1. Water Supply

This section provides an overview of the water supply in the Middle Rio Grande Water Planning Region, including climate conditions (Section 5.1), surface water and groundwater resources (Sections 5.2 and 5.3), water quality (Section 5.4), and the administrative water supply used for planning purposes in this regional water plan update (Section 5.5). Additional quantitative assessment of water supplies is included in Section 7, Identified Gaps between Supply and Demand.

The *Updated Regional Water Planning Handbook* (NMISC, 2013) specifies that each of the 16 regional water plans briefly summarize water supply information from the previously accepted plan and provide key new or revised information that has become available since submittal of the accepted regional water plan. The information in this section regarding surface and groundwater supply and water quality is thus drawn largely from the accepted *Middle Rio Grande Regional Water Plan, 2000-2050* (MRCOG and MRGWA, 2004)
and, where appropriate, updated with more recent information and data from a number of sources, as referenced throughout this section.

Currently some of the key water supply updates, including recent projects and studies, and issues impacting the Middle Rio Grande region are:

- The climate divisions within the planning region have all experienced drought in recent years. This is a particular concern for agricultural users that are dependent on surface water, but drought preparedness is important for each community in the region.

- The Rio Grande Compact requires delivery of specified amounts of water to Elephant Butte Reservoir based on the annual natural flow of the Rio Grande at the Otowi gage. When the stored water in Elephant Butte and Caballo Reservoirs legally available for release to the lower Rio Grande drops below a specified level, certain provisions of the Compact restrict storage in reservoirs upstream of Elephant Butte constructed after 1929, thus impacting water operations in the region.

- The Rio Grande is the main river in the planning region, and most of the groundwater in the region is within the Rio Grande UWB and is considered to be stream-connected. The Rio Grande Compact requires a proportion of the water that enters the middle Rio Grande valley to be delivered to Elephant Butte Reservoir (Section 4). This requirement limits combined depletions in the Jemez y Sangre, Middle Rio Grande, and Socorro-Sierra planning regions. The Rio Grande in the region is also considered by the State Engineer to be fully appropriated, and any new diversion of surface water or stream-connected groundwater requires the transfer of a valid surface water right. The availability of water rights may thus be a limiting factor in meeting the future water needs of the region.

- Water users seeking to obtain water rights to meet growing demands, such as municipal users, are challenged because they must transfer an existing senior water right. No new appropriations are available in the region. After the groundwater basin was closed to new appropriations in 1956, a number of entities applied for and were issued groundwater pumping permits with the condition that the effects of the pumping on the river would be offset when they occur. Municipal return flow, San Juan-Chama Project water, and the transfer of senior water rights are used as offsets as required by the specific permit requirements, with return flows comprising the greatest volume of offset. The amount of senior water rights needed to offset the pumping under these permits when the effects are fully realized on the river is roughly equal to all of the transferrable senior water rights from the irrigated land along the Rio Grande from north of Albuquerque to Elephant Butte (Schmidt-Petersen, 2011).

Rio Grande Compact

Signed in 1938 between Colorado, New Mexico, and Texas, and approved by Congress in 1939, the Rio Grande Compact apportions the surface waters of the Rio Grande Basin above Ft. Quitman, Texas, among the three states. The Rio Grande Compact establishes, among other things, annual water delivery obligations and depletion entitlements for Colorado and New Mexico. The Compact is administered by a commission consisting of one representative from each state and one from the federal government.

The Compact provides for debits and credits to be carried over and accrued from year to year until extinguished under provisions of the Compact. Annual Compact accounting, based on flows at index gaging stations and changes in reservoir storage determines Colorado's and New Mexico's delivery obligations each year.

The Compact affects water planning in New Mexico in several ways:

- The Compact established limitations on the amount of water available for depletion in the northern portion of the Basin in New Mexico. It also requires that a portion of the water that enters the Middle Rio Grande valley be delivered to Elephant Butte Reservoir. These requirements limit depletions in the Rio Chama, Taos, Jemez y Sangre, Middle Rio Grande, and Socorro-Sierra planning regions.
- When the stored water in Elephant Butte drops below specified levels, certain provisions of the Compact restrict storage in reservoirs upstream of Elephant Butte constructed after 1929, thus impacting water operations in the region. Additionally, should New Mexico end the year with an accrued debit balance, it is required to retain in storage an amount of water equivalent to that total debit.

In 1938, in *Hinderlider v La Plata River and Cherry Creek Ditch Co*., the U.S. Supreme Court ruled that compliance with the terms of an interstate stream compact have the highest priority within a stream system. Thus, from a regional water planning perspective, the waters of the Rio Grande Basin above Elephant Butte Reservoir are a singular supply shared among the Rio Chama, Taos, Jemez y Sangre, Middle Rio Grande, and Socorro-Sierra planning regions, the use of which is constrained by the terms of the Compact.

- Middle Rio Grande Conservancy District (MRGCD) (20,900 ac-ft/yr), Town of Belen (500 ac-ft/yr), Town of Bernalillo (400 ac-ft/yr), and Village of Los Lunas (400 ac-ft/yr).
- Since the accepted plan was completed, the ABCWUA has begun to use surface water from the San Juan-Chama project to supplement its water supply. This surface water use allows groundwater withdrawals to be reduced, and is intended to save groundwater for use as a drought supply when surface water is not available. As a result, ABCWUA, which holds upward of 70 percent of the permitted post-1956 groundwater pumping rights in the region, does not need to aggressively pursue acquisition of pre-1907 water rights for offset purposes for several decades. Prior to developing its surface diversion infrastructure, the ABCWUA leased portions of its San Juan-Chama Project water to other parties in the Middle Rio Grande for various uses. The smaller municipalities have not developed this renewable water supply and instead will likely continue to use their San Juan-Chama Project water for offset purposes as necessary.

