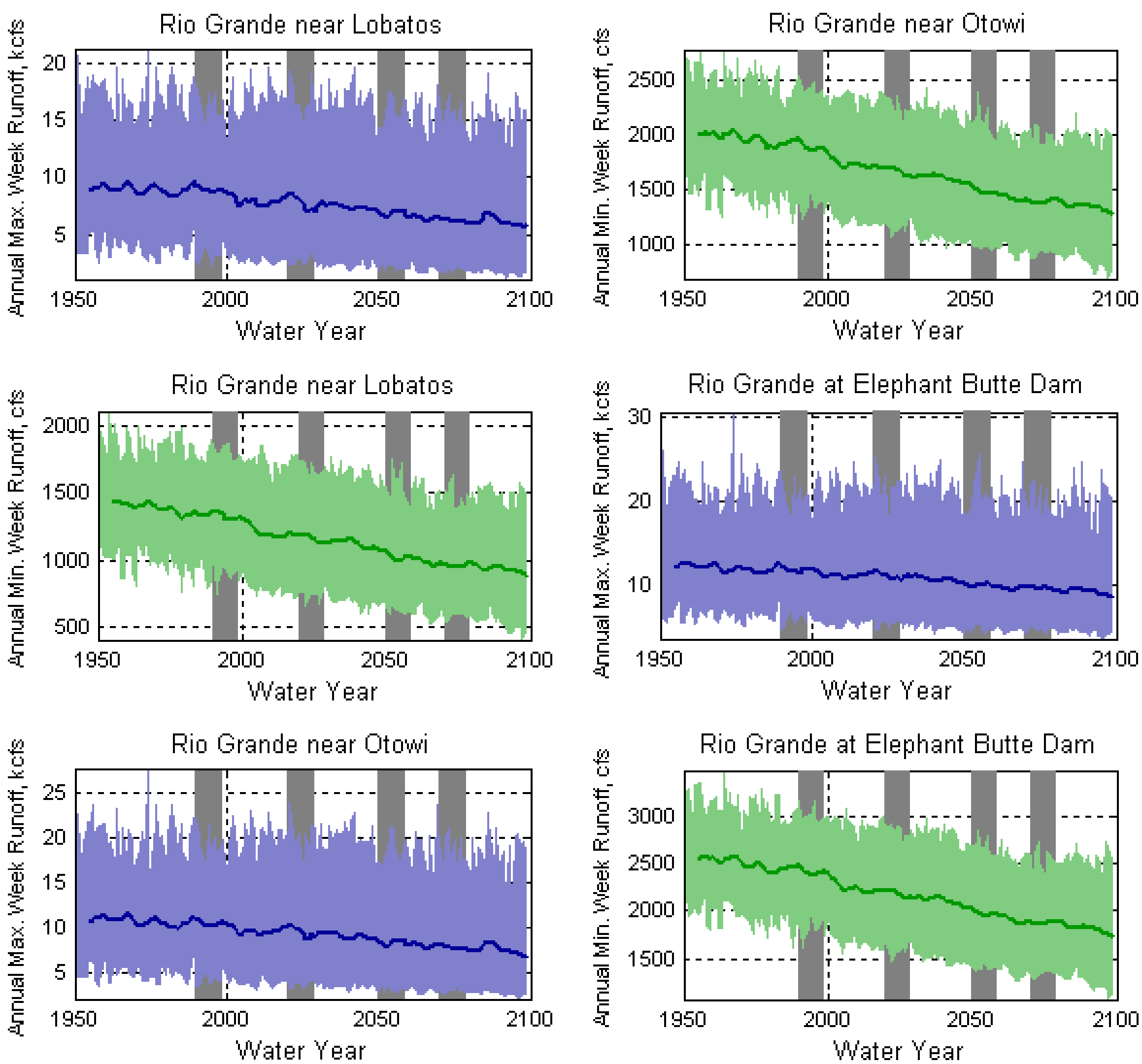

Figure 93. Simulated annual maximum and minimum week runoff for several sub-basins in the MRG Basin.