- The NMOSE adopted the Middle Rio Grande Administrative Guidelines in September 2000 for the administration of the Middle Rio Grande Administrative Area (MRGAA). These guidelines are designed to protect water rights, Rio Grande Compact compliance, and the aquifer, and to minimize land subsidence. Under the guidelines new groundwater appropriations will be approved in the MRGAA only if surface water rights are obtained and transferred to offset the diversion amount less any flow returned directly to the Rio Grande (guidelines Section 5.a). Surface water supplies are fully appropriated, and MRGAA Critical Management Areas, which are now limited to parts of Albuquerque, are closed to additional pumping.

- The MRGCD has four major river diversion points and a large network of irrigation canals and drains in the area between Cochiti and the Bosque del Apache National Wildlife Refuge. Additionally, passive diversion by MRGCD occurs from the river to the adjacent riverside drains in some reaches. MRGCD coordinates with the Bureau of Reclamation on El Vado Reservoir operations so that it can provide stored water to its farmers when native flow is insufficient to meet MRGCD irrigation demand.

- The MRGCD has not yet submitted documentation regarding the water that it has put to beneficial use since its permit was issued in 1930. Without such documentation and critical evaluation of the documentation by the State Engineer, it will remain unclear what the rights under the 1930 permit are.

- The Federal Emergency Management Administration recently released new floodplain maps of Sandoval, Bernalillo, and Valencia counties. The new maps define hazard areas and indicate flood insurance rate boundaries. These maps can help to define areas and infrastructure that are vulnerable to flooding during extreme climate events, thereby helping the region prepare for extreme precipitation. Communities can work to make their watersheds more resilient under climate change by assessing the adequacy of bridges and culverts to sustain peak flow events.

- The existing flood control infrastructure along the Rio Grande is many decades old and nearing the end of its design life. In a number of instances the levees were not engineered and consist simply of excavated materials placed alongside the river when the riverside drains were constructed. Further, because the bottom of the river is higher than the floodplain in some areas, failure of a levee in these areas will cause the river to leave its channel and flood the developed floodplain, including farms, communities, and irrigation and drainage infrastructure. The cost to replace or reinforce this infrastructure is estimated at more than $750 million. A task force of local stakeholder entities has been evaluating the situation, developing reports to the legislature, and seeking funding for higher-priority projects.

- In addition, the river channel has narrowed during the drought and islands have formed that are now vegetated. These conditions will make it difficult to move water through some areas when the next big snowmelt runoff occurs. The potential for extreme precipitation events highlights the need for flood preparation and maintenance of flood control structures.

- The ABCWUA has investigated aquifer storage and recovery (ASR) projects through a demonstration project at Bear Canyon and obtained the first full-scale underground storage and recovery (USR) permit in the state in August 2014. Between November 2014 and March 2015, the project recharged 520.6 acre-feet into the aquifer. ABCWUA is implementing a second ASR demonstration project to recharge water near the drinking water treatment plant in the Rio Grande Valley and is currently evaluating other potential projects that would allow them to store more surface water, building up a drought reserve.

- The City of Rio Rancho has demonstrated that surface infiltration and direct injection methods can be used to safely replenish the underlying aquifer with a purified, reclaimed water source. Projects include a 2-acre surface infiltration system and a direct injection facility, each of which has the capacity to recharge the underlying aquifer at a rate of approximately 2 and 3 acre-feet per day, respectively. Full-scale permits for operation of the direct injection facility have been recently issued by the New Mexico Environment Department and Office of the State Engineer.

- The Middle Rio Grande region is home to four federally listed endangered species—the Rio Grande silvery minnow, the New Mexico meadow jumping mouse, the western yellow-billed cuckoo, and the southwestern willow flycatcher—and water demand for these species has resulted in changes in some water uses in the region in recent years. Currently, a federally mandated Biological Opinion exists for all Middle Rio Grande water operations, specifying instream flow targets to assist in the recovery of the silvery minnow.

- The congressionally authorized Middle Rio Grande Endangered Species Collaborative Program has provided funding at a 75 percent federal/25 percent non-federal cost share to address endangered species and water user conflicts and maintain Endangered Species Act compliance for New Mexico water users above Elephant Butte Reservoir. The Collaborative Program has coordinated efforts by federal, state, and local government and Native American and private entities and expended more than $150 million since 2001. The NMISC has provided approximately 90 percent of the required non-federal cost share. Although new litigation has been filed, Endangered Species Act compliance has been maintained since 2003 and many projects benefiting the endangered species have been completed.

- Consultation toward a new Biological Opinion for Middle Rio Grande river and reservoir operations is in progress. The current Biological Opinion, which has provided endangered species coverage for Middle Rio Grande Water users since 2003, expired in 2013 but has been extended during the consultation on a new biological opinion.

- Pueblo water rights have not been fully characterized or quantified, yet they constitute the most senior water claims in the basin.

- Sandia and Isleta pueblos have EPA-approved water-quality standards, which means that upstream discharges, including treated wastewater return flows from Bernalillo, Rio Rancho, and Albuquerque, must meet Pueblo standards.

- The Middle Rio Grande Water Assembly, a non-profit organization dedicated to educating residents of the Middle Rio Grande about relevant water issues, developed a water budget for the Middle Rio Grande as part of the original water planning effort. Though this document uses a different approach from the common technical approach for all planning regions, the original water budget is still a useful tool that helps describe the water balance in the Middle Rio Grande. The budget has recently been updated (Thomson et al., 2014) by the Middle Rio Grande Water Assembly Water Budget Task Force.

- Due to the large amount of forested land within and upstream of the region, coupled with the recent drought conditions, the threat of wildfire and subsequent sedimentation impacts on streams and reservoirs remains a key planning issue. Continued and expanded efforts to reduce catastrophic fire risk through forest management, as well as additional information on the quantitative benefits of various management techniques, are needed.

- The Nature Conservancy is working to develop the Rio Grande Water Fund, which if funded, will generate sustainable income for a 10- to 30-year forest restoration program through a multi-party effort. Models of debris flow risk after high-severity fire indicate that key water sources are at risk, and the goal of the program is to reduce the risk of catastrophic wildfire and subsequent sedimentation and localized water quality impacts to protect the region's water supply. Details of the program plan are included in the *Rio Grande Fund, Comprehensive Plan for Wildfire and Water Source Protection* (Nature Conservancy, 2015).

- The U.S. Air Force, under direction from the NMED, is cleaning up a jet fuel spill at Kirtland Air Force Base. Plume assessment and interim remediation measures are in place, and a final remediation strategy will be developed under the Resource Conservation and Recovery Act (RCRA) (KAFB, 2015).

- In 2014, the U.S. EPA issued a National Pollutant Discharge Elimination System (NPDES) Watershed Based MS4 Permit NMR04A000, which covers the Middle Rio Grande Watershed. The watershed based MS4 Permit replaces an earlier MS4 Permit NMS000101 for four co-permittees that have been participating under a 2003 cooperative agreement to jointly conduct stormwater quality monitoring. The NMISC is concerned that compliance with the permit will reduce the amount of water reaching the river because, unless a flood control link is present, the permit requires retention of water on newly developed and redeveloped sites as opposed to detention, treatment, and release.

- While the largest urban populations are served by municipal suppliers, there are many small and rural drinking water systems in the region, outside of these urban areas. These small systems face challenges in financing infrastructure maintenance and upgrades and complying with water quality monitoring and training standards.

- The East Mountain area (east of the Sandia Mountains in the central part of the planning region) is supplied largely by domestic wells and small water systems. Yields are low in some areas, shallow wells are vulnerable to drought, and septic systems can impact water quality. Bernalillo County groundwater level monitoring has shown significant water level declines in some areas (McGregor, 2008).

- Between 2006 and 2008, under Section 72-12-25 NMSA, 35 entities filed notices of intent to drill more than 420 deep wells in the Middle Rio Grande for the withdrawal of more than 1.14 million acre-feet of nonpotable groundwater. Two test wells were drilled and tested for this purpose in Sandoval County. No other wells have been drilled associated with these notices, and no water has been put to beneficial use under any of these notices. These proposed groundwater withdrawals from deep aquifers have the potential to affect shallow freshwater aquifers and the surface water of the Rio Grande stream system.

5.1 Summary of Climate Conditions

The 2004 regional water plan (MRCOG and MRGWA, 2004) included a graph of long-term variations in precipitation in the Southwest based on reconstructed tree-ring records, and precipitation in the region was reflected in the regional water budget through tributary and storm drain inflows. This section provides an updated summary of temperature, precipitation, snowpack conditions, and drought indices pertinent to the region (Section 5.1.1), to be consistent with the common technical approach for regional water planning. Studies relevant to climate change and its potential impacts to water resources in New Mexico and the Middle Rio Grande region are discussed in Section 5.1.2.

5.1.1 Temperature, Precipitation, and Drought Indices

Table 5-1 lists the periods of record for weather stations in the Middle Rio Grande region and identifies two stations, Jemez Springs and the Albuquerque airport, that were used for analysis of weather trends. These two stations were selected based on location, how well they represented conditions in their respective counties, and completeness of their historical records (Table 5-1). The locations of the climate stations for which additional data were analyzed are shown in Figure 5-1.

Long-term minimum, maximum, and average temperatures for the climate stations are detailed in Table 5-2, and average summer and winter temperatures for each year of record are shown on Figure 5-2.

The average precipitation distribution across the entire region is shown on Figure 5-3, and Table 5-2 lists the minimum, maximum, and long-term average annual precipitation (rainfall and snowmelt) at the two representative stations in the planning region. The variability in total annual precipitation for the selected climate stations is shown in Figure 5-4 and is also reflected in the drought indices discussed below. In addition to annual variability, monthly variability in precipitation and resulting streamflow also presents a challenge since snowmelt and/or monsoon flows may not occur at times when water is most needed for agriculture or other uses.

Snowpack is an indicator of potential streamflow trends, but no Natural Resources Conservation Service (NRCS) SNOTEL or snow course stations are located in the planning region. Snow depth and snow water equivalent data are collected by the NRCS (2014a) at stations north of the region, and these data are used by water managers in the Middle Rio Grande region to anticipate spring snowmelt. The snow water equivalent is the amount of water, reported in inches, within the snowpack, or the amount of water that would result if the snowpack were instantly melted (NRCS, 2014b). The end of season snowpack is a good indicator of the runoff that will be available to meet water supply needs.

Another way to review long-term variations in climate conditions is through drought indices. A drought index consists of a ranking system derived from the assimilation of data—including rainfall, snowpack, streamflow, and other water supply indicators—for a given region. The Palmer Drought Severity Index (PDSI) was created by W.C. Palmer (1965) to measure the variations in the moisture supply and is calculated using precipitation and temperature data as well as the available water content of the soil. Because it provides a standard measure that allows comparisons among different locations and months, the index is widely used to assess the weather during any time period relative to historical conditions. The PDSI classifications for dry to wet periods are provided in Table 5-3.

There are considerable limitations when using the PDSI, as it may not describe rainfall and runoff that varies from location to location within a climate division and may also lag in indicating emerging droughts by several months. Also, the PDSI does not consider groundwater or reservoir storage, which can affect the availability of water supplies during drought conditions. However, even with its limitations, many states incorporate the PDSI into their drought monitoring systems, and it provides a good indication of long-term relative variations in drought conditions, as PDSI records are available for more than 100 years.