Table 53. Summary of simulated changes in decadal hydroclimate for several sub-basins in the MRG Basin

Hydroclimate Metric (change from 1990s)	***2020s***	***2050s***	***2070s***
Rio Chama near Abiquiu			
Mean Annual Temperature (°F)	1.9	3.8	5.3
Mean Annual Precipitation (%)	-1.1	-2.3	-2.5
Mean April 1 Snow Water Equivalent (%)	-47.6	-61.4	-68.2
Mean Annual Runoff (%)	-0.2	-7.3	-11.0
Mean December-March Runoff (%)	4.8	5.5	8.6
Mean April–July Runoff (%)	-1.3	-13.9	-21.7
Mean Annual Maximum Week Runoff (%)	-4.3	-9.5	-14.9
Mean Annual Minimum Week Runoff (%)	-12.1	-19.2	-23.9
Rio Grande near Otowi			
Mean Annual Temperature (°F)	1.9	3.7	5.2
Mean Annual Precipitation (%)	-1.5	-2.5	-2.4
Mean April 1 Snow Water Equivalent (%)	-48.5	-63.8	-72.9
Mean Annual Runoff (%)	-4.4	-14.4	-19.9
Mean December–March Runoff (%)	-3.1	-10.4	-12.0
Mean April–July Runoff (%)	-2.5	-15.9	-21.8
Mean Annual Maximum Week Runoff (%)	-9.3	-20.3	-25.3
Mean Annual Minimum Week Runoff (%)	-11.7	-21.6	-26.3
Rio Grande below Elephant Butte Dam			
Mean Annual Temperature (°F)	1.9	3.7	5.1
Mean Annual Precipitation (%)	-0.9	-2.3	-1.9
Mean April 1 Snow Water Equivalent (%)	-72.4	-80.7	-85.3
Mean Annual Runoff (%)	-4.1	-13.5	-16.4
Mean December–March Runoff (%)	-3.6	-8.9	-10.9
Mean April–July Runoff (%)	-1.6	-15.4	-20.0
Mean Annual Maximum Week Runoff (%)	-6.1	-15.7	-18.8
Mean Annual Minimum Week Runoff (%)	-9.6	-18.2	-22.4

Annual minimum-week streamflows also are projected to decline during the 21st century (figure 85). These results suggest that future low flow periods in the Rio Grande may be drier still. However, there is a high degree of variability among model simulations, suggesting that there is a high degree of uncertainty in the magnitude of this trend. Nevertheless, nearly all projections show an overall decrease in low flow values.

7.2 Regional Water Planning: Projected Impact of Population Growth and Water Demand on Water Supplies

Historically, land use in the MRG region depended solely on surface water; however, the shift from being a dominantly rural population to being a dominantly urban population has resulted in increased ground water consumption and reduced aquifer recharge. The continued growth of human population and water-based industry in the MRG affects the availability of all water supplies, both ground and surface water - native and imported.

In New Mexico, the surface waters of the Rio Grande have been considered fully appropriated since the Compact was consummated, and the NMOSE does not allow new Rio Grande surface water appropriations (NMOSE 2000). As discussed in section 5, the NMOSE conjunctively manages surface and ground water resources within the Rio Grande Basin because ground water diversions from aquifers hydrologically connected to the Rio Grande affect the fully appropriated surface flow (NMOSE 2000). Therefore, an increase of water use in any one sector requires a reduction or transfer of use from another sector if the water supply balance is to be maintained.

Under New Mexico law, a “disconnect” exists between land use planning and water rights administration. State statutes delegate land use decisions to cities and counties, while water rights administration is delegated to the NMOSE. The New Mexico Subdivision Act requires that the NMOSE advise whether, in its opinion, an adequate supply exists for new larger subdivisions that are outside of municipal jurisdictions (NM Stat. § 47-6-1 et seq.). A finding that the supply is not adequate, however, does not prevent county government approval of the subdivision (Land and Water 2011).

In 1987, the New Mexico Legislature[28] recognized the State’s need for water planning and created the State’s regional water planning program to balance current and future water needs for a region. Just upstream of the MRG and within the action area of this BA is the Jemez y Sangre Planning Region (Embudo to upstream of Cochiti Reservoir), which includes Española, Los Alamos, Santa Fe, and surrounding areas. The MRG is contained in two of the State’s 16 water planning regions: the Middle Rio Grande Planning Region (downstream from Cochiti Dam to Soccorro) and the Socorro and Sierra Planning Region (Socorro to below Caballo Dam). Unfortunately, water plans are not commonly implemented

[28] In 2003, the New Mexico Legislature mandated that the State develop a State Water Plan to provide a blueprint for the State to move forward into the 21st century with 21st century techniques and technologies applied to conserve and to increase the supply of water. NM Stat. § 72-14-3.1 (2011).

because they are not supported by appropriate regulations, development decisions, or in conformity with the plans; and they become outdated (Land and Water, 2011).