The PDSI is calculated for climate divisions throughout the United States. The Middle Rio Grande region falls within five New Mexico Climate Divisions (1, 2, 4, 5, and 6), though only a very small part of Division 1, located in the northwest corner of the region (Figure 5-1). The chronological history of drought, as illustrated by the PDSI for Climate Divisions 2, 4, 5, and 6, indicates that the most severe droughts in the last century occurred in the early 1900s, the 1950s, the early 2000s, and in recent years (2011 to 2013) (Figures 5-6a and 5-6b).

The 2004 regional water plan referenced a long-term tree ring study (Grissino-Mayer, 1996) which indicates that recent precipitation at the time the plan was prepared was lower than the long-term average and that greater drought conditions would likely be experienced in the future.

The likelihood of drought conditions developing in New Mexico is influenced by several weather patterns:

- *El Niño/La Niña:* El Niño and La Niña are characterized by a periodic warming and cooling, respectively, of sea surface temperatures across the central and east-central equatorial Pacific. Years in which El Niño is present are more likely to be wetter than average in New Mexico, and years with La Niña conditions are more likely to be drier than average, particularly during the cool seasons of winter and spring.

- *The Pacific Decadal Oscillation (PDO):* The PDO is a multi-decadal pattern of climate variability caused by shifting sea surface temperatures between the eastern and western Pacific Ocean that cycle approximately every 20 to 30 years. Warm phases of the PDO (shown as positive numbers on the PDO index) correspond to El Niño-like temperature and precipitation anomalies (i.e., wetter than average), while cool phases of the PDO (shown as negative numbers on the PDO index) correspond to La Niña-like climate patterns (drier than average). It is believed that since 1999 the planning region has been in the cool phase of the PDO.

- *The Atlantic Multidecadal Oscillation (AMO):* The AMO refers to variations in surface temperatures of the Atlantic Ocean which, similarly to the PDO, cycle on a multi-decade frequency. The pairing of a cool phase of the PDO with the warm phase of the AMO is typical of drought in the southwestern United States (McCabe et al., 2004; Stewart, 2009). The AMO has been in a warm phase since 1995. It is possible that the AMO may be shifting to a cool phase but the data are not yet conclusive.

- *The North American Monsoon* is characterized by a shift in wind patterns in summer, which occurs as Mexico and the southwest U.S. warm under intense solar heating. As this happens, the flow reverses from dryland areas to moist ocean areas. Low-level moisture is transported into the region primarily from the Gulf of California and eastern Pacific. Upper-level moisture is transported into the region from the Gulf of Mexico by easterly winds aloft. Once the forests of the Sierra Madre Occidental green up from the initial monsoon rains, evaporation and plant transpiration can add additional moisture to the atmosphere that will then flow into the region. If the Southern Plains of the U.S. are unusually wet and green during the early summer months, that area can also serve as a moisture source. This combination causes a distinct rainy season over large portions of western North America (NWS, 2015).

5.1.2 Recent Climate Studies

New Mexico’s climate has historically exhibited a high range of variability. Periods of extended drought, interspersed with relatively short-term, wetter periods, are common. Historical periods of high temperature and low precipitation have resulted in high demands for irrigation water and higher open water evaporation and riparian evapotranspiration. In addition to natural climatic cycles (i.e., el Niño/la Niña, PDO, AMO [Section 5.1.1]) that affect precipitation patterns in the southwestern United States, there has been considerable recent research on potential climate change scenarios and their impact on the Southwest and New Mexico in particular.

The consensus on global climate conditions is represented internationally by the work of the Intergovernmental Panel on Climate Change (IPCC), whose Fifth Assessment Report, released in September 2013, states, “Warming of the climate system is unequivocal, and since the 1950s many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased” (IPCC, 2013). Atmospheric concentrations of greenhouse gases are rising so quickly that all current climate models project significant warming trends over continental areas in the 21st century.

In the United States, regional assessments conducted by the U.S. Global Change Research Program (USGCRP) have found that temperatures in the southwestern United States have increased and are predicted to continue to increase, and serious water supply challenges are expected. Water supplies are projected to become increasingly scarce, calling for trade-offs among competing uses and potentially leading to conflict (USGCRP, 2009). Most of the major river systems of the southwestern U.S. are expected to experience reductions in streamflow and other limitations to water availability (Garfin et al., 2013).

Although there is consensus among climate scientists that global temperatures are warming, there is considerable uncertainty regarding the specific spatial and temporal impacts that can be expected. To assess climate trends in New Mexico, the NMOSE and NMISC (2006) conducted a study of observed climate conditions over the past century and found that observed wintertime average temperatures had increased statewide by about 1.5°F since the 1950s. Predictions of annual precipitation are subject to greater uncertainty "given poor representation of the North American monsoon processes in most climate models" (NMOSE/NMISC, 2006).

More recently, the U.S. Bureau of Reclamation, with technical assistance from Sandia National Laboratories and the U.S. Army Corps of Engineers, conducted a study of the Upper Rio Grande that evaluated climate impacts in northern New Mexico (USBR, 2013). The study, entitled the *Upper Rio Grande Impact Assessment* (URGIA), includes the Middle Rio Grande planning region. The study found that average temperatures from 1971 through 2011 rose at a rate of approximately 0.7 degree Fahrenheit (°F) per decade, approximately twice the global average, for a total warming of approximately 2.5 F since 1971. The study projected additional increases in temperature through the end of the century and a significant decrease in streamflow in the Rio Grande Basin.

A number of other studies predict temperature increases in New Mexico from 5° to 10°F by the end of the century (Forest Guild, 2008; Hurd and Coonrod, 2008; USBR, 2011). Predictions of annual precipitation are subject to greater uncertainty, particularly regarding precipitation during the summer monsoon season in the southwestern U.S.