7.2.1 The Jemez y Sangre Planning Region

The 2003 Jemez y Sangre Regional Water Plan (JyS Plan) includes the Rio Arriba, Los Alamos, and Santa Fe Counties and all or part of eight Pueblos. The JyS Plan states that demand for water may exceed available supply during years of average precipitation and that demand exceeds supply during drought years.

The region's surface water supply for agricultural use comes primarily from the Rio Grande and the Rio Chama. The city of Santa Fe receives approximately 40% of its supply from dams in the Santa Fe River watershed above the city (JyS Plan). As discussed in Section 5, Environmental Baseline, of this BA, the city of Santa Fe and Santé Fe County have initiated, under the Buckman Project, direct use of their 5,605 AFY allocation of SJC Project and native Rio Grande water to supplement their other water supplies and have been diverting water from the Rio Grande since January 2011. Ground water is the primary supply for municipal and industrial uses and provides a small amount for agricultural use (JyS Plan).

The city of Santa Fe and areas of Santa Fe County close to the city are among the fastest growing areas in the State. The population of the region nearly doubled from 1970 to 2000; however, population growth is projected to slow during the first half of this century. The population is projected to increase from about 160,000 in 2000 to about 360,000 by 2060, and nonagricultural demand for water in 2060 is projected to be 31,500 AFY greater than current demand. Agricultural use is on a decline in the region; therefore, the increased demand for nonagricultural use potentially could be met. However, the amount of wet water currently in agricultural use is uncertain because water diverted for agricultural use is not measured or monitored, and the water rights in the region have not been adjudicated (JyS Plan).

The JyS Plan found that the projected supply and demand gap cannot be entirely eliminated through conservation or growth management. Moreover, the available SJC Project water would only meet 40% of the projected gap in the best case scenario. Additionally, reductions in agricultural uses and the elimination of all outdoor watering may be detrimental to public welfare. Some of the JyS Plan recommendations for remedying the supply shortfall are as follow:

- Create advisory boards.
- Adjudicate water right.
- Restore watershed.

- Manage storm water to enhance recharge.
- Conduct pilot cloud seeding project.
- Evaluate establishing critical management areas to protect ground water resources.
- Develop conjunctive use strategies.
- Appropriate flood flows.
- Require wastewater reuse.
- Encourage rainwater collection.
- Line ditches.
- Remove sediment in Santa Cruz Reservoir and investigate Nambe Reservoir.
- Repair leaks in water systems.
- Consider aquifer storage and recovery of excess water.
- Pursue increased storage capacity in Abiquiu Reservoir.
- Pursue water conservation.
- Pursue growth management to reduce demand.
- Limited use of domestic wells (JyS Plan).

7.2.2 The Middle Rio Grande Planning Region

The 2004 MRG Regional Water Plan (MRG Plan) comprises Sandoval, Bernalillo, and Valencia Counties, the Six MRG Pueblos—and an area covering more than 5,000 miles. More than half of New Mexico's population makes its home in the MRG planning region, and it is the largest urban water user in the State. The MRG region averages just 9 inches of rain per year and relies on surface and ground water to supply the industry, agriculture, environment, and people of the region. Surface water supplies include the Rio Grande, Rio Jemez, the Rio Puerco, and the SJC Project. Surface flows are augmented by pumped ground water in the form of 'return flows' of treated sewage, and there is an ongoing exchange between surface water and the shallow aquifer. As discussed in Section 5, Environmental Baseline, of this BA, until 2008, the city of Albuquerque's and Bernalillo County's potable water supplies were provided exclusively from ground water. Population in the region had grown by 21% since 1993 and continues to expand by about 15% each decade, which will result in even greater deficits in the future, unless some conservation actions are taken (MRG Plan).

On average, water use in the region exceeds its renewable supply by approximately 55,000 AFY, which was being supplied by nonrenewable ground water. If no remedial actions are taken, the consumptive use by the region could result in a 150,000 AFY deficit by 2050 (figure 94) (MRG Plan).

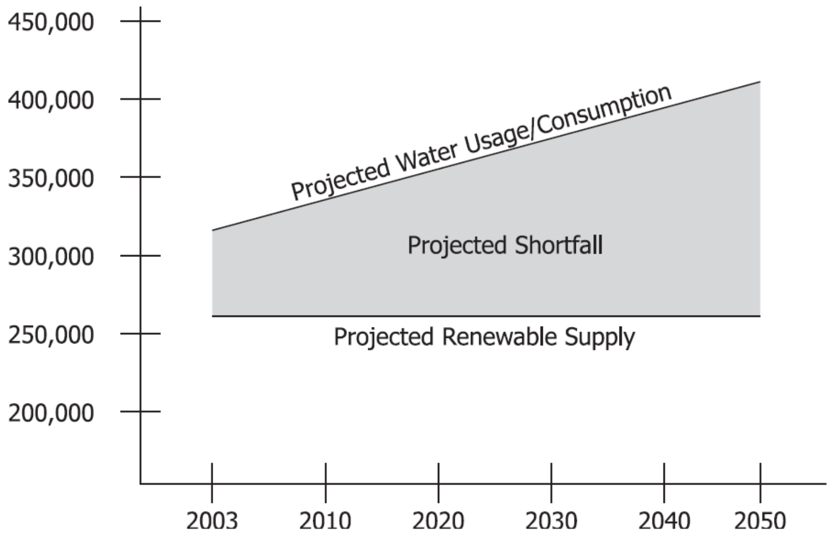

Figure 94. Projected MRG water supply shortfall (MRG Plan).

The following are some of the MRG Plan recommendations for remedying the supply shortfall:

- Establish a domestic well policy.
- Outdoor conservation programs.
- Rainwater harvesting.
- Conversion to low flow appliances.
- Urban water pricing.
- Greywater reuse.
- Treated effluent re-use.
- Growth of parks and golf courses.
- Watershed management plans.
- Water banking.
- Land use management and planning.
- Measure all water uses.
- Upgrade agricultural conveyance systems.

- Level irrigated fields.
- Implement upstream surface water storage.
- Implement upstream aquifer water storage.
- Implement aquifer storage and recovery for drought.
- Develop new water supplies through desalination.
- Investigate the potential for importing water (MRG Plan).

7.2.3 The Soccoro-Sierra Planning Region

The 2004 Soccoro-Sierra Regional Water Plan (SS Plan) includes Socorro and Sierra Counties, the latter of which is outside the action area for this BA, and covers an area of approximately 11,000 square miles. In 2004, the population in the region doubled over the last 30 years to 31,400 and was expected to increase 70%, reaching 60,000 persons in 2040. Surface water supply for the region includes the Rio Puerco, Rio Salado, and ungaged tributaries east and west of the Rio Grande; and the region has significant supplies of ground water. The SS Plan determined that demands from both human and natural processes deplete scarce water supplies, and demand outstrips supply by approximately 77,900 AFY. Results of modeling indicated that, in a low flow year, the supply falls short of meeting demand by 194,000 AF (SS Plan).

The following are some of the SS Plan recommendations for remedying the supply shortfall:

- Improve the efficiency of surface water irrigation conveyance systems.
- Improve onfarm efficiency.
- Control brush and weeds along water distribution systems and drains.
- Control nonreservoir surface water evaporation by reducing surface water in engineered and natural locations.
- Require proof of sustainable water supply for approval of new developments.
- Encourage retention of water within the planning region.
- Remove exotic vegetation (i.e., salt cedar, Russian olive) on a wide scale.
- Manage watersheds to increase yield and improve water quality.
- Develop economic potential for non-native species removal, harvest, and product output by local industries.

- Make water rights a noncondemnable resource.
- Improve reservoir management for better coordination of flows with demand.
- Identify and protect areas vulnerable to contamination.
- Adopt and implement local water conservation plans and programs, including drought contingency plans.
- Facilitate interregional water management decisions, public participation, and funding (SS Plan).