Based on these studies, the effects of climate change that are likely to occur in New Mexico and the planning region include (NMOSE/NMISC, 2006):

- Temperature is expected to continue to rise.
- Higher temperatures will result in a longer and warmer growing season, resulting in increased water demand on irrigated lands and increased evapotranspiration from riparian and forested areas, grasslands, and forests, and thus less recharge to aquifers.
- Reservoir and other open water evaporation are expected to increase. Soil evaporation will also increase.
- Precipitation is expected to be more concentrated and intense, leading to increased projected frequency and severity of flooding.

- Streamflows in major rivers across the Southwest are projected to decrease substantially during this century (e.g., Christensen et al., 2004; Hurd and Coonrod, 2008; USBR, 2011, 2013) due to a combination of diminished cold season snowpack in headwaters regions and higher evapotranspiration in the warm season. The seasonal distribution of streamflow is projected to change as well: flows could be somewhat higher than at present in late winter, but peak runoff will occur earlier and be diminished. Late spring/early summer flows are projected to be much lower than at present, given the combined effects of less snow, earlier melting, and higher evaporation rates after snowmelt.

- Forest habitat is vulnerable to both decreases in cold-season precipitation and increases in warm-season vapor pressure deficit (Williams et al., 2010). Stress from either of these factors leave forests increasingly susceptible to insects, forest fires, and desiccation. Greater temperatures increase insect survivability and fire risk.

To minimize the impact of these changes, it is imperative that New Mexico plan for dealing with variable water supplies, including focusing on drought planning and being prepared to maximize storage from extreme precipitation events while minimizing their adverse impacts.

5.2 Surface Water Resources

Surface water supplies approximately 70 percent of the water currently diverted in the Middle Rio Grande Water Planning Region, with its primary uses being for irrigated agriculture followed by public water supply. The dominant waterways flowing in the region are the Rio Grande and its tributaries the Jemez River and the Rio Puerco. Major surface drainages (including both perennial and intermittent streams) and watersheds in the planning region are shown on Figure 5-7.

When evaluating surface water information, it is important to note that streamflow does not represent available supply, as there are also water rights and interstate compact limitations. The administrative water supply discussed in Section 5.5 is intended to represent supply considering both physical and legal limitations, but excluding potential compact limitations. The information provided in this section is intended to illustrate the variability and magnitude of streamflow, and particularly the relative magnitude of streamflow in recent years.

Tributary flow is not monitored in every subwatershed in the planning region. However, streamflow data are collected by the USGS and various cooperating agencies at stream gage sites in the planning region. Table 5-4a lists the locations and periods of record for data collected at stream gages in the region, as well as the drainage area and estimated irrigated acreage for surface water diversions upstream of the station. Table 5-4b provides the minimum, median, and maximum annual yield for all gages that have 10 or more years of record.

In addition to the large variability in annual yield, streamflow also varies from month to month within a year, and monthly variability or short-term storms can have flooding impacts, even when annual yields are low. Table 5-5 provides monthly summary statistics for each of the stations with 10 or more years of record. These data indicate that most of the streamflow occurs in the March to June snowmelt period, with secondary peaks occurring at some gages in August and September as a result of monsoon flows.

For this water planning update, five stream gages, shown on Figure 5-7, were analyzed in more detail. These stations were chosen because of their locations in the hydrologic system, completeness of record, and representativeness as key sources of supply. The Otowi gage is upstream of the Middle Rio Grande planning region, but it is representative of the flow coming into the region. Figure 5-8 shows the minimum and median annual water yield for these gages. Figures 5-9a through 5-9c show the annual water yield from the beginning of the period of record through 2013 for the five gages. As shown in these figures, the annual yield is highly variable in all locations, but especially in the Rio Puerco and Jemez River, where flows are not moderated by upstream reservoir releases or supplemented with non-native water. The Rio Grande at Otowi flows shown on Figures 5-8 and 5-9a include non-native flows from the San Juan-Chama Project.

Though there are several reservoirs that store water supply for Middle Rio Grande users, only two large reservoirs (i.e., storage capacity greater than 5,000 acre-feet, as reported in the NMOSE *Water Use by Categories* report [Longworth et al., 2013]) are present in the planning region (Figure 5-7). Cochiti Reservoir's primary purpose is flood control and the Jemez Canyon Dam is for flood and sediment control; neither are authorized for conservation storage. Table 5-6 summarizes the characteristics of these two reservoirs as well as the upstream reservoirs (Heron, El Vado, and Abiquiu) that provide native and San Juan-Chama Project water to the Middle Rio Grande. As indicated on Table 5-6, El Vado provides water supply storage to the MRGCD and others, and Heron provides storage for the San Juan-Chama project. In addition to these large reservoirs, one smaller reservoir (Galisteo Reservoir on Galisteo Creek) is present in the planning region. Galisteo Reservoir is a flood control reservoir owned and operated by the U.S. Army Corps of Engineers and is not authorized for conservation storage.

The NMOSE conducts periodic inspections of non-federal dams in New Mexico to assess dam safety issues. Dams that equal or exceed 25 feet in height that impound 15 acre-feet of storage or dams that equal or exceed 6 feet in height and impound at least 50 acre-feet of storage are under the jurisdiction of the State Engineer. These non-federal dams are ranked as being in good, fair, poor, or unsatisfactory condition. Dams with unsatisfactory conditions are those that require immediate or remedial action. Dams identified in recent inspections as being deficient, with high or significant hazard potential, are summarized in Table 5-7. Many of the dams listed on Table 5-7 are flood control dams so don't affect the water supply balance in the region significantly, but they do represent safety hazards.

5.3 Groundwater Resources

Groundwater accounted for about 30 percent of all water diversions in the year 2010 (Longworth et al., 2013). It supplies most of the region's small drinking water systems and provides back up supply to the ABCWUA when surface water cannot be diverted.

5.3.1 Regional Hydrogeology

The accepted *Middle Rio Grande Regional Water Plan, 2000-2050* (MRCOG and MRGWA, 2004), did not independently investigate or describe the hydrogeology of the region, but abstracts to relevant publications (Thorn et al., 1993; McAda and Barroll, 2002; Bartolino and Cole, 2002; MRCOG and MRGWA, 2001; MRGWA and MRCOG, 2000; SSP&A, 2000; JSAI and Pioneer West, 2000; NMOSE/ISC, 2002; Niemi and McGuckin, 1997; Scurlock, 1998) were included as an appendix. A map illustrating the surface geology of the planning region, derived from a geologic map of the entire state of New Mexico by the New Mexico Bureau of Geology & Mineral Resources (2003), is included as Figure 5-10. As shown on this figure, portions of six physiographic regions exist within the planning region.

The Albuquerque-Belen portion of the Middle Rio Grande Basin, a north-south trending basin in the Rio Grande rift, is the primary groundwater supply in the region. The basin is bound on the north by Cochiti Pueblo, on the south by San Acacia, on the east by the Sandia and Manzano Mountains, and on the west by Llano de Albuquerque or West Mesa. Sediments that have accumulated in this basin are part of the Santa Fe Group (Hansen and Gorbach, 1997). Only the upper part is an important aquifer, and this saturated portion of the upper Santa Fe Group rarely exceeds 1,000 feet (Hansen and Gorbach, 1997). The Santa Fe Group sediments adjacent to the Rio Grande are overlain by 60 to 80 feet of valley-fill sediments, referred to as alluvium or post-Santa Fe fill (Hansen and Gorbach, 1997). Groundwater is transmitted readily through the alluvium and the upper portion of the Santa Fe Group. The most productive lithologies are the fluvial axial channel deposits of the ancestral Rio Grande and, to a lesser extent, the pediment slope and alluvial-fan deposits (Thorn et al., 1993).

Outside of the Albuquerque-Belen basin, groundwater supplies are more limited. Volcanic and alluvial deposits supply small amounts of groundwater in the Jemez Mountains, and sandstone and limestone supply domestic wells and small water systems in the East Mountain area.

5.3.2 Aquifer Conditions

Water enters the Santa Fe Group aquifer system from four main settings: mountain fronts and tributaries to the Rio Grande, the inner valley of the Rio Grande, the Rio Grande, and subsurface basin margins. Water entering the aquifer from the first three settings is usually termed recharge, whereas water entering the basin from the subsurface is typically termed underflow.
Groundwater discharges from the Santa Fe Group aquifer system in several ways: pumping from

wells, seepage into the Rio Grande and riverside drains, spring flow, evapotranspiration, and subsurface outflow to the Socorro Basin (Bartolino and Cole, 2002).

In order to evaluate changes in water levels over time, the USGS monitors groundwater wells throughout New Mexico (Figure 5-11). Hydrographs illustrating groundwater levels versus time, as compiled by the USGS (2014b), were selected for seven monitor wells with longer periods of record and are shown on Figure 5-12. A number of wells in the Albuquerque Basin showed significant declines, but there has been substantial recovery since 2010, when pumping was replaced by diversion of San Juan-Chama Project water from the river (Figure 5-12). Monitoring wells closest to pumping wells that have reduced pumping show recovery, while wells in other parts of the basin are not affected and continue to decline.

The major well fields in the planning region, along with the basins they draw from, are:

- The ABCWUA, Rio Rancho, and Belen all have well fields that pump from Santa Fe Group sediments in the Albuquerque-Belen portion of the Middle Rio Grande Basin. The ABCWUA well fields are by far the largest producers of the three.
- Smaller communities including Algodones, Bernalillo, San Ysidro, Corrales, Los Lunas, and Bosque Farms also pump from the Albuquerque-Belen portion of the Middle Rio Grande Basin.
- Small systems in the East Mountain area pump from fractured limestone and sandstone units.

5.4 Water Quality Assessment

Assurance of ability to meet future water demands requires not only water in sufficient quantity, but also water that is of sufficient quality for the intended use. This section summarizes the water quality assessment that was provided in the accepted regional water plan and updates it to reflect new studies of surface and groundwater quality and current databases of contaminant sources. The identified water quality concerns should be a consideration in the selection of potential projects, programs, and policies to address the region’s water resource issues.

Surface water quality in the Middle Rio Grande Water Planning Region is evaluated through periodic monitoring and comparison of sample results to pertinent water quality standards. Several reaches of rivers within the planning region have been listed on the 2012-2014 New Mexico 303(d) list (NMED, 2014a). This list is prepared by NMED to comply with Section 303(d) of the federal Clean Water Act, which requires each state to identify surface waters within its boundaries that are not meeting or not expected to meet water quality standards.

Section 303(d) further requires the states to prioritize their listed waters for development of total maximum daily load (TMDL) management plans, which document the amount of a pollutant a waterbody can assimilate without violating a state water quality standard and allocates that load capacity to known point sources and nonpoint sources at a given flow. Figure 5-13 shows the locations of lakes and stream reaches with impaired water quality. Table 5-8 provides details of impairment for those reaches. The primary documented contaminants in the Middle Rio Grande region include aluminum, *E. coli* bacteria, sediment/turbidity, temperature, and biological indicators and nutrients. Some locations also showed elevated arsenic, boron, mercury, polychlorinated biphenyls (PCBs), and gross alpha.

In evaluating the impacts of the 303(d) list on the regional water planning process, it is important to consider the nature of water quality impairment and its effect on potential use. Problems such as stream bottom deposits and turbidity will not necessarily make the water unusable for irrigation or even for domestic water supply (if the water is treated prior to use). However, the presence of the impaired reaches illustrates the degradation that can occur in the water supply, and some of these impairments can be very disruptive to a healthy aquatic community.