7.2.4 The MRG Water Assessment, the Water Budget, and Water Conservation

In 1997, Reclamation authored a report that assessed how human manipulation of the hydrologic system, in association with changing land use, has affected water resources in the MRG (Reclamation 1997). The Water Assessment was Reclamation's contribution to a multiagency effort, led by the city of Albuquerque, to better understand and to protect the aquifer in the MRG. The report found that meeting demands on the hydrologic system created by urbanization, agriculture, and other emerging needs will require adept and expedient regional cooperation for planning and implementing new approaches to land and water resource management. It presented that no magic bullet exists to solve the problem, that business as usual could result in gridlock, and that regional partnerships between competitors, along with innovative solutions were needed to meet the region's future water resource needs (Reclamation 1997).

In 1999, the Action Committee of the Middle Rio Grande Water Assembly published the Middle Rio Grande Water Budget (where water comes from, goes, and how much), Averages 1972–1997 (Water Budget 1999). The purpose of the Water Budget was to inform a broad audience of people interested in the MRG's water resources, with the hope that a well informed public would improve public input and water stewardship. Most significantly, the Water Budget found that a wet water deficit of 70,000 AFY (Water Budget 1999). See table 54.

Table 54. Middle Rio Grande water budget annual surface-water and ground water averages (rounded) for 1972–1997 (Water Budget 1999)

Annual Surface-Water Inflow		Amount (Native Water) (1000 ac-ft)	Annual Variability (1000 ac-ft)
Rio Grande native water at Otowi Gage ("Otowi Index")		1,100	297-2,170
San Juan-Chama Project imported water reaching Otowi Gage		55	2-150
Tributary inflow (the rios Santa Fe, Galisteo, Jemez, Tijeras, Puerco, Salado)		95	
Ungaged tributaries		unknown	
Storm-drain inflow from Albuquerque		5	
Municipal Wastewater inflow (pumped from groundwater)		70	
Discharge from shallow aquifer to surface system	*Otowi to San Acacia*	220	
		1545	
Annual Surface-Water Outflow			
Recharge to shallow aquifer	*Otowi to San Acacia*	295	
Open-water evaporation (incl.from farm fields)	*Otowi to San Acacia*	60	±30
Irrigated agriculture and valley-floor turf	*Otowi to San Acacia*	100	±30
Riparian ET, irrig. agric. & open-water evap.	*Combined below San Acacia*	100	80-180
Elephant Butte evaporation		140	41-228
Surface-water outflow from Elephant Butte Dam to downstream users		**850	300-1,435
		1545	
Groundwater Recharge(+) & Discharge(-)			
SHALLOW AQUIFER (underlying Rio Grande flood plain)			
Recharge {from surface wtr & percolation from irrig)	*Otowi to San Acacia*	+295	
Septic-tank return flow (from pumping)	*Otowi to San Acacia*	+ 10	
Inflow from deep aquifer	*Otowi to San Acacia*	+ 50	
Riparian evapotranspiration (all non-crop ET)	*Otowi to San Acacia*	- 135	
Discharge to surface-system drainage ditches	*Otowi to San Acacia*	- 220	
		0	
DEEP AQUIFER			
Deep groundwater inflow (from north & west)		+ 40	
Mountain-front & tributary recharge	*Otowi to San Acacia*	+110	
Groundwater pumped (all wells)	*Otowi to San Acacia*	- 170	
Consumed (that is, evaporated)	90		
Municipal wastewater to river	70		
Septic-tank return flow to shallow aquifer	10		
Outflow to shallow aquifer		- 50	
Groundwater mined from aquifer	*Otowi to San Acacia*	- 70	

7.2.5 Local Government Water Conservation Efforts

Local governments, specifically the County and city of Santa Fe and Santé Fe County, the city of Albuquerque, and the County of Bernalillo (ABCWUA), have undertaken substantial efforts to reduce use of and conserve water.