Generally the quality of groundwater in the planning region is good, but there are areas with naturally occurring elevated arsenic and uranium and isolated areas that have been contaminated by manmade sources as well. One particular concern in the Middle Rio Grande region is the Kirtland Air Force Base jet fuel spill that has affected the regional aquifer in the Albuquerque area. The project is part of the Resource Conservation and Recovery Act (RCRA) with oversight from NMED (2015).

Specific sources that have the potential to impact either surface or groundwater quality in the future are discussed below. Sources of contamination are considered as one of two types: (1) point sources (Section 5.4.1), if they originate from a single location, or (2) nonpoint sources (Section 5.4.2), if they originate over a more widespread or unspecified location. Information on both types of sources is provided below.

5.4.1 Point Sources

Point source discharges to surface water must comply with the Clean Water Act and the New Mexico Water Quality Standards (20 NMAC 6.4.1) by obtaining a National Pollutant Discharge and Elimination System (NPDES) permit to discharge. NPDES-permitted discharges in the planning region are summarized in Table 5-9 and shown on Figure 5-14. Most of the permits are for municipal wastewater treatment plants. Other permits types include mine, fish hatchery, utility, stormwater, and private domestic permits.

The NMED Ground Water Bureau regulates facilities with wastewater discharges that have a potential to impact groundwater quality. These facilities must comply with the New Mexico Water Quality Act (NMSA 1978, §§ 74-6-1 through 74-6-17) and the New Mexico Water Quality Control Commission (NMWQCC) regulations (NMWQCC, 2002) and obtain approval of a discharge plan, which provides for measures needed to prevent and detect groundwater contamination. A variety of facilities fall under the discharge plan requirements, including mines, sewage dischargers, dairies, food processors, sludge and septage disposal facilities, and other industries. The NMWQCC regulations contain requirements for cleanup of any groundwater contamination detected under discharge plan monitoring requirements. Until such cleanup is complete, these facilities may impact the availability of water supplies of sufficient quality for intended uses. Details indicating the status, waste type, and treatment for individual discharge plans can be obtained from the NMED Ground Water Bureau website (http://www.nmenv.state.nm.us/gwb/). A summary list of current discharge plans in the planning region is provided in Table 5-10; their locations are shown in Figure 5-14.

There are four sites in Bernalillo County listed by the U.S. EPA (2014) as Superfund sites. One additional site in Valencia County is no longer on the Superfund national priorities list (Table 5-11).

Leaking underground storage tank (UST) sites present a potential threat to groundwater, and the NMED maintains a database of registered USTs. Many of the facilities included in the NMED UST database are not leaking and even leaking USTs may not necessarily have resulted in groundwater contamination or water supply well impacts. These USTs could, however, potentially impact groundwater quality in and near the population centers in the future. UST sites in the Middle Rio Grande region are identified on Figure 5-14. Many of the UST sites listed in the NMED database require no further action and are not likely to pose a water quality threat. Sites that are being investigated or cleaned up by the state or a responsible party, as identified on Table 5-12, should be monitored for their potential impact on water resources. Additional details regarding any groundwater impacts and the status of site investigation and cleanup efforts for individual sites can be obtained from the NMED database, which is accessible on the NMED website (http://www.nmenv.state.nm.us/ust/ustbtop.html).

Landfills used for disposal of municipal and industrial solid waste can contain a variety of potential contaminants that may impact groundwater quality. Landfills operated since 1989 are regulated under the New Mexico Solid Waste Management Regulations. Many small landfills throughout New Mexico, including landfills in the planning region, closed before the1989 regulatory enactment to avoid more stringent final closure requirements. Other landfills have closed as new solid waste regulations became effective in 1991 and 1995. Within the planning region, there are 5 operating landfills and 38 closed landfills (Table 5-13, Figure 5-14).

5.4.2 Nonpoint Sources

Nonpoint source issues in the Middle Rio Grande region have been addressed through various watershed activities:

- In 2006 the Ciudad Soil and Water Conservation District prepared a Water Restoration Action Strategy (WRAS) for the Rio Grande Albuquerque reach. The WRAS was updated in 2012 (MRG-AR WG, 2012) with a focus on remediating fecal coliform bacterial contamination as characterized through a bacteria source tracking study (Parsons, 2005). Best management practices identified in the WRAS for addressing fecal coliform will also be helpful for addressing other contaminants.

- In 2012, the EPA issued National Pollutant Discharge Elimination System (NPDES) Permit No. NM000101 (U.S. EPA, 2012) for the Albuquerque MS4 co-permittees: Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), City of Albuquerque (COA), New Mexico Department of Transportation (NMDOT), and the University of New Mexico (UNM). These four entities have been participating under a 2003 cooperative agreement to jointly conduct stormwater quality monitoring in compliance with that permit. The final Watershed Based MS4 Permit NMR04A000, which covers the Middle Rio Grande Watershed, was published in December 2014, replacing the 2012 permit (No. NM000101). As defined by EPA, watershed-based NPDES permitting emphasizes addressing all stressors within a hydrologically defined drainage basin, rather than addressing individual pollutant sources.

- In a comment letter to the U.S. EPA regarding this permit, the NM ISC expressed concern that ". . . the permit may result in actions that reduce the volume of stormwater that reaches the channel of the Rio Grande in parts of Sandoval County and much of Bernalillo County, New Mexico." The NMISC further notes concern that ". . . the Permit, as written, will result in increased depletion of water (by evaporation), without water rights being transferred to offset the new depletions, and thus less water will reach the river to support compact deliveries." In this letter, the NMISC requests that the U.S. EPA consider modifying the permit so that stormwater is not retained by water quality improvement projects, which allow for greater evaporation and/or infiltration and thereby reduce the volume of stormwater that reaches the Rio Grande.