Santa Fe's longstanding water conservation and drought management programs have been successful in declining total annual water diversions (29%) to serve a growing number of customers (14%) since 1995. The annual water diversions shrunk to 9,226 acre-feet in 2010, compared with 12,737 acre-feet in 1995, while the number of customers served increased to approximately 79,244 people in 2010, from an estimated 67,839 in 1995. Santa Fe's water customers reduced their water use by 38 percent from 1995 to 2010. Per person usage dropped from 168 gallons per capita per day (gpcd) in 1995, to 104 gpcd by the end of 2010. Santa Fe has reduced its per capita water demand levels by implementing a comprehensive set of ordinances that require its citizens and businesses to comply with water conservation requirements. Santa Fe's low per capita per day water production statistics are among the lowest in New Mexico and the Southwestern United States (Santa Fe Conservation Plan, 2010). Santa Fe has implemented many of the recommended water conservation measures contained in the Jemez y Sangre Regional Water Plan, and Santa Fe's water conservation successes and the construction of the Buckman Direct Diversion project have significantly contributed to the closing of the 40-year supply shortfall 'gap' in the Santa Fe subregion. (Santa Fe Conservation Plan 2010).

ABCWUA has made substantial progress in its water conservation program, shifting from among the highest municipal water users in the Southwest to among the lowest. The conservation program has achieved a 44% overall water reduction in per account use over the last 16 years through a combination of public information, rate restructuring, in-school education, rebate incentives, landscape ordinances, and other programs. In 2010, the ABCWUA achieved a reduced average peak use that was 21% less than prior to the start of the conservation program, despite a population increase of more than 150,000 people. Per person usage dropped from 250 gpcd when the program began in 1995, to 157 by the end of 2010. When re-use water is deducted, usage actually drops to 154 gpcd, and ABCWUA is on track to reach 150 gpcd by 2014 (Authority Conservation Plan, 2012).

7.3 Water Rights Transfers and Offsets

As discussed in Section 5, Environmental Baseline, water rights are alienable private property rights that can be conveyed like other property rights, and water right owners in the MRG continue to transfer their water rights subject to the approval of the NMOSE. Demand for water in the MRG outstrips supply. Municipal and industrial uses of water are increasing; and because no new water is available, entities seeking water must acquire it from other uses and transfer it to new uses. In the MRG, as with other places in the Western United States, cities and towns have relied on ground water supplies and the transfer of water from irrigation use to municipal and industrial use.

Future changes in use of water rights in the MRG can impact flows in the Rio Grande in several ways. The movement of water from a place of use with a downstream point of diversion to a place of use with an upstream point of diversion can result in decreased flows in the intervening reach. Additionally, formally irrigated fields must be maintained to avoid revegetation with phreatophytic vegetation, such as salt cedar, which may consume as much or more water than the previous crops. Also, monitoring is required to ensure that the lands previously appurtenant to the transferred water rights do not continue to receive water deliveries.

7.4 Pueblo Water Rights

The Pueblos hold water rights that are recognized and protected under Federal law, including but not limited to aboriginal time-immemorial water rights. With respect to the Six MRG Pueblos, a certain portion of their water rights are statutorily recognized under the Acts of 1928 and 1935. However, these Acts of Congress may not establish the full extent of the water to which these Pueblos may be entitled. Section 5, Environmental Baseline, of this BA includes the junior, un-adjudicated uses of water by non-Pueblo water users and recognizes the existence of unquantified, aboriginal water rights held by the Six MRG Pueblos. At such time when the full extent of the Pueblos' water rights are quantified, through water rights settlement or otherwise, and applied to beneficial use, junior water uses may be curtailed pursuant to New Mexico water law.

7.5 Conclusion

The regional water plans for the MRG estimate a substantial additional water demand in 40–50 years in the municipal and industrial sector. If that increase is only accommodated through the transfer of water rights, about 57,000 acres of such rights would need to be transferred (Schmidt-Peterson 2007). Estimates of the total amount of land currently irrigated within the MRGCD are between 50,000 and 65,000 acres, and the claims to the water is likely much greater than the actual amount of wet water, particularly during drought. (Sandia Report 2004).

The degree to which the stakeholders in the MRG can work together to take remedial actions and return the hydrology of the basin to balance is uncertain. The efforts of the Collaborative Program/RIP participants both collectively and individually will help determine how well equipped the water managers will be to cope with future water conditions.

The long-term biological effects of future development in the MRG are uncertain. It is likely that less and less water will be available for the river and the species that depend on it. Less water in the river will have the greatest impacts on silvery minnow since they must carry out their entire life cycle within the waters of the MRG.