- The Ciudad Soil and Water Conservation District also prepared a WRAS to address nitrogen and phosphorus loading on Tijeras Creek (CSWCD, 2004).

- The Rio Puerco Management Committee has been working to reduce erosion and sediment and to improve vegetative communities along the Rio Puerco drainage.

- The Jemez River Watershed Group has prepared a WRAS that identifies actions to improve watershed health and reduce contaminant loads on the Jemez River and tributaries (JRWG, 2005).

In addition to surface water issues, a primary water quality concern in the planning region is groundwater contamination due to septic tanks. Because septic systems are generally spread out over rural areas, they are considered a nonpoint source. Collectively, septic tanks and other on-site domestic wastewater disposal systems constitute the single largest known source of groundwater contamination in New Mexico (NMWQCC, 2002), with many of these occurrences in areas with shallow water tables, such as those located along the Rio Grande. In areas with shallow water tables or in karst terrain, septic system discharges can percolate rapidly to the underlying aquifer and increase concentrations of (NMWQCC, 2002):

- Total dissolved solids (TDS)
- Iron, manganese, and sulfides (anoxic contamination)
- Nitrate
- Potentially toxic organic chemicals
- Bacteria, viruses, and parasites (microbiological contamination)

Bernalillo County has implemented a septic tank ordinance, but they remain a water quality concern, particularly in the East Mountain area and in areas with shallow groundwater, such as Corrales.

5.5 Administrative Water Supply

The *Updated Regional Water Planning Handbook* (NMISC, 2013) describes a common technical approach (referred to there as a *platform)* for analyzing the water supply in all 16 water planning regions in a consistent manner. As discussed in the handbook (NMISC, 2013), many methods can be used to account for supply and demand, but some of the tools for implementing these analyses are available for only parts of New Mexico, and resources for developing them for all regions are not currently available. Therefore, the state has developed a simple method that can be used consistently across all regions to assess supply and demand for planning purposes. The use of this consistent method will facilitate efficient development of a statewide overview of the balance between supply and demand in both normal and drought conditions, so that the state can move forward with planning and funding water projects and programs that will address the regions' and state's pressing water issues.

To assess the available water supply, the common technical approach considers legal and physical constraints on the supply and a range of conditions from severe drought to normal supply. The method to estimate this supply, hereafter referred to as *administrative water supply*, is based on recent diversions, which provide a measure of supply that considers both physical supply and legal restrictions (i.e., the diversion is physically available, permitted, and in compliance with water rights policies) and thus reflects the amount of water that can actually be used by a region. The recent diversion data are also adjusted to reflect drought supplies, as discussed in Section 5.5.2.

5.5.1 2010 Administrative Water Supply

The total diversions (i.e., administrative water supply) in 2010 for the Middle Rio Grande region, as reported by Longworth et al. (2013), were 431,640 acre-feet. Of this total, 302,514 acre-feet were surface water diversions and 129,126 acre-feet were groundwater. The breakdown of these diversions among the various sectors of use detailed in the NMOSE water use report is discussed in Section 6.1.

5.5.2 Drought Supply

The variability in surface water supply from year to year is a better indicator of how vulnerable a planning region is to drought in any given year or multi-year period than is the use of long-term averages. As discussed in Section 5.1.1, the PDSI is an indicator of whether drought conditions exist and if so, what the relative severity of those conditions is. For the four main climate divisions present in the Middle Rio Grande region (divisions 2, 4, 5, and 6), the PDSI classifications for 2010 were near normal for all four divisions (Figures 5-6a and 5-6b). Given that the water use data for 2010 represent a normal year, it cannot be assumed that this supply will be available in all years; it is important that the region also consider potential water supplies during drought periods.

There is no established method or single correct way of quantifying a drought supply given the complexity associated with varying levels of drought and constantly fluctuating water supplies. For purposes of having an estimate of drought supplies for regional and statewide water planning, the state has adopted the following method for regions with stream-connected aquifers:

- The drought adjustment is applied only to the portion of the administrative water supply that derives from surface water, as it is assumed that groundwater supplies will be available during drought due to the relatively stable thicknesses of groundwater aquifers that are recharged through their connection to streams. While individual wells may be depleted due to long-term drought, this drought adjustment does not include an evaluation of diminished groundwater supplies.

- The minimum annual yield for key stream gages on mainstem drainages (Table 5-4b) was compared to the 2010 yield, and the gage with the lowest ratio of minimum annual yield to 2010 yield was selected.

- The 2010 administrative surface water supply for the region was then multiplied by that lowest ratio to provide an estimate of the surface water supply adjusted for the maximum drought year of record.

For the Middle Rio Grande region, the gage with the minimum ratio of annual yield to 2010 yield is the Rio Grande at Albuquerque, with a ratio of 0.33 for a minimum annual yield

(248,321 acre-feet in 1977) to 2010 yield (759,441 acre-feet) (USGS, 2014c) Based on the region's total administrative surface water supply of 302,514 acre-feet (Section 5.5.1), the drought-adjusted surface water supply is 99,829 acre-feet. With the 129,126 acre-feet of groundwater supply, the total drought supply is 228,955 acre-feet, or about 53 percent of a normal year administrative water supply. Thus, approximately 228,955 acre-feet will be available to divert in an extreme drought year.

Though the adjustment is based on the minimum year of record to date, it is possible that drought supplies could be even lower in the future. Additionally, water supplies downstream of reservoirs may be mitigated by reservoir releases in early drought phases, while longer-term droughts can potentially have greater consequences. This approach does not evaluate mitigating influences of reservoir storage in early phases of a drought when storage is available or potential development of new groundwater supplies. Nonetheless, the adjusted drought supply provides a rough estimate of what may be available during a severe to extreme drought year.